BMS Development embedded board User Guide

Version: V1.0（2023-07）

Complied by: Polyhex Technology Company Limited（http://www.polyhex.net/）

Battery Management System (BMS), based on 32-bit Arm® Cortex-M0 microcontroller, and the REFSEMI REF6107 AFE chip, it further enables convenient and intelligent management and maintenance of each battery unit, to prevent the cell from over-charge, over-discharge, over-voltage, over-temperature, which can improve the utilization rate of the cell and prolong the service life of each cell.

BMS has excellent cell balancing, short circuit protection and other functions, widely used in sweeping machines, vacuum cleaners and other fields.

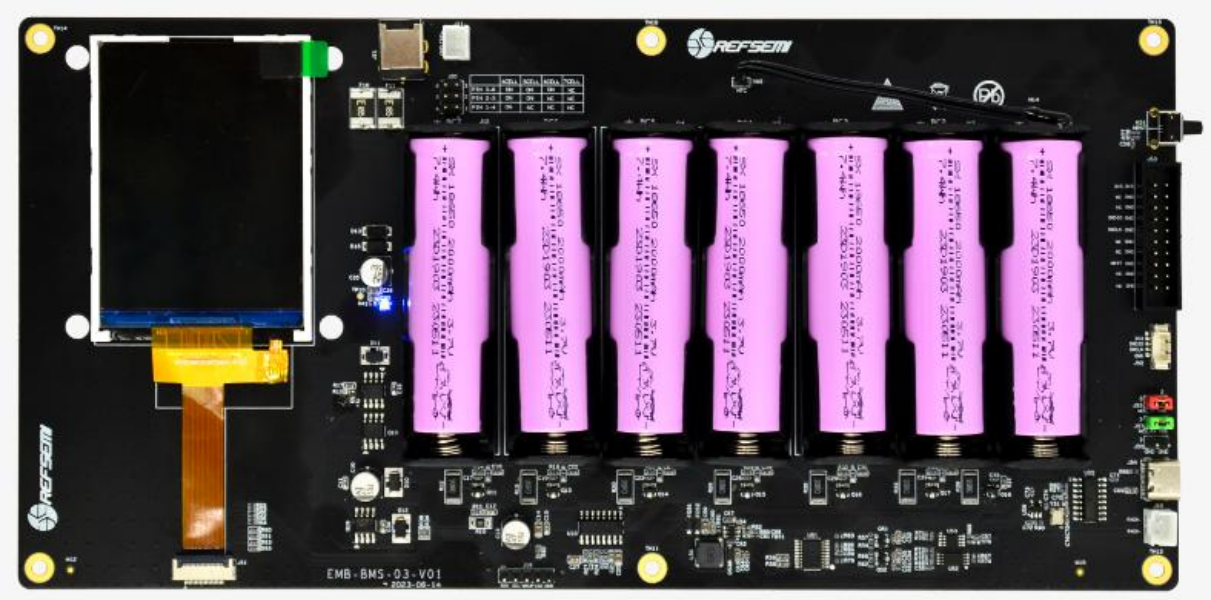


Figure 1 EMB-BMS-03

REVISION HISTORY		
Revision	**Date**	**Description**
1.0	2023.07.07	First edition

Index

Chapter 1 Security

1.1. Safety Precaution

The following messages inform how to make each cable connection. In most cases, you will simply need to connect a standard cable.

Table 1 Terms and conventions

Symbol	Meaning
Warning! 	Always disconnect the power cord from the chassis whenever there is no workload required on it. Do not connect the power cable while the power is on. A sudden rush of power can damage sensitive electronic components. Only experienced electricians should open the chassis.
Caution! 	Always ground yourself to remove any static electric charge before touching *EMB-BMS-03*. Modern electronic devices are very sensitive to electric charges. Use a grounding wrist strap at all times. Place all electronic components on a static-dissipative surface or in a static-shielded bag.

1.2. Safety Instruction

To avoid malfunction or damage to this product please observe the following:

1．Disconnect the device from the DC power supply before cleaning. Use a damp cloth. Do not use liquid detergents or spray-on detergents.

2．Keep the device away from moisture.

3．During installation, set the device down on a reliable surface. Drops and bumps will lead to damage.

4．Before connecting the power supply, ensure that the voltage is in the required range, and the way of wiring is correct.

5．Carefully put the power cable in place to avoid stepping on it.

6．If the device is not used for a long time, power it off to avoid damage caused by sudden

overvoltage.

7. Do not pour liquid into the venting holes of the enclosure, as this could cause fire or electric shock.

8. For safety reasons, the device can only be disassembled by professional personnel.

9. If one of the following situations occur, get the equipment checked by service personnel:

- The power cord or plug is damaged.
- Liquid has penetrated into the equipment.
- The equipment has been exposed to moisture.
- The equipment does not work well, or you cannot get it to work according to the user's manual.
- The equipment has been dropped and damaged.
- The equipment has obvious signs of breakage.

10. Do not place the device outside the specified ambient temperature range. This will damage the machine. It needs to be kept in an environment at controlled temperature.

11. Due to the sensitive nature of the equipment, it must be stored in a restricted access location, only accessible by qualified engineer.

DISCLAIMER: Polyhex disclaims all responsibility for the accuracy of any statement of this instructional document.

1.3. Technical Support

1. Visit Polyhex website http://www.polyhex.net/ where you can find the latest information about the product.
2. Contact your distributor, sales representative or Polyhex's customer service center for technical support if you need additional assistance. Please have the following info ready before you call:
   - Product name
   - Description of your peripheral attachments

- Description of your software(operating system, version, application software, etc.)
- A complete description of the problem
- The exact wording of any error messages

Email: *info@polyhex.net*

Chapter 2 BMS Introduction

BMS uses REFSEMI REF6107 AFE to monitor the cell voltage, temperature, etc., intelligently manage the cell charge and discharge, extend the battery life, and provide a flexible and reliable solution.

Main features:

- AFE chip: REF6107, can be configured with 4-7 18650 cylindrical Li-ion batteries
  - Integrated cell-balance drivers eliminate external components
  - Integrated reverse voltage protection (0.9V typical threshold)
  - Integrated under voltage lockout (UVLO)
  - Integrated cell disconnection detection
  - 3.3V output to power MCU
  - Integrated MOSFET Drivers: Charge (P or N) and Discharge (N)
  - I2C BUS communication with host MCU
  - Low power consumption
    - ✓ Full Power Mode < 90 μA
    - ✓ Sleep Mode < 5 μA
- Based on 32-bit Arm® Cortex-M0 microcontroller with operating frequency up to 72MHz
  - Support hibernation and wake-up
  - Support AFE temperature collection
- Support external balanced, maximum balance-current is 150mA
- Support cell voltage and temperature measurement
- Support over-charge protection, over-discharge protection, over-temperature protection and short circuit protection
- Boot loader supports On-chip Flash In-line System Programming (ISP)
- Support real-time data display and fault display

2.1. Overview of BMS

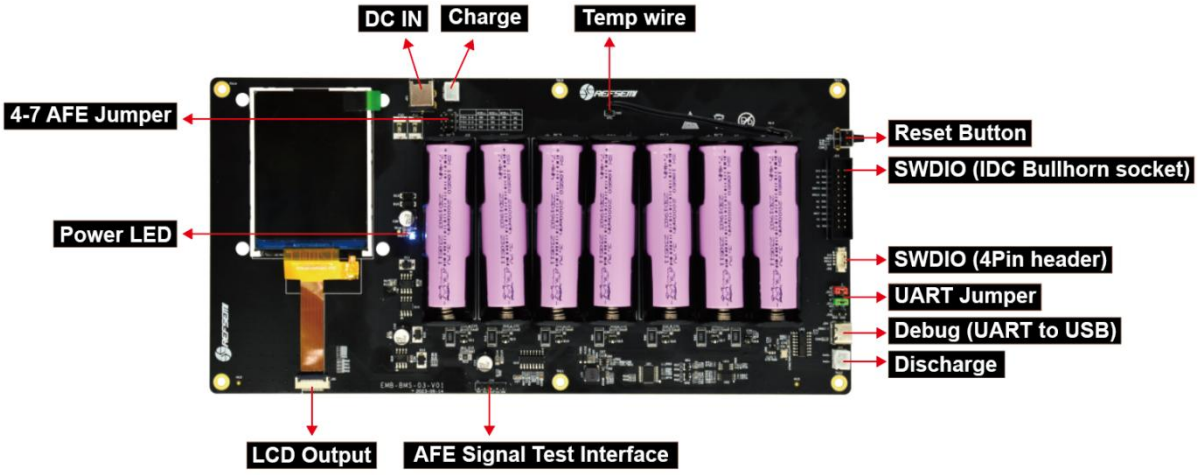


Figure 2 BMS Interface

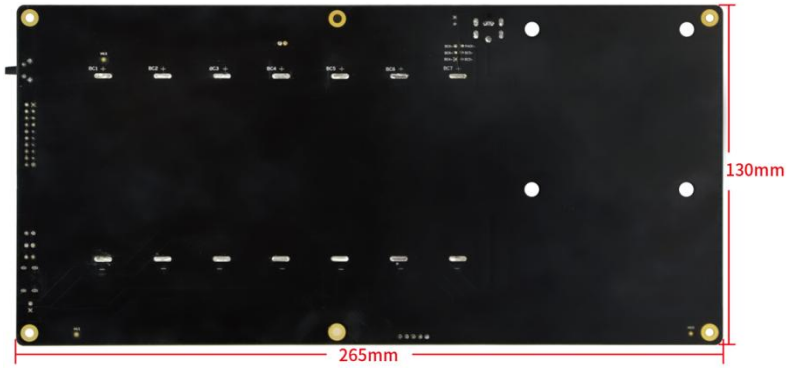


Figure 3 BMS Dimensions

BMS is based on MindMotion MM32F0141B1T / STMicroelectronics STM32F042F6P6TR MCU, and REFSEMI REF6107 AFE, supports cell-balance, hibernation and wake-up, etc. The charge and discharge is done in split-port mode, with the following specifications:

