Section 2

Battery Management System (BMS) and Sensors

This section will describe the function of the Battery Management System Control Module (BMS) and the sensors. The section explains how voltages effect the inputs and outputs of the BMS. The sensors are described, how they operate, and how to replace them. A brief description of other components in the pack is also included in this section.

Contents

General Description

This battery pack is equipped with a computer that provides the operator with state-of-the-art control of the battery pack system. Before we discuss the computers in this application, let's discuss how computers use voltage to send and receive information.

Computers and Voltage Signals

Voltage is electrical pressure. Voltage does not flow through circuits. Instead, voltage causes current. Current does the real work in electrical circuits. It is current, the flow of electrically charged particles, that energizes solenoids, closes relays and illuminates lamps.

Besides causing current flow in circuits, voltage can be used as a signal. Voltage signals can send information by changing levels, changing waveform (shape) or changing the speed at which the signal switches from one level to another. Computers use voltage signals to communicate with one another. The different circuits inside computers also use voltage signals to talk to each other.

There are two kinds of voltage signals, analog and digital. Both of these are used in computer systems. It is important to understand the difference between them and the different ways they are used.

Analog Signals

An analog signal is continuously variable. This means that the signal can be any voltage within a certain range.

An analog signal usually gives information about a condition that changes continuously over a certain range. For example, temperature is usually provided by an analog signal. There are two general types of sensors that produce analog signals, the 3-wire and the 2-wire sensors.

Three-Wire Sensors

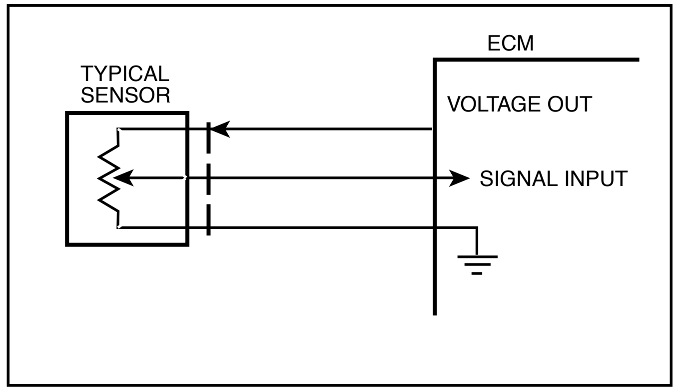

Figure 2-1 - Three-Wire Sensors

Figure 2-1 shows a schematic representation of a 3-wire sensor. All 3-wire sensors have a reference voltage, a ground and a variable "wiper." The lead coming off of the "wiper" will be the signal to the Battery Management System (BMS). As this "wiper" position changes, the signal voltage to the BMS also changes.

Two-Wire Sensors

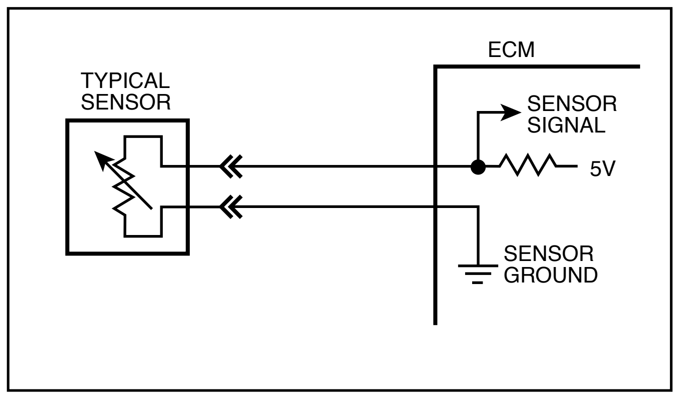

Figure 2-2 - Two-Wire Sensors

Figure 2-2 shows a schematic representation of a 2-wire sensor. This sensor is basically a variable resistor in series with a known-fixed resistor within the BMS. By knowing the values of the input voltage and the voltage drop across the known resistor, the value of the variable resistor can be determined. The variable resistors that are commonly used are called thermistors. A thermistor's resistance varies with temperature. There are several thermistors in each battery pack assembly.

