JK ENERGY

M SERIES BATTERY MANAGEMENT SYSTEM

MODULE MANAGEMENT UNIT -MMU

M12/M24/M36/M48 Data Sheet

4-48 Cell Battery Pack Monitoring and Control, Passive Cell Balancing, CAN, Auto CAN ID Assignment, Ultra-Low Power Dissipation

1 FEATURES

- Measures 4 to 48 cell voltages in series
- Measures 4 to 12 cell temperatures
- Power supply voltage：9-32V
- Isolated CAN to connect to BMU
- Cell Capacity, SOC, SOH and DC Resistance calculations
- 100mA Passive Cell Balancing
- Additional Digital I/O
- Fault Management and Diagnostics
- Automatic CAN Node ID assignment
- Current Sensor Monitoring
- Thermal Management
- Data Logging
- Ultra Low Power Dissipation
- Automotive Grade

2 DESCRIPTION

The M-Series Module Management Unit (MMU) with Passive Balancing is part of the M-Series Battery Management System (BMS). Functioning as a slave controller, single or multiple MMUs interface with the M-Series Battery Control Unit (BMU) to form a complete BMS.

The MMUs are used to monitor cells in large battery packs with up to 240 cells in series in a distributed BMS. Each MMU can be configured to monitor 4 to 12 cell voltages and temperatures. All cell measured voltages and temperatures are sent to the BMU. As well, the MMU calculates the ESR and Capacity of each cell it is monitoring. All communication between controllers is over an isolated CAN bus.

A total of two Digital I/O signals are equipped on X-MMUs. Two of these signals are configurable as either Digital Inputs or outputs. Together with two more Digital Outputs, these four Digital I/O channels provide the design flexibility to accommodate additional digital feedbacks and/or controls that systems may require.

The MMU controller is configurable for all lithium cell chemistries such as LFP, NMC, LMO, LTO and all cell form factors such as pouch, cylindrical, or prismatic form.

3 APPLICATIONS

- Electric, Hybrid, and Plug-In Hybrid Vehicles
- Distributed Battery Packs with multiple modules or boxes
- Backup and Standby Battery Systems, Industrial Battery Pack
- EV Bus

4 PRODUCT CATEGORY

Model	Cell Number		NTC Number	Relay Drive	Digital I/O	Address compilation	Current Sensor Chanel
	MIN	MAX					
M12	4	12	4	2	2	3	1
M24	4	24	8	2	2	3	1
M36	4	36	12	2	2	3	1
M48	4	48	16	2	2	3	1

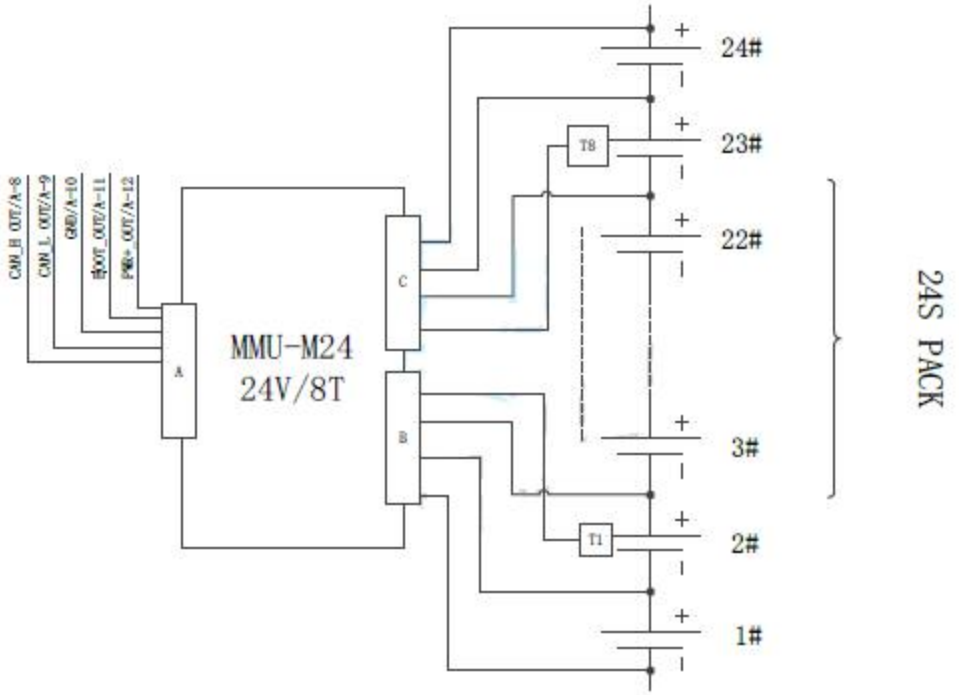
5 APPLICATION INFORMATION

- Cell Voltage Monitoring of up to 48 cells. Cell voltage is sampled every 50ms, and reported through CAN to BMU every 100ms to ensure fast response in protecting cells from brief over and under voltage events. Cell monitoring has 0 to 5V range, 1.5mV resolution and less than 0.25% error.
- Temperature monitoring of 4-16 temperature sensors to ensure the safety of the battery pack is always maintained and the lifetime of the cells are maximized by avoiding high temperature events that will deteriorate the cell`s performance.
- State of Charge (SOC) dynamically calculated for each cell with advanced self-correcting model based algorithms. Less than 3 – 5% SOC error depending on the cell chemistry. SOC algorithms adapt to changing cell characteristics over time as the cells in the battery age.
- State of Health (SOH) continually calculated and monitored on each cell, and is based on the capacity fade and internal resistance increase over the lifetime of the cell. SOH of each cell allows weak cells that limit the performance of the entire battery to be detected and early identification of premature failure.
- Cell Internal DC Resistance calculated for each cell and determines the charge rate limits and available power forecasting.
- Cell Capacity calculated and allows high SOC accuracy.
- Passive Cell Balancing eliminates cell to cell imbalance by removing energy from the highest charged cell at 300 mA per cell. This extends the battery pack’s effective lifetime.
- Cell voltage monitoring and passive balancing power isolated from the controller supply power, easily allowing multiple MMUs to be connected together in battery packs up to 1000 VDC.
- Battery current monitoring with a current sensor.
- Automatic CAN Node ID of all MMUs in the battery system.
- Isolated CAN communication with BMU and other diagnostic equipment. 2.5 kV RMS signal and power isolation and > 25 kV/us common-mode transient immunity.
- Two additional Digital Outputs available of which two are configurable as Digital Inputs for flexibility in control and readback design.
- Fault Management: Over 20 fault conditions continually monitored and status reported over CAN. Multiple alarms levels: warning, soft shutdown, hard shutdown, sensor faults, and service alarms are all configurable. Alarms include under and over cell voltage, low and high cell temperature, over charge, over discharge, voltage and temperature sensor failures, faulty mechanical connections on bus bars or cell terminals, and others.
- Reliable Power Supply Input with short circuit, reverse voltage, and surge protection. In addition, the MMU power input is fed from the BMU regulated power output which has high voltage, low voltage, reverse voltage protection, high voltage transient immunity, load dump, and current injection immunity.
- Power, Ground, and Digital I/O available for connection to relays, optional driver board to