Table 2 BMS Specification

System	
MCU	MindMotion MM32F0141B1T or STMicroelectronics STM32F042F6P6TR, 32-bit Arm® Cortex-M0
AFE	REFSEMI REF6107, adaptable to 4-7 18650 cylindrical lithium-ion cell
Model	EMB-BMS-03
Storage	1KB EEPROM

Communication	
UART	1 x UART, supports program debug and command control
Video	
Display	1 x SPI LCD output, 2.8 inches, and resolution is 240*320
I/O Interface	
DC Block	1 x DC socket, supports 5.5mm x 2.1mm plug
USB	1 x USB Type-C Debug (UART to USB), can be used as program debug and external control interface through jumper setting
LED & Button	● 1 x Power LED ● 1 x Reset button
SWDIO	1 x SWDIO flash interface, leading to 2 connectors: ● 2 x 10Pin/2.54mm Pitch IDC Bullhorn socket ● 4Pin/1.25mm Pitch header
Temp wire	1 x 100KΩ lead type NTC temperature probe, detect cell temperature, range from -20°C~60°C
Charge	1x 2Pin/2.5mm header, charge voltage depends on the number of cell, standard charge current 0.3C A
Discharge	1x 2Pin/2.5mm header, discharge voltage depends on the number of cell, standard discharge current 1.0C A
AFE Signal Test	1 x AFE Signal Test interface, the connector is 5Pin/2.54mm pitch header
Cell slot	7 x 18650 cell slots, optional 4-7 cells
Cell	
Cell Type	18650 cylindrical lithium-ion cell
Function	
Protection Function	● Integrated under voltage lockout, Integrated cell disconnection detection

	● Over-charge, over-discharge, over-temperature, and short-circuit protection
Power Supply	
Power Input	Depends on the number of cells (maximum voltage of a cell is 4.2 V): ● 4 cells at 16.8V ● 5 cells at 21.0V ● 6 cells at 25.2V ● 7 cells at 29.4V
Mechanical & Environmental	
Size (L x W)	265mm x 130mm
Weight	194g (without cells)
Operating Temperature	-45°C~80°C

2.2. Composition of BMS

The BMS assembly consists of a MindMotion MM32F0141B1T MCU chip, a REFSEMI REF6107 AFE chip and 7 cell slots. The MCU is primarily responsible for controlling AFE, management of algorithms, etc., and AFE is primarily responsible for charge-discharge management and cell-balance.

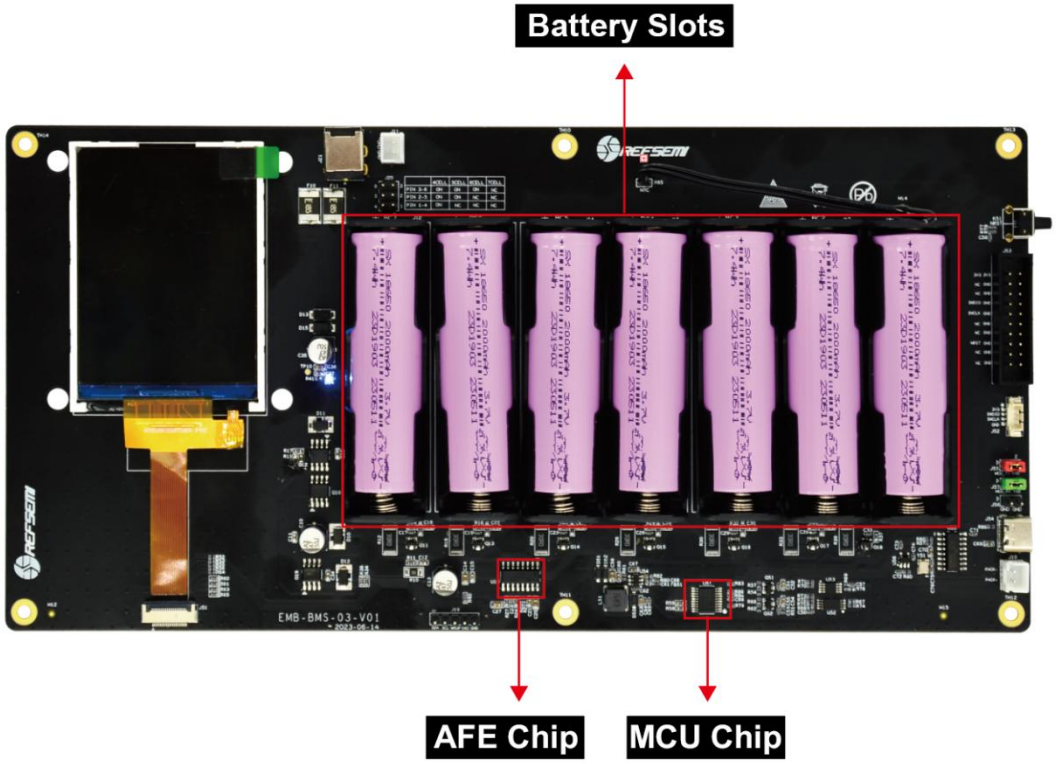


Figure 4 EMB-BMS-03

2.3. Interface of BMS

2.3.1. Charge Interface

BMS provides two charge connectors (J21, J11):

- One of them is a DC socket charge port (J21) with 5.5mm x 2.1mm plug support;
- One of them is a header charge port (J11) with a 2Pin/2.5mm header connector.

The charge voltage depends on the number of cells, as shown in the following table:

Table 3 Power voltage

Cell voltage(V)	Cell number	Power voltage(V)
4.2	4	16.8
	5	21.0
	6	25.2
	7	29.4

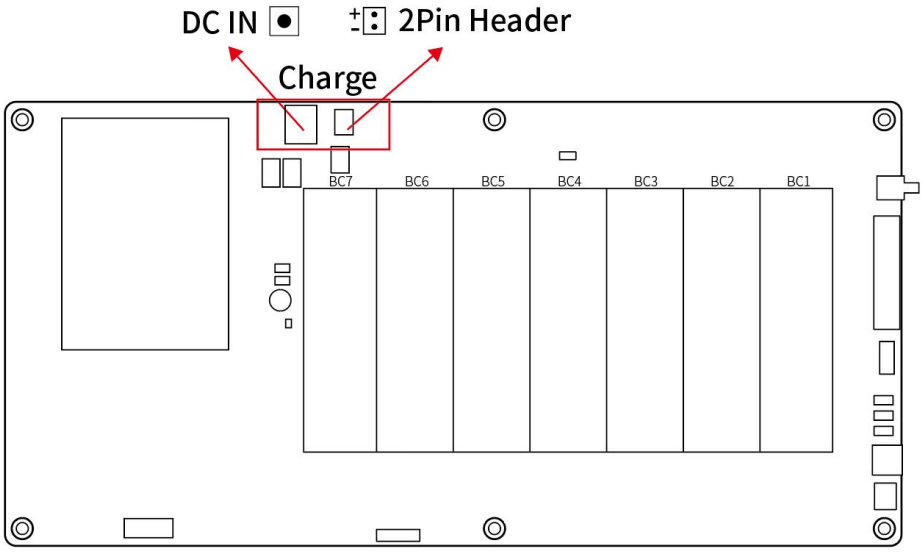


Figure 5 Power interface

The J11 pin sequence is as shown in the figure:

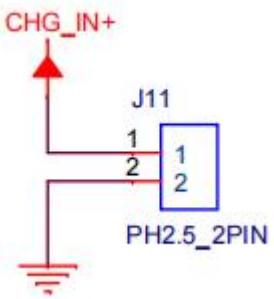


Figure 6 Pin sequence of J11

The J11 interface is defined as follows:

Table 4 Pin definition of J11

Pin	Definition	Description
1	CHG_IN+	Positive of charge port
2	GND	Ground

2.3.2. Discharge Interface

BMS provides one discharge port (J10) with a connector of 2Pin/2.5mm header for cell discharge, and the discharge voltage range is shown in the table below:

Table 5 Discharge voltage threshold

Cell voltage(V)	Cell number	Discharge voltage threshold(V)
2.85~4.2	4	11.40~16.80
	5	14.25~21.00
	6	17.10~25.20
	7	19.95~29.40

NOTE

When the discharge voltage reaches the lower threshold, the device enters the sleep state and needs to be charged in time.