Digital Signals

Digital signals are also variable, but not continuously. They can only be represented by distinct voltages within a range. For example, 1V, 2V or 3V would be allowed, but 1.27V or 2.56V would not. Digital signals are especially useful when the information can only refer to two conditions: “YES” and “NO,” “ON” and “OFF” or “HIGH” and “LOW.” This would be called a digital binary signal. A digital binary signal is limited to two voltage levels. One level is a positive voltage, the other is no voltage (zero volts). As you can see in Figure 2-3, a digital binary signal is a square wave.

The BMS uses digital signals in a code that contains only ones and zeros. The high voltage of the digital signal represents a one (1), and no voltage represents a zero (0). Each “zero” and each “one” is called a bit of information, or just a “bit.” Eight bits together are called a “word.” A word, therefore, contains some combination of eight binary code bits.

Binary code is used inside the BMS and between a computer and any electronic device that understands the code. By stringing together thousands of bits, computers can communicate and store an infinite varietis of information. To a computer that understands binary, 11001011 might mean that it should turn an output device “ON”. Although the BMS uses 8-bit digital codes internally and when talking to another computer, each bit can have a meaning.

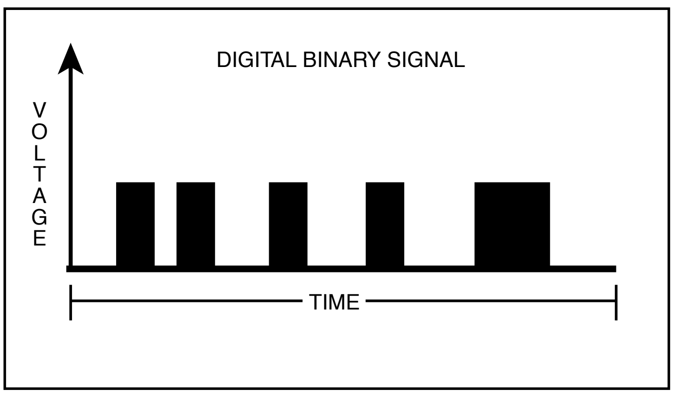

Figure 2-3 - Digital Voltage Signal

Switch Types

Switched inputs (also known as discretes) to the BMS can cause one bit to change, resulting in information being communicated to the BMS. Switched inputs can come in two types: “pull-up” and “pull-down” types. Both types will be discussed.

With a “pull-up” type switch, the BMS will sense a voltage when the switch is CLOSED. With a “pull-down” type switch, the BMS will sense a voltage when the switch is OPEN.

Pulse Counters

For the BMS to determine frequency information from a switched input, the BMS must measure the time between the voltage pulses. As a number of pulses are recorded in a set amount of time, the BMS can calculate the frequency. The meaning of the frequency number can have any number of meanings to the BMS.

Battery Management System (BMS)

The Battery Management System (BMS), is located on a bracket inside the battery pack assembly.

CAN
Controller area network

The data transmission function for the Battery Management System controller is known as CAN or Controller Area Network. CAN communication protocol is available in a number of different formats.

The communication rate for the CAN is 250 kBps and messages are transmitted on a twisted pair of wires.

The communication protocol is a Class C type communications network designed to support real-time closed loop control functions between electronic control devices which may be physically distributed throughout the pack assembly.

The battery pack uses CAN protocol which permits any device to transmit a message on the network when the bus is idle. Every message includes an identifier which defines the message priority, what device sent it, and what data is contained within it. Collisions are avoided due to the arbitration process that occurs while the identifier is transmitted. This, permits high priority messages to get through with low delay times because there is equal access on the network for any device.

Battery Management System CAN communication currently occurs mainly between the display instrumentation device and the contactor, it may include ordinary switching devices for control of accessory devices, and the like.