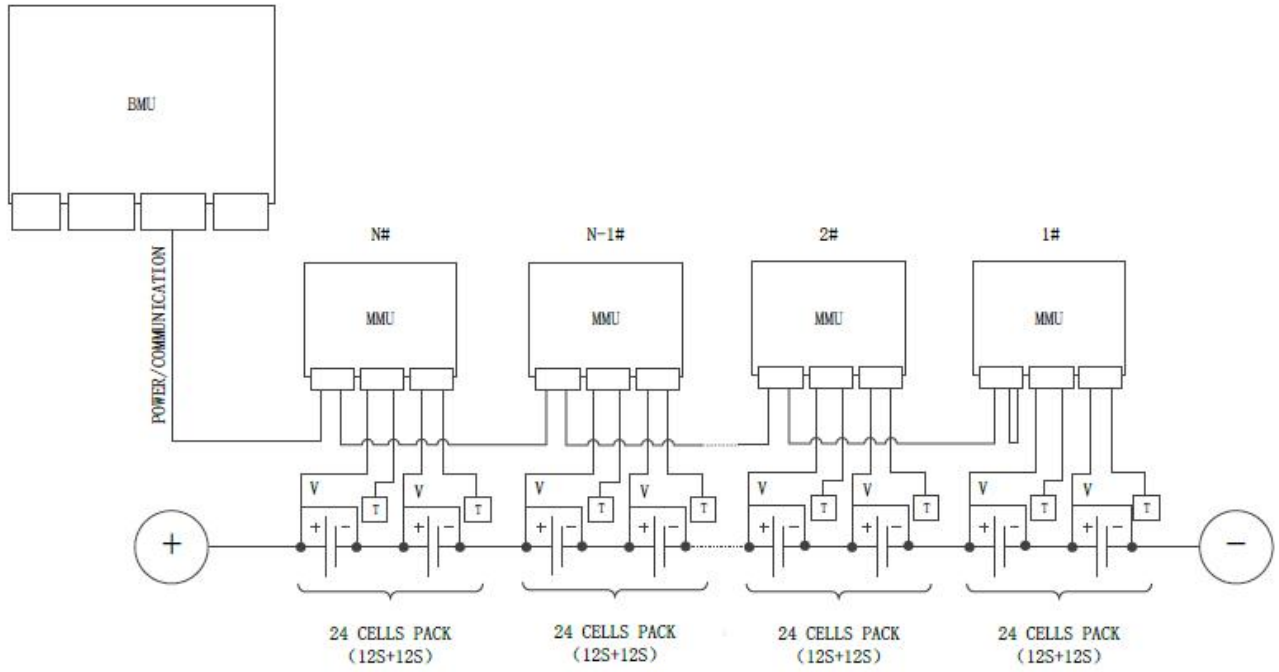
control components such as fans, heaters, relays, or other devices if needed.
- Battery pack Lifetime Data Logging of charge events, discharge events, and histograms of battery pack temperature, voltage, and SOC useful for troubleshooting and warranty.
- Internal controller temperature monitoring
- In system firmware upgrading available through CAN.
- Battery and cell monitoring and diagnostics available in real-time trough diagnostic CAN to a laptop or PC with BMS LINK software tool.
- IP54 protection rating
- Automotive grade electrical and mechanical components for temperature and vibration.

6 TYPICAL APPLICATION

- The M-Series product line is typically used on medium to high voltage (200 to 1000V) battery packs that contain greater than 48 cells in series, in a distributed BMS setup. For battery packs 48 cells or less and less than 200V, the S-Series BMS controllers may be better suited.
- Battery packs may be used for mobile applications, small passenger vehicles, industrial applications, backup power, or many others. Depending on the application the BMS will be configured differently. The most common accessories that may or may not be used in your application include, relays to isolate the battery pack from the system, LCD screen to display battery pack values, current sensor, fan, etc.
- The following shows how the MMU monitors a single module of 24 cells in a much larger battery pack.



- A complete distributed BMS for large battery packs is made up of multiple MMUs and a single BMU. The following shows how such an arrangement of controllers would look.



7 ELECTRICAL CHARACTERISTICS

PARAMETER	MIN	TYP	MAX	UNITS
Cell Voltage Range	0		5	V
Cell Voltage Measurement Offset	-5		5	mV
Cell Voltage Measurement Resolution		1		mV
Cell Temperature Range	-40		150	℃
Cell Temperature Measurement Offset	-1		1	℃
Cell Temperature Measurement Resolution		0.1		℃
Current Measurement Range	-500		500	A
SOC Calculate Error		±5	±8	%
Passive Balancing Current		100	110	mA

8 CONNECTING TO OTHER CONTROLLERS

CONNECTING TO OTHER CONTROLLERS

Several wires are required to be connected between an MMU and other MMUs or an BMU: power, ground, CAN high, CAN low, power enable. The controller will not function properly if the connections are swapped by mistake.

LAST CONTROLLER TERMINATION

The last controller in the in-out wire harness between multiple MMUs, which is monitoring the cells with the lowest potential in the battery pack, requires termination connections for the CAN high and CAN low. CAN High is connected to CAN Low with a 120 Ω resistor. The resistor must be through-hole type, with a power rating of 1W or higher. This ensures that the resistor leads are durable enough to be soldered into a wire harness.

NUMBER OF CELLS AND TEMPERATURE SENSORS

A MMU controller must be used with the same number of cells in series, and same number of temperature sensor for which it was configured for. The controller model number specifies how many cells and how many temperatures it is set up for. For more information on the model number, see the previous section on model numbering.

CELL INPUT PROTECTION

The cell voltage monitoring inputs (Cell 1 to Cell 48) are capable of measuring 0 – 5 volts. However the inputs have added protection to both protect the BMS controller and to ensure that connected cells are not discharged in the event that some of the voltage inputs are miss-wired. Each cell input has reverse voltage and high voltage protection in case two wires are swapped.

If a wiring miss-match does occur, and the cell input protection is tripped, the protection will automatically reset itself once the cell input connector is unplugged and the abnormal voltage is removed from the input pins. Extreme care must be taken to ensure that all cell voltage inputs are wired correctly.

