JK ENERGY

BATTERY MANAGEMENT SYSTEM

BATTERY CONTROL UNIT -BMU

Data Sheet

Up to 240 Cells and 1000V Battery Pack Monitoring and Control, Ground Fault Detection, CAN, Relay Control, Current Sensor, Thermal Management, Ultra-Low Power Dissipation, Automotive Grade.

1 FEATURES

- Monitors battery packs up to 240 cells in series
- Monitors battery packs up to 1000 volts
- Communicates with up to 20 module controllers (MMUs) over isolated CAN bus
- State of Charge, State of Health, Capacity, and DC Resistance Calculations
- Four Isolated CAN bus channels
- Support GB/T 27930-2015、GB/T18487-2015 Chinese charge national standard and compatibility with GB/T 27930-2011
- Eight high current relay drive
- Battery Relay and pre-charge control
- Ground Fault Detection
- High Voltage Monitoring of Battery and System
- The hardware system is designed for compatibility with GB/T 18384.
- Thermal Management
- Current Sensor Monitoring
- Four level fault Management and Diagnostics
- GPRS remote monitoring, real-time data recording
- Ultra Low Power Dissipation
- Automotive Grade

2 DESCRIPTION

The Battery Management Unit (BMU) is part of the Battery Management System (BMS). Functioning as the master controller, it can communicate with a single or multiple Module Management Units (MMUs) to form a complete BMS.

The BMU is capable of communicating with up to 20 module controllers (MMUs) each one capable of monitoring up to 12 cells. This allows the BMU to monitor and control battery packs that are up to 240 cells in series, and up to 1000 volts. In addition BMU can communicate with M-Series module controllers.

As the master controller the BMU receives all necessary information about the battery cells, such as cell voltages and temperatures, from each MMU. It then in turn calculates battery parameters such as state of charge, state of health, capacity, DC resistance, and available power that are critical to operation of the battery and the vehicle or system that the battery is in. The BMU interfaces with the vehicle, charging station or other systems with one or two (if required) isolated CAN bus channels to communicate all battery performance parameters, and diagnostic codes. The BMU controls safety relays with position feedback, pre-charging of the vehicle system, fan, and monitors battery voltage, battery current, and positive and negative to chassis isolation (ground fault detection).

The BMU controller is configurable for all lithium, cell chemistries such as LFP, NMC, LMO, and LTO.

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 OPERATIONS

- Power: Single or double (if required) power supply input from either 12 or 24 volt systems. Input range from 9 – 32 volts. Double power input may be useful for vehicles that plug in external battery charger that can power the BMS. Each power supply input has an enable signal which can be connected to the vehicles ignition key switch, to turn the BMU on and off。 Both power supply inputs come with high voltage, reverse voltage, low voltage, and over current protection, match the requirement of ISO 167502-2-2010.
- Monitor: Through the CAN bus to read all cells data from MMUs, such as voltage, temperature, capacity, internal resistance etc.
- Battery current monitoring with a dual-range automotive grade current sensor, to ensure accurate SOC measurements both at low or high currents.
- Battery voltage and output (system) voltage monitoring.
- Battery pack State of Charge (SOC) is dynamically calculated 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.
- Additional temperature input could be used for ambient air measurement.
- Charge: follow the standard of GB/T20234.1~3-2015, monitor the charging coupler temperature and report the relevant fault，monitor the charge relay status and report the relevant fault.
- Eight relay drivers (high side drive) that can be used for the positive relay, negative relay, dc charging relay, pre-charge relay, or others. Four relays have optional feedback sensing that can be used to monitor the position of the relay for fault diagnostics. Two relay drivers (low side drive) that can be used for the FAN relay, heating relay etc.
- Communication: Four channels isolated CAN for communication with a vehicle, charging station, MMU, or any other CAN enabled system. Both channels are SAE J1939 compatible, and completely configurable to your system needs. Communication with VCU, the default baud rate is 250kps. Communication with On-board charger, the default baud rate is 250kps. The baud rate can be configured according to the actual application for other standard baud rates. The communication protocols can be customized.
- 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 the light is always on, it mean that the system is reporting the serious fault, the fault level is 3.
- The lifetime histograms of temperature, voltage and current of every cell monitored by the controller are logged in the controller memory. This data can be useful for troubleshooting and warranty purposes.
- Single or double (if required) isolated CAN for communication with a vehicle, charging station,