It constantly looks at the information from various sensors and controls the systems that affect system performance. The BMS also performs the diagnostic function of the system. It can recognize operational problems, alert the user through the MIL (Malfunction Indicator Lamp) and store diagnostic trouble codes which identify the problem areas to aid the technician in making repairs. Refer to General Information section for more information on using the diagnostic function of the BMS.

BMS Function

The BMS may supply 5 volts to power various sensors or switches. This is done through resistances in the BMS which are so high in value that a test light will not light when connected to the circuit. In some cases, even an ordinary shop voltmeter will not give an accurate reading because its resistance is too low. Therefore, a digital voltmeter with at least 10 megohms input impedance is required to ensure accurate voltage readings. There a number of commercially available DVOM's (Digital Volt Ohm Meter) as an example, the Fluke 78/77 multimeter meets this requirement.

The BMS controls output circuits such as the battery charger, and contactors, etc. by controlling the ground or power feed circuit.

Memory

There are three types of memory storage within the ECM. They are ROM, RAM and EEPROM.

ROM

Read Only Memory (ROM) is a permanent memory that is physically soldered to the circuit boards within the BMS. The ROM contains the overall control programs. Once the ROM is programmed, it cannot be changed. The ROM memory is non-erasable, and does not need power to be retained.

RAM

Random Access Memory (RAM) is the microprocessor "scratch pad." The processor can write into, or read from this memory as needed. This memory is erasable and needs a constant supply of voltage to be retained. If the voltage is lost, the memory is lost.

EEPROM

The Electronically Erasable Programmable Read Only Memory (EEPROM) is a permanent memory that is physically soldered within the BMS. The EEPROM contains program and calibration information that the BMS needs to control the charge and discharge operations.

The EEPROM is not replaceable. If the BMS is replaced, the new BMS will need to be programmed by the OEM or service technician with the calibration information that is specific to each application.

These two inputs: state of charge and rate of discharge are the major inputs of the Battery Management System. The remaining sensors and switches provide electrical inputs to the BMS, which are used for modification of the charge and discharge rates