PASSIVE CELL BALANCING

The M-Series BMS with MMUs utilizes passive cell balancing to keep all cells within the battery pack equally charged. This is achieved by discharging energy from the highest charged cells. This ensures that cells that have slightly weaker performance are not degraded further by over-charging or over-discharging them during operation. A well balanced battery pack will have a higher capacity and a longer lifetime than an unbalanced one.

Depending on cell voltage the passive balance circuitry will discharge a balancing cell between 100 and 150 mA. The cell balancing is based on the amount of charge in each cell and not on the cell voltage. This means that balancing is active all the time unlike other BMS systems where balancing is only enabled while the battery is idle. The controller also monitors the internal balance circuitry temperature and may limit the number of balancing cells when operating in extreme ambient temperatures.

CAN BUS

Isolated controller area network (CAN) bus compatible with SAE J1939 and ISO 11898 goes in and out. It is configured to run at 500 kbps. This CAN bus is for internal communication between MMUs, BMU and the BMS Link monitoring tool. All communication on this CAN bus is encrypted.

To comply with SAE J1939 and ISO 11898 termination resistors are required at either end of the bus. At the one end of the bus, the BMU has internal CAN termination. At the other end, at the last MMU in the BMS, external termination is required between CAN High out and CAN Low out. Refer to the previous section on Last Controller Termination.

Each MMU is added on the internal CAN bus as a node. It has over 2kΩ of resistance split between the incoming CAN high and CAN low to reduce electromagnetic emission and increase bus noise immunity.

For the CAN bus physical layer it is recommended to use shielded twisted pair cables with the shield terminated at one end. For all other physical layer recommendations please consult SAE J1939 and ISO 11898.

ALARM DEFINITIONS AND REPORTING

Over 20 alarms are being evaluated at over 10 times a second to ensure safe battery operation, and to maximize the battery pack performance and lifetime. The list of alarms is configured for different battery cell types, and battery applications.

There are multiple levels of alarms depending on the severity. Alarms can be warning, soft shut down, hard shut down, service, or sensor fault alarms. A warning alarm means that the BMS will not take any action but there is some abnormal performance in the battery that may be the early signs of a problem.

A soft shutdown alarm means that something in the battery or in the system's operation of the battery is well outside of the normal operating window and

the battery pack must be disconnected from the system. Once a soft shutdown alarm has occurred the battery safety relays will automatically open after 20 seconds has passed.

A hard shutdown alarm means that something in the battery or in the system's operation of the battery is causing a safety hazard and immediate action must be taken. Once a hard shutdown alarm occurs the battery safety relays will open automatically after 2 seconds have passed.

A service alarm indicates that something in the battery pack may need to be serviced in the near future. It is not causing any immediate safety issues or performance loss but it may be soon. One example of a service alarm may be that the cells temperature difference may be high, because an air inlet filter may need to be changed.

A sensor fault alarm means that a sensor in the battery pack is no longer operating within its specified function. And will need to be serviced and possible replaced. One faulty temperature sensor on a pack will not cause any immediate danger, so the battery pack is still operational, and the battery pack control can continue without that sensor. However the senor should be serviced and replaced if needed.

Alarms may be standard set or customized for your application. MMUP alarm status is communicated over CAN to the BMU which then acts on the alarms and/or communicates it to the vehicle.

System Status Indication

Use LED as system operating status and fault state indication.

The LED is green and flash every 1s, it mean that the system is on the normal working status.

The indicator light is green, red, and the 1s cycle flashes alternately, it mean that the system is on the test status.

The LED is red and flash every 1s, it mean that the system is reporting the slight fault, the fault level is 1.

The LED is red and flash every 0.5s, it mean that the system is reporting the ordinary fault, the fault level is 2.

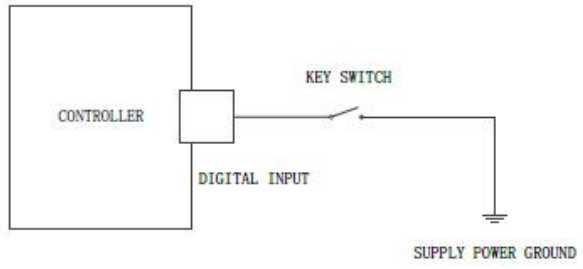
The LED is red and flash every 0.25s, it mean that the system is reporting the serious fault, the fault level is 3.

DIGITAL I/O

There are two general purpose Digital I/O ports. Two of them are software configurable to be used as either digital inputs or digital outputs, while the other two are digital outputs.

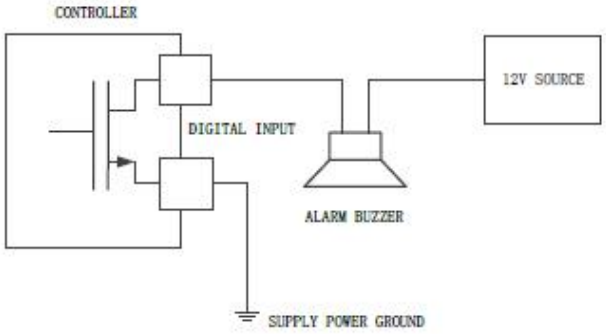
DIGITAL INPUTS

Digital inputs are active low inputs, meaning that if left floating or disconnected the input has an internal pull-up to a high level and will be considered off. To turn the input on, connect the input to system ground. The on condition is true when the input voltage is from 0 – 0.7 V. The inputs are typically used for a key switch status, charger connected status, or operator push buttons.



DIGITAL OUTPUTS

The digital outputs are implemented as low side sinking digital outputs. This means that the power for the device that the digital output is controlling is wired to a constant power source and the ground of the device is wired to the digital output. When the digital output is turned on then the ground of the device is connected to the supply power ground of the BMS, and the device will turn on. Each digital output is capable or sinking 750 mA. In total all digital outputs can sink up to a maximum of 2 Amps. The maximum switching voltage is 60 V. Digital outputs can be used to control fans, relays, heaters, LCD screen power or other components.



DATA LOGGING

Battery pack Lifetime Data Logging of charge events, discharge events, and histograms of battery pack temperature, voltage, and SOC useful for troubleshooting and warranty.

