BATTERY MANAGEMENT SYSTEM IN ELECTRIC VEHICLE

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Abstract - *The Battery is a fundamental component of electric vehicle, which represent a step forward towards sustainable mobility. The Battery Management System (BMS) is a critical component of electric and hybrid electric vehicles. The purpose of the BMS is to give safe and reliable battery operation. To maintain safety of battery, state monitoring and evaluation, charge control, and cell balancing are functionalities that have been implemented in BMS. As an electrochemical product, battery acts differently under different operational and environmental conditions. Due to the uncertainty of a battery's performance, it is challenge to implementation of these functions. State evaluation of a battery, including state of charge, state of health, and state of life, is critical task for a BMS. Through reviewing latest methodologies for the state evaluation of batteries, the future challenges for BMSs are presented.*

Key Words: Battery Management System, Lithium - ion Battery, Battery Monitoring And Management, State Of Charge, State Of Health, State Of Life, Electric Vehicles

1. INTRODUCTION

From portable electronics to electric vehicles (EVs), batteries are widely used as main energy source in various applications. Today, since EVs can reduce gasoline consumption up to 75% , EV batteries have gained renewed attention in the vehicle market. To enlarge the market share of EVs , safety and reliability are the top concerns of users. However, both of them subject to not only the battery technology but also the management system for the battery. Therefore, a battery management system (BMS), as the connector between the battery and the vehicle, plays a vital role in improving battery performance and optimizing vehicle operation in a safe and reliable manner. In view of the rapid growth of the EV market, it is urgent to develop a comprehensive as well as mature BMS. Like the engine management system in a gasoline car, a gauge meter should be provided by the BMS in EVs . BMS indicators shows the state of the safety, usage, performance, and longevity of the battery. If overcharged, due to volatility, flammability and entropy changes, a lithium-ion battery could ignite. This is a serious problem, especially in EV applications, because an explosion could cause a fatal accident. Over-discharge tends to reduced cell capacity due to irreversible chemical reactions. Therefore, BMS needs to monitor and control the battery based on the safety circuitry. Whenever any abnormal conditions, such as over-voltage or overheating, are detected, the BMS should notification to user and execute correction procedure. BMS also checks the system temperature to provide a better power consumption scheme, and communicates with individual components and operators [2].

2. BATTERIES USED IN ELECTRIC VEHICLES

Batteries used for electric vehicles are characterised by their relatively high power - to - weight ratio, specific energy and energy density. Use of smaller, lighter batteries reduce the weight of vehicles and improve its performance. The commonly used battery type in modern electric cars are lithium - ion and Lithium polymer battery , because of their high energy density to their weight. Lithium-ion batteries are widely used in electric vehicles (EVs) due to their high discharge volt, and high energy/power density. However, lithium - ion batteries must be strictly kept within temperature range to have an appropriate perfomance. Overheating will severely undercut among others , their power and life cycle . It has been found that the lifespan for a lithium - ion cell is reduced by approximately two months for every degree of temperature rise, while operating in a temperature range of 30 - 40 ºC [4].

3. PROPOSED BATTERY MANAGEMENT SYSTEM

The weaknesses of current BMSs are identified through a comprehensive review of the existing approaches. To tackle these weaknesses, we suggest that a comprehensive and mature BMS contain the components shown in Figure as basic functions.

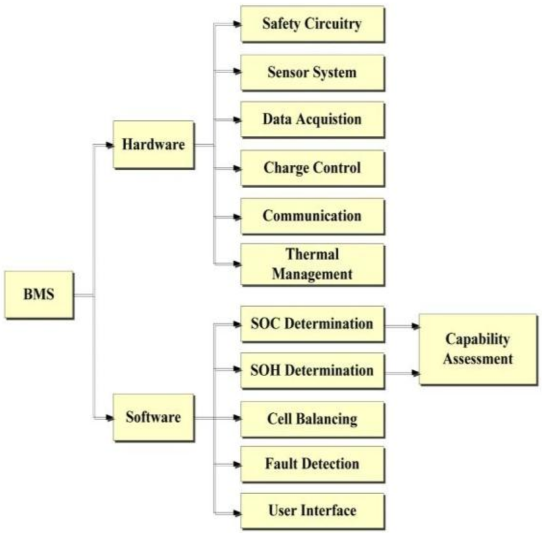

Fig -1: Components of BMS

3.1 HARDWARE

Security circuitry has long been used in BMS. As more sensors are used in the proposed BMS, improvements can be applied to current safety circuitry designs, such as the addition of precise alarms and controls to prevent overcharges, over-discharges, and overheating. The sensor system consists of various sensors to monitor and measure battery parameters, including cell voltage, battery temperature, and battery current. Some researchers have proposed the adoption of EIS to monitor internal impedance. However, both the lack of space and the cost of the device hinder the feasibility of these measurements outside the laboratory environment. Thus, current voltage, and temperature must be measured to improve state tracking capability in real-life applications. BMS has important parts for software to analyze and build databases for data acquisition (DAQ) and data storage system modeling. Charge control is the subsystem that controls the discharge protocol. Batteries are often charged by the constant current / constant voltage method (CC / CV) and thus will need to include a potentiostat and a galvanostat. A variable inhibitor may be required to help balance cells or perform internal resistance measurements. Cell balancing control is still an important design feature with room for improvement to equalize the battery pack and estimate the battery condition in an efficient way.