BMS Inputs and Sensor Descriptions

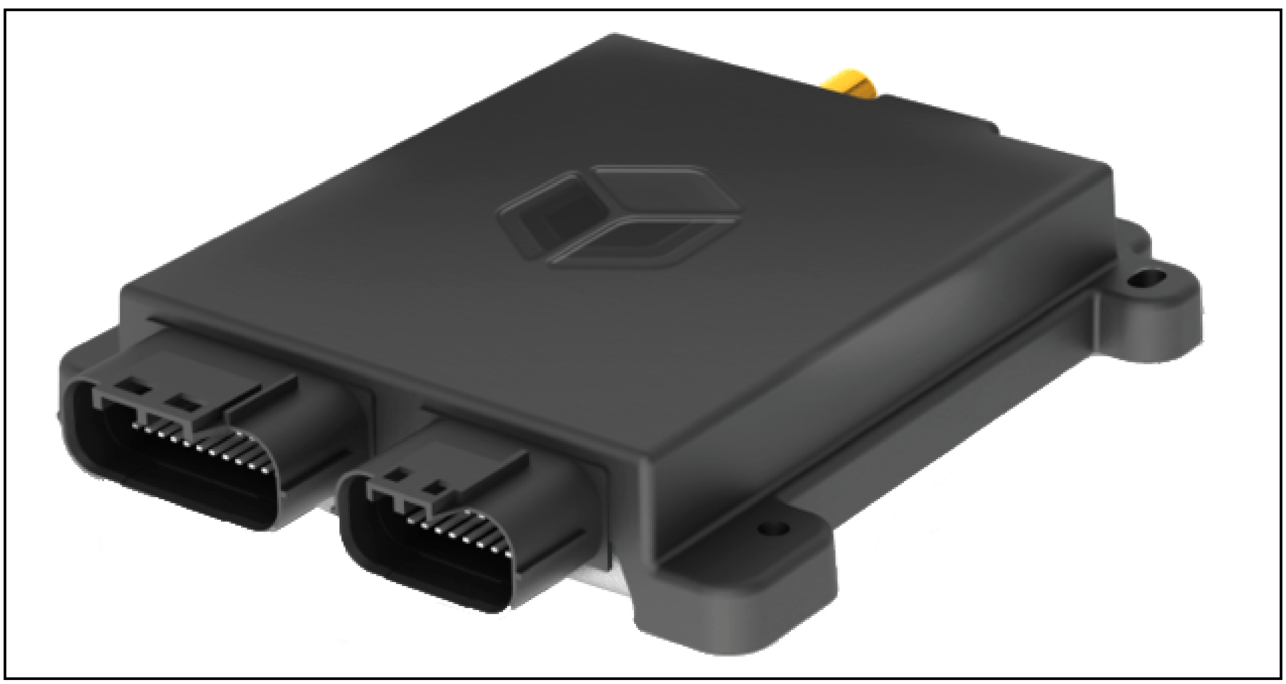

Figure 2-4 - Battery Management System (BMS) Typical. Version: Industrial

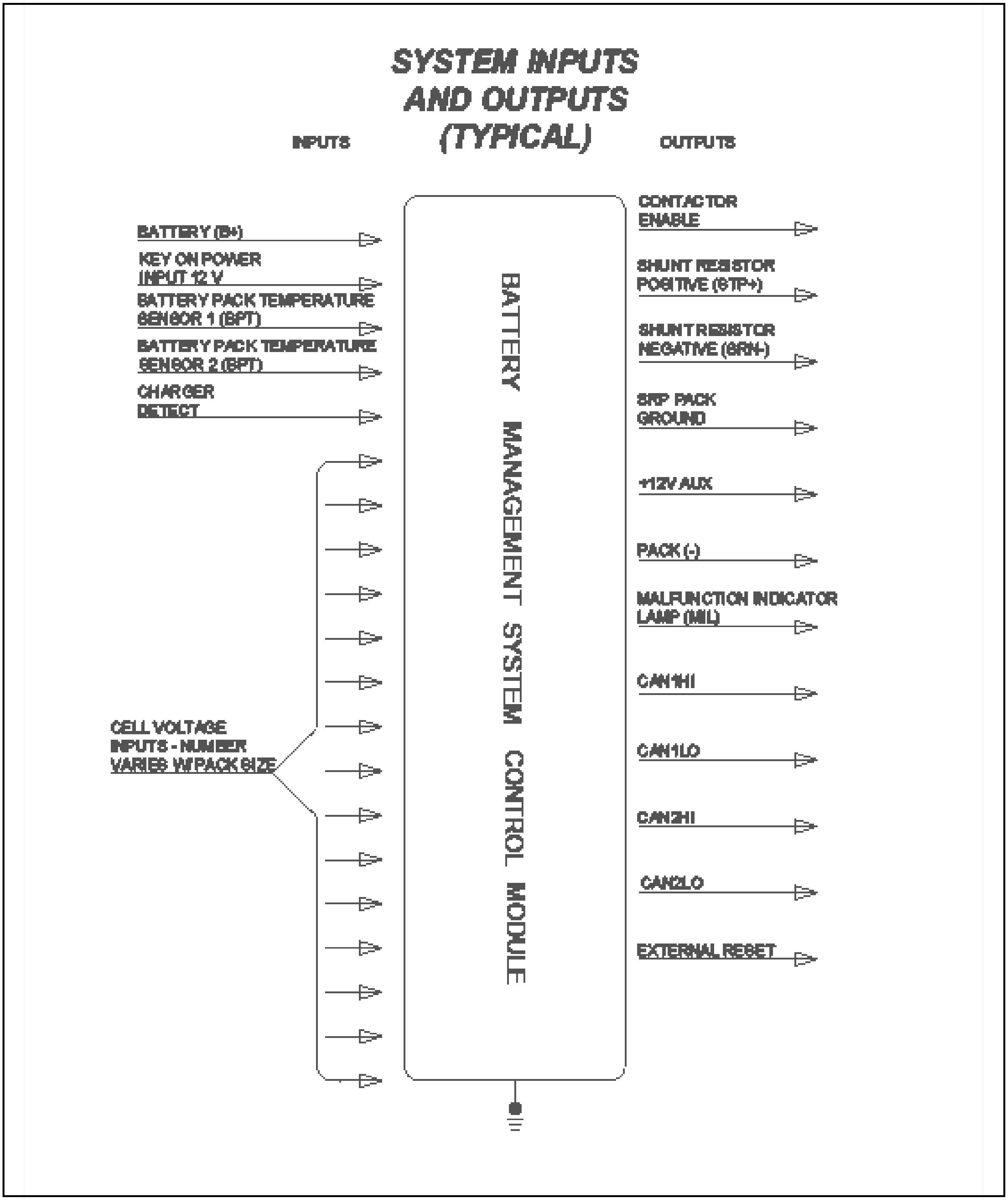

Figure 2-5 - BMS Inputs and Outputs (Typical)

Figure 2-5 lists the data sensors, switches and other inputs used by the BMS to control its various systems. Although we will not cover them all in great detail, there will be a brief description of each.

Diagnosis

Battery Management System (BMS)

To read and clear diagnostic trouble codes, use a scan tool or Diagnostic Trouble Code (DTC) tool.

Important: Use of a scan tool is recommended to clear diagnostic trouble codes from the BMS memory.

Since the BMS can have a failure which may affect more than one circuit, following the diagnostic procedures will determine which circuit has a problem and where it is.

If a diagnostic table indicates that the BMS connections or BMS is the cause of a problem;

and the BMS is replaced, but does not correct the problem, one of the following may be the reason:

- There is a problem with the BMS terminal connections. The diagnostic table will say BMS connections or BMS. The terminals may have to be removed from the connector in order to check them properly. Be sure to use the proper removal tools during the removal process or the terminals may be damaged and adversely effect the BMS ability to control the battery pack.
- EEPROM or the calibration program is not correct for the application. Incorrect components may cause a malfunction and may or may not set a DTC.