FIRMWARE UPGRADING

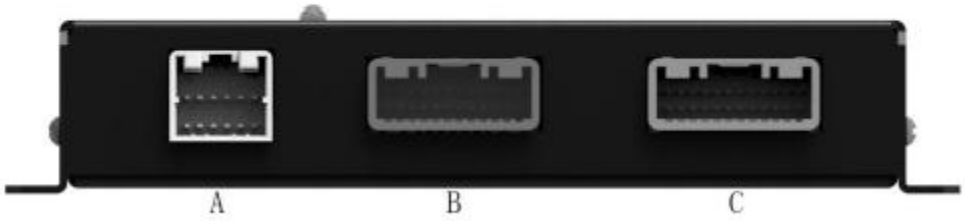
Firmware upgrading can be completed from a laptop or PC connected to the CAN bus with a CAN-USB tool, and the JK Firmware Loader software.。

BATTERY PACK MONITORING

Battery and cell monitoring and diagnostics available in real-time trough diagnostic CAN to a laptop or PC with BMS LINK software tool.

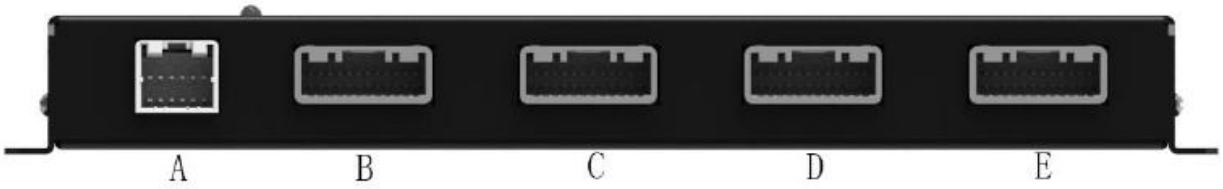
9 CONNECTORS AND PIN OUT

M12

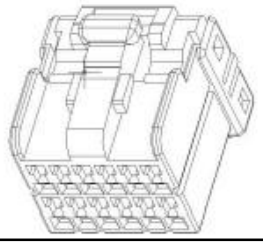


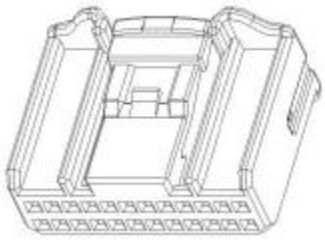
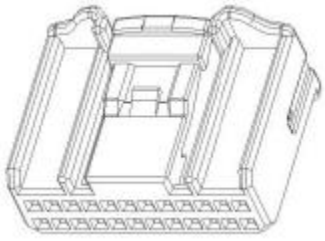
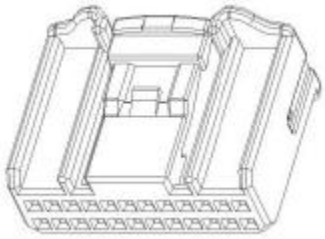
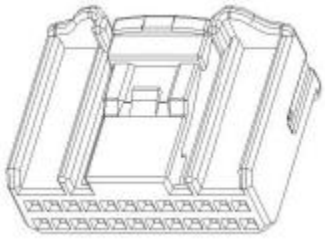
M24

M36

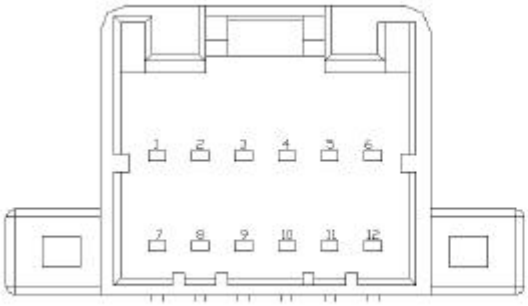


M48

Connector	TE Connector P/N	TE Socket P/N	TE Hand Crimp Tool	
A	174045-2	173681-1	5822-1	

B	1318917-1	1318143-1	1276652-1	
C	1318917-1	1318143-1	1276652-1	
D	1318917-1	1318143-1	1276652-1	
E	1318917-1	1318143-1	1276652-1	

Connector A –Power and Communication



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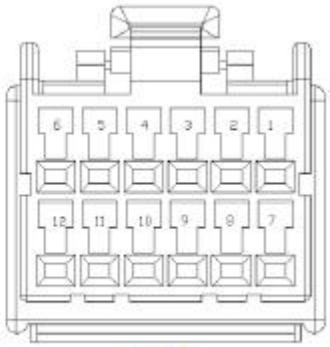
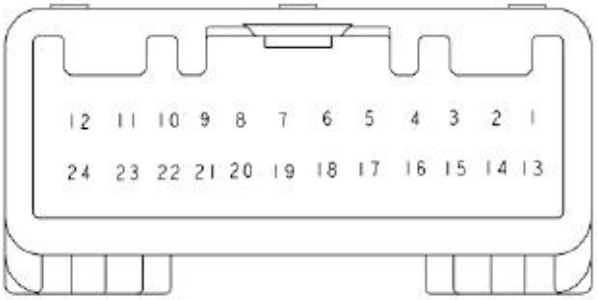


Plug

Pin	Tag	AWG	Description
1	DIO2	20	Configurable digital output 2 or digital input 2
2	CAN_H	22	CAN_H
3	CAN_L	22	CAN_L
4	GND	20	Power Supply GND
5	BOOT	22	Power Supply Enable
6	PWR	20	Power Supply+
7	DIO1	20	Configurable digital output 1 or digital input 1
8	A0	22	CAN Node ID Code
9	A1	22	CAN Node ID Code
10	A2	20	CAN Node ID Code
11	CS	22	Current Sensor Channel
12	+5V_PRT	20	Current Sensor Power+

Connector B –Cell Voltages and Temperature Sensors



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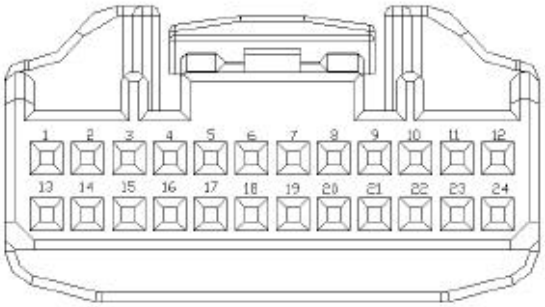
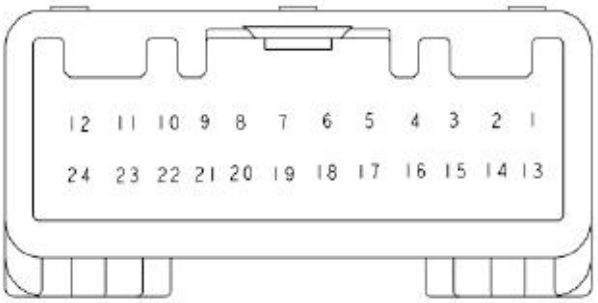


