3G INTEGRATED BATTERY MANAGEMENT SYSTEM

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***Abstract*—The battery management system (BMS), integrated with 3G communication, is designed to protect Lithium-ion polymer battery (LiPB) and optimize its utilization in applications such as Electric Vehicles, while relaying the battery status among other parameters, to the user. Possessing the functions of battery modeling, battery state estimation, battery balancing, etc., it aims to monitor the State of Heath (SOH) as well as State of Charge (SOC) of the Battery and generate appropriate alerts to be delivered over GSM communication. The BMS supports various operating modes and is also designed to be responsible to isolate the battery in cases of emergency.**

Keywords—Battery management system (BMS), Electric-vehicle (EV), State-of-charge (SOC), State-of-health (SOH), Lithium-ion polymer battery (LiPB), GSM communication, 3G systems

I. INTRODUCTION

T}{he} depletion of non-renewable resource has led to the sharp growth in demand for a viable solution adhering to optimization of renewable ones. For power solutions in transportation and other portable applications, electric battery packs are looked up to as a substitute for fuel power.

According to a survey in [1], of the energy that fuel provides to vehicles a substantial proportion is lost. These losses account to only about 21.5 percent of the energy being used to move the car [1]. Whereas, battery packs typically use about 50 percent of the total battery capacity [2].

Lithium-ion rechargeable batteries are gaining popularity over nickel-based rechargeable batteries, as the Li-ion characteristics are very attractive and unique with the greatest advantages being played by the high cell voltage and superior energy density [3].

However Li-ion batteries are much less tolerant of abuse than nickel-based chemistries and overcharging and over discharging greatly reduces cycle life[3]. Thus, whenever any abnormal conditions, such as over-voltage or overheating, are detected, the BMS should notify the user and execute the preset correction procedure and monitor the system temperature to provide a better power consumption scheme [4].

Thus, protection of the battery pack is determined to be of utmost importance along with the performance of the battery pack as a whole. The Battery Management System plays the role of monitoring the status of each battery to ensure protection from extreme conditions and guarantee optimum performance. The current available BMS technologies are in the premature stage facing various issues with accuracies in measurement of monitoring parameters as well as charging facilities.

In case of monitoring the battery state, voltage measurement poses a fundamental problem for many BMS systems where the accuracy is not sufficient for a Li-Ion battery, and this might impair safety or reduce the usable capacity of the battery [5]. Usually, the battery state includes SOC and SOH determination. While SOC is well defined, since there is no consensus on definition for SOH, each developing technology has developed their own formulas. Considering the factors of aging and environmental conditions further indurates the task of SOC and SOH determination.

The BMS also implements the tasks of cell balancing where according to the information of each cell, BMS adopts equalization methods such as equalizing charging, dissipative equalization or non-dissipative equalization to make the SOC between cells as consistent as possible [6].

We have designed a battery management system, keeping in hindsight the above factors, to strike a balance between efficiency and cost effectiveness, to deliver optimum performance.

II. OBJECTIVES

The battery management system (BMS), with the functions of battery modeling, battery state estimation, battery balancing, etc., aims to protect the battery and optimize the utilization of the battery in EVs. It has two major functions:

- Detecting malfunctions, such as overcharge,excessive rise of temperature and electric leak
- Estimating state of charge at temperatures and in the charging/discharging environment

Battery Management System should maintain all the cells within their operating limits. The system should not allow the battery to be overcharged or under discharged so as to avoid damaging the battery, shortening the battery life, and causing fire or explosions.

Another feature of the BMS is to keep track of the state of charge (SOC) of the battery by monitoring the conditions of individual cells which make up the battery. The SOC could signal the user and control the charging and discharging process.
The Battery Management System should alsosupport various operating modes and is responsible to isolate the battery in cases of emergency as stated in [7].