- The problem is intermittent. This means that the problem is not present at the time the system is being checked. In this case, refer to the Symptoms portion of the manual and make a careful physical inspection of all portions of the system involved.
- Shorted relay coil or harness. Relays are turned “ON” and “OFF” y the BMS using internal electronic switches called drivers. A shorted relay coil or harness may damage the BMS and may cause the relay to be inoperative.

Battery Pack Temperature (BPT) Sensor

Figure 2-

Notice: Care must be taken when handling the BPT sensor.

Battery Pack Temperature (BPT) Sensor

The battery pack temperature sensor is a thermistor (a resistor which changes value based on temperature) mounted between two cells in various positions in the pack assembly. Low temperature produces a high resistance (100,000 ohms at -40°C/-40°F) while high temperature causes low resistance (70 ohms at 130°C/266°F).

The BMS supplies a 5 volt signal to the BPT sensor through a resistor in the BMS and measures the voltage. The voltage will be high when the cells/pack is cold, and low when the cells/pack is hot. By measuring the voltage, the BMS calculates the cell/pack temperature.

In some instances, if the cell temperatures are outside of normal operating limits, the BMS may shut down the battery pack. A typical over temp value for shut-down may be in the area of 65*C or 149*F. If you suspect a BPT in your battery pack is sending an erroneous reading, you can reference the chart (Figure 2-7) to obtain an approximate reference temperature.

