X-SERIES BATTERY MANAGEMENT SYSTEM (BMS)

BATTERY CONTROL UNIT (X-BCU)

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 with Hardware Interlock Safety Layer

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 (X-MCUs) over isolated CAN bus.
- Can control passive or active balancing over entire battery pack
- State of Charge, State of Health, Capacity, and DC Resistance Calculations
- Cell over voltage, under voltage, and high temperature hardware interlock layer protection connection to X-MCUs
- Safety Device Hardware Interlock
- One or two Isolated CAN bus channels
- One or two power inputs with enable signals
- Charger Communication and Control
- Regulated 24V Power output to module controllers (X-MCUs).
- Automatic CAN Node ID assignment of all X-MCUs
- Battery Relay and pre-charge control
- Ground Fault Detection
- High Voltage Monitoring of Battery and System
- Thermal Management
- Power and Communication for optional Auxiliary Driver Unit
- Current Sensor Monitoring
- Fault Management and Diagnostics
- Data Logging
- Ultra Low Power Dissipation
- Automotive Grade

2 DESCRIPTION

The X-Series Battery Control Unit (X-BCU) is part of the X-Series Battery Management System (BMS). Functioning as the master controller, it can communicate with a single or multiple X-Series Module Control Units (X-MCUs) to form a complete BMS.

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

As the master controller the X-BCU receives all necessary information about the battery cells, such as cell voltages and temperatures, from each MCU. 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 X-BCU 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 X-BCU has one or two (if required) power inputs, with enable lines, to power the system from either 12V or 24 V source (9 – 32 V) such as a vehicle or charging station. The X-BCU 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).

In addition to software monitoring and control, a hardware interlock layer triggers on configurable thresholds for high cell voltage, low cell voltage, and high cell temperatures. The interlock signal is connected between all X-MCUs to the X-BCU controller. The X-BCU hardware will disconnect the battery pack from the vehicle by opening the battery safety relays in these extreme conditions to ensure safe operation.

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

3 APPLICATIONS

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

4 OPERATIONS

- 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 X-BCU on and off.
- Both power supply inputs come with high voltage, reverse voltage, low voltage, and over current protection.
- 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.
- Cell voltage and temperature monitoring of up to 240 cells in series through communication with module controllers. Compatible with both X-MCUs and M-Series controllers. All data is reported every 100ms to ensure fast response in protecting cells and the highest accuracy when calculated battery pack parameters.
- 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.
- Safety Hardware Interlocks: cell over voltage, cell under voltage, and high cell temperature from MCUs will trigger the hardware interlock line and cause the X-BCU to open the safety relays independently of the software system. This safety-critical system eliminates any events that could cause financial damage, injury, or loss of life without relying on the complexities or timing delays of the software system. The hardware system is designed for compatibility with IEC 61508 / ISO 26262.

  The safety hardware interlock layer functions as a second layer to the software controls forming dual-channel architecture as required in safety-critical systems. This has the advantage of detecting faults or failures even if a systematic fault has occurred in the software controls. JTT's dual-channel architecture with hardware and software levels meets all safety critical system requirements. It minimizes controller cost and space when compared to other approaches used in other BMS systems where two independent but identical software systems are running in parallel.
- 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 X-BCU controls active or passive cell balancing on all module controllers to achieve balancing across the entire battery pack. This maximizes battery capacity to extend the battery operational range, and extends battery lifetime by avoiding overcharging or over discharging the weak cells. Continuous cell balancing during operation based on cell SOC.
- Fault Management: Over 80 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.
- Four relay drivers that can be used for the positive relay, negative relay, dc charging relay, pre-charge relay, or others. Each relay has optional feedback sensing that can be used to monitor the position of the relay for fault diagnostics.
- Relays are used to isolate the battery from the system in extreme cases that could result in a dangerous situation. Capable of breaking over 2000A, and withstand voltages of greater than 2200 Vrms.
- 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
- 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.
- Safety Device Hardware Interlock can connect to inertia switch, crash sensor, tilt switch, manual service disconnect (MSD) and other safety devices. Any of these devices if tripped will automatically open the battery safety relays.
- Additional temperature input could be used for ambient air measurement.
- Ability to control fans, pumps, heaters, and other components for battery thermal management with high current output driver. Control is based on configurable high and low temperature operating limits.
- One general purpose high side digital output.
- One general purpose low side digital input.
- 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.
- Automatic CAN Node ID of all X-MCUAs in the battery. There is no configuration necessary when swapping, replacing, or upgrading controllers. All X-MCU controllers in the distributed BMS can detect their position within the battery and are assigned a corresponding CAN Node ID by the X-BCU.
- Regulated 24V output for MCU power with soft-start features and the ability to turn off for low power or idle modes.
- Power, Ground, and Digital communication available for connection to optional driver board to control additional components such as fans, heaters, relays, or other devices if needed.
- In system firmware upgrading available through CAN.
- Battery and cell monitoring and diagnostics available in real-time through internal (MCU) CAN to PC/laptop with BMS LINK software tool.
- IP55 protection rating.
- Automotive grade electrical and mechanical components for temperature and vibration.

