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Smart Battery Management System for Electric Vehicles

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Abstract

Electric vehicles are showing some promises in the automotive industry and can be the answer for mitigating carbon footprint. In the process of upgrading electric vehicles to the customer demands, battery performance serves a crucial part in deciding the performance of the electric vehicles. So, Battery Management System becomes the brains behind monitoring and controlling the battery. Real-time sensing of the battery parameters, decision-making capability to choose the type of charging, and which cell to be charged are all the functionalities of BMS. All these criteria can be assessed precisely and efficiently via processors like Raspberry pi, along with IoT and cloud computing technologies. These approaches can be used for remote accessing of the battery's performance, which will help the customer and the company to analyse the vehicle's condition. They also help prevent battery degradation. Since IoT and cloud computing technologies are being used, if an adverse state occurs in the battery, the customer can be notified directly via their mobile. In this article, a combined technology of locally hosted processor and cloud-based decision making has been discussed to improve the battery intern Electric Vehicle's performance.

Keywords: *Electrical Vehicles, Battery Management Systems, IoT, Raspberry pi, Cloud computing, Remote access.*

1. Introduction

Electric vehicles are becoming more common and widespread all over the world. Electric vehicles have some benefits that traditional internal combustion engine vehicles do not have. Electric motors are much more reliable and stable than diesel motors, regardless of the environment in which they operate [1]. EVs can also aid in the reduction of pollution that contributes to global warming and help boosting public health and reducing environmental damage. Using sustainable energy to charge your EV, such as solar or wind, minimizes emissions even further. The Electric vehicle market is predicted to grow due to widespread communal interest and awareness around the world, and also government inducements, those included in the greener recovery from the COVID-19 pandemic. Electric cars are anticipated to grow from 2% of the global market in 2016 to 22% in 2030, according to a pre-COVID 2019 research [2]. EVs are frequently more digitally linked than traditional vehicles. There are a variety of charging options since the electric grid is virtually everywhere: at home, at work, or on the road.

The Battery and the Battery management system are the most essential components of an electric car. Lithium-ion batteries are the most common type of batteries used in EV. Lithium battery advancements which were initially powered by the Mobile devices and portable electronics industry, now allow massive, highway-capable Electric Vehicles to traverse almost as fast on a full charge as traditional automobiles can on a full tank of gas. The costs of producing these very light, higher-energy density lithium-ion batteries are gradually reducing because of the evolution in technology and growth in the production of the batteries.

PARAMETERS	Li-Ion	Na-NiCl	Ni-MH	Li-S
Consumption of Electricity(kW/h)	15.6	13.5	16.2	12.4
Self sufficiency	146	153	138	193
Input Energy(kJ)	9546	8692	7854	8235
Output Energy(kJ)	193	182	169	165

TABLE 1: Different types of battery with considered parameters

The table above compares various battery types based on factors such as energy consumption, self-sufficiency, and input and output energies. [3].

In this article a method for managing individual cells in a battery system, especially electrochemical and rechargeable cells [4][5][6]. Here, the emphasis was primarily on lithium-ion batteries. A battery device, such as a battery bank or a battery string, usually consists of a number of cells [7]. A battery is a set of unit or individual cells connected in sequence. When individual batteries are connected in sequence, each cell has a tendency to have different characteristics such as energy storage capacity and discharge rates. Temperature, initial resistance, material impurities, porosity, electrolyte density, and a variety of other factors all contribute to these characteristics [8][9]. However, not all of these factors can be considered when monitoring cell charging and discharging. As a result, current, voltage, and temperature are utilized to monitor the cell's charging and discharging in order to optimize the battery's performance and lifespan. The standard charge properties of lithium-ion cells are listed in the table below. [10].

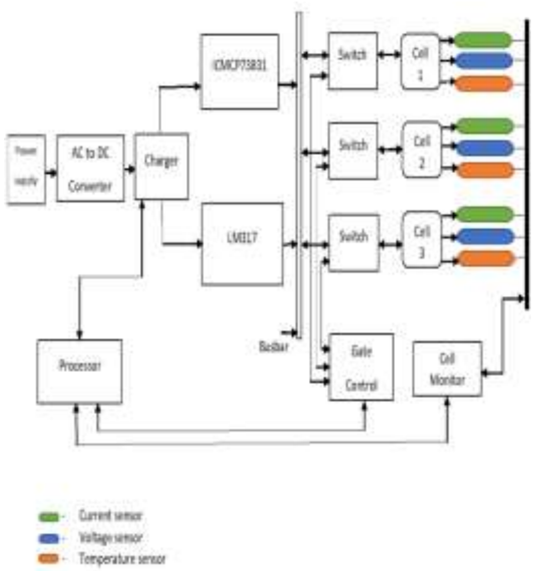
Charge (V/cell)	capacity at cutoff voltge	Charge	Capacity with full saturation
3.80	~40%	120 min	~65%
3.90	~60%	135 min	~75%
4.00	~70%	150 min	~80%
4.10	~80%	165 min	~90%
4.20	~85%	180 min	100%