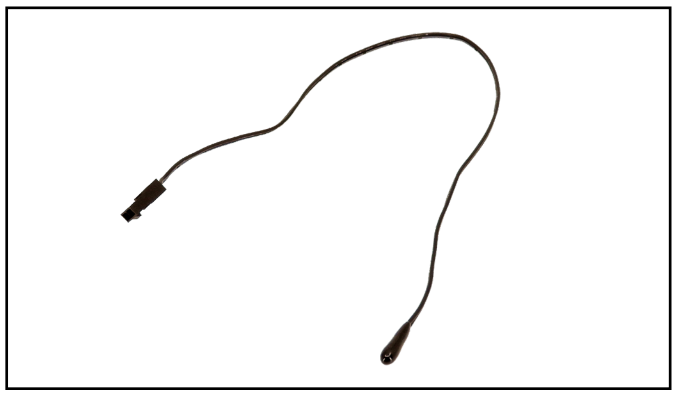

Figure 2-6 - Battery Pack Temperature (BPT) Sensor

˚°F	˚°C	Ohms
Temperature vs Resistance Values (Approximate)		
-35	-37.22	279880
-31	-35.00	242427
-25	-31.67	196227
-19	-28.33	159488
-15	-26.11	139316
-9	-22.78	114165
-5	-20.56	100218
1	-17.22	82670
5	-15.00	72911
11	-11.67	60592
15	-9.44	53647
21	-6.11	44874
25	-3.89	39921
31	-0.56	33599
35	1.67	29996
41	5.00	25395
45	7.22	22770
51	10.56	19376
55	12.78	17437
61	16.11	14925
65	18.33	13478
71	21.67	11590
75	23.89	10501
81	27.22	9078
85	29.44	8251
91	32.78	7163
95	35.00	6530
101	38.33	5697
105	40.56	5207
111	43.89	4561
115	46.11	4182
121	49.44	3679
125	51.67	3380
131	55.00	2985
135	57.22	2751
141	60.56	2438

Figure 2-7

Contactor

The contactor is an electro-mechanical device that serves to connect the battery pack to the device which is being powered by the battery.

It contains a primary side which is controlled by low voltage that is applied from the BMS. When a low voltage signal from the BMS is sent to the contactor, the contactor will energize and connect the battery to the device. So, for example, when the key switch is activated to the on position, the BMS sends the low voltage signal to close the contactor.

Fig. 2-8 Contactor

Shunt

The shunt is a low-resistance connection between two points in the main power circuit that forms an alternative path for a portion of the current. The alternative current path is typically a low current diversion that can easily be monitored by the BMS to equate the current draw on the main circuit.

Fig. 2-9 Shunt

Battery Cell

Each battery pack is constructed from a group of cells. The cells are electrically joined together with buss bars. In our battery packs each cell has a nominal voltage of ~3.3 volts. Cells joined in series have their value added together.

Fig. 2-10 Battery Cell

Key Switch

All of the devices that use battery packs have some type of switching device; either a key switch or a toggle switch like the one shown in figure 2-11. The switch is used to “wake-up” the BMS. The BMS in turn energizes a contactor that allows current to flow from the battery pack to the host device or vehicle.

Fig. 2-11 Key Switch

Buss Bar

The buss bar is a strap component that connects cells. The connected cells make up the actual battery pack. The buss bars are used because they are highly conductive and offer nearly no resistance between the cell packs. They are typically constructed of a metal that will act as an excellent conductor. Most of the buss bars used are made of copper material.

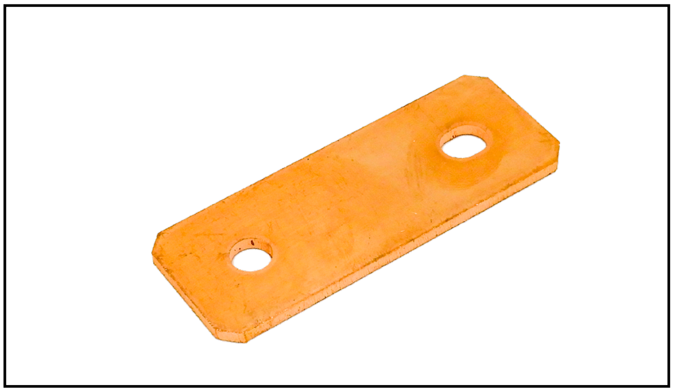

Fig. 2-12 Buss Bar

BDI Display

Most of the devices powered by cell packs have some type of display device. The display is used to alert the device user of the status of the battery pack. Most will have some type of MIL (Malfunction indicator lamp) and some will also display text that can provide alerts or display fault messages.