5 BLOCK DIAGRAM

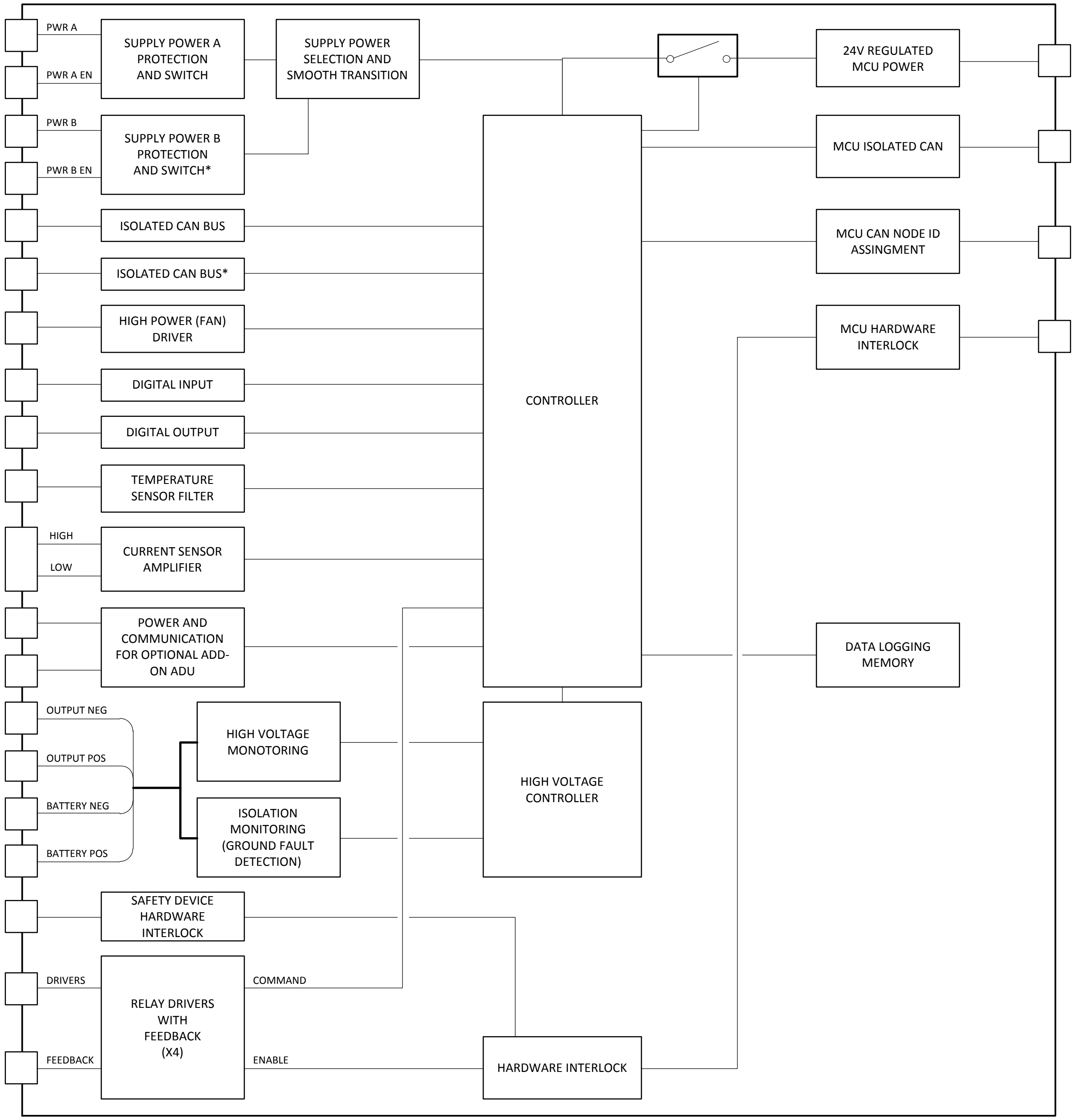


Figure 1. Controller Block Diagram

*Optional features. Default configuration does not include second CAN channel or second power input.

6 TYPICAL APPLICATION

The X-BCU is the master controller in a multiple controller distributed battery management system (BMS). The X-Series product line 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 X-BCU can be used as a master controller for both X-Series and M-Series module control units (MCUs), 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.

7 CONFIGURATIONS AVAILABLE

The X-BCU has several hardware options that may be included if needed for a particular application.

A secondary power supply input with additional enable input can be added if needed. This may be useful if the battery pack may be powered from a vehicle supply power or from an off-board source that is connected during charging and the vehicle is off.

A secondary CAN bus can be added if needed. This may be required when communication with a vehicle and a charging station is required, but they operate at different CAN bus baud rates.

The default X-BCU has only one power supply input, and one external CAN bus. Either option may be added if required.

The different hardware configurations are specified by the X-BCU model number in the next section.

8 MODEL NUMBERING

X-BCU-____

Additional Hardware Features

C – Second Isolated CAN Communication
P – Second Power Supply Input

Example Model Number:

Default Controller: *X-BCU*

Controller with second CAN and Power Options: *X-BCU-CP*

9 ELECTRICAL CHARACTERISTICS

PARAMETER	MIN	TYP	MAX	UNITS
Supply Power Specifications (Supply Power A & B)				
Supply Voltage (Vmain)	9	12 / 24	32	V
Supply Voltage Under voltage Cut-out (while operating)	7.7			V
Supply Voltage Over voltage Cut-out (while operating)			33.0	V
Supply Current, Active Mode*				
Default Configuration (@ 12/24V)		180/90		mA
With second Isolated CAN (@ 12/24V)		200/100		mA
Supply Current, Idle (Low Power) Mode (@ 12/24V)		50/25		mA
Supply Current, OFF Mode (@ 12/24V)		0.35/0.70		mA
Power Enable Inputs (Pwr A EN, Pwr B EN)				
Input Voltage	0		Vmain	V
Input Enable Voltage	Vmain-1		Vmain	V
Input Disable Voltage	0		Vmain-1	V
Input Resistance		50		KΩ
Isolated CAN Communication Specifications (all 3 chan.)				
Isolation		2.5		kV rms
Common-mode Transient Immunity		25		kV/µs
Recessive Bus Voltage	2.0		3.0	V
CANH Output Voltage	2.75		4.5	V
CANL Output Voltage	0.5		2.0	V
Maximum Data Rate		1		Mbps
I2C Communication Specifications				
Input High Voltage	3.5		5.0	V
Input Low Voltage	0		1.5	V
Internal Pull-Ups		10		KΩ
Bus Capacitive Loading			200	pF
Data Rate	25	100	250	KHz
FAN Driver Specifications				
Output Voltage		Vmain		V
Output Current			6.0	A
Load Inductance (@Imax)			60	µH
Digital Output Specifications				
Low Side Digital Output Current Sink			750	mA
Low Side Digital Output Current Source		0		mA
Low Side Digital Output Switching Voltage	0		60	V
Digital Input Specifications				
Digital Input Active High Level	5		Vmain	V
Digital Input Pull-Down		150		KΩ
MCU Power Specifications				
Output Voltage		24		V

PARAMETER	MIN	TYP	MAX	UNITS
Output Current			3.7	A
Current Protection		3.8		A
Current Monitoring Specifications				
Sensor Supply Voltage	4.9	5.0	5.1	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
Battery Voltage Monitoring Specifications				
Range (Full)	0		900	V
Resolution (Full)		28		mV
Range (High Range Configuration)	0		450	V
Resolution (High Range Configuration)		14		mV
Range (Medium Range Configuration)	0		225	V
Resolution (Medium Range Configuration)		7		mV
Range (Low Range Configuration)	0		110	V
Resolution (Low Range Configuration)		3.5		mV
Input Resistance		4		MΩ
Accuracy		0.1		%
Relay Driver Specifications (all 4 chan.)				
Output Voltage		Vmain		V
Output Current - Continuous			600	mA
Output Current – Pulse			1.7	A
Position Feedback Output Voltage		5		V
Position Feedback Input Threshold		2.5		V
Position Input Resistance		110		KΩ
Ground Fault Detection (GFD) Specifications (Battery & System)				
Isolation		1000		V
Resistance (Leakage) Detection Range	10	4	3000	KΩ
Resolution		10		KΩ
Detection Response		25		Ms
Safety Device Hardware Interlock Specifications				
Interlock Output Voltage		2.5		V
Interlock Output Source Current			20	mA
Interlock Return Non-Fault Condition	2.0		3.0	V
Ambient Temperature Sensor Specifications				
Measurement Resolution		0.1		°C
Measurement Accuracy		1.0		%
Temperature Range	-45.0		100.0	°C

* Without MCUx load current from 24V MCU-out

** See section on current sensor in the application information on resolution, accuracy, and range of measuring battery current with recommended current sensor.

10 APPLICATION INFORMATION

CONNECTING TO OTHER CONTROLLERS

Several wires are required to be connected between the X-BCU and X-Series or M-Series MCUs. For X-Series MCUs: power, ground, CAN high, CAN low, hardware interlock, and node ID go from the X-BCU and then in and out of each module controller. For M-Series MCUs just power, ground, CAN high and CAN low are needed.

MODES OF OPERATION

The X-BCU 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 X-BCU 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.

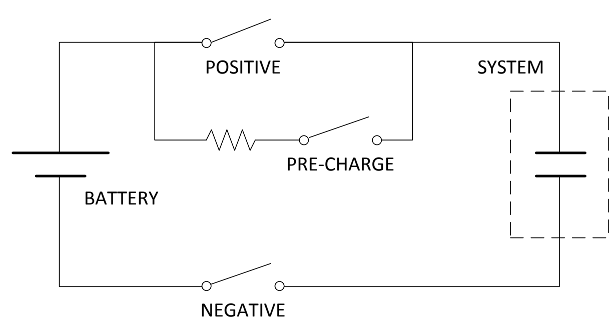
CONTROLLER STATE FLOW

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. For this reason the S-Series controller state flow is customized for each customer's application. 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
- Cold or Hot Temperature Hibernation

RELAY CONTROL WITH PRE-CHARGE

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

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

The X-Series BMS can use either active or passive cell balancing depending on which MCUs are used. In either case the X-BCU controls which cells are balanced by which MCUs as balancing is done across the entire battery pack.

