

## BATTERY MANAGEMENT SYSTEMS: A BRIEF ANALYSIS

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### ABSTRACT

For the automotive engineer the Battery Management System is a component of a much more complex fast acting Energy Management System and must interface with other on board systems such as engine management, climate controls, and communications and safety systems. Importance of BMS, safety measures in battery and communication protocol has been discussed in this paper.

**Key words:** BMS – Battery Management Systems, HV- Hybrid Vehicle, EV- Electric Vehicle

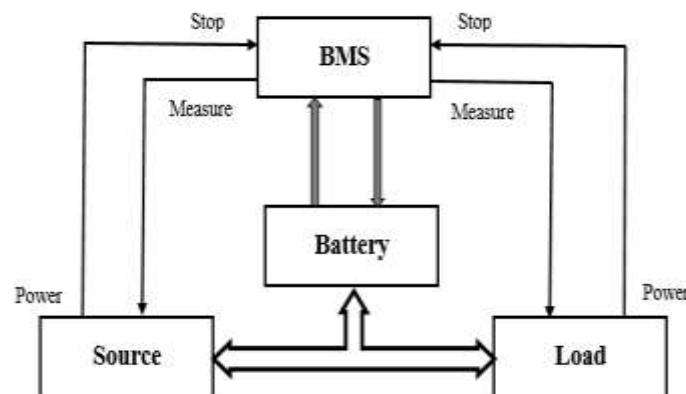
### 1. INTRODUCTION

BMS means different things to different people. To some it is simply Battery Monitoring, keeping a check on the key operational parameters during charging and discharging such as voltages and currents and the battery internal and ambient temperature (1). The monitoring circuits would normally provide inputs to protection devices which would generate alarms or disconnect the battery from the load or charger should any of the parameters become out of limits.

For the power or plant engineer responsible for standby power who's battery is the last line of defence against a power blackout or a telecommunications network outage BMS means Battery Management Systems. Such systems encompass not only the monitoring and protection of the battery but also methods (2) for keeping it ready to deliver full power when called upon and methods for prolonging its life (3). This includes everything from controlling the charging regime to planned maintenance.

### 2. DESIGNING A BMS

In order to control battery performance and safety it is necessary to understand what needs to be controlled and why it needs controlling. This requires an in depth understanding of the fundamental cell chemistries, performance characteristics and battery failure modes particularly Lithium battery failures. The battery cannot simply be treated as a black box.



**Figure-1** Block diagram of Battery Management Systems

The above figure 1 gives the basic building blocks used in a battery management systems. The major blocks are

- Source
- Battery
- Battery Management Systems circuit
- Load
- Transmitting & control signal

There are three main objectives common to all Battery Management Systems as,

- Protect the cells or the battery from damage
- Prolong the life of the battery

- Maintain the battery in a state in which it can fulfil the functional requirements of the application for which it was specified.

To achieve these objectives the BMS may incorporate one or more of the following functions (4-6). (Follow the links to see how these functions are implemented.)

- **Cell Protection** Protecting the battery from out of tolerance operating conditions is fundamental to all BMS applications. In practice the BMS must provide full cell protection to cover almost any eventuality. Operating a battery outside of its specified design limits will inevitably lead to failure of the battery. Apart from the inconvenience, the cost of replacing the battery can be prohibitive. This is particularly true for high voltage and high power automotive batteries which must operate in hostile environments and which at the same time are subject to abuse by the user.
- **Charge control** This is an essential feature of BMS. More batteries are damaged by inappropriate charging than by any other cause.
- **Demand Management** While not directly related to the operation of the battery itself, demand management refers to the application in which the battery is used. Its objective is to minimise the current drain on the battery by designing power saving techniques into the applications circuitry and thus prolong the time between battery charges.
- **SOC Determination** Many applications require a knowledge of the State of Charge (SOC) of the battery or of the individual cells in the battery chain. This may simply be for providing the user with an indication of the capacity left in the battery, or it could be needed in a control circuit to ensure optimum control of the charging process.
- **SOH Determination** The State of Health (SOH) is a measure of a battery's capability to deliver its specified output. This is vital for assessing the readiness of emergency power equipment and is an indicator of whether maintenance actions are needed.
- **Cell Balancing** In multi-cell battery chains small differences between cells due to production tolerances or operating conditions tend to be magnified with each charge / discharge cycle. Weaker cells become overstressed during charging causing them to become even weaker, until they eventually fail causing premature failure of the battery. Cell balancing is a way of compensating for weaker cells by equalising the charge on all the cells in the chain and thus extending battery life.
- **History - (Log Book Function)** Monitoring and storing the battery's history is another possible function of the BMS. This is needed in order to estimate the State of Health of the battery, but also to determine whether it has been subject to abuse. Parameters such as number of cycles, maximum and minimum voltages and temperatures and maximum charging and discharging currents can be recorded for subsequent evaluation. This can be an important tool in assessing warranty claims.
- **Authentication and Identification** The BMS also allows the possibility to record information about the cell such as the manufacturer's type designation and the cell chemistry which can facilitate automatic testing and the batch or serial number and the date of manufacture which enables traceability in case of cell failures.
- **Communications** Most BMS systems incorporate some form of communications between the battery and the charger or test equipment. Some have links to other systems interfacing with the battery for monitoring its condition or its history. Communications interfaces are also needed to allow the user access to the battery for modifying the BMS control parameters or for diagnostics and test

### Intelligent Batteries

The life of rechargeable NiCad and Nickel Metal Hydride batteries such as those used in power tools can be extended by the use of an intelligent charging system which facilitates communications between the battery and the charger. The battery provides information about its specification, its current condition and its usage history which is used by the charger to determine the optimum charging profile or, by the application in which it is used, to control its usage.

The prime objective of the charger/battery combination is to permit the incorporation of a wider range of Protection Circuits which prevent overcharging of, or damage to, the battery and thus extend its life. Charge control can be in either the battery or the charger. The objective of the application/battery combination is to prevent overloads and to conserve the battery. Similar to the charger combination, discharge control can be in either the application or in the battery.

**The functions of a BMS suitable for a hybrid electric vehicle are as follows:**

- Monitoring the conditions of individual cells which make up the battery
- Maintaining all the cells within their operating limits

- Protecting the cells from out of tolerance conditions
- Providing a "Fail Safe" mechanism in case of uncontrolled conditions, loss of communications or abuse
- Isolating the battery in cases of emergency
- Compensating for any imbalances in cell parameters within the battery chain
- Setting the battery operating point to allow regenerative braking charges to be absorbed without overcharging the battery.
- Providing information on the State of Charge (SOC) of the battery. This function is often referred to as the "Fuel Gauge" or "Gas Gauge "
- Providing information on the State of Health (SOH) of the battery. This measurement gives an indication of the condition of a used battery relative to a new battery.
- Providing information for driver displays and alarms
- Predicting the range possible with the remaining charge in the battery (Only EVs require this)
- Accepting and implementing control instructions from related vehicle systems
- Providing the optimum charging algorithm for charging the cells
- Providing pre-charging to allow load impedance testing before switch on and two stage charging to limit inrush currents
- Providing means of access for charging individual cells
- Responding to changes in the vehicle operating mode
- Recording battery usage and abuse. (The frequency, magnitude and duration of out of tolerance conditions) Known as the Log Book function
- Emergency "Limp Home Mode" in case of cell failure.

### 3. CONCLUSION

BMS done correctly, a building automation system will deliver greater energy efficiency, lower operating and maintenance costs, better indoor air quality, greater occupant comfort, and productivity. Maintaining control of large buildings can be a huge challenge. This paper have been discussed elaborately about BMS.

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