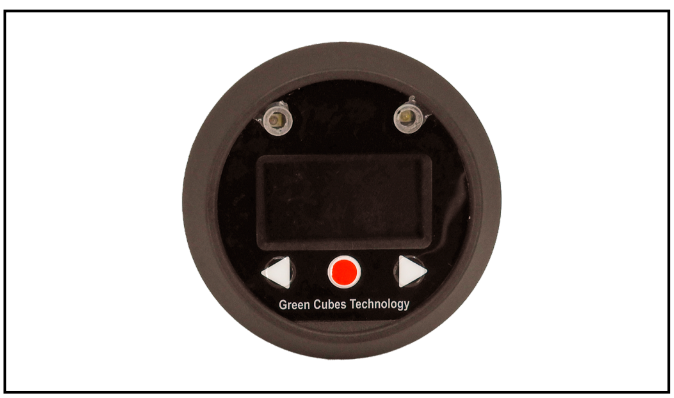

Fig. 2-13 BDI Display

Fuse

All battery packs contain some type of fuse. You will frequently find more than one fuse. The fuses will be of varied types. Smaller fuses are used on the primary side of the circuit such as the wires that interconnect with the BMS. Larger fuses like the one in Figure 2-14 are used to protect the secondary (higher voltage) side of the circuit.

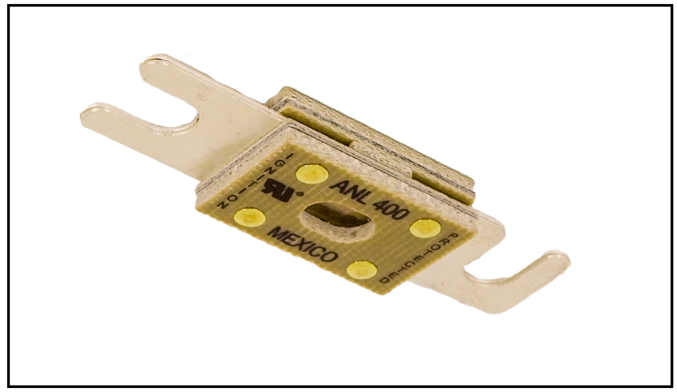

Fig. 2-14 Fuse

Charger

Some smaller battery packs will contain an on-board charger like the one shown in figure 2-15. Larger packs 36 volt and above frequently use a remote charger. Whether the charger is on-board or remote, the charge rate is monitored and controlled by the BMS.

Fig. 2-15 Charger

CAUTION

REMOVE ALL RINGS AND JEWELRY WHEN

WORKING AROUND ELECTRICAL DEVICES.

WEAR PROTECTIVE GLOVES RATED TO

CLASS: 00 OR TO 100V DC

On-Board Service

Battery Management System Module (BMS)

Figure 2-9

Notice: When replacing the BMS, the main power switch must be “OFF” and/or disconnect the battery before disconnecting or reconnecting the BMS connectors to prevent internal damage to the BMS.

Notice: To prevent possible electrostatic discharge damage to the BCS, do not touch the connector pins. The BMS is an electrical component. Do Not soak in any liquid cleaner or solvent, and keep the assembly dry as damage may result.

Remove or Disconnect

1. Switch the main power switch to the off position and /or remove Negative battery cable.
2. “J1” (J100) and “J2” (J101) JAE connectors from BMS.
3. Four BMS mounting screws. The Mounting screws can be removed using a T-25 Torx bit. If the BMS is mounted using a stud and nut, the nuts can be removed using a 7mm or 5/16 socket or nut driver.
4. BMS from mounting bracket.

Important

- Make sure the new BMS has the same part number and service number as the old BMS, to insure proper battery pack performance.

NOTE: Some applications will contain two BMS units a PRIMARY and a SECONDARY (Formerly designated as “master” and “slave”)

- Make sure the new BMS has the correct calibration. Please note: In packs with Primary and Secondary BMS units- the BMS calibration will be different for each BMS.