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.

CELL VOLTAGE AND TEMPERATURE HARDWARE INTERLOCKS

Cell hardware interlocks based on cell over voltage, cell under voltage, and high cell temperature will trigger the hardware interlock on an MCU, which is monitored by the hardware on the X-BCU causing the safety relays to open independently of the software system. This safety-critical system eliminates any events that could cause financial damage, injury, or loss of life without relying on the complexities or timing delays of the software system. The hardware system is designed for compatibility with IEC 61508 / ISO 26262.

The safety hardware interlock layer functions as a second layer to the software controls forming dual-channel architecture as required in safety-critical systems. This has the advantage of detecting faults or failures even if a systematic fault has occurred in the software controls. JTT's dual-channel architecture with hardware and software levels meets all safety critical system requirements. It minimizes controller cost and space when compared to other approaches used in other BMS systems where two independent but identical software systems are running in parallel.

The X-MCUA hardware interlock circuit works in combination with an X-BCU. The X-BCU generates and monitors the hardware interlock signal that travels in and out of all X-MCUAs in the BMS. If any X-MCUA hardware interlock occurs then it will trip the hardware interlock signal from the X-BCU, the X-BCU hardware will detect this and automatically open the battery safety relays.

SAFETY DEVICE HARDWARE INTERLOCK

The X-BCU has a single safety device hardware interlock (SDHI). This interlock comes out of the controller, can be wired through multiple devices in series, and then returns to the controller. The safety device hardware interlock output will source 2.5V. The safety device hardware interlock will fault if its input is less than 2V or higher than 3V. This will be triggered if any device in the circuit breaks the circuit, by opening the connection between the out and in. The interlock will also detect and trigger on failures of shorting to ground or to a higher voltage.

Multiple devices can be used to trigger the interlock by connecting them in series. Typical devices may include an Emergency Stop, manual service disconnect (MSD), inertia switch (crash sensor), tilt switch, or auxiliary feedback contacts in the battery positive and negative power connector. If there are no safety devices required then the SDHI input must be wired directly to the SDHI output.

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. This layout results in the nominal 60Ω bus load.

The X-BCU controller does not have end of line termination on either of its CAN channels. It is meant to be added to an existing CAN bus as a node. It does however have over 2kΩ of resistance split between the incoming CAN high and 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.

MCU (INTERNAL) CAN BUS

A isolated controller area network (CAN) bus is implemented for MCU 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 JTT Firmware loader. BMS Link 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.

OPTIONAL DRIVER BOARD

The X-BCU can control an optional Auxiliary Driver Unit (ADU). Four wires are provided for digital control, power and ground. In addition a single hardware interlock signal is used for safety. The ADU may be used to drive relays, fans, heaters, or other components.

ALARM DEFINITIONS AND REPORTING

Over 80 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 X-BCU 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/15 and S/18. 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

Four relay drivers are provided for control of the battery safety relays, charging relays, pre-charge relays, and others. Each relay 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.

All relay drivers are enabled or disabled with the hardware interlock signal. As mentioned previously a hardware interlock fault may be triggered by a cell over voltage, cell under voltage, high cell temperature, on a MCU or the safety device hardware interlock on the BCU. Once the hardware interlock is triggered, there is a 3 second delay and then the relay drivers are disabled.

Relay driver 1, 2 and 3 can be used if either Power supply A or B is being used. Relay driver 4 is different as the relay command can only be driven high if Power supply A is being used at the given time. If Power supply B is on, then the relay command will not work. This is a hardware limitation that was built in for safety reasons. A typical application could be a battery in a vehicle that is powered by the vehicle on power supply B, and powered by the off-board DC charging station power on power supply A. This way if the vehicle is driving then the charging relay, driven by relay driver 4, can never close. Only if the charging station is connected and the X-BCU is powered from power supply A then relay driver 4 will close the charging relay. This is to ensure that the dangerously high battery pack voltage is never present on the charging port connector, unless the connection to the charging station is already made.

RELAY POSITION FEEDBACK

Each relay 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.

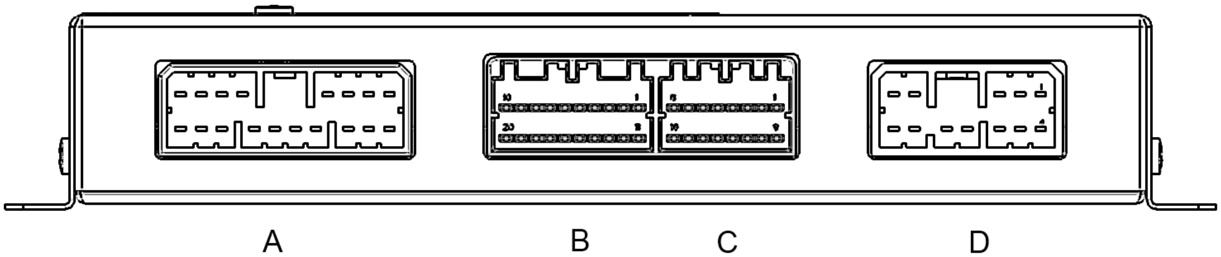
FIRMWARE UPGRADING

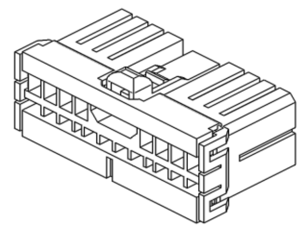
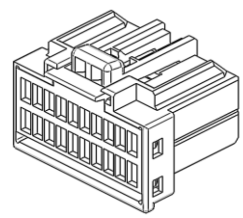
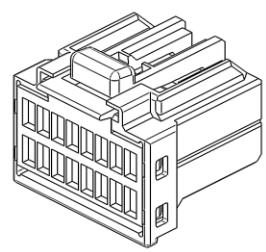
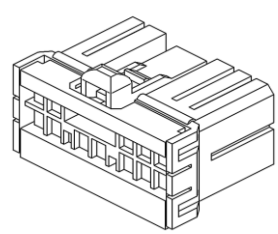
Firmware upgrading can be completed from a laptop or PC connected to the CAN bus with a CAN-USB tool, and the JTT Firmware Loader software.

BATTERY PACK MONITORING

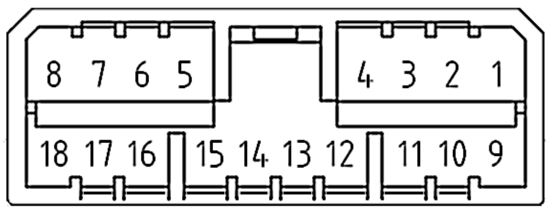
Battery pack monitoring can be done in real time with a laptop or PC connected to the CAN bus with a CAN-USB tool and the JTT software BMS LINK.