III. SYSTEM DESIGN

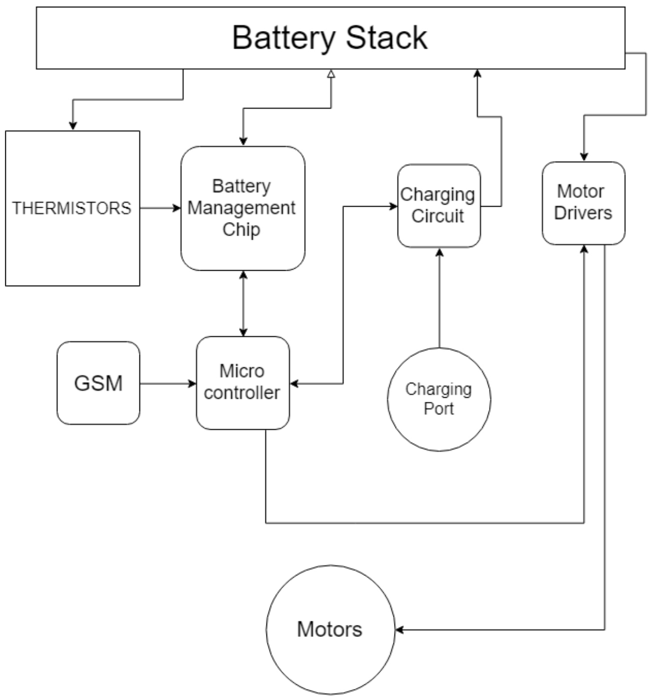

Fig 1. Block Diagram Of the System

The system comprises of:

- Battery Management Integrated Chip: To monitor the various battery parameters such as individual battery voltages in the stack and their temperatures.It also detects the under and over voltage of a battery
- Micro controller: Handles all peripherals in the system along with the battery management chip
- GSM module: Used for remote monitoring of the battery status and to grant power control to the designated user
- Thermistors: To measure the temperature of the battery stacks and indicate the over-heating of the batteries.
- Motor drivers and Motors:Motor Drive is controlled by the micro controller it is used to change the speed and direction of rotation of the motor

Fig. 1. illustrates a simple block diagram of the battery management system which can manage up to 16 cells presenting a single battery. The battery stack consists of up to 16 series connected cells. Each cell is connected to a thermistor which determines the current working temperature of the cell. The battery management chip measures all the parameters of each cell in the battery stack and feeds it to the micro-controller.

The communication of the battery management chip and the micro controller is critical. The micro-controller is the brain of the battery management system which makes all the relevant decisions regarding the functioning of the cells. The micro-controller sends real-time information to the GSM module to which it is connected and is instructed to send messages to the user in case the parameters of the cell are not within the specified range of operation. A charging circuit is present which is connected to the battery stack to charge each cell and to the micro-controller. Connection to the micro-controller is so that it can control the charging of each cell so that each cell does get overcharged or undercharged. Finally, the battery stack is connected to the motor drivers. The battery stack will power the motor drivers which will run the motors. Ideally, a single battery stack cannot power a heavy load such as an electric vehicle leading to the use many such battery stacks.

Many battery management systems can be connected to individual battery stack. This leads to the formation of a daisy chain of battery management systems. Auto-addressing mode is available and hence each battery management is auto-assigned an identification ID so that there is no ambiguity in communicating with each cell. Out of the many battery management systems, one is assigned as the master and the rest are assigned as the slaves. The above-mentioned features of the invention will become more clearly understood when the detailed description of invention is read together with the drawing

IV. Design Requirements

A. bq76PL455A-Q1 16-Cell EV/HEV Integrated Battery Monitor and Protector

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B. Quectel M95 GSM chip

The Quectel M95 chip is one of the smallest GPRS modules. It is Quad-band module which adopts the latest MTK chipset and is quite compact. It is an ultra-low consumption GPRS chip powered with an extended operational temperature. It is quite cost-effective and is a feature rich platform. In the Battery Management System, the M95 chip is used for sending real-time alerts to the user regarding parameters of the battery including battery overvoltage, undervoltage and shut-down.

C. Atmel ATSAMD20G18A-AU:

This is the micro-controller: the brain of the BMS. This device drives the battery management chip and is a low power high performance Microchip's ARM Cortex-m0+ based flash microcontroller. This chip is ideally used for a wide range of applications including home automation and industrial automation.it has 128KB Flash memory and 16KB of SRAM. Inputs are given to this chip from the GSM module, charging circuit and battery management chip.

V. Methodology

Rechargeable batteries and cells attain a longer life with greater capacity when the battery and its cells are charged and discharged within its optimal operating parameters. Charging or discharging individual cells or groups of cells allows the battery or battery pack to not be limited by a cell that was not fully charged or does not have the capacity of the other cells. The battery management system features include charging, cell equalization, load controlling, load monitoring and protection, and battery pack management.

Charging returns the cells to their optimum voltage such that the cells have optimum charge to function in the desired manner. One thing that must be noted is that the cells must not be under-voltage or over-voltage. This may affect the functioning of the electric appliance which is being powered by the battery.

Cell equalization is balancing the cells present in the battery such that each individual is having approximately the same voltage and same state of charge and they are within limits. If a particular cell is under-voltage then the entire battery stops functioning. Hence, we use cell equalization where a cell with higher state of charge charges up the under-voltage cell until it has obtained the same state of charge.