or any other CAN enabled system. Both channels are SAE J1939 compatible, and completely configurable to your system needs, with 2.5 kV RMS signal and power isolation and > 25 kV/us common-mode immunity.
- Contact type ESD protection level is not less than 8kV, Non-contact ESD protection level is not less than 15kV, safety interlock device signal detection.
- State of Health (SOH) continually calculated and monitored, and is based on the capacity fade and internal resistance increase over the lifetime of the battery。
- Battery pack available power forecasting for the next 2, 10, and 30 seconds. The available power calculation allows the hybrid controller to fully utilize the battery pack energy without violating battery pack safety limits。
- The BMU controls passive cell balancing on all module controllers to achieve balancing across the entire battery pack.
- Fault Management: Over 60 fault conditions continually monitored and status reported over CAN. Multiple levels alarms: 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, battery isolation low, high voltage differential, high temperature differential, sensor failures (voltage, temperature, and current), faulty mechanical connections on bus bars or cell terminals, and others.
- Monitoring of battery positive and negative terminals and output (system) positive and negative terminals isolation to vehicle or system chassis. Ground Fault Detection (GFD) ensures that there is no high voltage or potential on the battery that may cause a safety risk to service or other personnel.
- 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 through internal (MMU) CAN to PC/laptop with BMS LINK software tool.
- IP54 protection rating
- Automotive grade electrical and mechanical components for temperature and vibration。

5 TYPICAL APPLICATION

- The BMU is the master controller in a multiple controller distributed battery management system (BMS). The BMU is typically used on medium to high voltage (200 to 1000V) battery packs that contain greater than 48 cells in series. For battery packs 48 cells or less and less than 200V the S-Series BMS controllers may be better suited.
- The BMU can be used as a master controller for M-Series module control units (MMUs), depending on the customer requirement and level of system protection and monitoring required.
- 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.

6 ELECTRICAL CHARACTERISTICS

PARAMETER	MIN	TYP	MAX	UNITS
Power				
Supply Voltage	9	12 / 24	32	V

Supply Voltage Under voltage Cut-out	8			V
Supply Voltage Over voltage Cut-out			34	V
Supply Current, Active Mode（12V/24V）		200/100		mA
Power enable input voltage	9		32	V
Isolated CAN Communication Specifications (4 channel.)				
Isolation		2.5		kV rms
ESD protection voltage level		15		kV/μs
Data Rate	125	250/500	1000	kbps
Digital Input Specifications				
Digital Input Active High Level	5		32	V
Digital Input Active Low Level		0	0.7	V
Digital Output Specifications				
High side drive voltage	9	12/24	32	V
High side drive current		1	1.7	A
Current Monitoring Specifications				
Sensor Supply Voltage	4.75	5.0	5.25	V
Sensor Supply Current			100	mA
Low Channel Resolution		1.2		mV
Low Channel Range	0		5	V
Low Channel Error		±2.5		mV
High Channel Resolution		1.2		mV
High Channel Range	0		5	V
High Channel Error		±2.5		mV
Range	0		600	A
Resolution		0.1		A
Accuracy		≤1		%
Battery Voltage Monitoring Specifications				
Range	0	750	1000	V
Resolution		0.1		V
Accuracy		≤1		%
Ground Fault Detection (GFD) Specifications (Battery & System)				
Isolation		1000		V
Range	10	4	10000	KΩ
Resolution		1		KΩ
Accuracy		＜10		%
Ambient Temperature Sensor Specifications				
Measurement Resolution		0.1		℃
Measurement Accuracy		≤1		%
Temperature Range	-45.0		150.0	℃

7 APPLICATION INFORMATION

CONNECTING TO OTHER CONTROLLERS

Several wires are required to be connected between the BMU and M-Series MMUs.: power, ground, CAN high and CAN low.

MODES OF OPERATION

The BMU controller has multiple modes of operation that may be configured for each application. Some of them are defined as Active, Idle, Hibernation, etc. The modes are defined by which components and peripherals on the BMU are powered and operating. In active mode the controller is fully functioning, all sensors are being actively monitoring, and all calculations are operating. In other modes different components can be turned on or off to decrease the power consumption of the entire BMS.

The controller can be configured to switch between idle, active or any other mode by either a digital input, like a key switch type signal, or by communication commands, or a timeout over CAN.

The functionality active in idle mode may be customized for a particular application. In some applications minimum power consumption is most important and so all monitoring and peripherals are powered down. In other applications, it may be more important to keep large capacity cells balanced and so cell voltage monitoring and cell balancing circuitry is still running in idle mode.

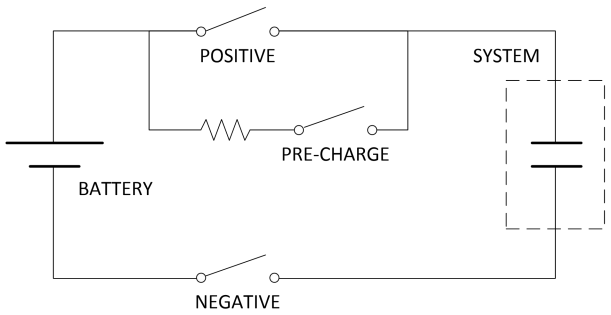
CONTROLLER STATE FLOW

The controller state flow, or how it functions, can be completely different for each battery application. It can change drastically between batteries used for backup and standby power, batteries used in medium voltage industrial applications, to batteries used in high voltage automobiles. In each state, different actuators can be commanded on or off. The following is a list of a few common controller states:

- Self-Test
- Contactors Open
- Pre-Charge
- Contactors Closed – Normal Mode
- Contactors Closed – Low Power Mode
- Charging
- Charge Complete
- Idle

RELAY CONTROL

Safety relay(s) are required to be installed on lithium batteries in order to disconnect the battery from the system, or vehicle in order to protect the battery and to avoid any dangerous conditions. For a battery system of 60 V or less a single relay on the positive on the battery may be used. For battery systems greater than 60V two relays should be used, one relay on the positive terminal and another on the negative terminal of the battery.