11 CONNECTORS AND PIN OUT



Connector	TE Connector P/N	TE Socket P/N	TE Hand Crimp Tool	
A	173853-1 (white) 173853-2 (black)	173631-1 (strip) 175027-1 (loose) (20-16 AWG)	90654-1	
B	174047-1 (white) 174047-2 (black)	173681-1 (strip) 175062-1 (loose) (22-20 AWG)	58522-1	
C	174046-1 (white) 174046-2 (black)	173681-1 (strip) 175062-1 (loose) (22-20 AWG)	58522-1	
D	173851-1 (white) 173851-2 (black)	173631-1 (strip) 175027-1 (loose) (20-16 AWG)	90654-1	

Connector A – Power, CAN, Fan



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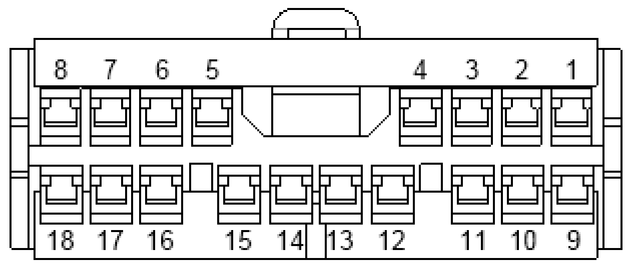
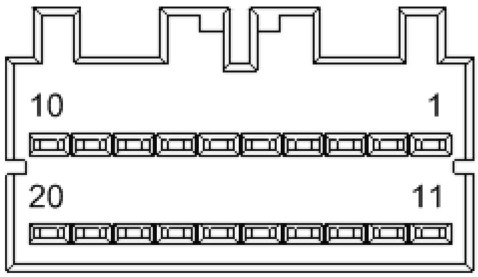


Plug

Wire insulation must be: 1.8 – 2.6 mm diameter.

Pin	Tag	AWG	Description
1	Vehicle CAN_L	20	Vehicle CAN_L
2	Vehicle CAN_H	20	Vehicle CAN_H
3	Secondary CAN_L	20	Secondary CAN_L (Optional)
4	Secondary CAN_H	20	Secondary CAN_H (Optional)
5	Supply Power A	16	Supply Power A (9-32V)
6	Supply Power A	16	Supply Power A (9-32V)
7	Supply Power B	16	Supply Power B (9-32V) (Optional)
8	Supply Power B	16	Supply Power B (9-32V) (Optional)
9	Digital Out	20	Digital Output
10	Pwr A EN	20	Supply Power A Enable
11	Pwr B EN	20	Supply Power B Enable
12	Digital Input	20	Digital Input
13	Fan Supply Power	16	Fan Supply Power
14	Fan Supply GND	16	Fan Supply GND
15	Supply Power A GND	16	Supply Power A GND
16	Supply Power A GND	16	Supply Power A GND
17	Supply Power B GND	16	Supply Power B GND
18	Supply Power B GND	16	Supply Power B GND

Connector B – MCU Control, Current Sensor, Ambient Temperature, ADU Interface



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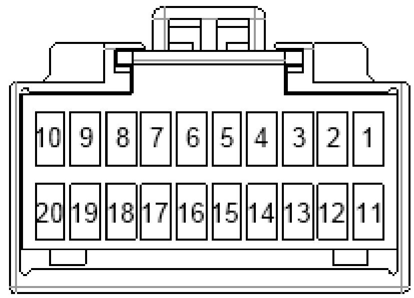
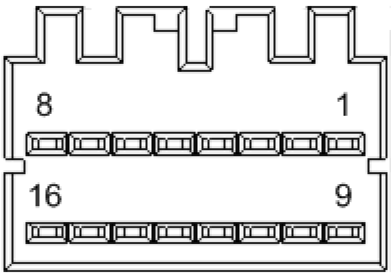


Plug

Wire insulation must be: 1.8 – 2.0 mm diameter.

Pin	Tag	AWG	Description
1	Cur_Sense GND	20	Current Sensor GND
2	Cur_Sense Low Signal	20	Current Sensor Low Signal
3	Cur_Sense High Signal	20	Current Sensor High Signal
4	Cur_Sense +5V Prot	20	Current Sensor +5V Prot
5	MCU Interlock Out	20	MCU Interlock Out
6	MCU CAN_L	20	MCU CAN_L
7	MCU CAN_H	20	MCU CAN_H
8	Node ID Out	20	Node ID Out
9	MCU Supply GND	18	MCU Supply GND
10	MCU Supply Power	18	MCU Supply Power
11	SDHI Return	20	Safety Device Hardware Interlock Return
12	SDHI Send	20	Safety Device Hardware Interlock Send
13	N/C	20	N/C
14	N/C	20	N/C
15	GND	20	GND
16	+5V Prot	20	+5V Prot
17	I2C Data	20	I2C Data
18	I2C Clock	20	I2C Clock
19	N/C	20	N/C
20	Chassis	20	Chassis Connection for Current Sensor wire shielding

Connector C – Relay Control and Feedback



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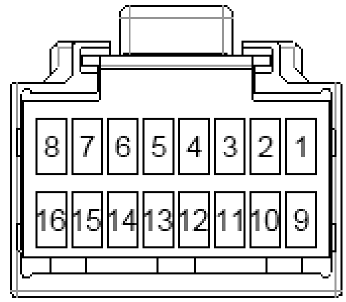
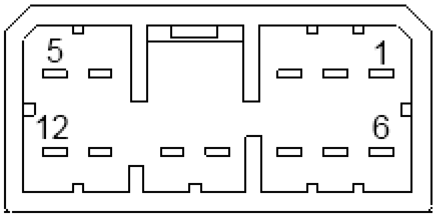


Plug

Wire insulation must be: 1.8 – 2.0 mm diameter.

Pin	Tag	AWG	Description
1	RLY 4 Rb Send	20	Relay 4 Read-back Send
2	RLY 3 Rb Send	20	Relay 3 Read-back Send
3	RLY 2 Rb Send	20	Relay 2 Read-back Send
4	RLY 1 Rb Send	20	Relay 1 Read-back Send
5	RLY 4 Ctrl Power	18	Relay 4 Power Send
6	RLY 3 Ctrl Power	18	Relay 3 Power Send
7	RLY 2 Ctrl Power	18	Relay 2 Power Send
8	RLY 1 Ctrl Power	18	Relay 1 Power Send
9	RLY 4 Rb Return	20	Relay 4 Read-back Send
10	RLY 3 Rb Return	20	Relay 3 Read-back Send
11	RLY 2 Rb Return	20	Relay 2 Read-back Send
12	RLY 1 Rb Return	20	Relay 1 Read-back Send
13	RLY 4 Ctrl GND	18	Relay 4 Power Ground
14	RLY 3 Ctrl GND	18	Relay 3 Power Ground
15	RLY 2 Ctrl GND	18	Relay 2 Power Ground
16	RLY 1 Ctrl GND	18	Relay 1 Power Ground

