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Electric Vehicle Battery Management System with Charging

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Abstract

The battery quality and durability is most important factor for growing use of electric vehicles. Hence it requires battery management system with charging system to enhance battery performance along with health of battery. Battery management system main functions are to monitor battery state, protection against operating beyond safe operating area, informing and calculating secondary data, controlling and balancing battery environment. Battery management system exchange information with external communication data bus and also be charged by a intelligent battery charger. This paper discuss about electric vehicle fast charging system with battery management system which consist of master controller which communicates with user interface. Master controller manages whole charging system.

Keywords: *battery management system, master controller, Pulse charging, State of charge*

1. Introduction

One of the key reasons for the rapidly growing pollution and fuel consumption is road transportation. Increasing price of energy global warming and health problems are combine indicator of that an appropriate solution is required to switch conventional combustion engine vehicles. It's vital to develop low carbon and oil independent transport solution. This issue will be tackled by improving efficiency of current vehicles, bio fuels and power trains. With the rise of population and development of society more and more vehicles are imminent the road. Total independence on oil and 0 tail pipe emission technology is that the need within the future thanks to increment within the passengers. Battery Electric Vehicles (BEVs) satisfy these two conditions. BEVs care for the easy principle: motor is powered by A battery and eliminate the requirement of combustion Engine Vehicle (ICEV) and fuel tank. BEVs will be plugged sure charging when not in use. Advantages of BEVS are: High efficiency, zero emission, good acceleration and might be charged any time with low cost power. If voltage is produced by renewable energy sources BEVs can operate with clean energy and good for local air quality. Challenges for BEVs are: Long battery charging, expansive storage of electricity and limited range of vehicles. Adequate charging spot infrastructure must be in situ before penetration. Impact of BEVs on power grid grid is damaging. Another confront for BEVs is social acceptance. The high cost of BEVs could be a barrier and will not be overcome by the low operating cost[1,2,3]. The range of BEVs is less than conventional vehicle and creates anxiety in users that they'll not be ready to complete their journey.

2. Battery Management System

2.1. Check and observe function by BMS as follows:

- Current out and in of the cell or battery pack
- Individual cells voltage and total voltage, highest and lowest cell voltage
- Coolant in and out and battery pack temperature
- Battery state of charge and state of health to indicate charge and health level

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- State of power (SOP) i.e the amount of power available for a time interval defined safety state
  - Safety state

2.2. Communication

- The controller of BMS internally connected to the hardware operating at cell level and externally connected to the high level hardware for e.g laptop
- Simple and multiple methods are used for high level external communication for example CAN bus communication, DC-Bus for serial communications, different types of Wireless communication.

Centralized BMSs measures low level cell voltage by resistance divide though they do not have any internal communication.

Modular BMSs must utilize low level internal cell-controller or controller-controller that's distributed architecture communication except for high voltage system it's difficult thanks to voltage shift between cells. The first cell ground signal very large in amount than other cell ground. Optical isolator and wireless communication are two types of hardware communication. Also maximum number of cell is limitation for internal communication. Maximum 255 nodes is limited for modular hardware architecture. Seeking time of all cells, limiting minimum bus speed and losing some hardware options are another restriction for top voltage systems. Cost of modular systems is vital, because it's going to be such as the cell price. Combination of hardware and software restrictions results to be some options for internal communication: wireless serial communications and isolated serial communications.

2.3. Protection:

A BMS restricting battery from operating beyond its safe operating area such as:

- Over-current during charging and discharging modes
- Over-voltage condition during battery charging
- Under-voltage during battery discharging
- Under-temperature
- Over-temperature
- Over-pressure
- Ground fault current detection

The BMS may restrict operation beyond the battery's safe operating area as follows:

- Controlling the environment for example air conditioning and liquid cooling, through heaters, fans etc
- if the battery is operated beyond its safe operating area then added internal switch for example solid state device or relay get opened
- Communicate with the devices to which the battery is connected to scale back or maybe terminate using the battery.

2.4. SOC Estimation:

SoC estimation for the battery packs is one amongst the foremost important issues in EVs applications. Precise SoC estimation can avoid unpredicted system interruption and forestall the batteries from being over-charged and over-discharged. it's well-known that the terminal voltage and also the internal resistance of battery are two parameters which will easily be obtained and thus are convenient for SoC estimation. However, these two parameters not only change irregularly with the depth-of-discharge, the charging/discharging rate and also the ambient temperature, but also depend highly on the SoH of the batteries. The complex interrelationship of those factors causes the difficulties within the pursuit of an explicit SoC estimation [4,10]. To

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define the SoC, consider a very charged battery at time t0. With Ib(t) the discharging current, the charge delivered by the battery at time t is t0. With Q0, denoting the whole charge the battery can deliver (hold), the SoC of the battery is defined as follows [4]

$$S(t)=\frac{Q_0-\int I_b(\tau)d\tau}{Q_0}$$

Typically, it's desired that the SoC of the battery be kept within appropriate limits. it's then essential to be able to estimate the SoC of the battery so on maintain it within safe operating limits. Estimating the SoC is complicated because that the SoC depends on many factors like temperature, battery capacitance and internal resistance.

3. Charging System with BMS

Charging system in electric vehicle is connected through charging connector. Battery management system, user interface and connector for safety all are communicate with master controller for effective charging. Hence whole charging system is managed by master controller. Master controller examines all connection of charging connector and receives the charging converter modules and states of BMS.