Many applications will have a motor controller, inverter or some other device in the system that may have internal large capacitors. This capacity can cause a large current in-rush when the battery relays are closed, as it begins to charge from 0V up to battery voltage. This large in-rush current will cause arcing on the relay contacts, damaging them, and significantly reducing the relay lifetime. To prevent this damage a pre-charge relay and pre-charge resistor are added, as in the previous figure. The battery turn on sequence is then as follows:

1. Negative Relay Closes
2. Pre-charge Relay Closes, allowing current to go through and charge capacitor
3. When system voltage reaches 90% of battery voltage the Positive Relay Closes
4. Pre-Charge Relay Opens
5. If the battery pack is used in a system that can be connected to an off-board DC charger, then a DC charging relay may be used as well.

CELL BALANCING

BMU have real-time dynamic balance function. Cell balancing is required to keep all cells within the battery pack equally charged. This ensures that cells that may have slightly weaker performance are not degraded further by over-charging or over-discharging them during operation. A well balanced battery pack will have higher capacity and a longer lifetime then an unbalanced one. 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.

BATTERY AND OUTPUT VOLTAGE MEASUREMENT

The battery voltage measurement circuitry can be configured in firmware for low, medium, high and full ranges depending on the voltage of the battery pack. The low range is from 0 to 110V and has a resolution of 3.2 mV. The medium range is for 0 to 225V batteries, and has a resolution of 7.0 mV. The high range is from 0 to 450V and has a resolution of 14 mV. Full range is from 0 to 900V and has a resolution of 28mV. All ranges have an accuracy of 0.1 %. The voltage measurement is taken on the battery side and output (system) sides of the safety relays. It is used for alarms, control of pre-charging the system, and to determine if a relay has failed open or closed without the relay position feedback.

CAN BUS

There is one or two (if required) isolated controller area network (CAN) buses compatible with SAE J1939 and ISO 11898. They can be configurable to run at speeds up to 1 Mbps, although 250 or 500 kbps is recommended for automotive and industrial applications.

A CAN bus that complies with SAE J1939 and ISO 11898 requires termination resistors at each end of the cable, or linear bus. The bus should be linear and not star or other topologies. The standard termination is 120Ω between the CAN High and CAN Low cables, at each cable end.

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.

MMU (INTERNAL) CAN BUS

A isolated controller area network (CAN) bus is implemented for MMU communication and diagnostic purposes such as firmware upgrading and battery monitoring. This CAN bus is meant to be connected through a CAN-USB device to your laptop or PC. Firmware upgrading may be completed with the JK Firmware loader. BMS easyLink can be used to monitor and log all the battery and BMS data to your laptop for troubleshooting and servicing. This CAN bus does include the end of line 120Ω termination. It is configured to 500 kbps and all communication is encrypted.

ALARM DEFINITIONS AND REPORTING

Over 60 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.

CURRENT SENSOR

The BMU controller has been designed to work with an automotive Hall Effect current sensor. A 5V supply that can source up to 100mA and sensor ground have been supplied to power the current sensor. The 5V source has reverse protection and overcurrent protection. In addition two 0 – 5V analog input channels, one for low and one for high, can read the current sensor feedback.

Typical sensors include the dual channel LEM DHAB series S/18 and S/24. Each sensor has separate low and high range channels that allow the BMS to monitor the current in and out of the battery with the highest accuracy.

AMBIENT TERMPERATURE

The ambient temperature input sensor can monitor any temperature but may be most useful as a feedback for thermal management control. Such as the incoming air temperature if a fan is used for cooling the battery pack.

The standard configuration is a NTC thermistor with 10kΩ at 25°C.

RELAY DRIVER

Eight relay drivers are provided for control of the battery safety relays, charging relays, pre-charge relays, and others. Four relays output is capable of 600mA continuous with a pulse power of over 1.7 Amps allowed for relay in-rush currents. The controller supply voltage is sent out as the relay command voltage level.

RELAY POSITION FEEDBACK

Four relays driver is implemented with an optional position feedback. The relay position feedback sends out 5V and the return is a 5V digital input. This is used on auxiliary position feedback contacts present on high power EV relays. When the auxiliary contacts are closed then the BMS can be sure that the relay has actually responded to the relay close command. If the relay commands to open or close the relay and the position feedback do not match than a relay failed open or failed closed alarm can be generated.