Plug

Pin	Tag	AWG	Description
1	CV1_6	22	Module 1 Cell 6 Positive Terminal Voltage Input
2	CV1_7	22	Module 1 Cell 7 Positive Terminal Voltage Input
3	CV1_8	22	Module 1 Cell 8 Positive Terminal Voltage Input
4	CV1_9	22	Module 1 Cell 9 Positive Terminal Voltage Input
5	CV1_10	22	Module 1 Cell 10 Positive Terminal Voltage Input
6	CV1_11	22	Module 1 Cell 11 Positive Terminal Voltage Input
7	CV1_12	22	Module 1 Cell 12 Positive Terminal Voltage Input
8	N/C		
9	TS4	22	Temperature Sensor4
10	TS3	22	Temperature Sensor3
11	TS2	22	Temperature Sensor2
12	TS1	22	Temperature Sensor1
13	CV1_5	22	Module 1 Cell 5 Positive Terminal Voltage Input
14	CV1_4	22	Module 1 Cell 4 Positive Terminal Voltage Input
15	CV1_3	22	Module 1 Cell 3 Positive Terminal Voltage Input
16	CV1_2	22	Module 1 Cell 2 Positive Terminal Voltage Input
17	CV1_1	22	Module 1 Cell 1 Positive Terminal Voltage Input
18	CELL_GND1	22	Module 1 Cell 1 Negative terminal/GND
19	N/C		
20	N/C		
21	CELL_GND1	22	Temperature Sensor4
22	CELL_GND1	22	Temperature Sensor3
23	CELL_GND1	22	Temperature Sensor2
24	CELL_GND1	22	Temperature Sensor1

Connector C –Cell Voltages and Temperature Sensors



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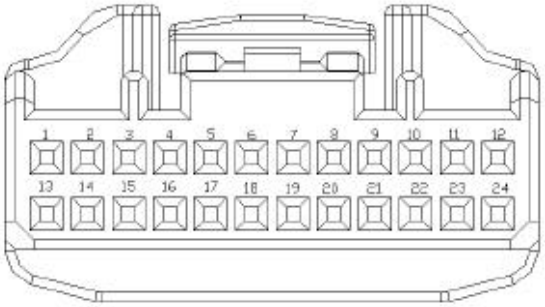
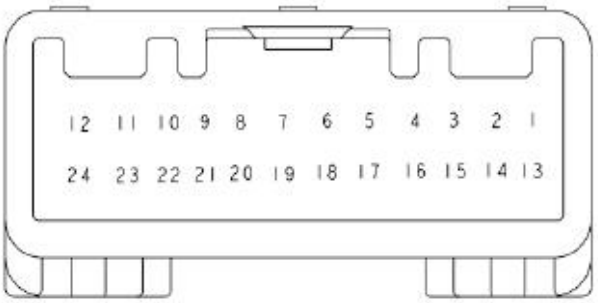


Plug

Pin	Tag	AWG	Description
1	CV1_6	22	Module 2 Cell 6 Positive Terminal Voltage Input
2	CV1_7	22	Module 2 Cell 7 Positive Terminal Voltage Input
3	CV1_8	22	Module 2 Cell 8 Positive Terminal Voltage Input
4	CV1_9	22	Module 2 Cell 9 Positive Terminal Voltage Input
5	CV1_10	22	Module 2 Cell 10 Positive Terminal Voltage Input
6	CV1_11	22	Module 2 Cell 11 Positive Terminal Voltage Input
7	CV1_12	22	Module 2 Cell 12 Positive Terminal Voltage Input
8	N/C		
9	TS8	22	Temperature Sensor8
10	TS7	22	Temperature Sensor7
11	TS6	22	Temperature Sensor6
12	TS5	22	Temperature Sensor5
13	CV1_5	22	Module 2 Cell 5 Positive Terminal Voltage Input
14	CV1_4	22	Module 2 Cell 4 Positive Terminal Voltage Input
15	CV1_3	22	Module 2 Cell 3 Positive Terminal Voltage Input
16	CV1_2	22	Module 2 Cell 2 Positive Terminal Voltage Input
17	CV1_1	22	Module 2 Cell 1 Positive Terminal Voltage Input
18	CELL_GND2	22	Module 2 Cell 1 Negative terminal/GND
19	N/C		
20	N/C		
21	CELL_GND2	22	Temperature Sensor8
22	CELL_GND2	22	Temperature Sensor7
23	CELL_GND2	22	Temperature Sensor6
24	CELL_GND2	22	Temperature Sensor5

Connector D –Cell Voltages and Temperature Sensors



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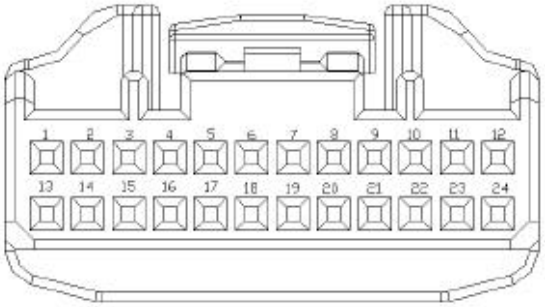
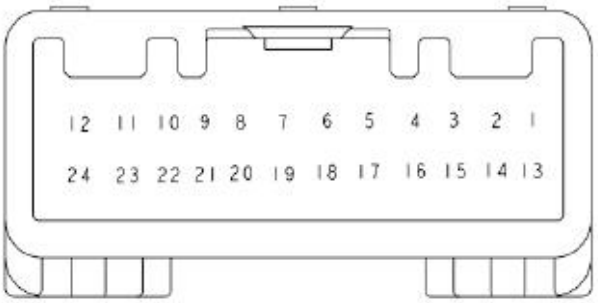


Plug

Pin	Tag	AWG	Description
1	CV1_6	22	Module 3 Cell 6 Positive Terminal Voltage Input
2	CV1_7	22	Module 3 Cell 7 Positive Terminal Voltage Input
3	CV1_8	22	Module 3 Cell 7 Positive Terminal Voltage Input
4	CV1_9	22	Module 3 Cell 9 Positive Terminal Voltage Input
5	CV1_10	22	Module 3 Cell 10 Positive Terminal Voltage Input
6	CV1_11	22	Module 3 Cell 11 Positive Terminal Voltage Input
7	CV1_12	22	Module 3 Cell 12 Positive Terminal Voltage Input
8	N/C		
9	TS12	22	Temperature Sensor12
10	TS11	22	Temperature Sensor11
11	TS10	22	Temperature Sensor10
12	TS9	22	Temperature Sensor9
13	CV1_5	22	Module 3 Cell 5 Positive Terminal Voltage Input
14	CV1_4	22	Module 3 Cell 4 Positive Terminal Voltage Input
15	CV1_3	22	Module 3 Cell 3 Positive Terminal Voltage Input
16	CV1_2	22	Module 3 Cell 2 Positive Terminal Voltage Input
17	CV1_1	22	Module 3 Cell 1 Positive Terminal Voltage Input
18	CELL_GND3	22	Module 3 Cell 1 Negative terminal/GND
19	N/C		
20	N/C		
21	CELL_GND3	22	Temperature Sensor12
22	CELL_GND3	22	Temperature Sensor11
23	CELL_GND3	22	Temperature Sensor10
24	CELL_GND3	22	Temperature Sensor9

