Battery management system

From Wikipedia, the free encyclopedia

A **battery management system** (**BMS**) is any electronic system that manages a rechargeable battery (cell or battery pack), such as by protecting the battery from operating outside its Safe Operating Area, monitoring its state, calculating secondary data, reporting that data, controlling its environment, authenticating it and / or balancing it.[1]

A battery pack built together with a battery management system with an external communication data bus is a smart battery pack. A smart battery pack must be charged by a smart battery charger.

Contents

Functions

Monitor

A BMS may monitor the state of the battery as represented by various items, such as:

- Voltage: total voltage, voltages of individual cells, minimum and maximum cell voltage or voltage of periodic taps
- Temperature: average temperature, coolant intake temperature, coolant output temperature, or temperatures of individual cells
- State of charge (SOC) or depth of discharge (DOD), to indicate the charge level of the battery
- State of health (SOH), a variously-defined measurement of the overall condition of the battery
- Coolant flow: for air or fluid cooled batteries
- Current: current in or out of the battery

Electric Vehicle Systems: Energy Recovery

- The BMS will also control the recharging of the battery by redirecting the recovered energy (i.e.- from regenerative braking) back into the battery pack (typically composed of a few batteries, each composed of a few cells).

Computation

Additionally, a BMS may calculate values based on the above items, such as:

- Maximum charge current as a charge current limit (CCL)
- Maximum discharge current as a discharge current limit (DCL)
- Energy [kWh] delivered since last charge or charge cycle
- Internal impedance of a cell (to determine open circuit voltage)
- Charge [Ah] delivered or stored (sometimes this feature is called Coulomb counter)
- Total energy delivered since first use
- Total operating time since first use
- Total number of cycles

Communication

The central controller of a BMS communicates internally with its cell level hardware, or externally with high level hardware such as laptops or HMI.

High level external communication are simple and use several methods:

- Different types of Serial communications.
- CAN bus communications, commonly used in automotive environments.
- DC-BUS (http://www.yamar.com/sig60.php) - Serial communication over power-line
- Different types of Wireless communications.[2]

Low voltage centralized BMSs mostly do not have any internal communications. They measure cell voltage by resistance divide.

Distributed or modular BMSs must use some low level internal cell-controller (Modular architecture) or controller-controller (Distributed architecture) communication. These types of communications are difficult, especially for high voltage systems. The problem is voltage shift between cells. The first cell ground signal may be hundreds of volts higher than the other cell ground signal. Apart from software protocols, there are two known ways of hardware communication for voltage shifting systems, Optical-isolator and wireless communication. Another restriction for internal communications is the maximum number of cells. For modular architecture most hardware is limited to maximum 255 nodes. For high voltage systems the seeking time of all cells is another restriction, limiting minimum bus speeds and losing some hardware options. Cost of modular systems is important, because it may be comparable to the cell price.[3] Combination of hardware and software restrictions results to be a few options for internal communication:

- Isolated serial communications

- wireless serial communications

Protection

A BMS may protect its battery by preventing it from operating outside its safe operating area, such as:

- Over-current (may be different in charging and discharging modes)
- Over-voltage (during charging)
- Under-voltage (during discharging), especially important for lead–acid and Li-ion cells
- Over-temperature
- Under-temperature
- Over-pressure (NiMH batteries)
- Ground fault or leakage current detection (system monitoring that the high voltage battery is electrically disconnected from any conductive object touchable to use like vehicle body)

The BMS may prevent operation outside the battery's safe operating area by:

- Including an internal switch (such as a relay or solid state device) which is opened if the battery is operated outside its safe operating area
- Requesting the devices to which the battery is connected to reduce or even terminate using the battery.
- Actively controlling the environment, such as through heaters, fans, air conditioning or liquid cooling

## Battery connection to load circuit

A BMS may also feature a precharge system allowing a safe way to connect the battery to different loads and eliminating the excessive inrush currents to load capacitors.

The connection to loads is normally controlled through electromagnetic relays called contactors. The precharge circuit can be either power resistors connected in series with the loads

BMS Main Controller

until the capacitors are charged. Alternatively, a switched mode power supply connected in parallel to loads can be used to charge the voltage of the load circuit up to a level close enough to battery voltage in order to allow closing the contactors between battery and load circuit. A BMS may have a circuit that can check whether a relay is already closed before precharging (due to welding for example) to prevent inrush currents to occur.

Optimization

In order to maximize the battery's capacity, and to prevent localized under-charging or over-charging, the BMS may actively ensure that all the cells that compose the battery are kept at the same voltage or State of Charge, through balancing. The BMS can balance the cells by:

- Wasting energy from the most charged cells by connecting them to a load (such as through passive regulators)
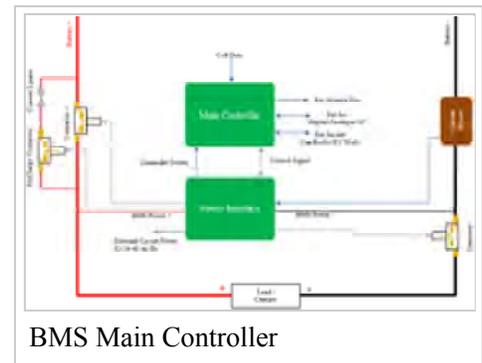
- Shuffling energy from the most charged cells to the least charged cells (balancers)
- Reducing the charging current to a sufficiently low level that will not damage fully charged cells, while less charged cells may continue to charge (does not apply to Lithium chemistry cells)
- Modular charging [4]