DATA LOGGING

The lifetime histograms of temperature, voltage and current of every cell monitored by the controller are logged in the controller memory. This data can be useful for troubleshooting and warranty purposes.

Battery cell serial numbers can be set and stored in the controller during pack assembly and used for cell tracking.

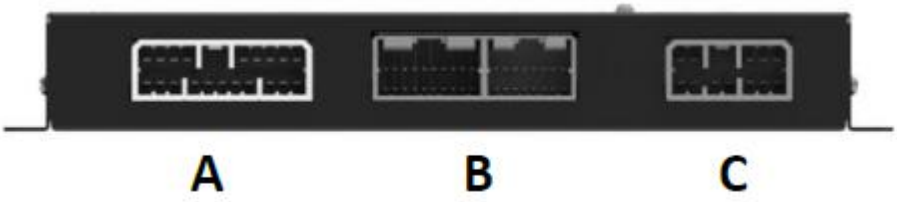
FIRMWARE UPGRADING

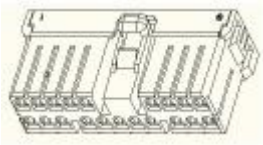
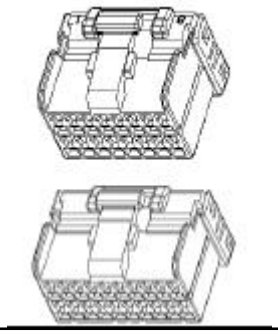
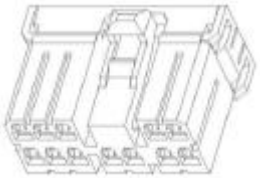
Firmware upgrading can be completed from a laptop or PC connected to the CAN bus with a CAN-USB tool, and the JK Firmware Loader software.

BATTERY PACK MONITORING

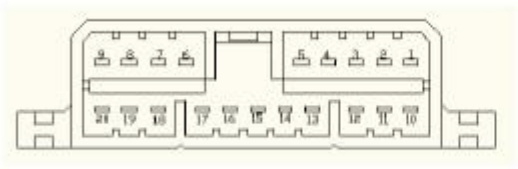
Battery pack monitoring can be done in real time with a laptop or PC connected to the CAN bus with a CAN-USB tool and the JK software BMS LINK.

8 CONNECTORS AND PIN OUT

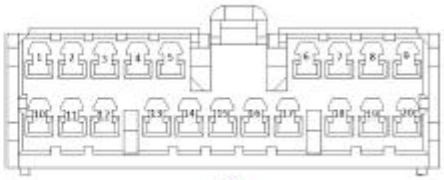


Connector	TE Connector P/N	TE Socket P/N	TE Hand Crimp Tool	
A	174952-1	173631-1	90654-1	
B	174046-2 174047-2	173681-1	58522-1	
C	173851-1	173631-1	90654-1	

Connector A –Power, CAN



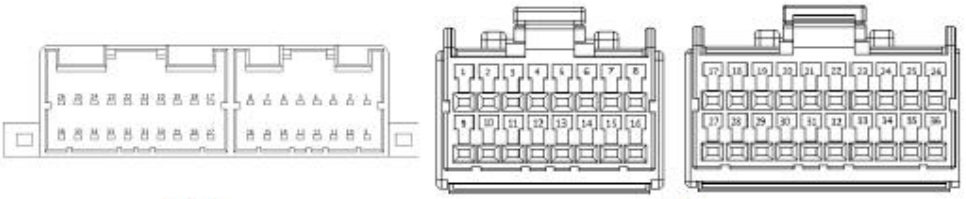
Header



Plug

Pin	Tag	AWG	Description
1	VMS KEY	20	Vehicle ACC/ON signal
2	CHG KEY	20	On-board charger signal
3	N/C		
4	A+	20	On-board/Off-board charger Low voltage auxiliary power supply +
5	PWR+	20	Vehicle low voltage power supply +
6	AMB TP	20	Ambient temperature +
7	CAN2P	20	Vehicle CAN_H
8	CAN3P	20	On-board/Off-board charger CAN_H
9	CAN4P	20	CAN_H
10	DO1	20	Digital Output 1
11	DO2	20	Digital Output 2
12	CP	20	Slow charge CP signal
13	A-/GND	20	On-board/Off-board charger Low voltage auxiliary power supply -/Vehicle low voltage power supply/GND
14	CC2-2	20	On-board charger connection confirmation
15	CC	20	Slow charge CC resister
16	DI2	20	Digital Input 2
17	AMP TN	20	Ambient temperature -
18	CAN2N	20	Vehicle CAN_L
19	CAN3N	20	On-board/Off-board charger CAN_L
20	CAN4N	20	CAN_L