Table 2: Charge properties of lithium-ion cell

The current, voltage and temperature sensors present in the system is used obtain the cells parameter [11]. These values will be extracted from the cells, and processed by the processor and transmitted to customers mobile device through IOT platform. The data from the mobile would then be sent to the local server and cloud further review. After the analysis of the obtained battery data, a report or action plan will be decided by the trained algorithms and the results will be sent to the processor to adopt the optimal charging techniques, temperature controls are to provide an alert message to the customer etc.

I. THE PROPOSED MODEL

The primary objective of this system is to automatically monitor individual cells. Each cell in the battery unit is charged and maintained based on its conditions [12]. The identity of multiple individual cells exhibiting a problem is visually prompted along with a detailed time report on the cloud and also sent to the local server through the processor [4]. The general framework designed to maintain the battery is depicted in FIG.1.



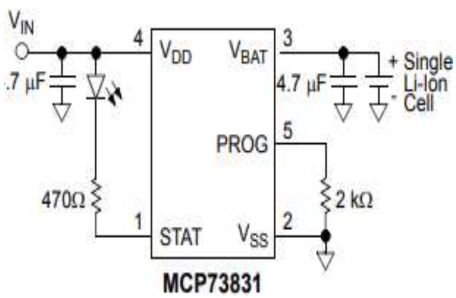
The system employs a main charger to supply power to two additional chargers, which control the current and voltage that is delivered to the cell to prevent over charging. The motive of using these two charges is for fast and slow charging, with the voltage and the amps of the cell being assessed for fast charging, The IC MCP73831, which includes constant current/constant voltage algorithms as well as configurable preconditioning and charge termination, is used. Because of the following characteristics, this IC is being used. Constant voltage control is set with four choices to satisfy modern and emerging battery charging requirements: 4.19v, 4.34v, 4.39v, or 4.49v. To set the constant current value, external resistor is used. During peak power or peak ambient circumstances, the MCP73831/2 devices control the charging current based on depleted temperature. High thermic management improves the charge cycle while sustaining device safety. The prerequisite threshold, prerequisite current value, charge terminating value, and automated recharging threshold can all be customized [13].

IC LM317 is used for slow charging or trickle charging. The LM317 is a three-terminal adjustable positive voltage regulator with a 1.25v to 37v output voltage range that can supply more than 1.5A. To configure the output voltage range, only two external resistors are required. The default line and load control of the unit are 0.01% and 0.1%, respectively. It has a current limitation, thermal overheat prevention, and a secure operating structure. The overload barrier protection remains active nevertheless the ADJUST port being dissociated [14].

The processor receives current, voltage, and temperature digital signals from the charger and cell monitor. It is programmed in such a way that it records and analyses the feedback from current, voltage, and temperature sensors and then sends the data via Bluetooth or Wi-Fi from the app installed on the mobile. The data will be sent to a local server, which will be analyzed and return with the requisite adjustments to optimize the charging and discharging of the cells. By measuring the cells' state of charge and state of health with their respective current, voltage, and temperature values and comparing those to the previous values, cloud-based battery monitoring can help predict the lifetime of a cell. If something is wrong with the data acquired from the processor, for example, if the values of any cells are not within the expected values, a warning message will be sent to the consumer and the relevant company, and a warning will be displayed in the vehicle. All these operations shall take place in real-time.

A. *FAST CHARGING*

Circuit diagram:



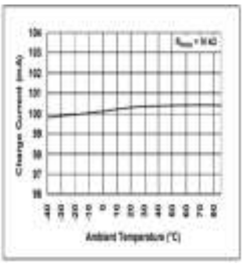
Working:

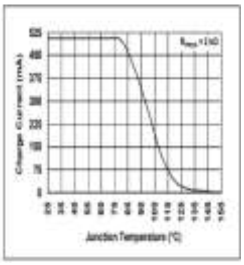
During constant-current mode, the battery receives the intended charging current. The charging current is determined by a fixed resistor flowing from PROG to VSS. The period till the voltage at the VBAT pin approaches the VREG voltage, the constant-current mode is sustained.

Constant voltage regulation commences upon the voltage at the VBAT pin approaches the regulating voltage VREG during the constant voltage phase. With a tolerance of ±0.75%, the regulating voltage is originally reset to 4.19V.

The MCP73831/2 constantly observes the voltage at the VBAT pin in Charge Complete state. A new charge cycle begins if the voltage falls under the recharge limit, and the current is delivered to the battery once more. [13].