Connector D – High Voltage Monitor



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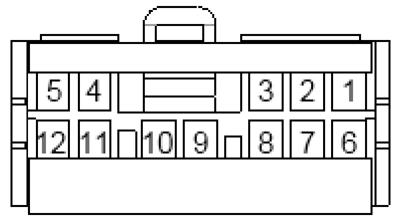
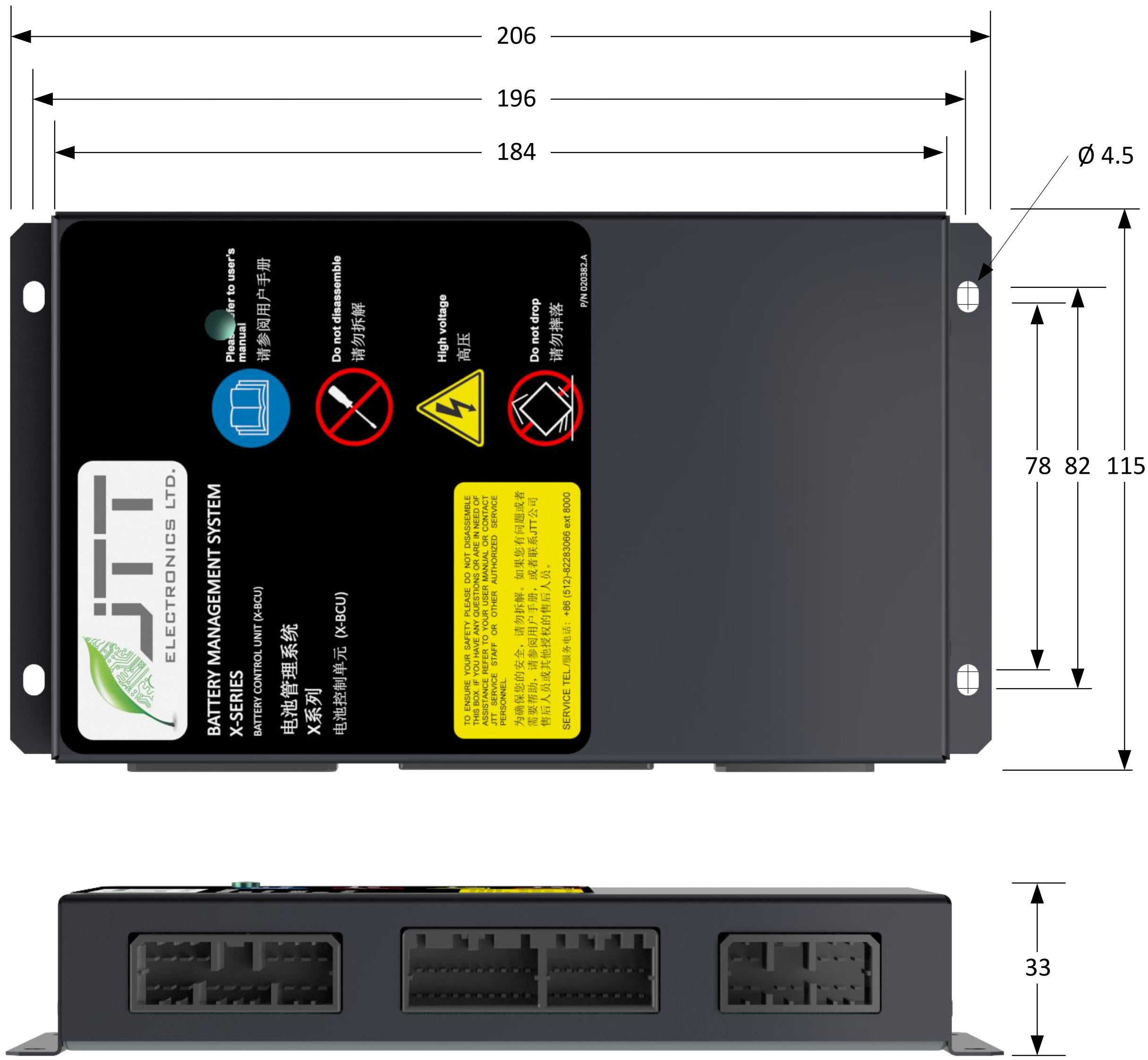


Plug

Wire insulation must be: 2.01 – 2.05 mm diameter.

Pin	Tag	AWG	Description
1	N/C	18	
2	N/C	18	
3	Output V-	18	Output Voltage Negative Monitoring
4	N/C	18	
5	Battery V+	18	Battery Voltage Positive Monitoring
6	Output V+	18	Output Voltage Positive Monitoring
7	N/C	18	
8	N/C	18	
9	N/C	18	
10	Battery V-	18	Battery Voltage Negative Monitoring
11	N/C	18	
12	N/C	18	

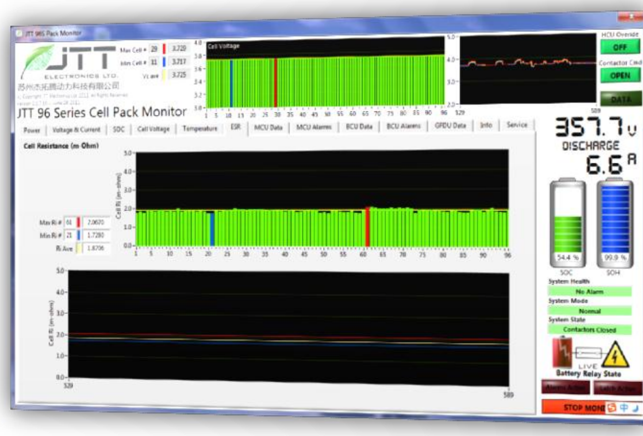
12 SIZE AND MOUNTING



All dimensions are in mm.

13 BMS Link – Monitor and Diagnose Your Battery Pack

- Monitor and Diagnose problems in the Battery Pack from your PC or Laptop in real time.
- BMS Link is compatible with all JTT BMS products
- The most comprehensive, battery integrated monitoring, logging and control software
- Windows (XP, 7)
- 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