Most sub-systems in BMS are stand-alone modules, and therefore, data transfer is required throughout the BMS. Communication via the CAN bus is a major way of transferring data within the BMS. With the development of smart batteries, there may be more data collected to communicate with the user and charger via microchips included within the battery. In addition, wireless and telecommunications technologies are gradually being incorporated into charging systems that facilitate communication between batteries and chargers. A module is important for thermal management because temperature differences have an effect on cell imbalance, reliability, and performance. Thus, it has been reported that it is important to minimize the temperature difference between cells, which must be monitored and operated under appropriate temperature conditions [2].

3.2 SOFTWARE

BMS's software is the center of the entire system because it controls all hardware operations and analyzes of sensor data to make decisions and assess the state. Switch control, sampling rate monitoring, cell balance control, and even dynamic protection circuit design in the sensor system must be controlled by the software of BMS. In addition, online data processing and analysis is required to continuously update and control battery functions. Reliable and robust automated data analysis is an important factor of success because the analysis assesses the state and detects the fault. This information will be shown to the user through a user friendly interface with appropriate suggestions. Specific functions of BMS software are discussed below. The determination of SOC and SOH will be integrated into a capacity assessment, which also presents the battery life state and sets operating limits according to state-of-the-art algorithms, such as fuzzy logic, neural networks, and so on. Based model, and so on. The purpose of cell balancing is to maximize the performance of the battery without overcharging or over-discharging. Its nature is to make SOC levels close to each other. The controller will control the charging process based on a comprehensive strategy that depends on the SOC of each cell. Thus, accurate SOC estimation of each cell is basic to improve equilibrium.

Most soft faults defects will be discovered through online data processing. An intelligent data analysis is required to warn of a battery fault and indicate a state of out-of-tolerance. Historical data will be recorded and provide pre-alarm status before possible faults. The user interface should display the required information of BMS to the users. The remaining range should be indicated on the dashboard according to the battery's SOC. Additionally, unusual hazardous and replacement suggestions are required to inform users in terms of battery estimation and prediction [2].

4. PROGRAM STRUCTURE OF BMS

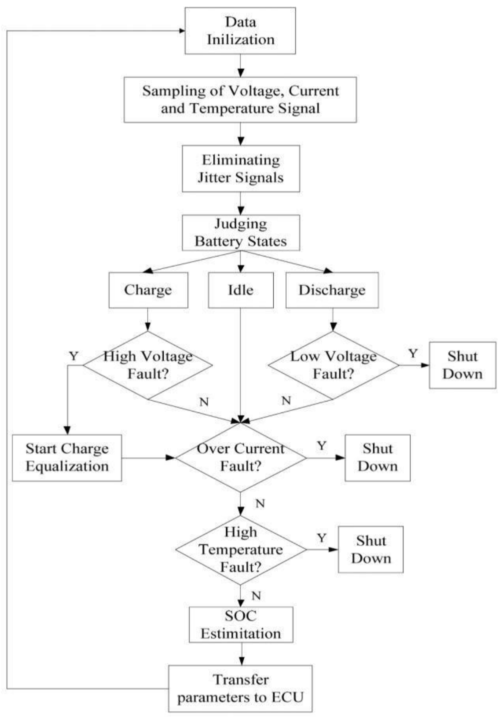

Fig -2: Software Flow Pattern of BMS

The BMS designed in this article is programmed in C, and the flow chart is shown in Figure . Hardware interface program is generated automatically by the expert system of the software "Code Warrior". In the program of MCU, the functions of reading voltage, current and temperature signals, anti-jitter of the current signal, the protection of over-charge/over-discharge, over current, high/low temperature, charge equalization and SOC estimation is implemented. The method of anti-jitter of the current signal is selecting the signals which is out of the range of the threshold set beforehand, eliminating it and computing the signal in that moment by smoothing the signals a moment before. We apply the method in reference in charge equalization. If one of the faults of low voltage, over current and high temperature happens, the MCU would shut down the whole circuit to avoid permanent damages of the battery stack or even explosion events. SOC estimation is one of the most difficult parts of BMS design, and we will introduce it in next section in detail. Once the BMS starts to work, it recycles the program in Figure 2 until abnormal conditions occurred.MCU would shut down the whole circuit to protect the battery stack [3].