The battery management system also ensures that each cell in the battery is functioning within its specified working limits-that is it is neither under-voltage or undercharged. Hence, battery life is maximized for seamless use.

Figure1 illustrates a simple block diagram of the battery management system which can manage up to 16 cells present in a single battery. The battery stack consists of up to 16 series connected cells. Each cell is connected to a thermistor which determines the current working temperature of the cell. The battery management chip measures all the parameters of each cell in the battery stack and feeds it to the micro-controller. The communication of the battery management chip and the micro-controller is critically important. The micro-controller is the brain of the battery management system which makes all the relevant decisions regarding the functioning of the cells. The micro-controller sends real-time information to the GSM module to which it is connected and is instructed to send messages to the user in case the parameters of the cell are not within the specified range of operation. A charging circuit is present which is connected to the battery stack to charge each cell and to the micro-controller. Connection to the micro-controller is so that it can control the charging of each cell so that each cell does get overcharged or undercharged. Finally, the battery stack is connected to the motor drivers. The battery stack will power the motor drivers which will run the motors.

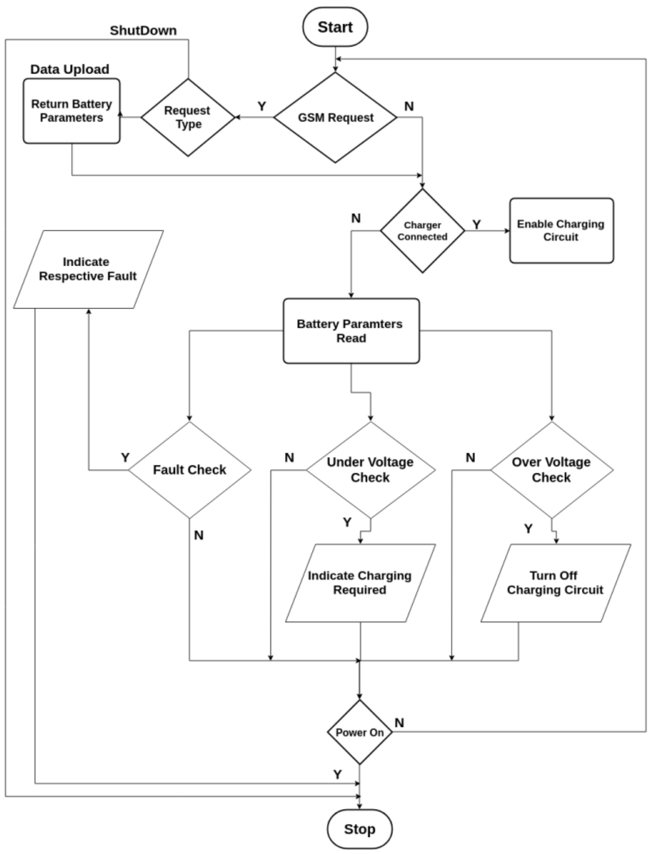

Fig 2. Flowchart

Ideally, a single battery stack cannot power a heavy load such as an electric vehicle. Hence, we use many such battery stack. Hence many battery management systems are connected to each battery stack. This leads to the formation of a daisy chain of battery management systems. Auto-addressing mode is available and hence each battery management is auto-assigned an identification ID so that there is no ambiguity in communicating with each cell. Out of the many battery management systems, one is assigned as the master and the rest are assigned as the slaves.

VI. CONCLUSION

We have designed a modular battery management system which will make electric devices powered by portable batteries more reliable. The power to the BMS itself has been rendered secure as there is no threat of failure of an external power source since the BMS relies on the battery stack for power. A GSM module integrated within the body ensures that the user gets real-time updates of current parameters of the battery and can remotely power on or shut down the battery system, thereby preventing any major damage that the BMS itself cannot control. All in all, as the most reliable course of action is through the user himself and the establishment of communication between the BMS and the user will ensure maximum energy utilization and protection of the power applications. With all major threats secured, this advanced battery management system will help in facilitating easy maintenance and fault detection in batteries.

VII. FUTURE SCOPE

Most state-of-the-art algorithms and monitoring methods are yet to conquer the title of reliability. The presented technology itself faces the same issue as there is no way to prevent system failure if the battery stack itself fails. An in-depth analysis of present technologies reveals that Battery Management Systems has a lot of scope for advancement in the fields on self-control over the system. Though establishment of real time communication brings us a step closer to better reliability, introduction of advanced self-control mechanisms will help bridge the gap. In the future as we look to power almost all devices with portable batteries, the Battery Management System will serve as the building blocks for the automation and power industries.

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