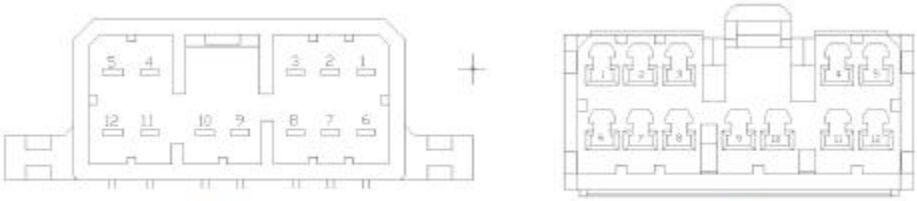
Connector B –MMU Control, Current Sensor, Charger Temperature, Relay control



Header Plug

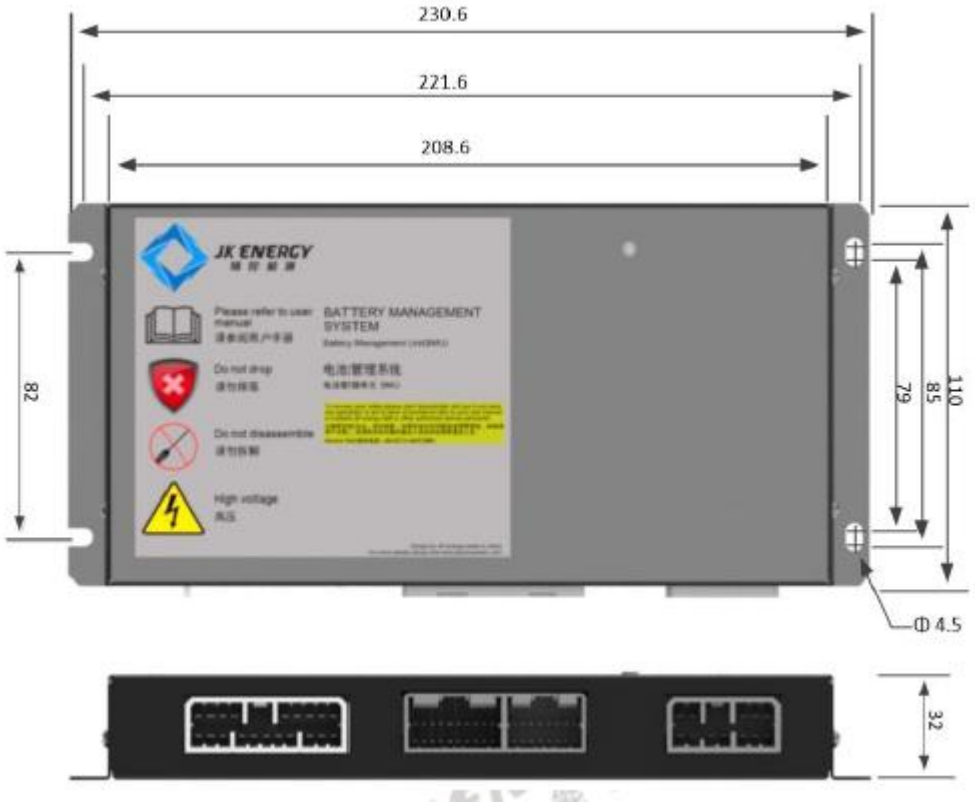
Pin	Tag	AWG	Description
1	CS H	20	Current Sensor High Signal
2	CS_5V	20	Current Sensor +5V
3	MMU PWR+	20	MMU Power+
4	MMU PWR EN	20	MMU Power EN
5	CAN1P	20	MMU CAN_H
6	DC TP-	20	DC charge socket negative temperature
7	AC TP-	20	AC charge socket N pole temperature
8	N/C	20	
9	CS_L	18	Current Sensor Low Signal
10	CS GND	18	Current Sensor GND
11	MMU PWR-/GND	20	MMU PWR-/GND
12	MMU PWR-/GND	20	MMU PWR-/GND
13	CAN1N	20	MMU CAN_L
14	DC TN-	20	DC charge socket negative temperature
15	AC TN-	20	AC charge socket N pole temperature
16	N/C	20	
17	DC TP+	20	DC charge socket positive temperature
18	AC TP+	20	AC charge socket L pole temperature
19	N/C	20	
20	RLY7 PWR	20	Relay 7 Power Send
21	RLY6 PWR	20	Relay 6 Power Send
22	RLY5 PWR	20	Relay 5 Power Send
23	RLY4 PWR	20	Relay 4 Power Send
24	RLY3 PWR	20	Relay 3 Power Send
25	RLY2 PWR	20	Relay 2 Power Send
26	RLY1 PWR	20	Relay 1 Power Send
27	DC TN+	20	DC charge socket positive temperature
28	AC TN+	20	AC charge socket L pole temperature
29	N/C	18	
30	RLY GND	18	Relay Power Ground
31	RLY GND	20	Relay Power Ground
32	RLY SEND/+5VPRT	20	Relay Read-back Send
33	RLY RB4	20	Relay 4 Read-back Send
34	RLY RB3	20	Relay 3 Read-back Send
35	RLY RB2	20	Relay 2 Read-back Send
36	RLY RB1	20	Relay 1 Read-back Send