Topologies

BMS technology varies in complexity and performance:

- Simple passive regulators achieve balancing across batteries or cells by bypassing charging current when the cell's voltage reaches a certain level. The cell voltage is a poor indicator of the cell's SOC (and for certain Lithium chemistries such as LiFePO4 it is no indicator at all), thus, making cell voltages equal using passive regulators does not balance SOC, which is the goal of a BMS. Therefore, such devices, while certainly beneficial, have severe limitations in their effectiveness.
- Active regulators intelligently turning on and off a load when appropriate, again to achieve balancing. If only the cell voltage is used as a parameter to enable the active regulators, the same constraints noted above for passive regulators apply.
- A complete BMS also reports the state of the battery to a display, and protects the battery.

BMS topologies fall in 3 categories:

- Centralized: a single controller is connected to the battery cells through a multitude of wires
- Distributed: a BMS board is installed at each cell, with just a single communication cable between the battery and a controller
- Modular: a few controllers, each handing a certain number of cells, with communication between the controllers

Centralized BMSs are most economical, least expandable, and are plagued by a multitude of wires. Distributed BMSs are the most expensive, simplest to install, and offer the cleanest assembly. Modular BMSs offer a compromise of the features and problems of the other two topologies.

The requirements for a BMS in mobile applications (such as electric vehicles) and stationary applications (like stand-by UPSs in a server room) are quite different, especially from the space and weight constraint requirements, so the hardware and software implementations must be tailored to the
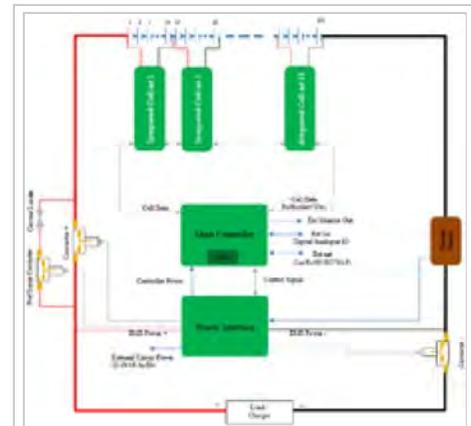
Distributed Battery Management system
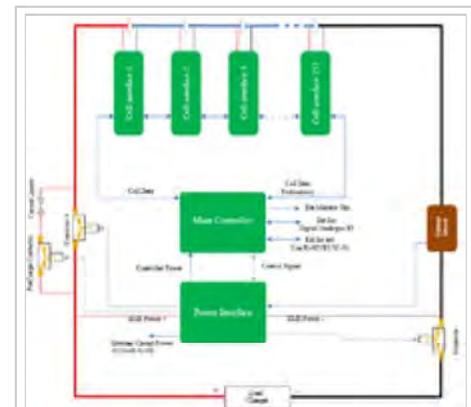
Cable Data transfer module
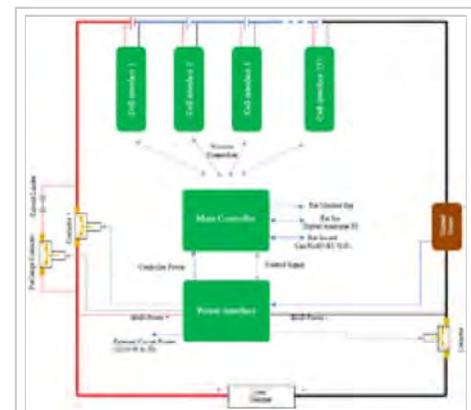
BMS Wireless Communication

specific use. In the case of electric or hybrid vehicles, the BMS is only a subsystem and cannot work as a standalone device. It must communicate with at least a charger (or charging infrastructure), a load, thermal management and emergency shutdown subsystems. Therefore, in a good vehicle design the BMS is tightly integrated with those subsystems. Some small mobile applications (such as medical equipment carts, motorized wheelchairs, scooters, and fork lifts) often have external charging hardware, however the on-board BMS must still have tight design integration with the external charger.

Various Battery balancing methods are in use, some of them based on state of charge theory.

See also

- Battery balancer
- Battery monitoring
- Battery charger

External links

- Electropaedia on Battery Management Systems (http://www.mpoweruk.com/bms.htm)
- NREL Energy Storage Systems Evaluation (http://www.nrel.gov/transportation/energystorage/evaluation.html)
- Modular Approach for Continuous Cell-Level Balancing to Improve Performance of Large Battery Packs (http://www.nrel.gov/docs/fy15osti/61263.pdf), National Renewable Energy Laboratory, September 2014
- A Modular Battery Management System for HEVs (http://www.nrel.gov/vehiclesandfuels/energystorage/pdfs/3a_2002_01_1918.pdf), National Renewable Energy Laboratory, 2002

References

1. *Battery Power Management for Portable Devices*.
2. "Kapper ledninger for å gi lengre rekkevidde til elbiler". *Teknisk Ukeblad*. Retrieved 20 November 2016.
3. "Different Battery Management System Topology".
4. http://www.metricmind.com/audi/14-battery.htm

Retrieved from "https://en.wikipedia.org/w/index.php?title=Battery_management_system&oldid=750534215"

Categories: Energy conversion │ Battery charging │ Embedded operating systems