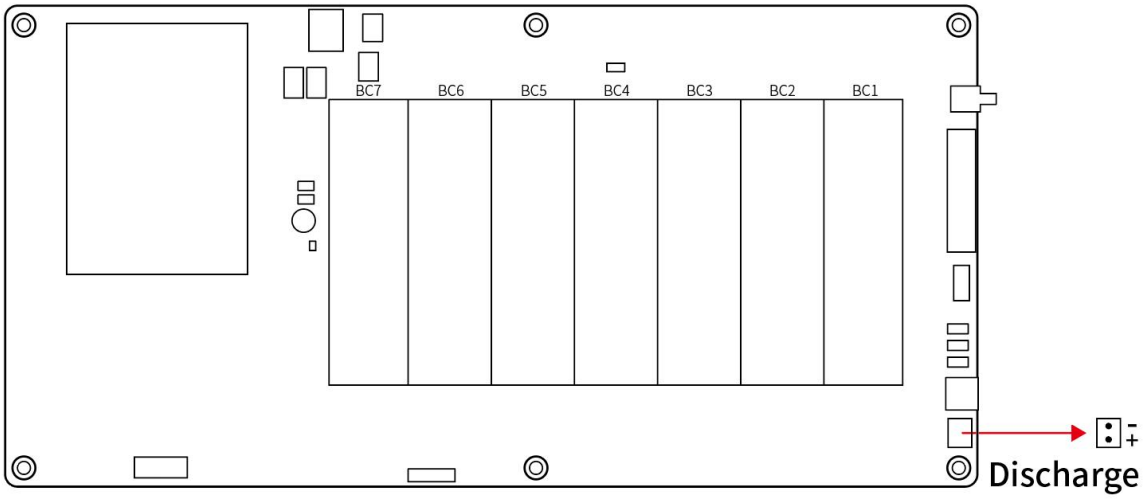


Figure 7 Discharge interface

The J10 pin sequence is as shown in the figure:

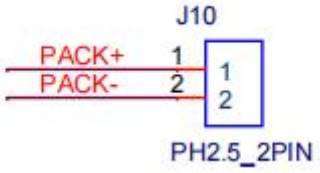


Figure 8 Pin sequence of J10

The J10 interface is defined as follows:

Table 6 Pin definition of J10

Pin	Definition	Description
1	PACK+	Positive of pack discharge port
2	PACK-	Negative of pack discharge port

2.3.3. 4-7 cells AFE Jumper

According to the number of connected cells, the appropriate battery power supply voltage can be selected through the J20 interface jumper shorting.

Warning

In order to protect the board, and to avoid smoke, hardware deformation or even other dangers from wrong operation, the following points must be done:

1. Before connecting the cell, make sure that there is **no jumper** on the J20 interface;
2. After connecting the cell, set the J20 interface pin jumper according to the **onboard silkscreen table**.
3. If **switching cell scenario** occurs, please **remove all jumper first**, install or remove the cell, and then pin jumper.

Important

Battery slots configuration sequence:

1. Optional configuration of 4-7 cells, not less than 4.
2. Priority is given to inserting cell from the right battery slot of the board (BC1 --> BC7) in sequence, and empty slots in the middle are prohibited.

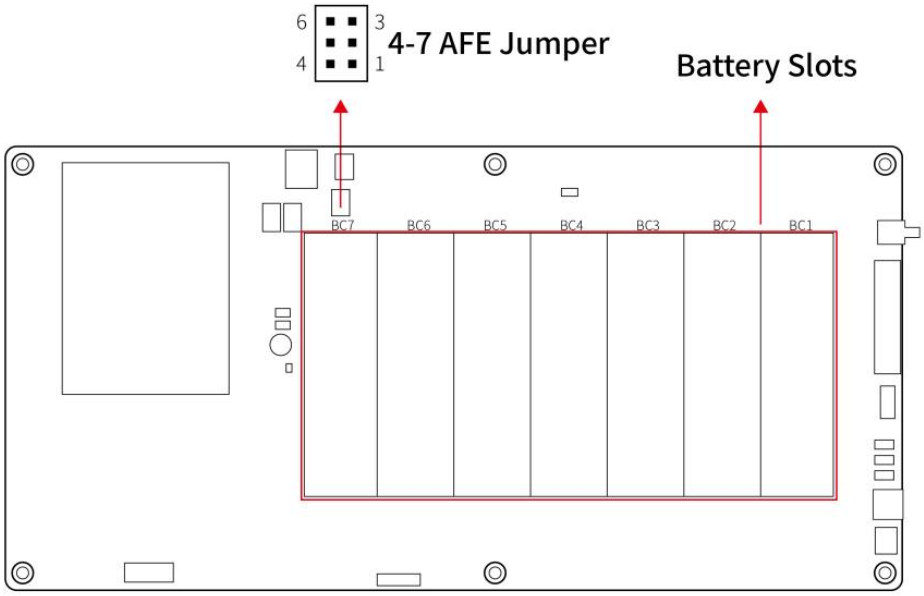
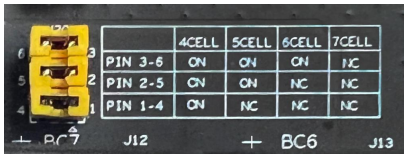
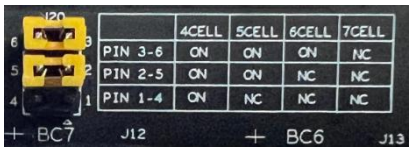
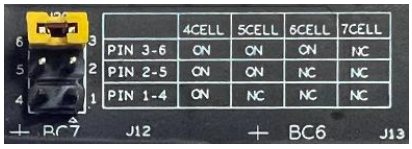
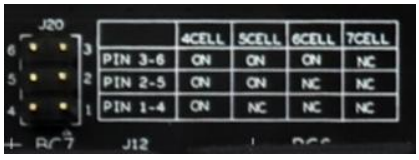


Figure 9 4-7 AFE Jumper

The short settings for AFE jumper are shown in the table below：

Table 7 Interface jumper setting

J20 / Cell Number	Pin1-4	Pin2-5	Pin3-6	Legend
4 cells	Jumper shorting	Jumper shorting	Jumper shorting	
5 cells	-	Jumper shorting	Jumper shorting	
6 cells	-	-	Jumper shorting	
7 cells	-	-	-	

The AFE jumper pin sequence is as shown in the figure:

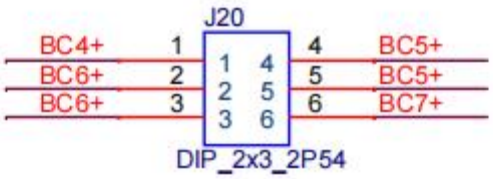


Figure 10 Pin sequence of J20

The AFE jumper interface is defined as follows:

Table 8 Pin definition of AFE jumper

Pin	Definition	Pin	Definition
1	BC4+	4	BC5+
2	BC6+	5	BC5+
3	BC6+	6	BC7+

2.3.4. AFE Signal Test Interface

There is one AFE signal test interface (J19) on board, the connector is 5Pin/2.54mm pin header, which is mainly used to monitor signals such as I2C, VAO, WAKEUP status, etc.