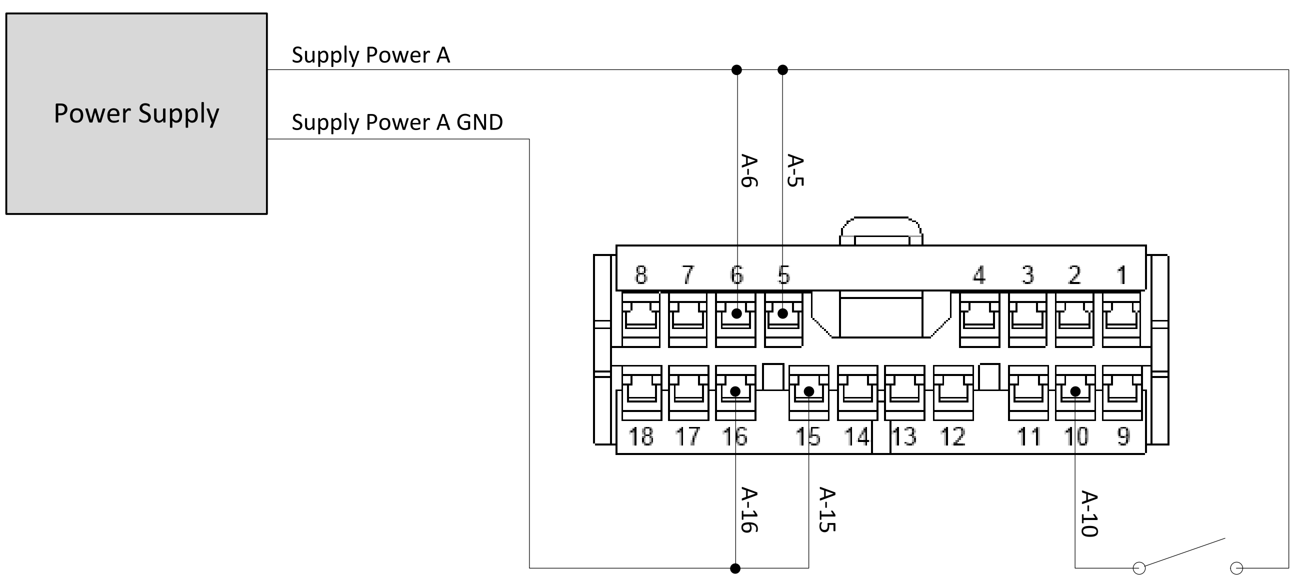
14 TYPICAL WIRING

POWER

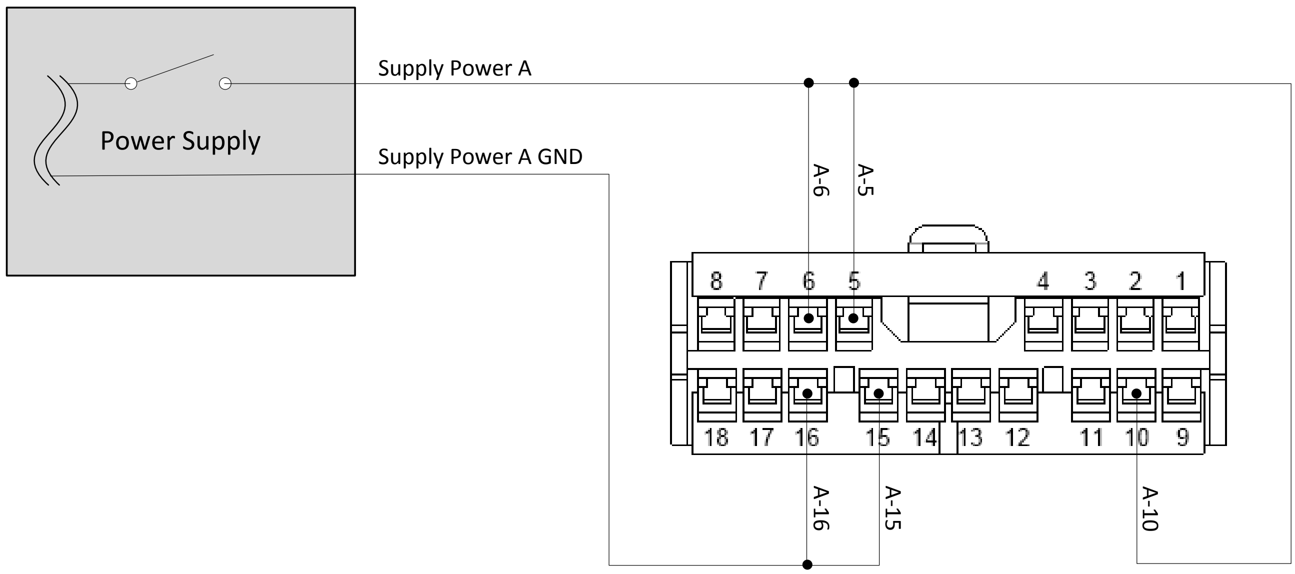
The following diagrams show the wiring for supply power, ground, and power enable. There are several different ways in which the power and enable inputs can be used.

The default configuration of the X-BCU has a single power input and enable. The recommendation is to wire power directly to the power and ground inputs on power supply A with heavier wire gauge, and to use the power supply A enable input to turn the power on and off. For example this could be tied to the vehicle ignition key switch. If the system is already setup to have the main power supply cycled already somewhere else, then you can wire this power input to the power supply and enabled pins as shown in the second diagram.

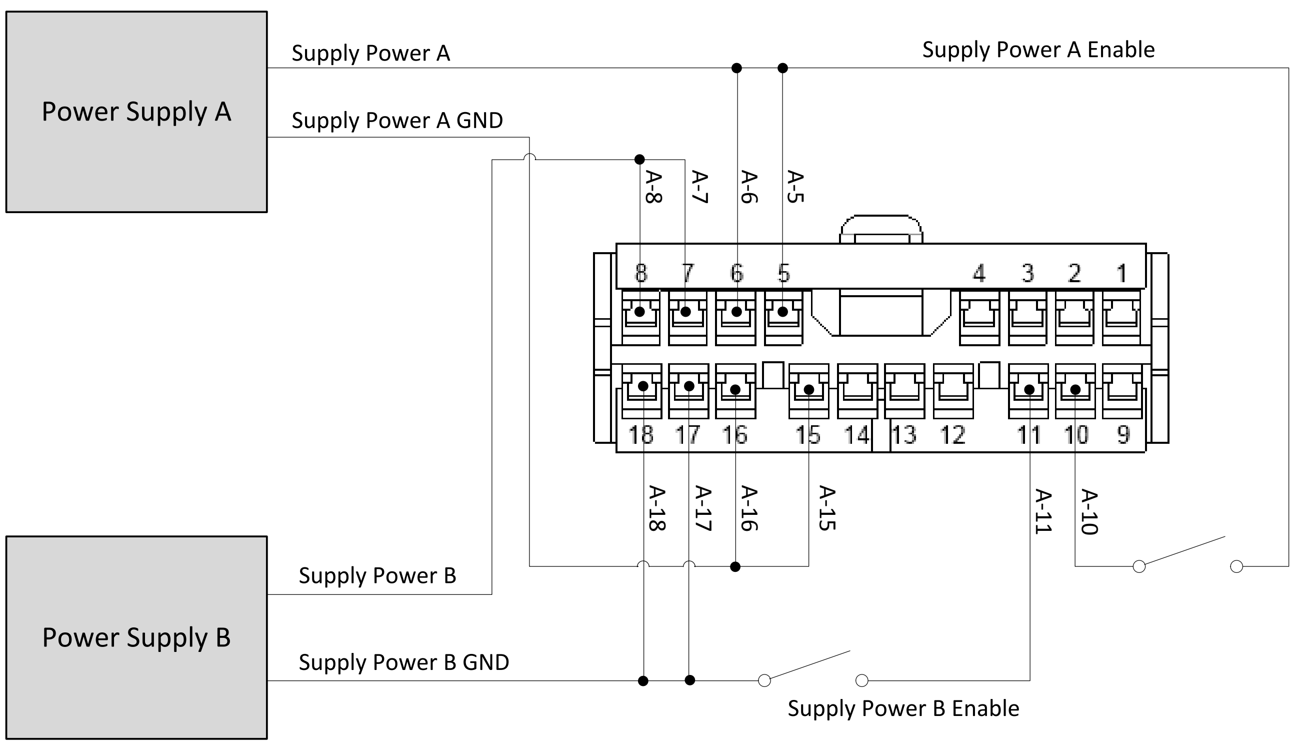
If the controller is configured with the second optional power supply input B then the two power inputs with two enable signals may be used. As mentioned previously this could be useful in a vehicle that powers the BMS from vehicle power during regular driving operation, and then powers the BMS from the battery charger, while the vehicle is turned off and connected to charging station. The power supply input A has priority over B, and Relay 4 can only be actuated while the controller is powered from power input A. Relay 4 could be used as the charging relay and so can only be actuated if the controller is indeed powered on input A from charging station. Please see the previous section for a more in-depth explanation of the dual power supply inputs. The following diagram shows how both power supply inputs could be used.