Connector E –Cell Voltages and Temperature Sensors



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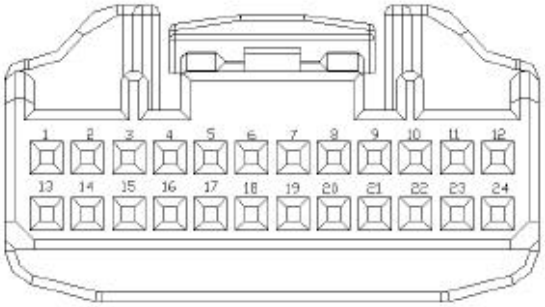
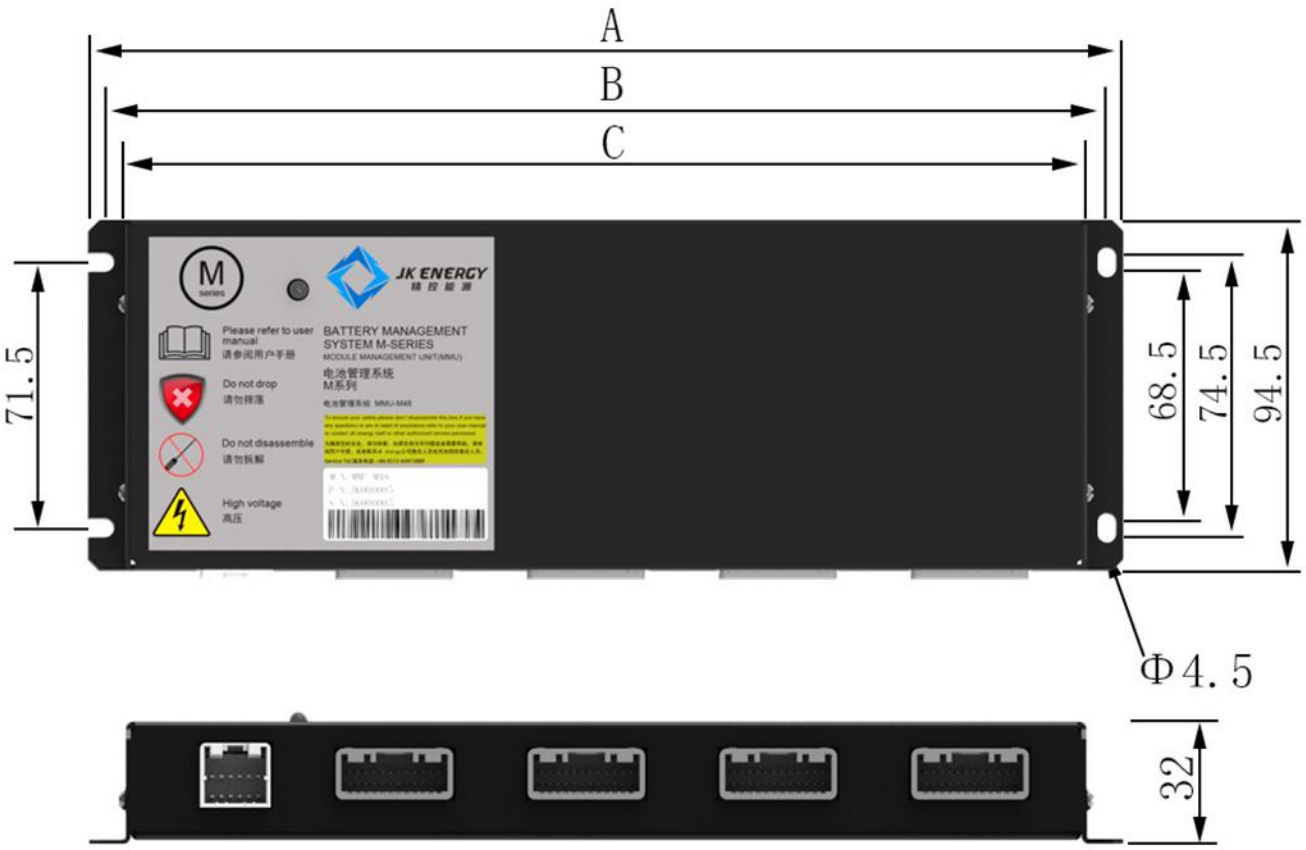


Plug

Pin	Tag	AWG	Description
1	CV1_6	22	Module 4 Cell 6 Positive Terminal Voltage Input
2	CV1_7	22	Module 4 Cell 7 Positive Terminal Voltage Input
3	CV1_8	22	Module 4 Cell 8 Positive Terminal Voltage Input
4	CV1_9	22	Module 4 Cell 9 Positive Terminal Voltage Input
5	CV1_10	22	Module 4 Cell 10 Positive Terminal Voltage Input
6	CV1_11	22	Module 4 Cell 11 Positive Terminal Voltage Input
7	CV1_12	22	Module 4 Cell 12 Positive Terminal Voltage Input
8	N/C		
9	TS16	22	Temperature Sensor16
10	TS15	22	Temperature Sensor15
11	TS14	22	Temperature Sensor14
12	TS13	22	Temperature Sensor13
13	CV1_5	22	Module 4 Cell 5 Positive Terminal Voltage Input
14	CV1_4	22	Module 4 Cell 4 Positive Terminal Voltage Input
15	CV1_3	22	Module 4 Cell 3 Positive Terminal Voltage Input
16	CV1_2	22	Module 4 Cell 2 Positive Terminal Voltage Input
17	CV1_1	22	Module 4 Cell 1 Positive Terminal Voltage Input
18	CELL_GND4	22	Module 4 Cell 1 Negative terminal/GND
19	N/C		
20	N/C		
21	CELL_GND4	22	Temperature Sensor16
22	CELL_GND4	22	Temperature Sensor15
23	CELL_GND4	22	Temperature Sensor14
24	CELL_GND4	22	Temperature Sensor13