5. REQUIREMENTS AND STANDARD FOR BATTERY MONITORING AND MANAGEMENT

Battery management is mandatory for Li-ion batteries to ensure energy availability, lifespan, and safety of the energy storage system. Battery current, voltage, and temperature over time are key inputs of the electronic battery management system. It is in charge of battery safety and state-in-charge (SOC), state-health (SOH) and state-of-the-work (SOF) assessments. Additional functions are controlling the heating / cooling subsystem and main power switch, ensuring high voltage separation from the vehicle, implementing isolated communication with the in-vehicle network. From an electronic point of view, the challenges are the accurate and synchronous measurement of the voltage of battery current and pack cells, along with data communication over many types of voltage domains and meeting ASIL-C security requirements. Typical accuracy targets are 0.5–1% for currents up to 450 A and 1–2 mV, respectively, and 0.1% for voltages at the cell and pack levels. This strict demand for voltage accuracy is mainly driven by LiFePO4 chemicals. It is one of the preferred technology for automotive applications, as it has a good agreement between energy density, cost, safety properties, lifetime, and cycle resistance. A very flat feature for open circuit voltage vs. state charge stands for this battery technology. This makes precise positioning of charge very difficult by voltage measurements, especially in the 20% to 80% state-charge range. Other automotive Li-ion chemistry, such as Li-Titanate (which has better cycle resistance, faster charge properties but lower energy density) or Li-Mangan, is less demanding in terms of voltage measurement accuracy than LiFePO4 cells. From the point of view of the semiconductor component, it is necessary to design for integrated error compensation techniques and according to the ISO26262 design flow. In addition, accurate estimation of product parameters requires high-precision production testing equipment and extensive product qualification [5].

6. BATTERY INTEGRATION IN ELECTRIC VEHICLES

The way a battery system is integrated into an electric vehicle depends on many different aspects. Therefore, a rule applicable to all possible integration cases cannot be called. Instead, an example will be given to show the most relevant aspects. The example is taken from the experience gained in the E3Car project. The battery system uses 96 series connected Li-ion cells with a 50 Ah capacity to reach the required voltage level up to 400 V. The cells are divided into modules of four cells. The battery pack consists of 24 modules, each of which includes an electronic circuit for monitoring and balancing cells, which is designed according to the requirements. In addition to the battery module with a module management unit, the battery system includes a pack management unit. Its role is to obtain data from module management units and current sensors, calculating battery parameters, such as charge conditions, state-of-health and work conditions, communicating with vehicle control systems, operating power switches, and controlling batteries Cooling and heating subsystem. Battery module management units and pack management units can communicate through a CAN bus. As MMUs are monitoring voltages at levels up to about 400 V, it is necessary to provide galvanic isolation of the communication lines and the power supply of the monitoring circuit from the rest of the vehicle. Gives a more detailed overview of the battery monitoring module and its monitoring circuit. The core of the monitoring circuit is the battery monitoring IC. In this case the newly developed AS8505 was used by Micro Systems of Austria. It is the first IC to feature an integrated active cell balance method, described as a module-to-cell method. This monitoring IC communicates directly with the SPI bus and various digital I / O lines with a microcontroller. The role of the microcontroller is to enable communication between the IC and the PMU through the CAN bus, controlling cell data acquisition, and monitoring the balancing process. Therefore, it is sufficient to use an 8-bit microcontroller, an ATMEL AT90CAN128 in this case [5].

7. POSSIBLE SOLUTIONS FOR BMS

Progostics and Health Management (PHM) is an enabling strategy for BMS, consisting of techniques and methodologies. By monitoring sensor signals and processing real-time data from a BMS, battery positions including SOC, SOH and SOL can be estimated and to provide the end user with an accurate "gauge meter" in an EV . Can be estimated. Based on the data collected, the BMS determines the corresponding maintenance strategies. In the meantime, signals for detection of an abnormality can be used to update forecast results and to guarantee the safety and reliability of batteries. Inaccessible internal responses of the battery and varying external loads, in terms of precise battery.

Modeling should be established that takes into account the factors imposed. The regression technology combined with the state-space model has been proposed as a competitive approach for battery degradation modeling. Regression approaches use data training to reduce the trend of degradation based on specific battery materials. Once the Markov process uses the fitted parameters as its initial information, empirical degradation characteristics can be combined with real-time state information to obtain accurate prediction results. Our approach is to measure and collect current, voltage and temperature as the main operating parameters to improve feasibility and reduce design costs [2].

8. CONCLUSION

Since batteries are the main power source in EVs, their performance greatly affects EVs' power. Therefore, manufacturers are seeking breakthroughs in both battery technology and BMS. Chemical reactions in batteries are subject to operating conditions, and therefore, battery degradation may vary in different environments. Developing a comprehensive and mature BMS is important for manufacturers who want to increase the market share of their products. The major concerns of BMS were discussed in this report. They include battery state evaluation, modeling, and cell balancing, in which methods for the evaluation of battery state were seen as important issues. Thus, the corresponding functions on SOC, SOH and SOL batteries were compared with the comparisons. A BMS framework was proposed to deal with the deficiencies of current BMS in both research and commercial products. Based on previous work, the specific challenges facing BMS and their potential solutions were presented as a sound basis for future research. Due to changing circumstances in real-world applications, a standard solution was not required. Depending on the specific situation, different strategies should be implemented to improve and optimize the performance of BMS in future EVs.

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