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Reivew on Battery Data Online Monitoring System for EV

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Abstract – Battery Management System BMS, for Electric/hybrid electric vehicles is to increase the lifecycle of the batteries. The intelligence in the BMS is included in monitor and control functions. The monitor functions involve the measurement of battery voltage, charger status or load activity. The control functions act on the charging and discharging of the battery on the basis of these measured variables. Implementation of these monitor and control functions should ensure optimum use of the battery and should prevent the risk of any damage being inflicted on the battery. By analyzing battery data a better system can be designed for proper battery charge and discharge.

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INTRODUCTION

Battery management involves in the monitoring of a battery or a set of batteries to work out their state of charge at a point in time. This can then be extended to actually control the rate of charge of a battery or pack or even batteries in a pack on an individual basis. There are different methods in monitoring battery packs. The pack can be monitored as a whole or each battery can be monitored individually. Each method has its own merits. Battery management from a pack point of view is cheap as it requires significantly fewer components and is less complex in terms of communication and calculation. However, it does not offer the ability to show what the state of an individual battery is in the pack. Being able to see the state of individual batteries allows better fault diagnosis and can also be extended to control charge and discharge of individual batteries in the pack. This method does however increase the cost of the system and, due to calculation and communication needs, makes it more complex. Proper charging and discharging of a battery can significantly lengthen its life and also produce more efficient use of the battery. Being able to individually control the charging and discharging of a battery means that the batteries can all be kept in same state of charge (SOC) and more stress is not placed on a weak battery.

A. Objective:

The objective of battery data study is to develop a better battery management system to assure a maximum lifetime of the battery pack and also optimizing the cost, weight, size and reliability of major EV/HEV. In the comparison of components in an EV/HEV, the costliest is the battery pack, which may represent 50 - 60% of the total cost of the propulsion system. The heaviest components of the propulsion system are the batter pack. Hence, an efficient designing is required which impact on the lifecycle of battery packs.

II. BATTERY MANAGEMENT

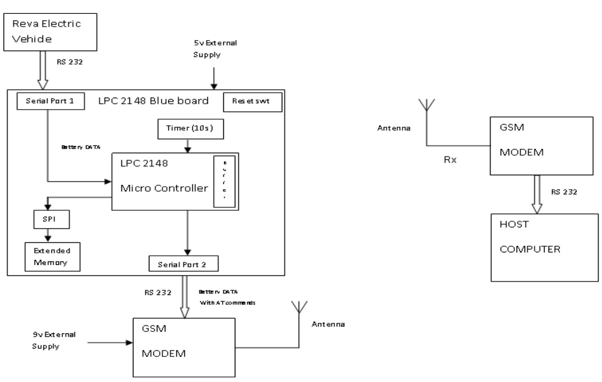

Figure: Data Aquistion system for Electric vehicle

In the Figure provides a block diagram of a typical Data Acquisition system and online data monitoring system.

Data acquisition is the process of sampling signals that measure real world physical conditions and converting the resulting samples into digital numeric values that can be manipulated by a computer. Data acquisition systems (DAS or DAQ) typically convert analog waveforms into digital values for processing.

In Reva EV, this process of measuring voltage, current and temperature is provided by manufacturer of the Car and made these data available in a serial port (RS 232) for external interfaces.

Hence an embedded system has to be designed for data logging. Data in Reva EV are available at every second. The designed system has to log these data at every second in a reserved memory. These availed battery data helps for analyzing the behavior of batteries in EV. Since these data are logged at various situations while EV in propulsion.

Comprising the pack are the battery cells, junction block(s), BMS, thermal management system, wiring and connectors, and the pack housing. (While it is possible for the BMS to be physically located outside of, or even remote from, the pack housing itself, for this paper it is assumed to be located within the boundaries of the pack.) In most applications, the cells are wired in series to develop the necessary high voltage. The primary functions of the battery pack are to store electrical energy produced by the vehicle (during regenerative braking) and to provide electrical energy for use by the vehicle particularly during acceleration or other peak energy demands. The pack needs to do so in a manner that is safe, reliable, and cost efficient. This includes not only minimizing initial purchase costs, protecting the vehicle from voltage surges or drop-outs, and preventing harmful conditions, but also minimizing operational stresses that can shorten the life of the battery cells. These operational stresses include excessive temperature, excessive discharging, and excessive over-charging.

The pack housing provides the physical housing of the pack's components. The cooling system provides the physical capability for the air (or liquid) thermal media circulation. The junction module provides the high voltage connection to the vehicle, as well as the necessary relays and safety interlocks for the pack.

A. 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.

B. BMS Building Blocks:

There are three main objectives common to all Battery Management Systems:

- Protect the cells or the battery from damage.
- Prolong the life of the battery.
- Maintain the battery in a state in which it can fulfill 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:

- **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 :**

Charge control 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 reduce the current drain on the battery by designing an efficient and power saving techniques into the applications circuitry and this prolong the time between battery charges as well as battery discharging.