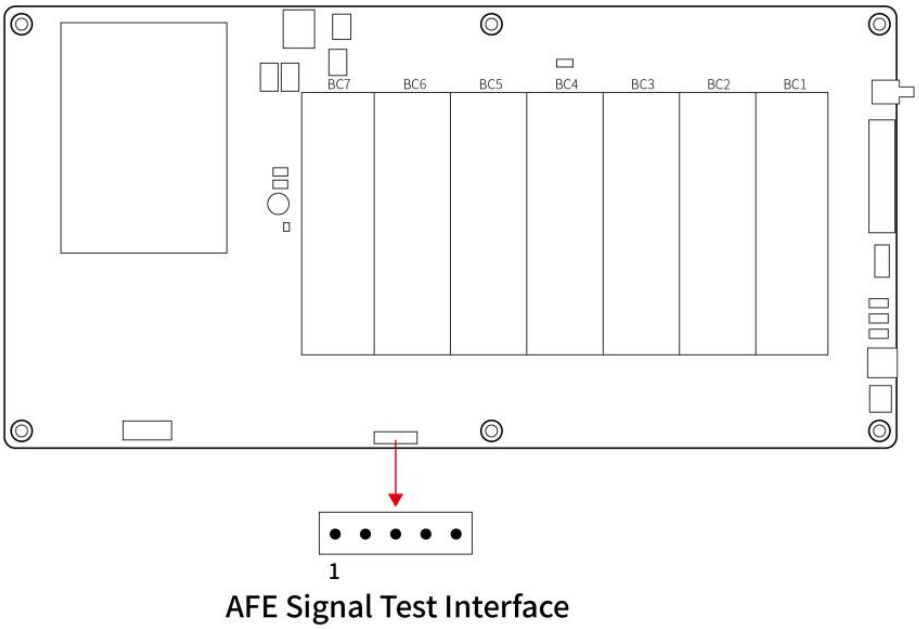


Figure 11 AFE Signal Test interface

The J19 pin sequence is as shown in the figure:

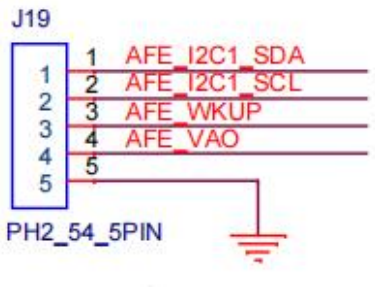


Figure 12 Pin sequence of J19

The J19 interface is defined as follows:

Table 9 Pin definition of J19

Pin	Definition	Pin	Definition
1	AFE_I2C1_SDA	2	AFE_I2C1_SCL
3	AFE_WKUP	4	AFE_VAO
5	GND		

2.3.5. Debug Interface

BMS provides a USB Type-C Debug interface (J54) as a debug port for device troubleshooting.

Before the Debug port is used, the J55 and J57 interface jumper need to be set.

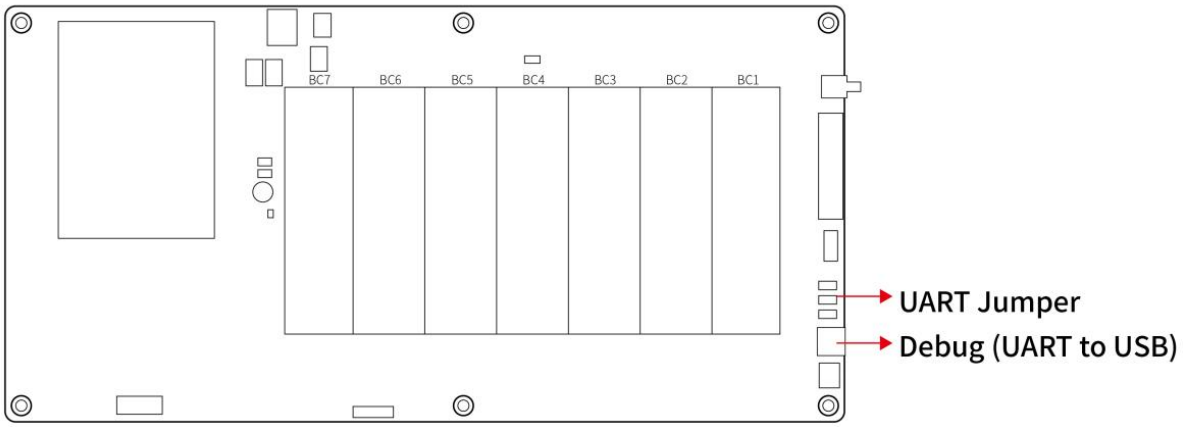


Figure 13 URAT jumper to Debug

2.3.6. UART Jumper

According to the need to use Debug port, through the J55, J57 interface jumper shorting to convert UART to USB for debug operation.

NOTE

> If the Debug port is not used, there is no need to short the J55 and J57 interfaces.

Table 10 J55, J57 jumper setting

Function / Interface	UART to USB	UART (MCU) connectable with DuPont cable
	Short to J55, J57 	-

2.3.7. LCD Interface

BMS provides a 2.8-inch LCD display interface (J51) with a connector of 18Pin/0.5mm pitch horizontal FPC holder, and supports 240*320 resolution.

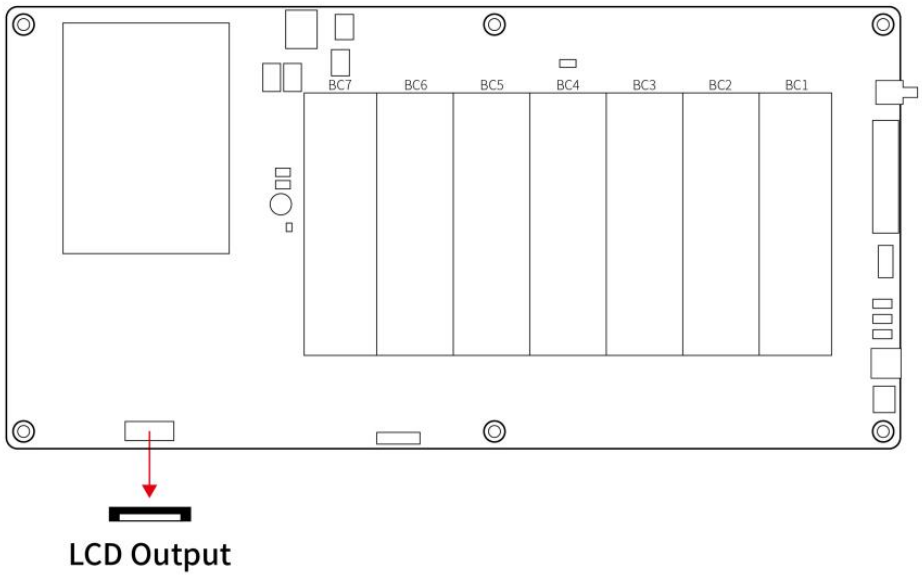


Figure 14 LCD Output

The LCD output interface pin sequence is as shown in the figure:

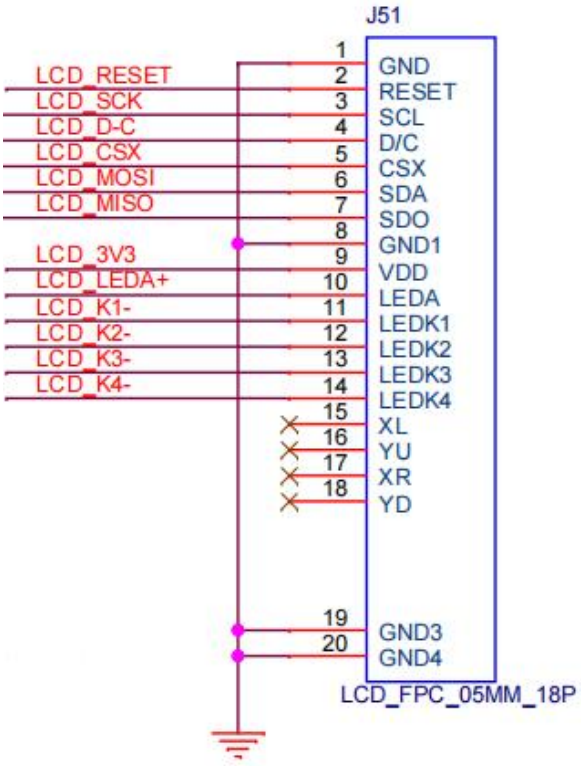


Figure 15 Pin sequence of LCD output interface

The LCD output interface is defined as follows:

Table 11 Pin definition of J53

Pin	Definition	Pin	Definition
1	GND	2	LCD_RESET
3	LCD_SCK	4	LCD_D-C
5	LCD_CSX	6	LCD_MOSI
7	LCD_MISO	8	GND
9	LCD_3V3	10	LCD_LEDA+
11	LCD_K1-	12	LCD_K2-
13	LCD_K3-	14	LCD_K4-
15	NC	16	NC
17	NC	18	NC
19	GND	20	GND

2.3.8. SWDIO Interface

BMS provides a SWDIO flash interface, and two connectors are introduced for user convenience:

- 2 x 10Pin/2.54mm pitch IDC bullhorn socket (J53)
- 4Pin/1.25mm pitch header (J52)