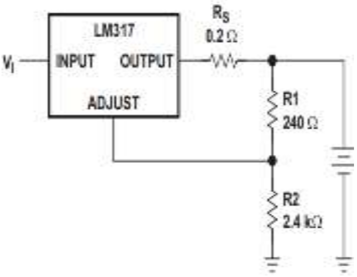
Waveforms:





B. Slow Charging (trickle charging)

Circuit diagram:



Working:

Trickle charging, often known as slow charging, is the mechanism of charging a fully charged battery at a rate equivalent to its discharge rate, enabling the battery to maintain an optimal charge level. This condition happens almost exclusively when the battery is not loaded, as trickle charging cannot hold a battery charge if the current is being drawn by the load. [15].

The charging can be done in four more modes:

1) Normal Charging: To provide output regulation, the device output pin will source the current necessary to make the OUTPUT pin 1.25v greater than ADJUST terminal.

2) Operating with limited input voltage:

To operate in regulation, the system requires up to 3v headroom (Vi – Vo). The system will fail, and the OUTPUT voltage will be the same as the INPUT voltage with less headroom.

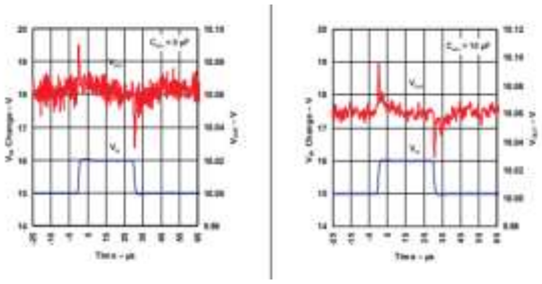
3) Operating at light loads:

The device's bias current is directed to the output pin. If the load or input does not absorb this minimum current for regulation, the output may be too high.

4) Operating in self-Protection:

When an overload occurs, the system either shuts down the Darlington NPN output stage or reduces the output current to avoid device harm. The computer will automatically reset as a result of the overload. The performance can be decreased or alternated between on and off before the overload is eliminated [14].

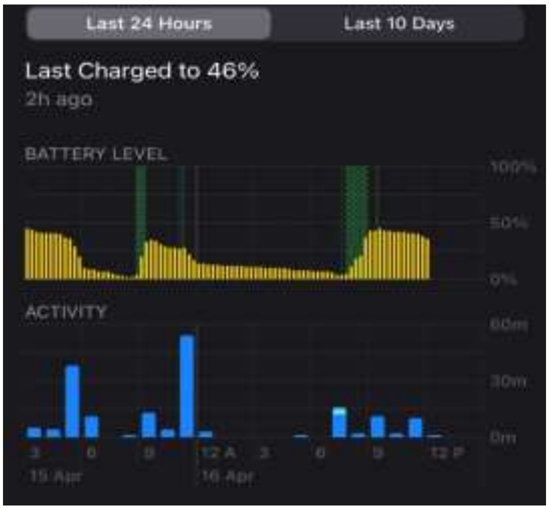
Waveforms:



C. IOT and Cloud based computing

The purpose of cloud computing is to give remote access to the data. The batteries data will be stored in the cloud. The data is analysed to help predict the battery's health and life span. The data stored in the cloud will be timestamped. This will further help in regular monitoring and periodic analysis of the battery. The intent of IOT is to collect data from the vehicle and help send it to the cloud and the local server for further analysis. These data can be accessed by the user and the company at any time and from any place. If something goes wrong with the vehicle, a virtual scan can be performed to determine the source of the problem and the best course of action. This would save the service provider a significant amount of time.

The vehicle's safety can be increased by using this system. For instance, if the battery parameter obtained from the processor is not within the expected range, the device can send an alert signal to the user's cell phone and also display in the vehicle. The service provider will review the background of issues in the future to assess the vehicle's condition. Since this information can be accessed remotely, the service provider or the company may not require the vehicle to do a primary analysis of the vehicle's problem. A protype of battery charge & charging data made available to the customer through the handheld device is as shown below:



4. Conclusion

This article illustrates how to manage the battery in electric cars in an effective and accurate manner, and also a consistent platform for checking the state of each cell in the battery and, based on the status of the cell, choosing an optimal charging system to charge the cells in order to maximize charging and attempt to improve or sustain the battery's lifetime.

All these operations are carried out in a precise and efficient manner with the aid of IoT and cloud-based technologies, allowing customers and companies to monitor battery performance remotely if required. The ability to view data remotely assists the service provider and company in doing a primary inspection of the vehicle. When the vehicle has an issue, it saves the customer and the service provider a great deal of time because the primary inspection can be done virtually. The proposed model also aims to mitigate automotive harm by optimizing the charging potential of the cells and attempting to regulate the temperature inside the battery. In hazardous situations, an alarm or a alert message is initiated which aid them by a possible set of instructions to deal with the situation using the app.

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