10 SIZE AND MOUNTING

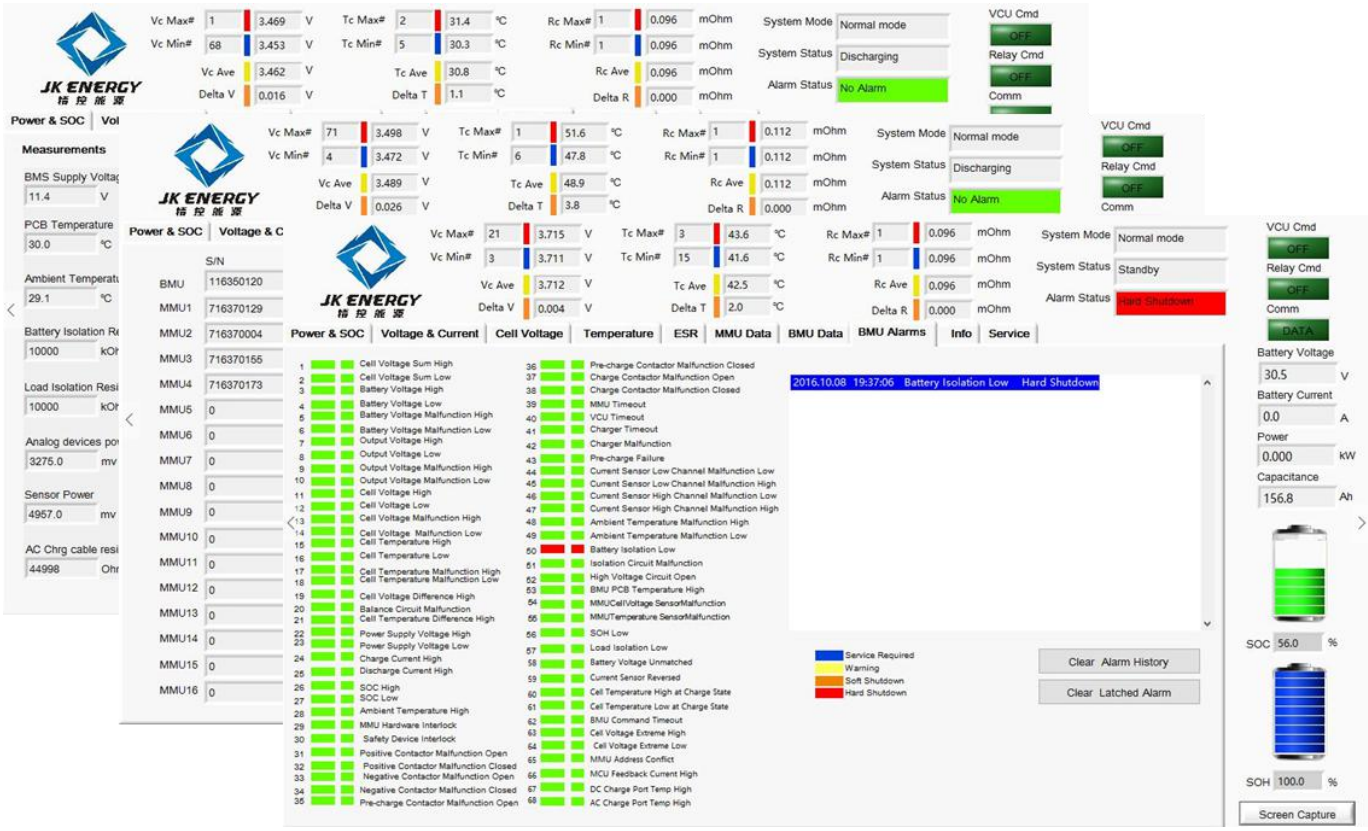


All dimensions are in mm.

MMU	A	B	C
M12	123	114	103
M24	175	166	155
M36	227	218	207
M48	279	267.5	259

11 BMS easyLink –Monitor and Diagnose the Battery Pack

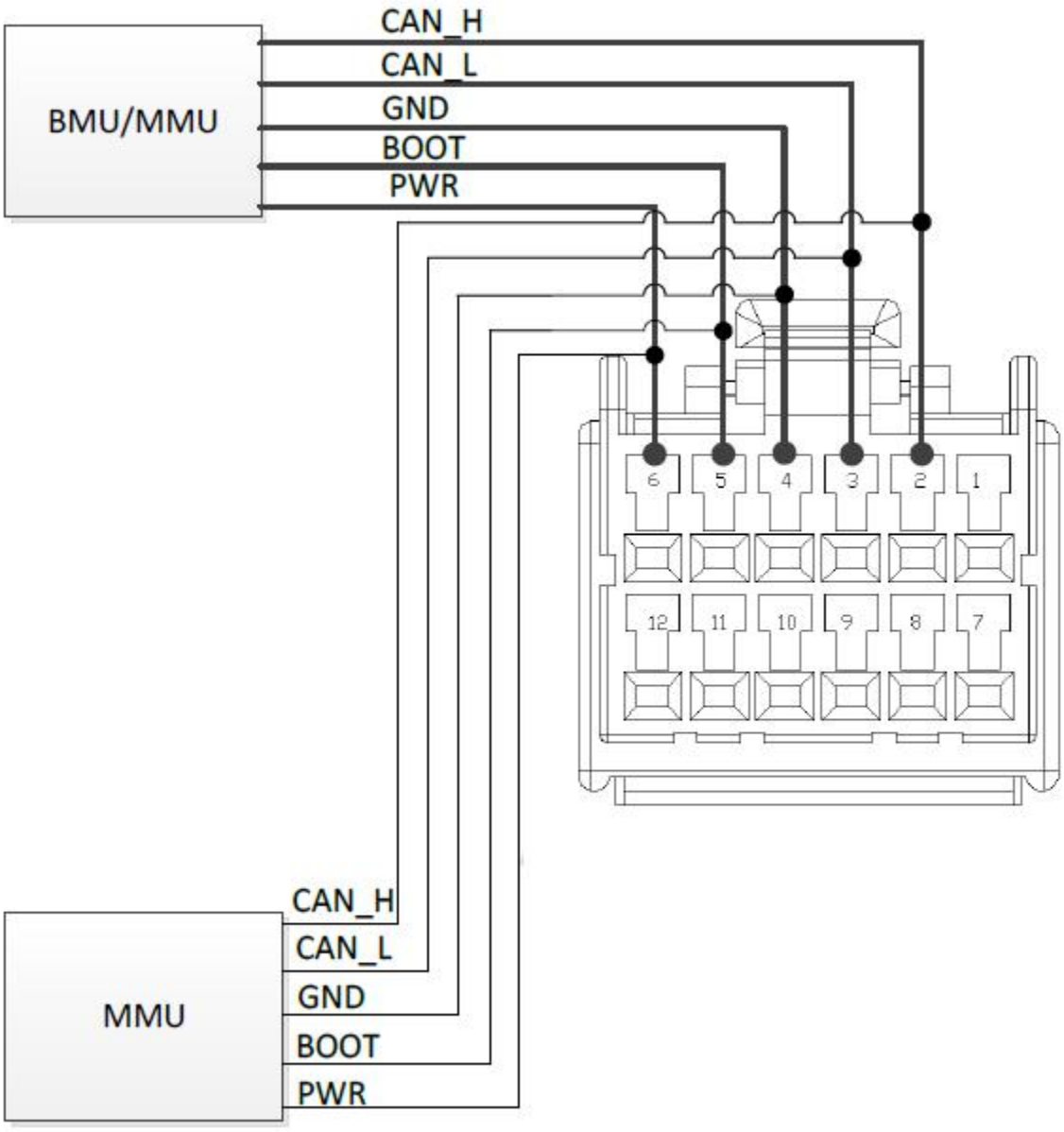
- Monitor and Diagnose problems in the Battery Pack from your PC or Laptop in real time。
- BMS Link is compatible with all JK BMS products.
- The most comprehensive, battery integrated monitoring, logging and control software.
- Multi-page layout for displaying battery data in numerical and graphical form.
- Cell voltages, temperatures, SOC, SOH, cell DCRs, balancing status, alarm status, battery voltage, battery current, and more available in real time.
- Service Mode available for additional data, and forcing all battery components such as fans, heaters, relays, cell balancing on and off.
- Controller identification by serial number and firmware version.
- Cell identification and tracking by serial number and cell lifetime data for warranty and troubleshooting.
- Record, save, and analyze data log files
- Updates with all cell and battery pack information every 100ms
- Alarm status information for all controllers within the battery.