Recommended Power Supply A Wiring



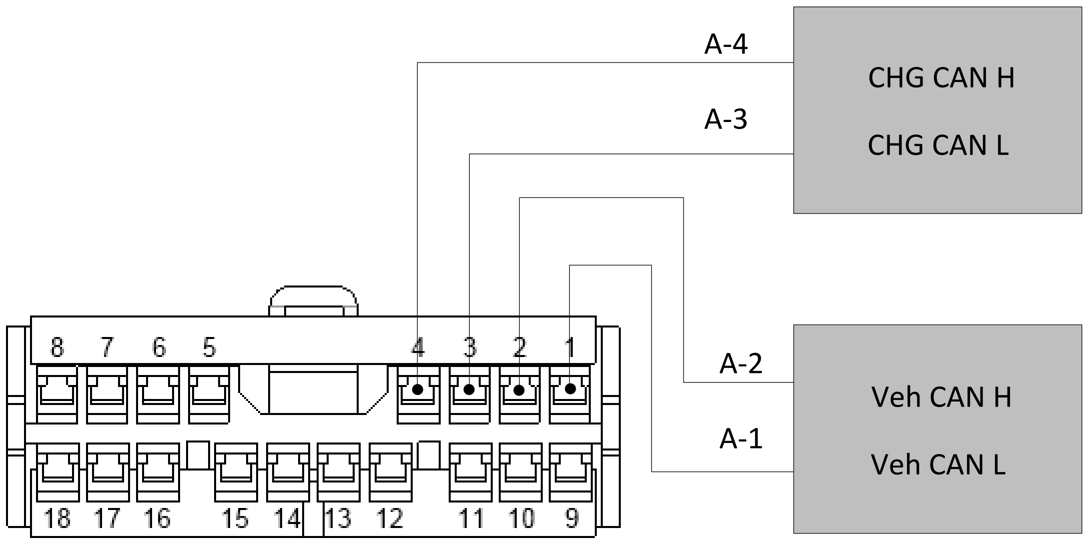
Power Supply A Wiring with external Switch



Power Supply A & B Wiring

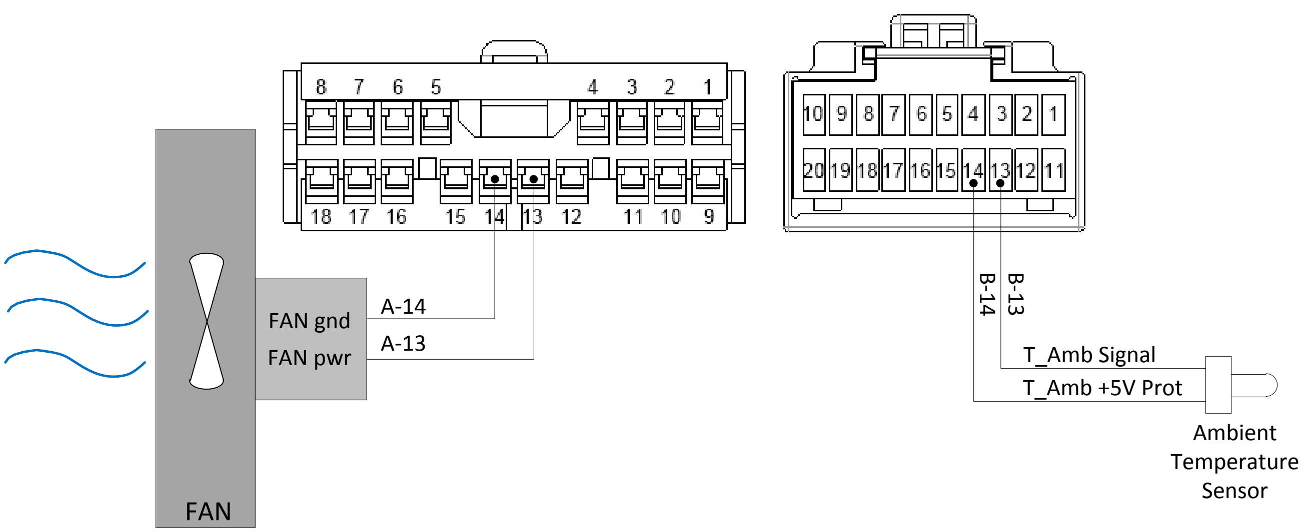
CAN COMMUNICATION

The following diagram shows the wiring for the both external isolated CANs. This includes the second optional CAN.



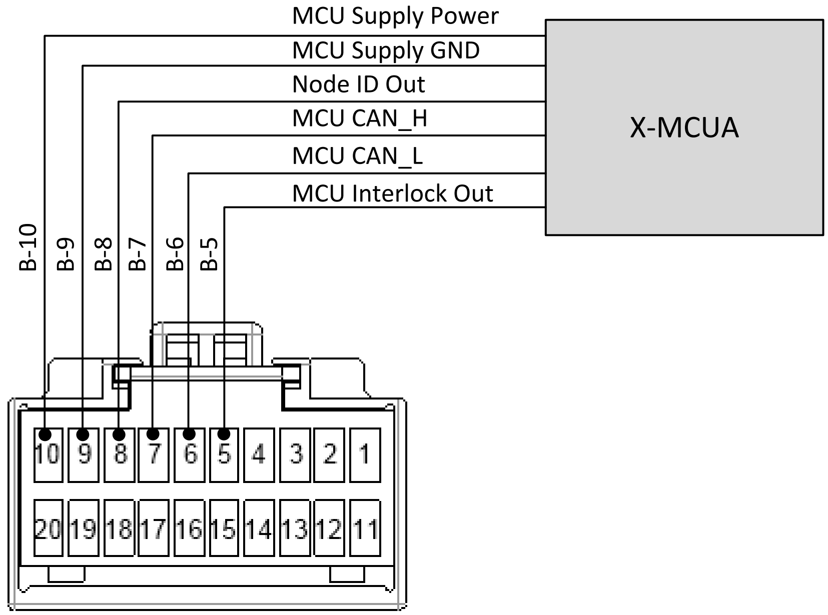
FAN AND AMBIENT TEMPERATURE

The following diagram shows the wiring for the Fan and ambient temperature sensor if they are used.



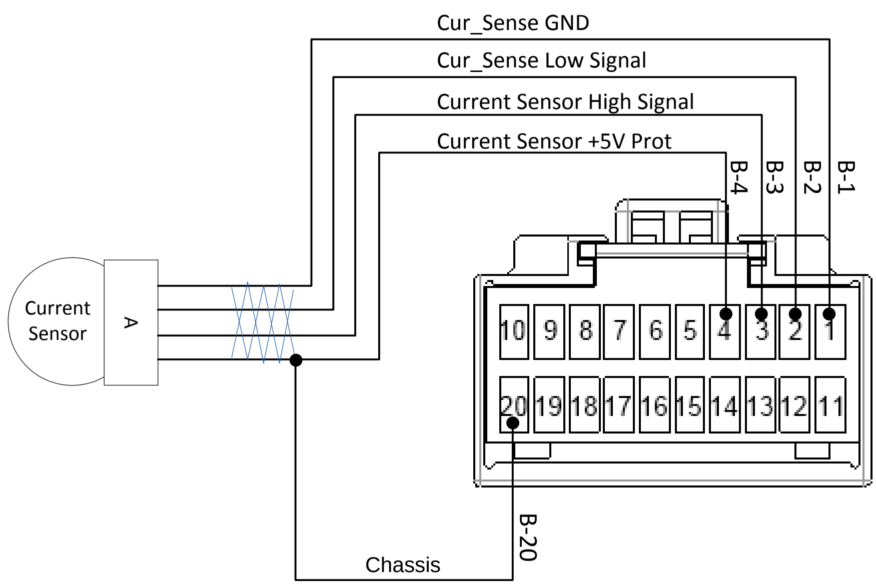
MCU POWER AND COMMUNICATION

The following diagram shows the wiring for the power and communication required to interface with a single or multiple X-MCUs.