Connector C –High Voltage Monitor



Pin	Tag	AWG	Description
1	N/C		
2	N/C		
3	HVP-	20	Output Voltage Negative Monitoring
4	N/C		
5	HVB-	20	Battery Voltage Positive Monitoring
6	HVP+	20	Output Voltage Positive Monitoring
7	N/C		
8	N/C		
9	N/C		
10	HVB+	20	Battery Voltage Negative Monitoring
11	N/C		
12	N/C		

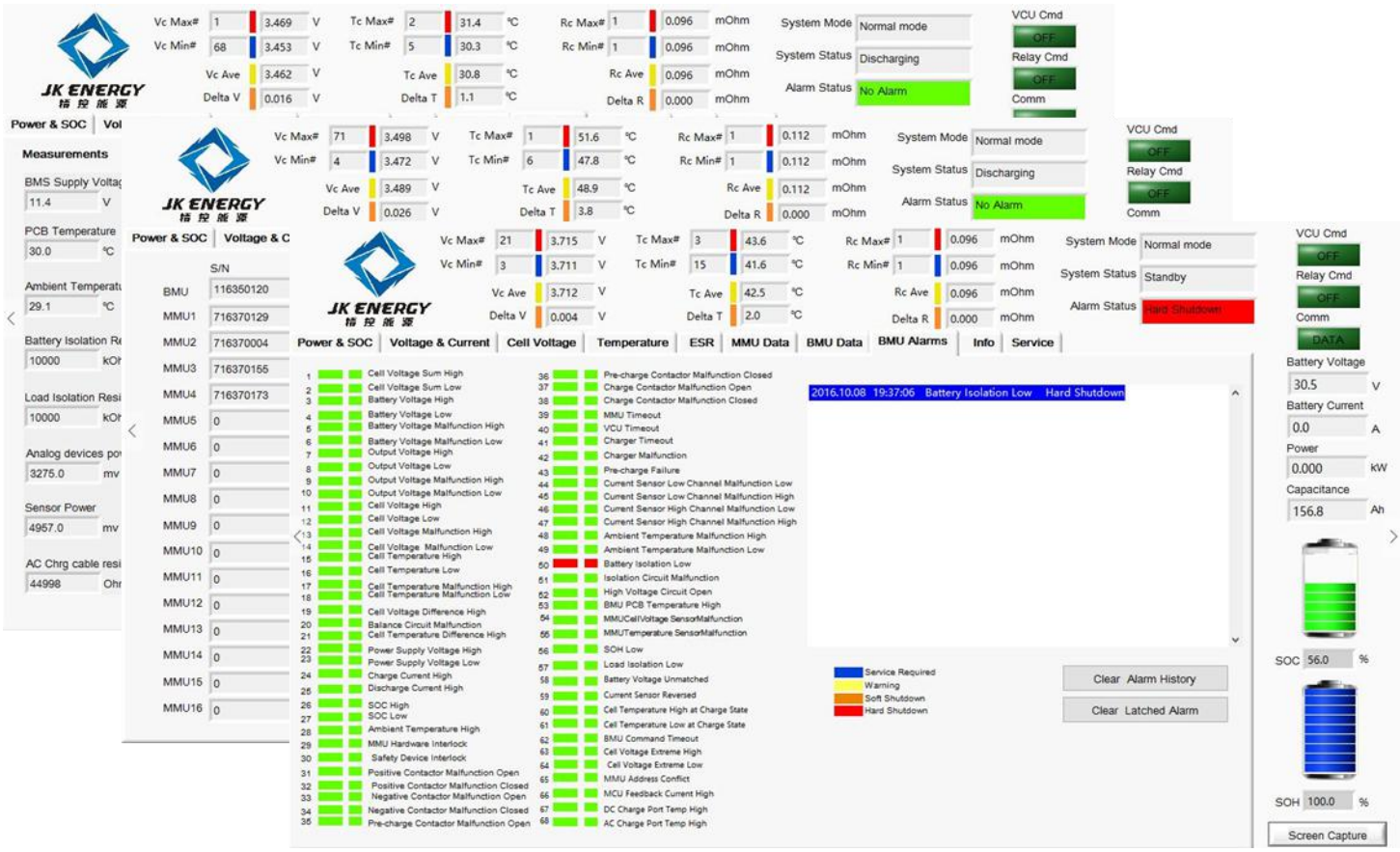
9 SIZE AND MOUNTING



All dimensions are in mm

10 BMS easyLink –Monitor and Diagnose the Battery Pack

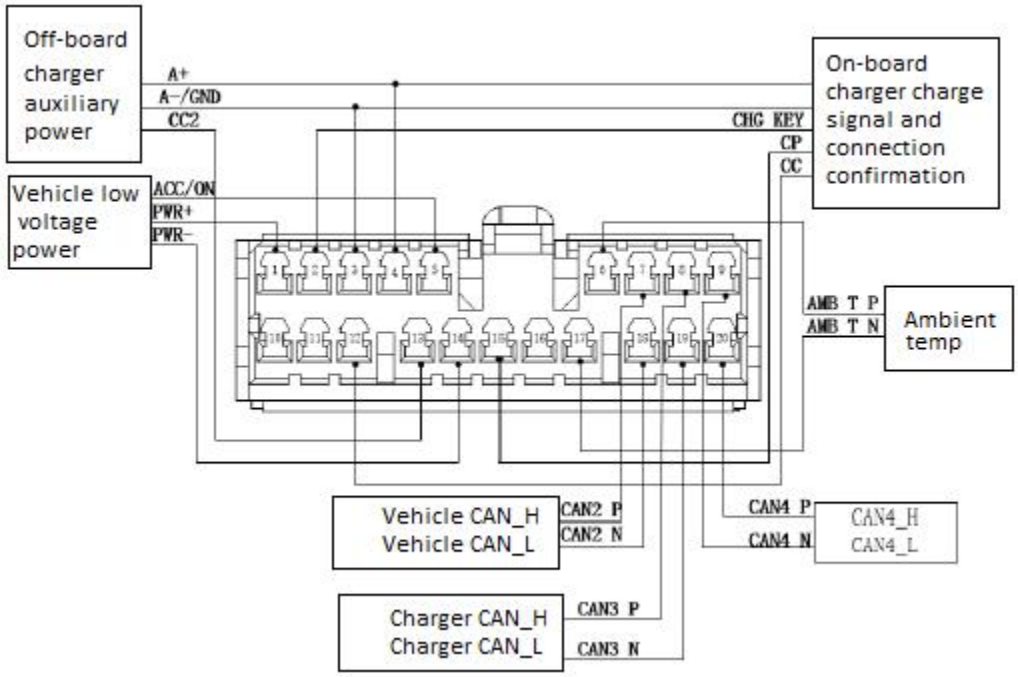