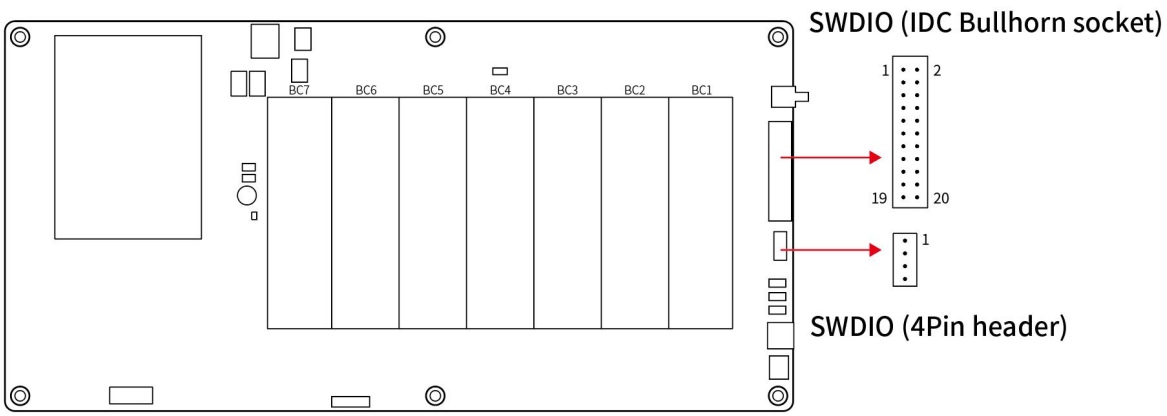


Figure 16 SWDIO interface

The SWDIO(IDC Bullhorn socket) interface pin sequence is as shown in the figure:

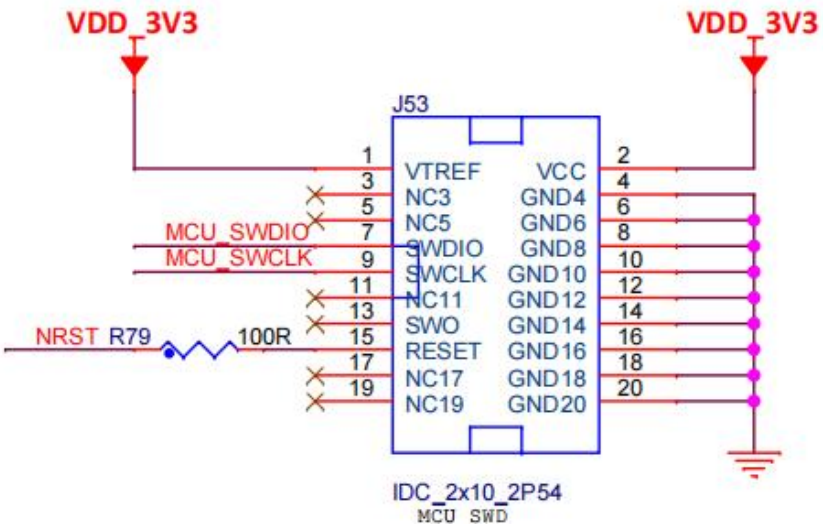


Figure 17 Pin sequence of J53

The SWDIO(IDC Bullhorn socket) interface is defined as follows:

Table 12 Pin definition of J53

Pin	Definition	Pin	Definition
1	VDD_3V3	2	VDD_3V3

3	NC	4	GND
5	NC	6	GND
7	MCU_SWDIO	8	GND
9	MCU_SWCLK	10	GND
11	NC	12	GND
13	NC	14	GND
15	NRST	16	GND
17	NC	18	GND
19	NC	20	GND

The SWDIO(4Pin header) interface pin sequence is as shown in the figure:

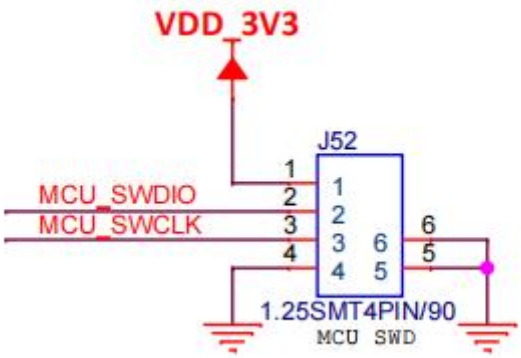


Figure 18 Pin sequence of J52

The SWDIO(4Pin header) interface is defined as follows:

Table 13 Pin definition of J52

Pin	Definition	Pin	Definition
1	VDD_3V3	2	MCU_SWDIO
3	MCU_SWCLK	4	GND

2.3.9. LED & Button

There are a power LED status indicator (D14) and a Reset button (K51).

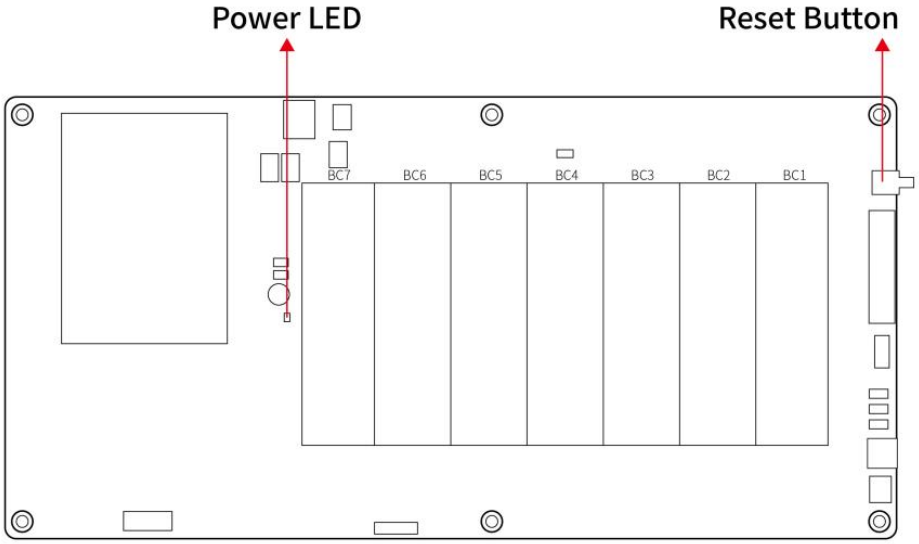


Figure 19 LED & Button

Table 14 LED & Button description

LED & Button	Status	Description
Power LED	Lighting	Power is on
	off	Power is off
Reset	Press	System reset after hardware abnormality repair

2.4. Packing List

- 1 x BMS Board
- (4 - 7) x 18650 Cylindrical Lithium-ion Cells (default 7 cells)
- 1 x 2.8-inch LCD Display

Chapter 3 Getting started

3.1. Installation

1. **LCD installation (factory installed):** First pull up the black plastic snap of the LCD output interface on BMS, insert the FPC cable, and press the snap to fix it, as shown below:

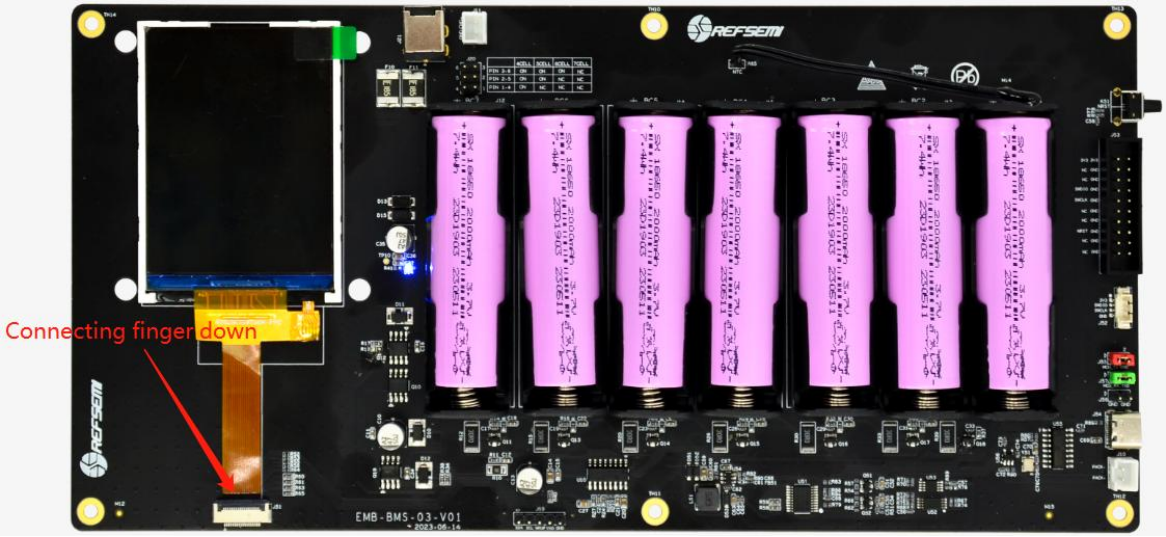


Figure 20 LCD installation

2. **Cell installation:** Put the cells into the battery slots in right-to-left order (BC1-->BC7).
3. The power LED (blue) lights up after connecting the cells;
4. **J20 jumper to set the number of cells:** Set the actual number of cells installed through J20 jumper;

- If you place 7 cells, directly put them into BC1-BC7, J20 no jumper, as shown below:

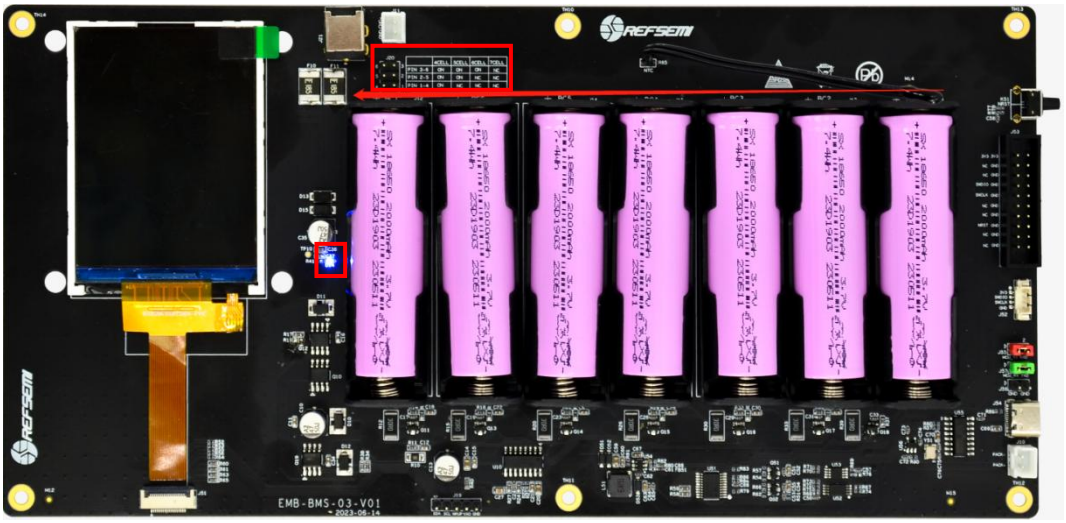


Figure 21 7 cells installation

- If you place 4 cells, you need to put them into BC1-BC4, J20 jumper as shown in the following figure:

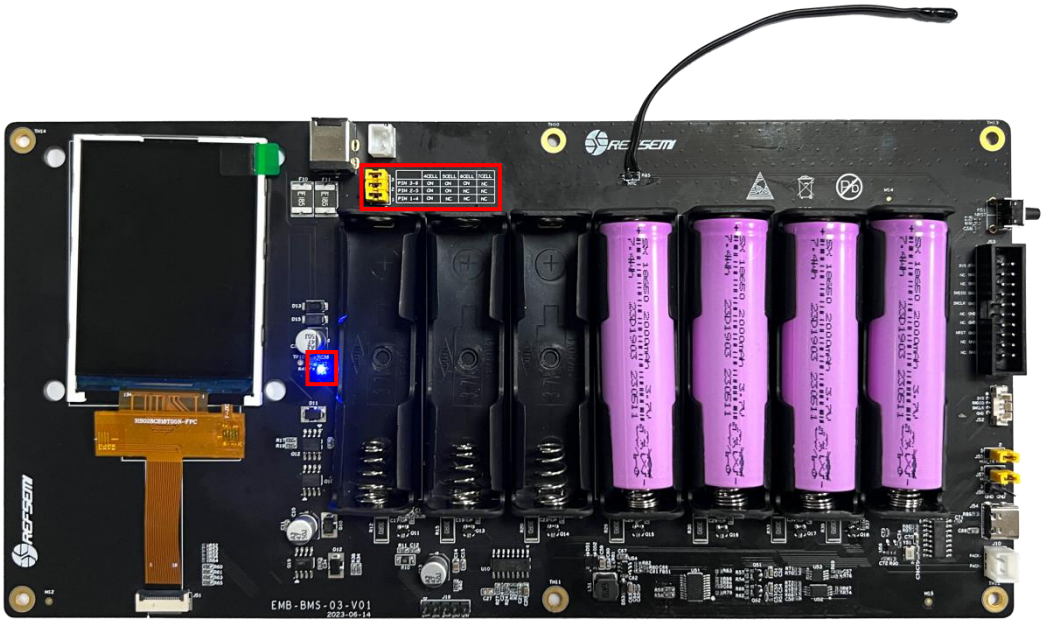


Figure 22 4 cells installation

- If you place 5 cells, you need to put them into BC1-BC5, J20 jumper as shown in the following figure:

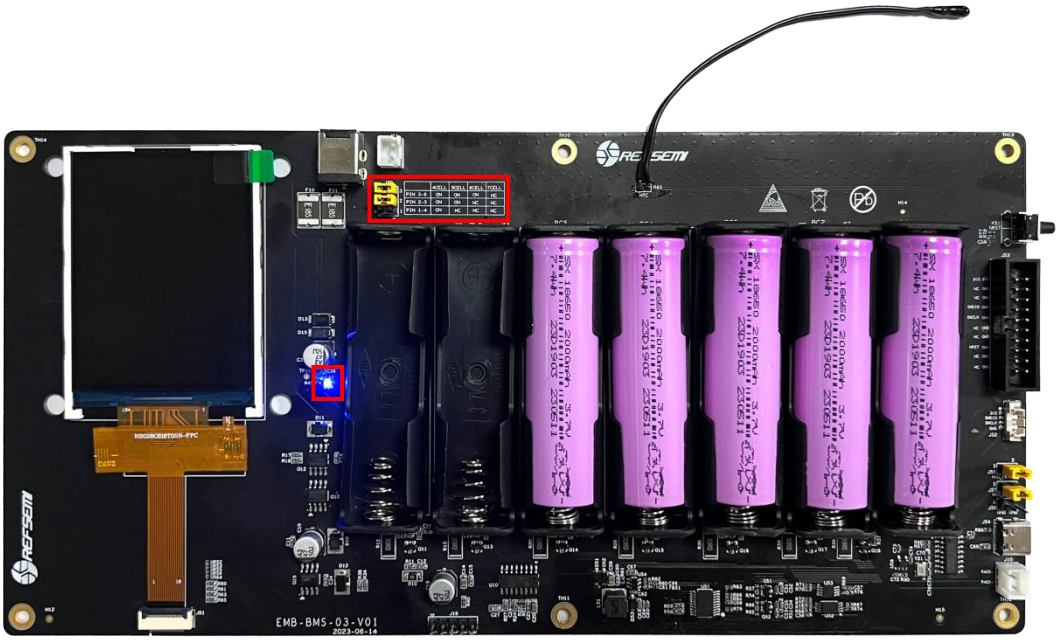


Figure 23 5 cells installation

- If you place 6 cells, you need to put them into BC1-BC6, J20 jumper as shown in the following figure:

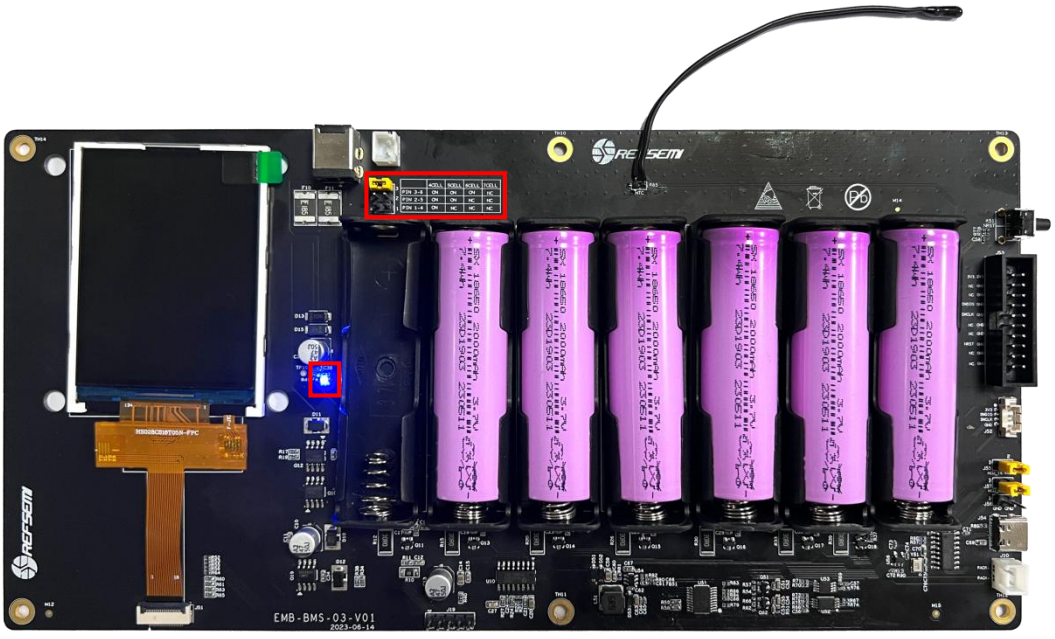


Figure 24 6 cells installation

5. **Software command set the number of cells:** send AA 55 85 01 0X (X is 4-7, the number of installed cells) command to the BMS through the serial tool (sscom), after BMS receives it, and “CELL_NUM” is X (set value) in the LCD screen; if the display value is consistent with the actual number of cells, it proves that the number of cells is set correctly.