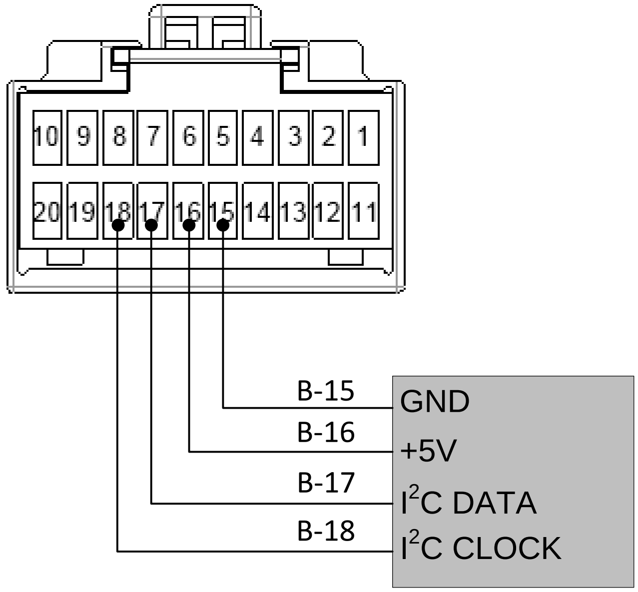
CURRENT SENSOR

The following diagram shows the wiring for the current sensor.



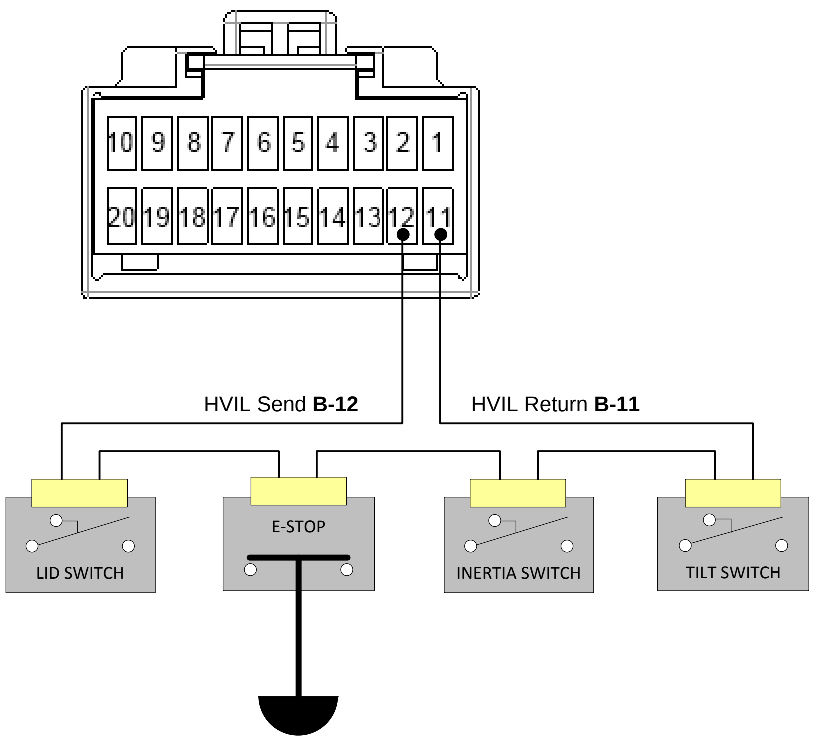
POWER AND COMMUNICATION FOR AUXILIARY BOARDS

The following diagram shows the wiring for power and communication to optional auxiliary boards.



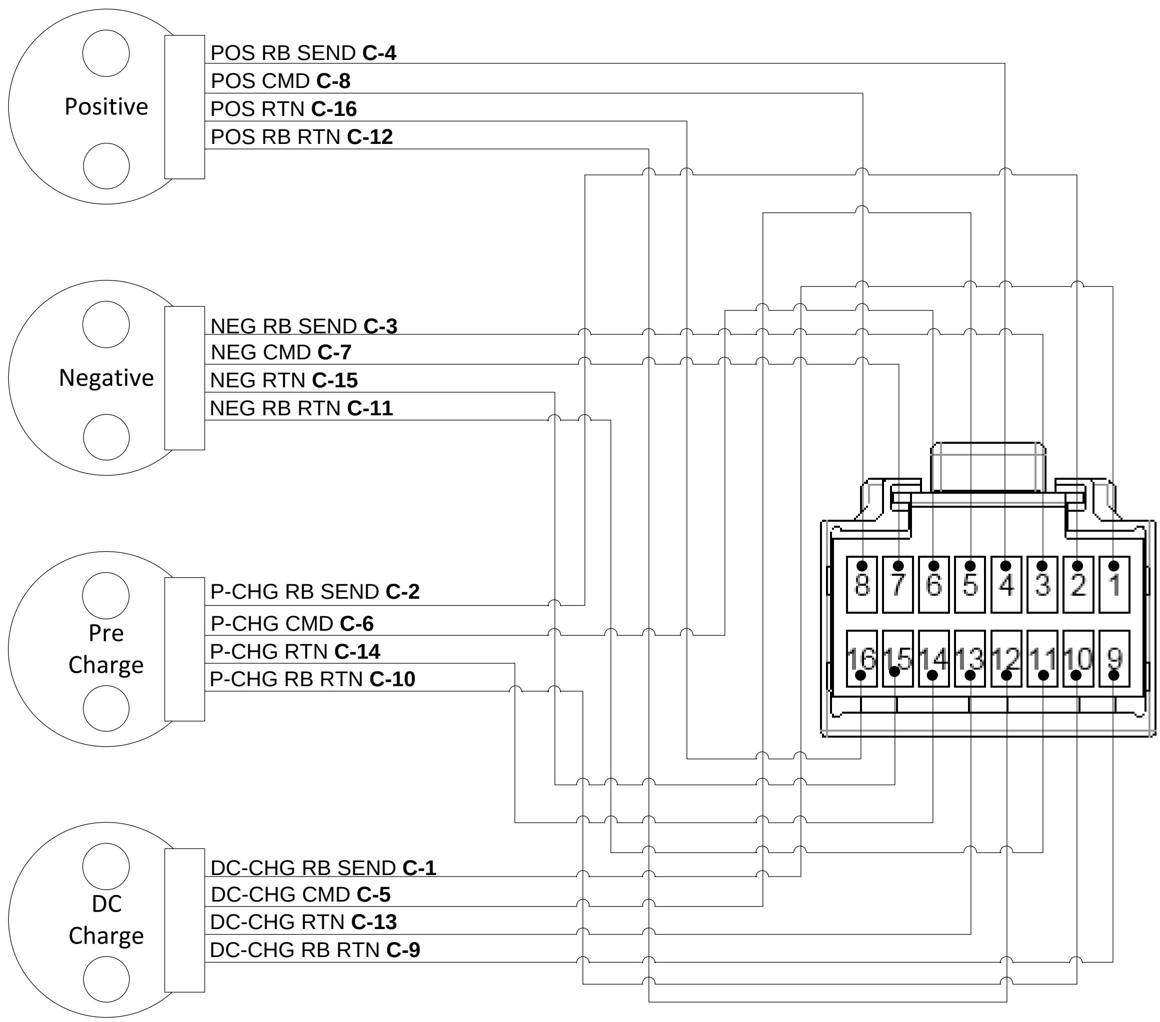
SAFETY DEVICE HARDWARE INTERLOCK (SDHI)

The following diagram shows the wiring for the Safety Device Hardware Interlock being used.



RELAYS

The following diagram shows the wiring for all four relays with optional position feedback.



HIGH VOLTAGE MONITORING AND GROUND FAULT DETECTION (GFD)

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