After all charging arrangements are completed, MC transfers charging command from BMS to charging converter modules [13].

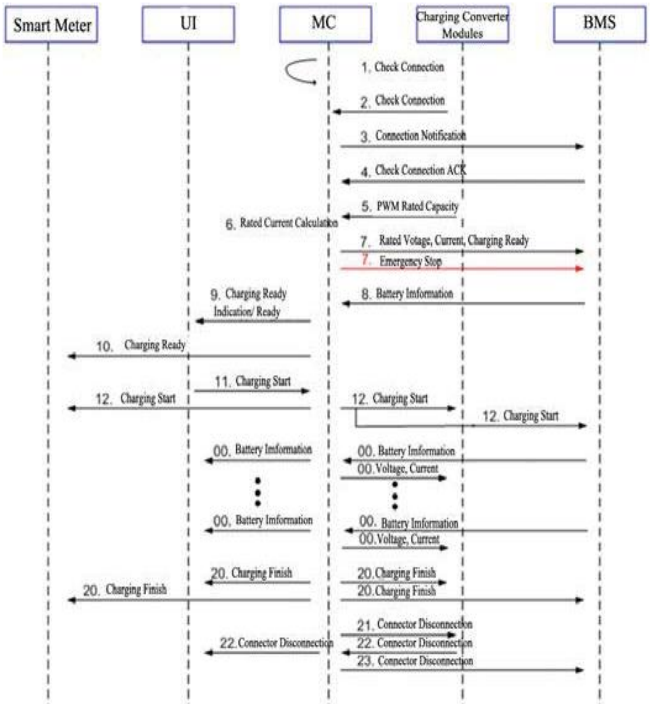

Figure 1. Charging Process

3.1. Lithium Battery Charging

Conventionally, constant current-constant voltage (CC-CV) charging is that the most generally spread method in Li-ion battery chargers. From the first age of discovery of Li-ion battery, researchers have done comprehensive studies on charging strategies like Constant Tickle Current (CTC) strategy Constant Current Strategy (CC) before modern CC and CV strategy and people strategies were incorporated inadequate charging performances. Multi-Stage Constant Current Voltage (MCC-CV) will be found as another widely spread fast charge method. Pulse charging of Li-ion battery is proven empirically and experimentally as a promising charging technology, which offers fast and efficient charge performance. Among other different flavors of charging techniques, pulse charging provides bunch of additional advantages like longer

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battery era, maximal battery material utilization, low heating, and low degradation of battery material. Batteries charged with fast chargers, which uses high currents are deteriorated because of the dendritic deposition on electrode surfaces. Among different practices, scrutinizing the corresponding electrochemical impedance equivalent circuit may be a great way of understanding chemical behavioral of Li-ion cell. The resultant impedance of the battery Zbat are often considered as a measure of momentous electrochemical condition. Zbat could be a function of the frequency of applied pulse. so as lower the battery impedance, the heart beat frequency should be adjusted accordingly to the varying battery conditions. Lithium ion production, at the cathode in charging mode, which is proportional to the present density (io) must be regulated so as to get the most charging performance consistent with the work done by Chen within the charge performance will be intensified by maximizing the charging factor as shown in Eq.1. Since, doesn't linearly relate with duty, an optimal duty should exist, which offers both maximum charge speed and efficiency. Furthermore, Eq.1 has been modified to Eq.2 sure easy tracking the foremost suitable duty for a selected moment during charging process. Basically, duty is modified so as to manage exchange current density. the simplest duty, which supplies the utmost charging factor is tracked by applying sequence of pulses with different duties for tiny low time at fixed frequency as shown in Eq.3. Moreover, the charging factor can further be improved by changing the frequency for fixed duty as shown in Eq.4.

$$\eta = D.i_0 \tag{1}$$

$$\eta_{Dk} = \frac{i_{b,k}}{D_k} \tag{2}$$

$$D_{best} = \left(D_k \middle| MAX\,(\eta_{Dk}, k = 1,2,3,....K\right) \tag{3}$$

Where, η_{Dk} is pulse charge factor for Duty Dk (Dk =50 + k, k = 5,10,15,….45)

$$f_{best} = (f_n \mid MAX\,(i_{b,n}\ , n = 1,2,3….N) \tag{4}$$

Where, f1,f2,f3….fN are testing frequencies while duty is held at the optimal, obtained according to Eq.3, ib,n is the corresponding average current for fn .Number of pulse charging strategies have been proposed and most of the them are design to track the optimum pulse duty and frequency this study is a further algorithmic improvement of works done in.

4. Conclusion

Electric vehicles for road transport is inevitable for the security of climate and energy as illustrated by their important role despite the fact that there are some challenges which must have to be overcome. Hence it is clear that the future demand for the road transport will be composed of different propulsion technologies. BEVs will most likely comfortable for urban in small to medium size vehicles, while hybrid vehicles and fuel cell vehicles appear to be more acceptable for longer ranged and larger vehicles. Battery management systems can be comprises using a diversity of functional blocks and design techniques. After consideration of goals of battery requirements and battery life it is necessary to select the right architecture, functional blocks and related ICs to design battery management system and charging scheme to optimize battery life.

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