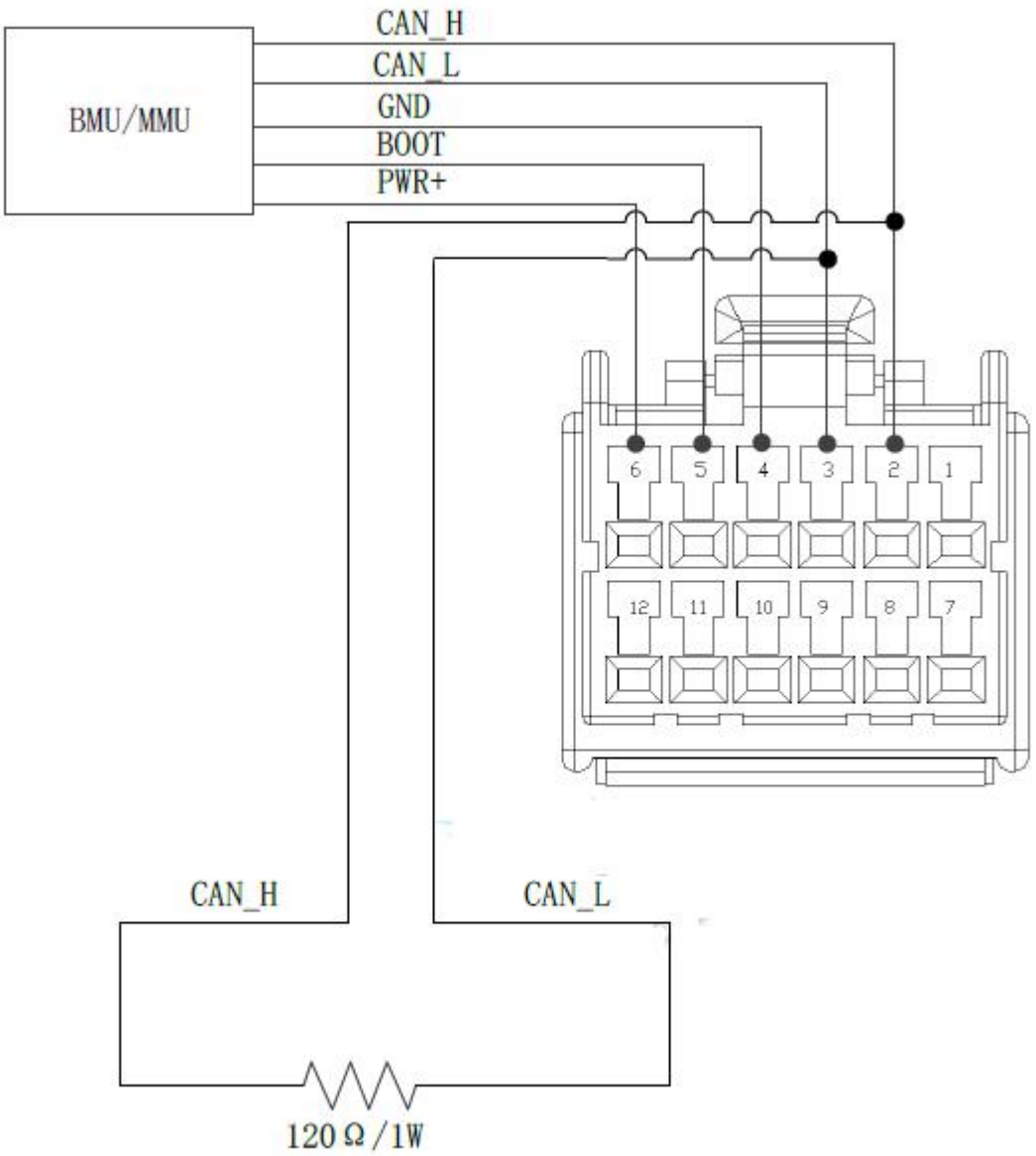


12 TYPICAL WIRING

Power and Communication

The following diagram shows the wiring for power, CAN of the MMU.




BMU/MMU
CAN_H
CAN_L
GND
BOOT
PWR+
6
5
4
3
2
1
12
11
10
9
8
7
CAN_H
CAN_L
120 Ω /1W

Cell Voltages and Temperature Sensors Wiring（12S cells in series）

The following is an example of how the cell voltage/temperature wiring is done with 12 cells in series. The cell voltage wiring follow the order of CELL_GND1、CV1_1・・・CV1_12、CELL_GND2、CV2_1・・・CV2_12 from low voltage(GND) to high voltage. A temperature sensor is generally mounted on a battery or electrode surface.