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RESEARCH ARTICLE

Battery Management System(BMS80) to Improve Battery Life in Electric Vehicles

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Abstract – The transportation sector is moving towards environmentally sustainable energy sources that are dependable, regulatory, and sustainable as the world battles with the negative impacts of conventional vehicles in conjunction with the shortage of fossil resources. Electric cars (EVs) are the Solution to the problem, However, the battery of an electric vehicle is crucial to its operation and the motor with all its operations use a sizable portion of an EV's battery which results in limited battery life. Therefore, preserving battery life in electric vehicles is a challenge that needs to be overcome by regulating the consumption of battery energy efficiently. The proposed work is focused on creating a Battery Management System(BMS) that limits the charging process using an eco-charging software function. The battery's state of charge (SoC) is monitored through a microcontroller, working in tandem with a software function to cease charging at 80%. The battery management system promises to increase battery life while also enhancing the convenience of charging and lowering the cost of EV ownership in the long run.

Index Terms – Electric Vehicle, Lithium-Ion Battery, Battery Management System, State of Charge(SoC), Battery Life.

I. INTRODUCTION

The transport industry is concentrating on reducing its global carbon footprint as from [1], 12 billion tons of oil equivalent (BTOE) of energy are consumed a year, resulting in the release of 39.5 Giga tons of carbon dioxide (Gt-CO2) of which a sizable portion of the emissions are due to internal combustion engines (ICE). This has resulted in the widespread adoption of EV vehicles, [2] puts forward that the global fleet of EVs across all modes of transportation increased from more than 11 million in 2020 to more than 145 million by 2030, an annual average growth rate of about 30% of the anticipated scenario. By 2030, EVs will make up roughly 7%-8% of the vehicle fleet worldwide. Nearly 15 million electric vehicles will be sold in 2025, and over 25 million in 2030, accounting for 10% and 15% of sales of all road vehicles, respectively.

This has reduced carbon emissions, but it has not entirely stopped them because, as from Table I, electric vehicles also leave a significant carbon imprint. [3] puts forward that the typical EV battery weighs 8 kilograms (17 pounds) of lithium carbonate, 35 kilograms (77 pounds), 20 kilograms (44 pounds), and 14 kilograms (30) of cobalt (NMC532). The difficulties in obtaining each of these specific raw materials harm the environment. From [4] we learn that the extraction of lithium inevitably results in soil damage and air pollution. The repercussions of mining are increasingly affecting communities where this harmful extraction takes place, putting their access to water in jeopardy as demand grows. About 21 million litres of water are consumed every day in the evaporation ponds used to make lithium. To produce one ton of lithium, 2.2 million gallons of water are needed. Therefore, the battery charging process must be considered to increase battery life, enhance charging efficiency, and lessen the need for frequent battery replacements, all of which would help to lower the carbon footprint of the batteries themselves.

TABLE I. Comparing Lifetime Emissions of EV vs ICE

Vehicle Type	Manufacturing Emission [a]	Emission/year [b]	Lifetime average emission
Internal Combustion Engine(ICE)	7 Metric tons of CO2	5 Metric tons of CO2	57 Metric tons of CO2
Electric Vehicle (EV)	17 Metric tons of CO2	2 Metric tons of CO2	28 Metric tons of CO2

a. Manufacturing considers the average carbon footprint of every component of a car.

b. Emission per year is taken for national average of 11,800 miles/18990 km

c.

It is crucial to control the battery's State of Charge (SoC) if the aforementioned issues are to be resolved. Typically, consumers are encouraged to charge their EVs up to 80% because, after that, charging rates begin to substantially decrease. Additionally, keeping the battery pack below 100% is optimal for the long-term health of the vehicle.

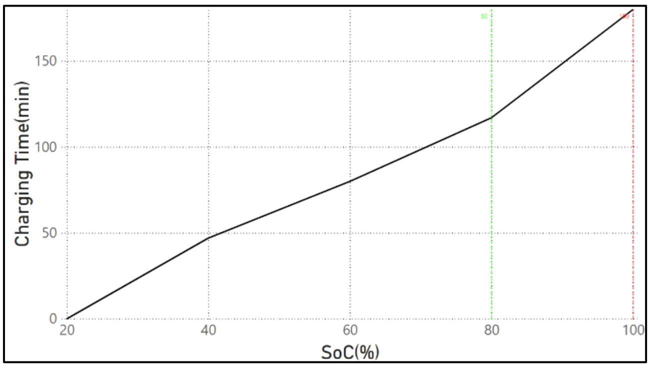

Figure 1. Average charging time curve.