- Monitor and Diagnose problems in the Battery Pack from your PC or Laptop in real time。
- BMS Link is compatible with all JK BMS products.
- The most comprehensive, battery integrated monitoring, logging and control software.
- Multi-page layout for displaying battery data in numerical and graphical 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.



11 TYPICAL WIRING

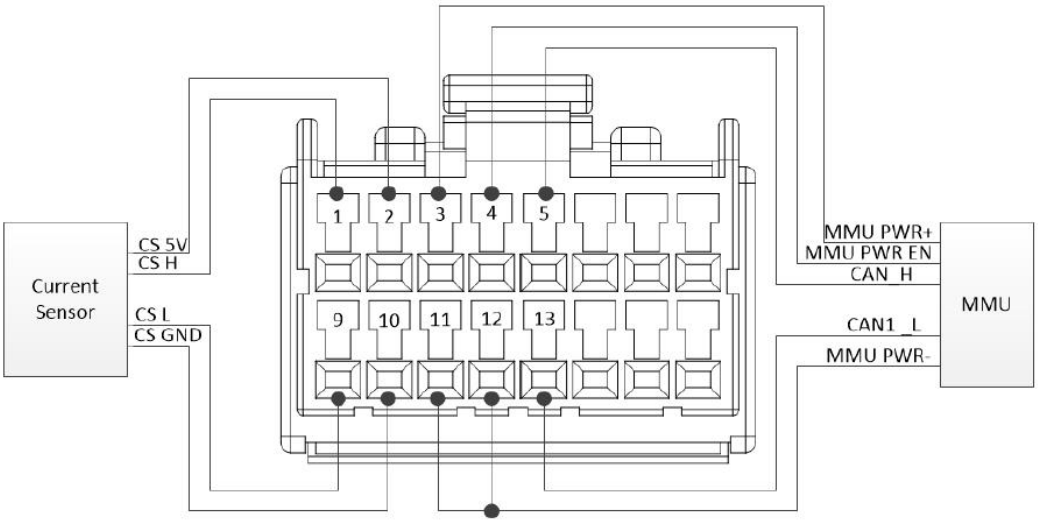
Power

The following diagrams show the wiring for supply power, ground, power enable, and ambient temperature, CAN bus communication.