6. LCD shows the BMS parameter data, the status is OK, it can be directly connected to the load to use.

7. If the cell voltage is insufficient, you need to charge the cells according to the number of cell connections, when the voltage is higher than the minimum value of the discharge voltage, you can connect the load to use. The LCD shows the information as shown below:

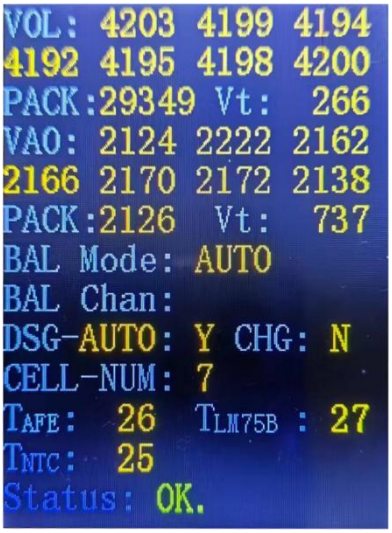


Figure 25 LCD information

3.2. LCD information

In order to more clearly show the performance of BMS, LCD display provides the value of each performance parameter, and fault types. LCD display shows the specific information as follows:

Table 15 Information of LCD display

Parameter	Definition	Description
VOL	Cell voltage	Lines 1-2 show the voltage of 1-7 cell Line 3 "PACK" shows the current total cell voltage, and "Vt" shows AFE internal temperature channel voltage
VAO	AVO channel voltage	Lines 4-5 show the VAO voltage 1-7 cell Line 6 "PACK" shows battery pack VAO voltage, and "Vt" shows AFE internal temperature channel VAO voltage
BAL Mode	Balance Mode	● "AUTO": Auto-balance ● "MANL": manual-balance
BAL Chan	Balance channel	● no value shown, indicates no balance channel ● a value shown, indicates that channel X is in balance status
DSG-	Discharge status	When it is "DSG-AUTO": automatic control When it is "DSG-MANL": manual control ● "Y": discharging ● "N": not discharge
CHG	Charge status	● "Y": charging ● "N": not charge
CELL-NUM	Number of cell set	Value range: 4-7
T_{AFE}	AFE internal temperature value	Temperature range: -40°C~85°C

T_{LM75B}	Check value of LM75B for AFE internal temperature	Temperature range: -55°C~125°C
T_{NTC}	Temperature value of cell measured by NTC	Temperature range: -20°C~60°C
Status	BMS working status	"OK": System is normal "AFE I2C ERR": I2C communication abnormality of AFE chip "AFE CRC ERR": I2C communication CRC detection abnormality of AFE chip "EEPROM I2C ERR": I2C read/write abnormality of EEPROM "LM75B Not Found": LM75B not found "Uncalibrated": AFE internal temperature not currently calibrated

Chapter 4 Function

4.1. AFE

BMS is based on REFSEMI REF6107 AFE chip (U10), an analog front end (AFE) IC for 4 to 7 cell battery pack applications. It senses the cell voltages and the pack voltage, after level shifting and scaling, buffer them as a ground based low analog signal at VAO pin. This low voltage analog signal can be measured by a ground based analog to digital (A/D) converter. REF6107 also integrates cell balance driver and RVP function. It is designed to work with a host MCU with an A/D converter. It is widely used in electric meters and gardening tools, power storage systems, light electric vehicles, and power backup systems.

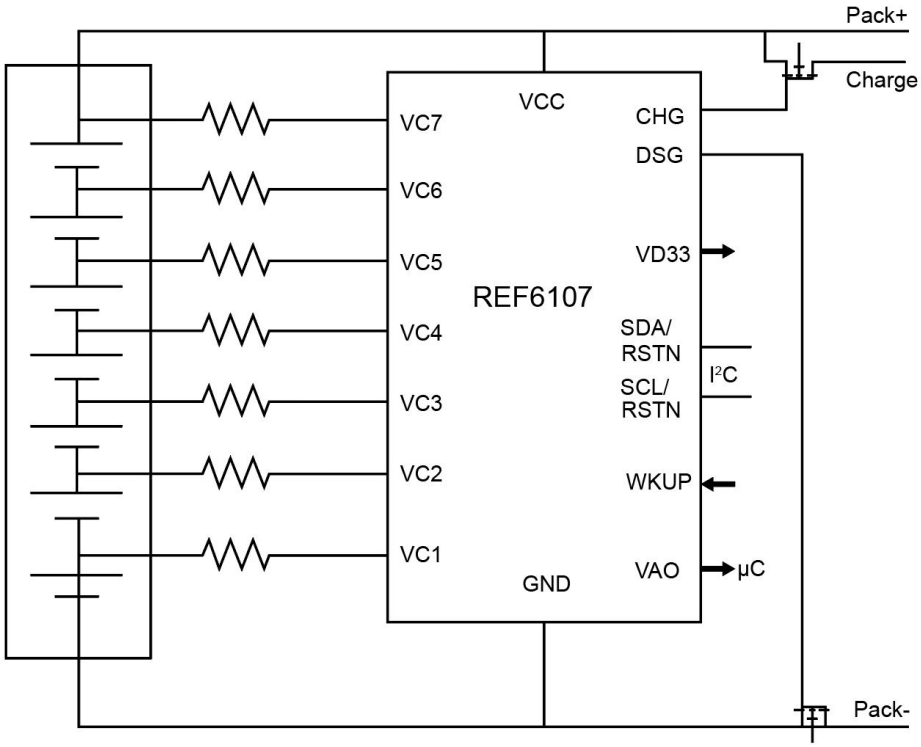


Figure 26 AFE application

Main function:

- Analog Multiplexer: monitor individual battery cell voltage, the whole battery pack voltage and IC internal temperature sensor output voltage
- AFE includes reverse voltage protection (RVP) to monitor each individual cell voltage

- AFE integrates one internal temperature sensor to monitor the die temperature
- AFE integrates an internal cell balance function, which is controlled by external MCU
- Cell Balance Timeout: When the cell balance time is longer than approximately 1 minute (the exact period is determined by the internal 32K Oscillator accuracy), cell balancing will stop
- Supports under-voltage lockout protection and cell disconnection detection
- AFE integrates an internal 32 KHz oscillator to provide clock for I^2C BUS communication and other internal functional blocks
- Supports two work mode: Full power mode (Wake up) and Sleep mode

Table 16 Work mode of AFE

Mode	Description
Full Power	● All the function blocks work normally ● Cell voltage, pack voltage and internal temperature scan is dictated by MCU ● Charge and discharge MOSFETs are fully controlled by MCU; if RVP or UVLO event is confirmed, the discharge MOSFET will automatically turn off
Sleep	● All analog blocks are off, except for the 3.3V LDO and WAKEUP detection block ● I^2C is active ● Charge and discharge MOSFETs are off

NOTE

- If the MCU sends a sleep command to AFE while it is balancing a cell, AFE will enter sleep mode and the balancing will immediately pause.
- If the MCU sends a sleep command to AFE during discharge or charge, AFE will enter sleep mode and the discharge or charge will immediately stop.
- If AFE is in sleep mode, and a voltage source is applied at the WKUP pin, the IC will wake up and enter full power mode.
- When using charger to wake up AFE, it must make sure that the positive voltage signal at WKUP pin is more than 2.8V and persists for longer than 1ms.

4.2. Cell Parameters

BMS can be configured with 4-7 18650 cylindrical lithium-ion cells (light, small size, long service life, environmentally friendly), the specific parameters are shown in the table below:

Table 17 Cell parameters

Parameter	Definition	Description
Model	Cell model	INR18650-2000/3C
Nominal Capacity	Cell nominal capacity	2000mAh (at 0.3CA Discharge)
Minimum Capacity	Cell minimum capacity	1950mAh (at 0.3CA Discharge)
Charging Voltage	Cell charge voltage	4.20V±0.05V
Average working Voltage	Cell average working voltage	3.70V@30%DOD
Standard Charge Method	Cell standard charge method	Constant Current and Constant Voltage (CC/CV) ● Current 0.3C A ● Voltage 4.2 V ● End Current 36mA±5mA
Maximum Charge Current	Maximum charge current of cell	1.0C A
Standard Discharge Method	Cell standard charge method	Constant Current (CC) ● Current 1.0C A ● End Voltage 2.75V
Maximum Discharge Current	Maximum discharge current of cell	3.0C A
Weight of Bare Cell	Cell weight	42g/PCS

4.3. UART communication

BMS communicates through the UART port (tool name: SSCOM), the parameters need to be set consistently, the parameter settings are shown below:

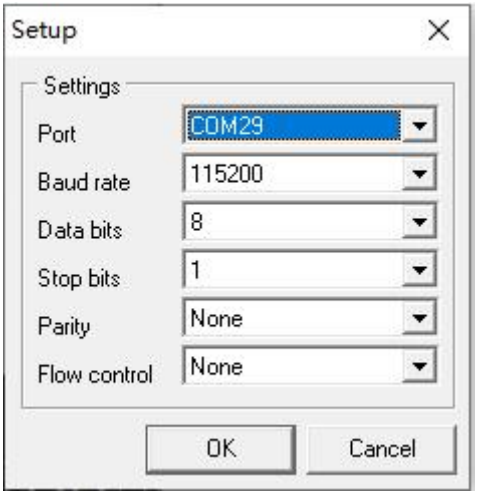


Figure 27 SSCOM setting

NOTE

When using the UART port to send commands, you need to convert the temperature, voltage and other values to hexadecimal.