It has been demonstrated in [5] that battery deterioration is decreased when the SoC is maintained between 20 and 80%. To illustrate this, a real-world test using a BMW i3 (EV) was conducted. The automobile was repeatedly drained while being driven along a predefined route that featured various sorts of traffic, initially charging it up to 80% of SoC and then up to 100% of SoC. The results of charging time are given in Figure 1, it was observed that the battery's rate of charging slowed down after reaching a particular SoC level. It took an average of 3 hours and 6 minutes to charge the car from 20% to 100% of SoC, whereas it took nearly 2 hours to charge the car from 20% to 80% of SoC and about an hour to charge the remaining 20% of SoC.

As a result, losses are almost twice as significant as they are in the recommended SoC range (20%-80%), and the vehicle's average specific actual energy consumption is generally higher than what is displayed

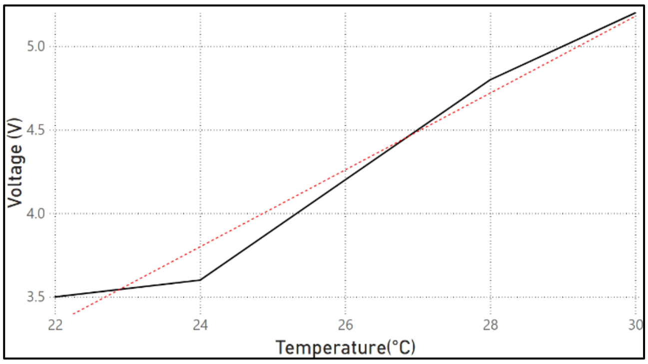

Figure 2. Temperature on average while charging

on the EV Dashboard. Furthermore, Additionally, charging the EV outside of the advised SoC area lowers the average temperature that the battery is subjected to.

According to [6], the temperature is an important factor that significantly affects the functionality of lithium-ion batteries and limits their use. Figure 2 shows the Temperature on average while charging. Additionally, many detrimental effects are caused by various temperature ranges. Accurately measuring the temperature inside lithium-ion batteries and understanding the effects of temperature is essential for effective battery management. The proposed work, therefore, tries to prolong battery life by controlling the battery's SoC and temperature with a Battery Management System (BMS) that restricts the charging procedure using an eco-charging software function. Eliminating the need to replace EV batteries, would eventually reduce the cost of EV ownership.

II. LITERATURE SURVEY

Reference	Title	Description	key Points
[5]	Real-world study for the optimal charging of electric vehicles	The utilization of Renewable Energy Sources (RES) in conjunction with Electric Vehicles (EVs) is the answer to decarbonizing the transportation industry and is unquestionably on the increase. The current work quantitatively analyses the energy losses that occur during the charging of a Battery Electric Vehicle (BEV), focusing particularly in the previously unexplored 80%-100% State of Charge (SoC)	1. The transport sector's decarbonization. 2. Increased EV sales. 3. Investigating a lithium-ion battery's 80–100% SoC. 4. Experimental evidence that charging above 80% damages the battery in the long run.

		region. The study was experimentally carried out under real-world driving situations. The findings indicate that losses during charging inside the area are about two times higher than those within the 20%-80% SoC band.	
[7]	Battery Management Systems for Improving Battery Efficiency in Electric Vehicles	Rise in EV sales has created an unprecedented Demand for lithium-ion battery. This research offers an innovative strategy to raise the battery efficiency of electric vehicles. The suggested approach parallel-connects lead-acid and lithium-ion batteries to the power source and combines their discharge characteristics to optimize power management to increase battery efficiency and decrease battery cost for electric vehicles. The experiment's findings show that the lead-acid battery's available capacity can increase by 30% to 50% over its rated capacity.	1. Growing demand for lithium-ion batteries. 2. Using lead-acid and lithium-ion batteries in parallel. 3.The total range of the EV is enhanced.
[8]	Advanced Electric Vehicle Fast-Charging Technologies	The world is moving progressively towards electrified transportation as a result of the negative effects of the preponderance of petroleum-based transportation. Electric vehicle (EV) battery charging times must drop to the 5–10 minute range in order to compete with petroleum-based transportation. The report also offers exciting new options and methodologies for research on power electronic converter topologies and systems level to progress the state-of-the-art in fast charging.	1. Transportation around the world is becoming more electrified. 2. Examining EV charging durations. 3. A summary of rapid charging technologies.
[9]	A Review of Battery State of Health Estimation Methods: Hybrid Electric Vehicle Challenges	The longevity and safety of electric and hybrid vehicles, as well as the ability to address new transportation problems, depend on effective and trustworthy battery health management systems. The State of Health (SOH) provides important details regarding the battery's state of health. The real-time measurement of battery SOH is essential for the identification of battery issues. The viability and accuracy of a model-based adaptive filtering-based online and on-board SOH estimation technique are demonstrated through experimental validation. The State of Health (SOH) contains crucial details regarding the battery's status.	1. research on the durability of EV batteries. 2. Estimation of the State of Health (SOH). 3. There are various ways to calculate SOH.