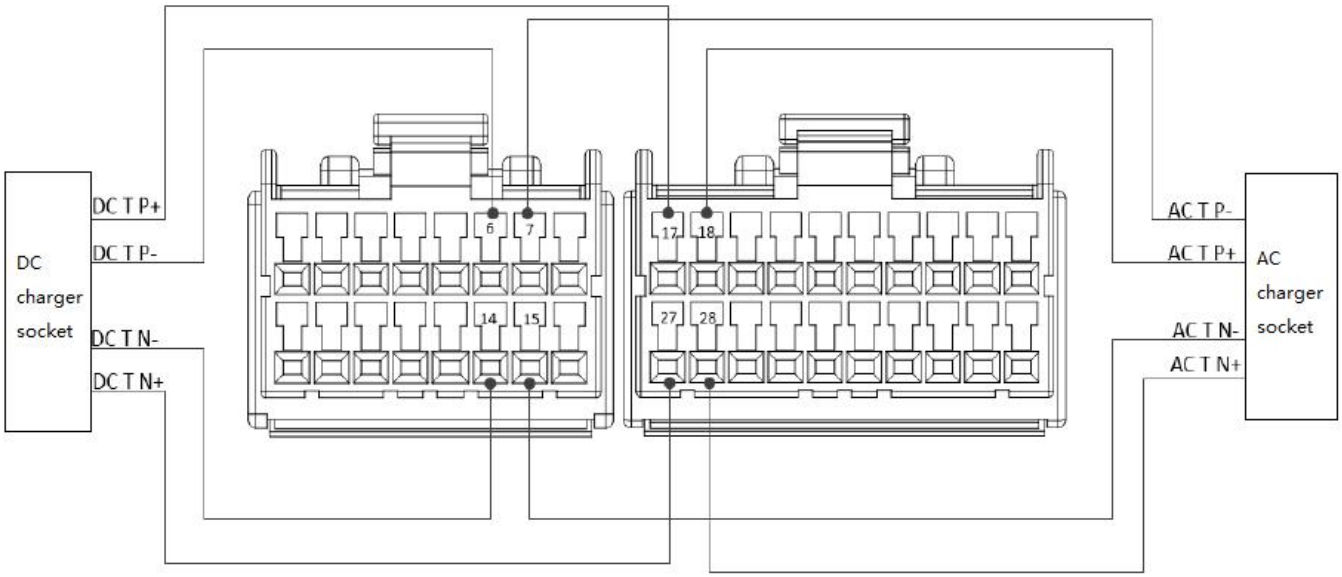


MMU power supply and communication, current sensor

The following diagrams show the wiring for MMU power supply and communication, current sensor.



Charger socket temperature monitor



Relay control

The following diagrams show the wiring for relay control, the relay state feedback is optional, for the relay definition, recommend the following:

RLY1_EN: Positive relay

RLY2_EN: Negative relay

RLY3_EN: Pre-charge relay

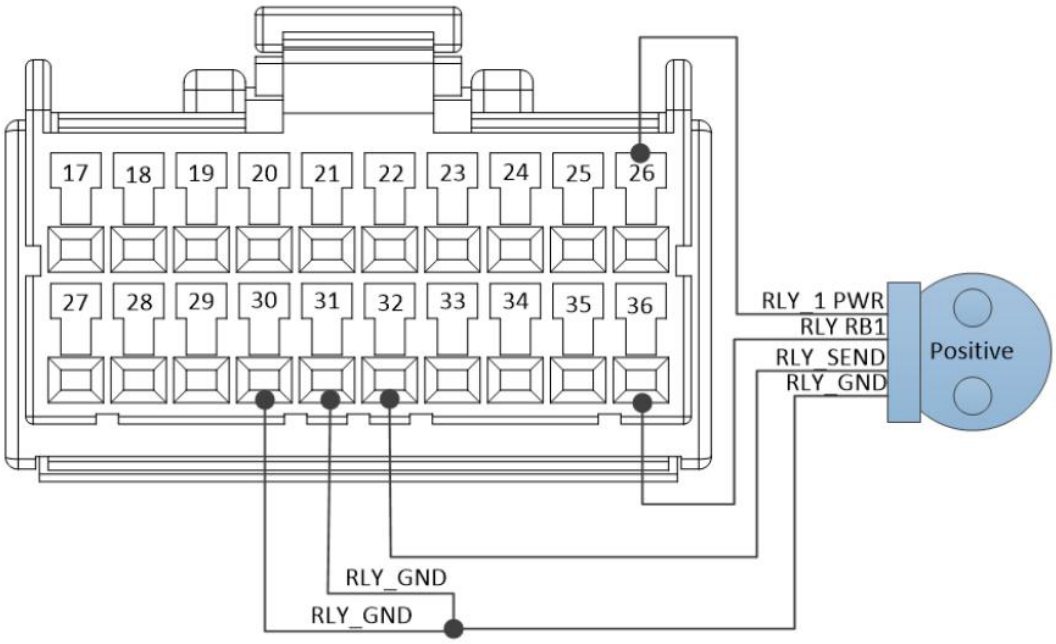
RLY4_EN: Charge relay

RLY5_EN:快充继电器

RLY6_EN: DC/DC relay

RLY7_EN: Air conditioner relay

PIN (30,31)RLY_GND 与 GND 并线，为所有继电器的供电电源地；PIN32 RLY_SEND relay feedback send, 为所有继电器的反馈发送线。



HIGH VOLTAGE MONITORING AND GROUND FAULT DETECTION (GFD)

The following diagram shows the wiring for the high voltage monitoring and ground fault detection.