For example, if you set the charge-discharge threshold temperature as 60°C, the temperature value of sending data is 3C.

The data format for sending commands is shown in the table below:

Table 19 Command data format

	Frame header		Command code	Data length	Data content	Verification
	2 bits		1 bit	1 bit	0~256 bits	1 bit
PC sends to BMS	0xAA	0x55	Specify Command	0~0xFF	Hexadecimal value	XOR
Received by BMS	0x55	0xAA	As above	As above	Each parameter value	XOR
Note: None of the commands in this document contain an XOR value.						

4.4. Temperature Detection

Set the temperature limit value of 60°C through the command AA 55 97 01 3C, when the temperature of cell or AFE is greater than 60°C, MCU will automatically turn off the charge-discharge function.

Table 20 Temperature range

Name	Function	Temperature range
NTC	To monitor the temperature of the cell	-20°C~60°C, accuracy: ±1°C
MCU	To monitor the internal temperature of AFE	-40°C~85°C, accuracy: ±1°C
LM75B	To calibrate the internal temperature of AFE	-55°C~125°C, accuracy: ±2°C

NOTE

When the temperature of the cell or AFE exceeds the threshold value of 60°C after the LM75B calibrates the AFE temperature, MCU will automatically turn off charge and discharge.

4.5. MCU sleep wake-up

When MCU monitors the abnormal cell status (i.e., triggers the protection), it automatically enters the sleep mode, and at the same time controls AFE sleep mode to achieve low power consumption.

The sleep/wake-up mode and setting method of MCU are shown in the table below:

Table 21 Sleep and wake-up of MCU

Mode	Scene
Sleep	1. Severe low voltage of a battery 2. No charge or discharge, sleep after 1 second of balance completion 3. No charge or discharge, sleep after 30 seconds of incomplete balance
Wake-up	After sleep, wake up automatically through UART interrupt or IWDG interrupt in 30s intervals.

4.6. Battery quantity setting

Complete the setting of cell quantity by the following steps, take 4 cells as an example:

1. Place 4 cells in the BC1-BC4 battery slots;
2. Short the Pin1 and Pin4, Pin2 and Pin5, Pin3 and Pin6 of J20 (J20 jumper setting with cell number);

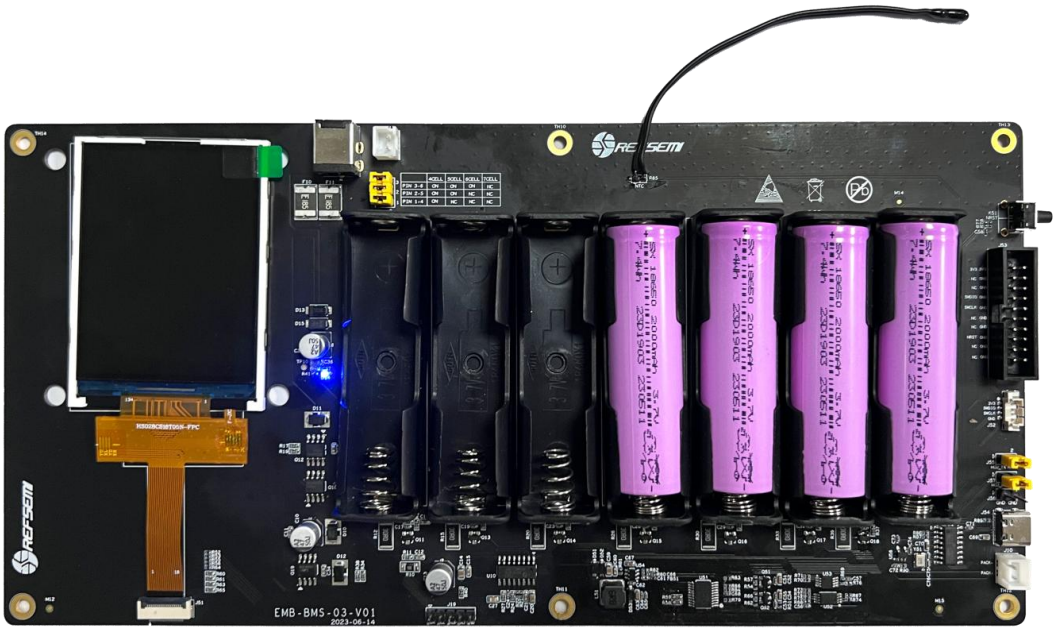


Figure 28 With 4 cell installed

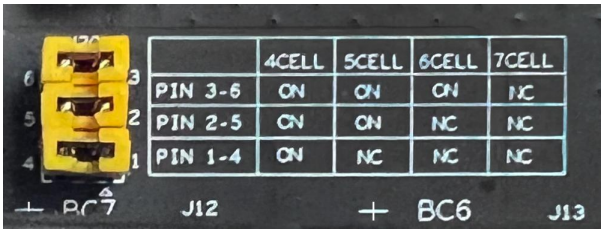


Figure 29 J20 jumper for 4 cell

3. Then send AA 55 85 01 04 command to BMS through serial tool, after BMS receives it, it will display CELL_NUM in LCD screen to show 4, when the display value is consistent with the actual number of cells, it proves that the number of cells is set correctly.

Warning

If the number of cells set by the command is not the same as the actual number of cells, BMS enters into the protection function:

1. Command to set cell number > actual number, enter low-voltage protection, MCU sleep;
2. Command to set cell number < actual number, enter over-voltage protection, system automatically turn off the discharge function.

4.7. Cell-balance function

Energy balance makes up for the differences between individual cells and manages active or passive charge or discharge to ensure the consistency of the cell and prolong the life of the cell. There are two methods of Cell balance: passive balance and active balance.

- Passive balance primarily equalizes the power of the high capacity cell by resistive consumption;
- Active balance is done to mainly transfer the power of the high capacity cell to the cell with low power through capacitor, inductor or transformer to achieve balance.

BMS adopts a passive balance method, with default external auto-balance (controlled by MCU), and a maximum balance current of 120mA;

1. The switch between auto-balance and manual-balance is achieved by sending commands through the serial port;

- Balance status: 1 indicates auto-balance is on, 0 indicates auto-balance is off
- Enable auto-balance command: AA 55 91 01 01
- Turn off auto-balance command: AA 55 91 01 00

2. When auto-balance, a maximum of 4 non adjacent cells can be balanced at the same time, and two adjacent cells cannot be balanced at the same time;

3. When manual-balance, it is realized by sending a command through the serial port to specify the balance bit;

- Set single channel balance command: AA 55 93 01 0X, where X is 1-7, set the corresponding cell channel to be balanced; when X is 0, no balance.

Table 22 Automatic cell balance parameters

NO.	Protection	Description	Standard
1	Balance	Balance reference (voltage difference)	**100mV**
		Balance condition	**Balance all cells with a voltage difference of more than 100mV, based on the lowest cell voltage.**
		Balance current	**150mA**

4.8. Abnormality protection

- BMS has excellent short circuit, over-voltage, over-temperature and other protection functions, the specific scenarios are shown below:

Table 23 Description of protection function

Scene	Function	Description
A cell voltage <900mV	Cell reverse connection, cell short circuit	Automatic shutdown of charge and discharge, MCU goes into hibernation and LCD backlight is turned off after 30s.
A cell voltage <2850mv or a cell pack voltage < number of cells *2850mv	Low-voltage protection	Automatically turn off the discharge function, MCU into hibernation, turn off the LCD backlight after 30s.
A cell voltage >4200mv or a cell pack voltage > number of cells *4200mv	Over-voltage protection	Automatic shutdown of charge function
Cell temperature > 60°C	Over-temperature protection	Automatic shutdown of charge and discharge

- The high-precision voltage detection of each cell under each protection function is as follows:

Table 24 High-precision voltage detection for cell

NO.	Protection	Description	Standard
1	Short circuit protection	Protection voltage	**0.90V±20mV**
		Protection delay time	**15mS**
2	Overcharge protection	Protection voltage	**4.20V±20mV**
		Protection delay time	**20mS**
3	Over-discharge protection	Protection voltage	**2.85V±20mV**
		Protection delay time	**20mS**
		Protection release	**Charge**
4	Sleep	Voltage	**2.5V±20mV**
		Quiescent current	**2.5mA**
		Sleep Release	**NRST reset, or set sleep RTC 30s, or run serial port wake-up command**