III. PROPOSED WORK(BMS80)

The time taken to charge from 80-100 percent will result in a relatively large difference in the time taken to charge from 20-80 percent. In most cases of battery, when the battery charges above 80 percent of its capacity it produces more heat which reduces the battery charging efficiency and stresses the battery out significantly more, which leads to the deterioration of the lithium-ion battery. To use the lithium-ion battery effectively, we can switch off the power supply to the battery when it is charged to 80 percent. At this point, by controlling the charge levels of the battery we will be able to reduce stress and higher temperatures on the lithium-ion battery and reduce charging time.

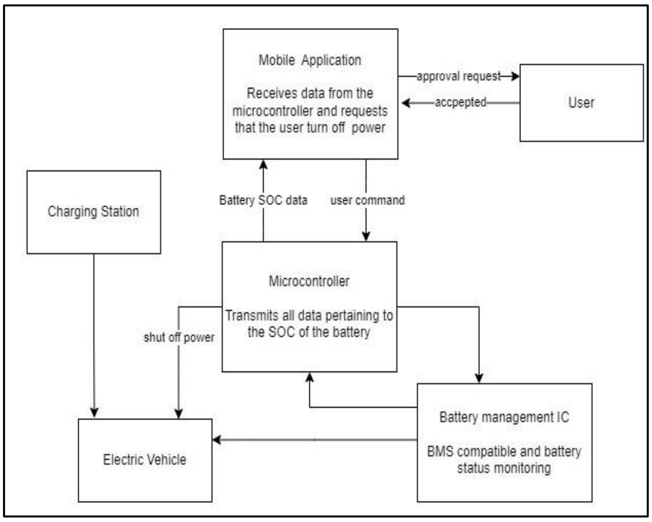

Figure 3. The Proposed Battey Management System(BMS80)

Figure 3, illustrates the proposed configuration of the battery management system(BMS80) for improving the battery life of an electric vehicle. The battery management system includes a highly integrated battery management IC which estimates the battery capacity and current battery levels. Additionally, the IC is connected to a microcontroller which supports REST API creation.

A. System components:

The Components of the proposed Battery Management System are explained in this section. The system components consist of three parts: the chosen IC, the communication method, and the monitoring System.

a) The chosen IC.

The IC MAX17843 is utilized for this proposed work because it is programmable, high-voltage, highly integrated, and has a 12-channel innovative data acquisition interface with many safety features. It is designed to work well with secondary metal batteries used in automotive systems, hybrid electric battery packs, electric vehicles, and various other systems that stack them in long series strings. A high-speed differential UART bus is built into this highly integrated battery sensor for dependable daisy chained serial communication.

b) The communication method.

RESTful API is a type of web service that uses HTTP/HTTPS to transfer data between two similar and different systems .It has a standardized set of operations such as GET, POST, PUT and DELETE that can be applied to resources identified by URLs. RESTful APIs typically use standard data formats such as JSON or XML to represent the data being transferred and can be used across different platforms and devices.. This service can also support a variety of authentication and authorization methods to secure communication between the client and server.

c) The monitoring system.

In the proposed system we need to establish a connection between the battery management IC to the microcontroller and install the required libraries and dependencies on the microcontroller platform to support the creation of the REST API. At this point, we need to define the REST endpoints that will provide the set of commands and data that the application can use to communicate with the battery management IC. Using a web server and the JSON parsing library we implement the REST endpoints which define the HTTP methods and the JSON response formats for each endpoint. In our proposed case we need strategies to fetch the current battery level and to switch off the power supply to the battery when the user decides to.

When the electric vehicle is at the charging station and plugged in to charge, the microcontroller monitors the battery charge levels and when 80 percent of the battery is charged the microcontroller sends a signal to disconnect the power supply to the battery. Doing so increases the efficiency and health of the battery and reduces the time to charge the electric vehicle in charging stations.