Install or Connect

1. New BMS to mounting bracket.
2. Four BMS mounting screws/nuts. Torque to 10-14 N•m (88-124 lb..in.).
3. “J1”, (J100) and “J2” (J101) ” JAE connectors to BMS.
4. Negative battery cable (if removed) .

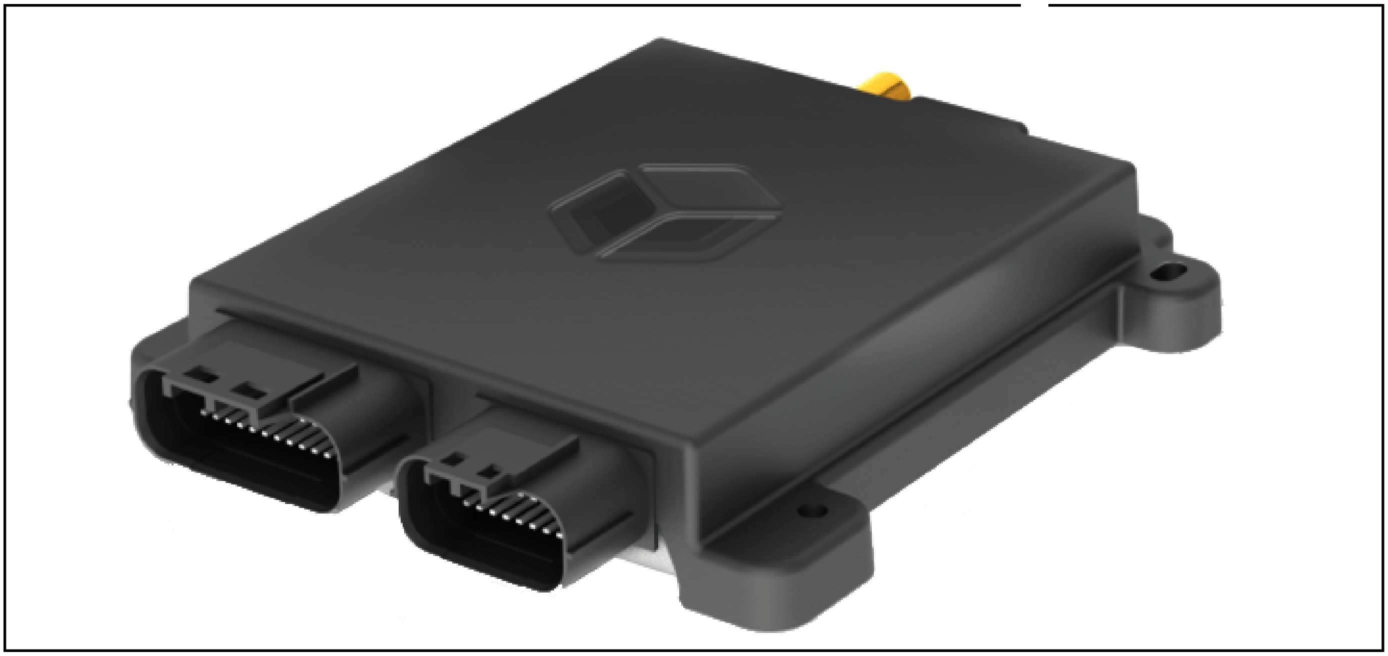

Fig. 2.10 Battery Management System Module (BMS) - Type: Industrial

Fastener Tightening Specifications

Application	N.m	Lb.in
Battery Cell bolts/nuts	8	55-61.5
BMS Mounting Screws M5	3	26.3
Pack enclosure (box) (pack assembly) lid screws	3	26.5
Contactor Mounting Screws M5	3	26.5
Contactor terminal stud nuts	12-13	106-115
Slider bolts (17mm head)	9-11	80-97
Shunt Terminal stud nuts	12-13	106-115

This page left
intentionally
blank