- **SOC Determination**:

Many applications require knowledge of the State of Charge (SOC) of the battery or the individual cells SOC in the battery chain. This provides the user with an indication of the capacity or amount of charge 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

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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 equalizing 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 (SOH) of the battery. Parameters such as number of cycles of the battery, maximum and minimum voltages, temperatures and maximum charging and discharging currents can be recorded for evaluation. This can be an important tool in assessing warranty claims at battery damages.

- **Authentication and Identification:**

The BMS allows 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 of that battery pack 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.

III. SOC AND SOH

The functions listed above, accurate SOC and SOH estimation are the most critical functions in optimizing the size and weight of a battery pack, as well as protecting the cells and providing a reliable, “transparent” driving experience.

- Accurate SOC estimation allows for optimal and smooth blending of battery power with the internal combustion (IC) engine;

- Maximum charge and discharge power limits based on SOC, temperature and SOH are needed to maximize battery life; and,

- Battery service indicators and diagnostic tools rely on accurate state information.

The BMS must have knowledge of the internal state and parameters of its cells in order to perform many of its functions. However, in most cases, the internal cell states and parameters cannot be directly measured, but must be estimated in some way.

This paper focuses on refinements to an approach for continually and dynamically estimating the state-of charge of battery cells during HEV operation. Much attention is paid to SOC estimation accuracy because of the potential for optimizing battery usage and therefore size, weight, cost and reliability. The reported SOC can be trusted over the operating range and life of the HEV.

The most significant benefit of an accurate SOC estimate is the ability to minimize the number and size of cells needed to provide the range of power and energy required by the propulsion system. HEVs typically operate in an SOC range of 20% to 80%. If the SOC estimate uncertainty is high, several undesirable conditions could arise with the potential for over discharging and overcharging. If the SOC estimate is too optimistic (i.e., it reports an available charge greater than reality), the propulsion system may demand power in excess of the ability of the battery to provide it while remaining above the minimum SOC. Several effects could then result:

- The pack will discharge deeper than expected, and therefore take longer to recharge to a median level. Also, if the vehicle is turned off in this state, the battery may not have the power re-start the engine when required;

- The BMS may detect an over-current condition and abruptly reduce available power to the propulsion system, resulting in a perception of poor drivability dynamics; and,

- In the worst case, battery cell damage may occur if no secondary over-discharge protection is available in the BMS.

These conditions will adversely affect customer perception of vehicle performance and reliability. One solution, in the absence of a better SOC estimate, is to add cells to provide the necessary “headroom” to compensate.

If the SOC estimate is too pessimistic (i.e., it reports an available charge lower than reality), several adverse conditions may arise. During acceleration events, the propulsion system may unnecessarily limit the demand for battery power in favor of the internal combustion (IC) engine, resulting in lower fuel efficiency. Or, during deceleration/regen events, the BMS may "allow" recharge energy in excess of the ability of the battery to accept it while remaining below the maximum SOC. Battery cell damage may result in extreme cases. Again, customer perception will suffer, particularly if fuel economy or performance expectations are not met, or battery cells need premature replacement.

The above conditions pose considerable risks in terms of battery cost and reliability. To the extent the SOCestimate operates in a wide range of uncertainty (error), propulsion system designs will require excess battery cost and weight to ensure satisfactory battery and vehicle performance.

The potential for over-discharging and over-charging actually applies to both electric vehicles (EVs) and HEVs. However, HEVs place an additional burden on the SOC estimation algorithm in that, unlike EVs, many HEVs typically do not have a "plug-in" recharging feature. When connected to an external charger, a reasonably well-designed BMS can "reset" the SOC estimate to a high degree of accuracy. During the subsequent driving period, the SOC estimate may drift, but such drift error would be limited to a few hundred miles of driving until the user again plugs in the vehicle. Moreover, an "intelligent" BMS could use each subsequent manual recharge event to further refine the SOC algorithm and further reduce drift error. In a "plug-free" HEV, the SOC estimator must maintain its expected accuracy for tens of thousand of miles, and provide for operation (and memory) not only during normal operation, but also during vehicle shutdown and start-up (key-on, key-off), and fault conditions.

IV. CONCLUSION

This paper work has demonstrates that when the batteries are charged individually, then all the batteries can be charged fully. Various battery data obtained from these tests will be highly useful in development of battery SoC and life predicting models. The battery performance is improved when all the batteries are charged to the same level. When those batteries are allowed to discharge, they discharge uniformly reaching the threshold voltage almost at the same time. The warning from the battery monitoring helps to prevent the batteries from being over discharged. When there are not much variation between the batteries in the pack, then there is less chance that one battery affecting the others performance. This obviously increases the lifecycle of the batteries.

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