B. Pseudo Code :

a) Import required libraries:

```
from flask import Flask, request, jsonify
from flask_restful import Resource, Api
import serial
import json
import requests
from datetime import datetime
```

b) Create end points:

```
# Endpoint to start charging the EV
@app.route('/start_charging', methods=['POST'])
def start_charging():
    # Code to start charging the EV
    return 'Charging started', 200

# Endpoint to stop charging the EV
@app.route('/stop_charging', methods=['POST'])
def stop_charging():
    # Code to stop charging the EV
    return 'Charging stopped', 200

# Endpoint to get the current battery level of the EV
@app.route('/battery_level', methods=['GET'])
def battery_level():
    # Code to get the current battery level of the EV
    battery_level = 70 # Example value, replace with actual code
```

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```
    return jsonify({'battery_level': battery_level}), 200

# Endpoint to stop charging the EV when it reaches 80%
@app.route('/stop_charging_at_80', methods=['POST'])
def stop_charging_at_80():
    # Get the current battery level of the EV
    battery_level = int(request.json['battery_level'])
    # Stop charging if the battery level is above 80%
    if battery_level >= 80:
        # Code to stop charging the EV
        return 'Charging stopped', 200
    else:
        return 'Battery level is below 80%', 400
```

The necessary libraries are first imported into the code. Next, the code creates two endpoints—one to initiate charging and the other to terminate it. Another function in the code returns the EV's current battery level in JSON format. When the charge is 80%, the next endpoint is called. This endpoint measures the EV's current battery level and stops charging if it is greater than 80%. A charging endpoint for the EV is being created by the code. Two endpoints in the code are used to start and stop charging, respectively. When a user wants to begin charging the EV, they would call the start_charging endpoint. When a user wants to stop charging the EV, they would call the stop_charging endpoint.

IV. RESULTS AND DISSCUSSION

By implementing BMS80, Charging an electric vehicle (EV) up to only 80% can have many benefits, such as mainly prolonging the battery life and reducing the risk of overheating. Here are some of the potential results of charging an EV up to only 80%.

- Prolonged battery life: Charging the battery up to only 80% can help reduce the depth of discharge, which can help prolong the battery life.
- Reduced risk of overheating: When a battery is fully charged, it generates more heat than when it is partially charged. This can increase the risk of overheating, which can damage the battery and reduce its performance. By charging the battery up to only 80% by using BMS80, the risk of overheating can be reduced.
- Reduced charging time: BMS80 reduces charging time and is especially beneficial when you need to top up the battery quickly as charging a battery up to 80% takes less time than charging it to 100%.
- Reduced energy consumption: Charging a battery up to 100% can result in energy waste due to overcharging. BMS80 ensures to reduce energy consumption and helps reduce carbon footprint.

- It is crucial to remember that charging an EV merely 80% of the way can also have certain Limitations, BMS80 lets you find the right balance between battery life and driving range based on your specific needs and driving habits.

V. CONCLUSION

The main objective of this paper is to quantitatively describe the battery behaviour of EVs during the charging procedure and preserve battery life in electric vehicles by regulating the consumption of battery energy efficiently. The significance of the results is due to the fact that measurements were made while actual driving conditions were present. After a thorough literature review concerning the optimum SoC range that Li-ion batteries should operate should be 20%-80% and understanding that temperature is an important factor that significantly affects the functionality of lithium-ion batteries and limits their use, accurately measuring the temperature inside lithium-ion batteries and understanding the effects of temperature is essential for effective battery management, a noteworthy Battery management system is proposed. The proposed BMS80 consists of three components, namely (I)The chosen IC which is MAX17843, (II)The communication method is a RESTful API and (III)The monitoring system is implemented by using a microcontroller. Lastly, although charging the automobile over 80% of SoC will not cause the electricity cost to increase significantly, from an environmental and economic standpoint, the battery's capacity to hold energy drastically reduces in due course of time. This causes a replacement of EV's battery sooner which is 60% of EV's Total cost and hence not economical and reduces the battery's value for any second-life applications and a detrimental effect on the environment. For this reason, a BMS that can restrict the charging process, essentially up to 80% of SoC, via an eco-charging software function on the EV's dashboard is required for EV users to save money in the long term and the electro-mobility market is enhanced.

VI. FUTURE SCOPE

The future scope of EV-optimized charging is very promising as electric vehicles (EVs) become increasingly popular and accessible. Here are some potential developments and trends that are likely to shape the future of EV-optimized charging. Expansion of EV charging infrastructure: As more people adopt EVs, the demand for charging stations will increase. Governments, utility companies, and private companies are investing in building more charging stations to meet this demand. As the rate of charging up to 80% is very high, EV owners can stop for a quick pitstop to charge and continue their journey. This ensures that there is a charger available for everyone. Faster charging times: Charging times for EVs will be improved significantly, by charging only to 80%. This will make EVs more convenient and attractive to consumers, as they can charge their vehicles more quickly and efficiently. Greater second-hand applications of discarded batteries: EV batteries will have larger and more significant applications in other domains as they still have a good capacity to hold charge.

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