

Predictive Twin Technology Battery Management System

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Abstract—Electric vehicles are the way of the future. The rising EV market, along with the diminishing supply of petroleum fuels, demands the development of more efficient EVs. A battery management system (BMS) is an essential component of any electric vehicle. It consists of a number of electrical and electronic circuits (including converter and inverter circuits) that have been programmed to monitor and extract the maximum output from a battery system. The chemical reactions are what determine the battery's performance. The performance of a battery degrades as chemicals decay. As a result, these features of a battery must be regularly monitored. Because of their high charge density and lightweight, Lithium-ion batteries have proven to be a popular choice among electric vehicle producers. Despite the fact that these batteries have a lot of power for their size, they are quite unstable. It is critical that these batteries are never overcharged or discharged, requiring the use of voltage and current regulators. In this research paper, we will monitor various aspects of the vehicles like current, Voltage, SOC and temperature with the help of Node MCU which is the Wi-fi enabled microchip that will send the data or crucial parameters to the server which is the ThingSpeak. Therefore in this way we can monitor these parameters from anywhere and also monitor battery health.

Keywords—IOT, BMS, Battery management, Vehicle, Battery system, SOH, insert

I. INTRODUCTION

1.1 ELECTRIC VEHICLE

Electric vehicle (EV) is one that is made to run by an electric motor rather than an internal-combustion engine (IC). It generates energy by burning a mixture of Petroleum and its other products. Due to Which, these vehicle are found out to be a one of the replacement for current-generation of vehicles in order to address challenges such as rising pollution, global warming, and natural resource depletion. Electrical vehicles are attracting customers due to its environment-friendly nature as it does not have an internal-combustion engine which creates harmful gases for the planet, also they have less cost of maintenance and they are potential to a tax credit as the customer is cutting down the impact on the environment by choosing a zero-emission system. Countries like the United

States, China and Japan had updated its policies and standards to support the development of EVs.

History of Electric Vehicles

Electric vehicles, which run on batteries rather than gas engines, are becoming more common. Electric vehicles are preferred by those who want to safeguard the environment and maybe go greener. However, many people are astonished to hear that electric vehicles are not a new technology. While it is unclear who invented the first electric car, electric motors were clearly in use as early as the 1800s. Around 1828, Anyos Jedlik invented the very first electric motor. Using a small electric engine, he developed a self-moving tiny model automobile. A bigger electric motor designed by Scottish inventor Robert Anderson has been used to run a carriage between 1832 and 1839.

American innovators returned to the electric car in the 20th century. William Morrison created what many consider to be the first practical electric car around this period, however it lacked range. During this period, hybrid vehicles were also developed to address a variety of concerns with electric vehicles.

Electric vehicles in the entire history have never been so in news, and a lot of them can drive many miles just by charging only once. In 2008, Tesla introduced the Roadster. Due to many hindrance and faults, it was being able to travel which was more than 200 km just by charging once. It was quickly followed by the Mitsubishi kilometers in Japan. The creation and introduction of these two cars, particularly Tesla, signalized.

the start of the modern era of electric vehicles. Other major automakers rapidly followed behind, developing ev's of their own. A vast number of people had already created hybrids, suggesting that the method was well-established. The Chevrolet Volt was made by General Motors, and the Nissan Leaf was presented by Nissan. Smaller companies, such as Tesla, are pushing significant advancements in electric vehicles.

An electric car can be purchased for a variety of reasons. The motors are whisper quiet, and the trip is wonderfully relaxing. Since the power is sent directly to the wheels, the torque is higher than most people believe. There's no need to stop at a gas station, and while drivers must pay for the electricity needed to charge the car, it's less expensive than gasoline.

Components of Electric Vehicle

In all-electric cars (EVs), an electric motor replaces the internal combustion engine. The electric motor in the car is powered by a large traction battery pack that must be hooked into a wall outlet or an EVSE. Because it operates on electricity, the automobile has no emissions and no traditional liquid fuel components like a fuel pump, fuel line, or gasoline tank.

- **Battery (all-electric auxiliary):** Auxiliary batteries in electric vehicles provide power to operate vehicle accessories.
- **Charge port:** The charging port allows you to connect the vehicle to an external power source to charge the traction battery pack.
- **DC/DC converter:** This device converts the high voltage DC power from the traction battery pack into the low voltage DC power needed to run vehicle accessories and charge the auxiliary battery.
- **DC motor:** This motor uses energy from the traction battery pack to move the wheels of the vehicle. Engine generators are used to power and rejuvenate various vehicles.
- **On-board charger:** Charges the traction battery by converting the input AC voltage from the charging port to DC. Connected to the charger, it analyzes battery parameters such as voltage, current, temperature and charge status during the charging process.
- **Power electronics controller:** This unit controls the speed of the electric traction motor and the torque produced by controlling the flow of electrical energy supplied by the traction battery.
- **Thermal system (cooling):** This system maintains a safe operating temperature range for motors, electric motors, power electronics, and other components.
- **Traction battery pack:** The electric traction motor consumes the power stored here.
- **Transmission (electric):** The transmission is responsible for transferring mechanical energy from the traction motor to the wheels.

1.2 BATTERY MANAGEMENT SYSTEM

A battery pack is an arrangement of battery cells electronically arranged in a row x column matrix format to be able to produce a specified range of current and voltage for a given amount of time in response to projected load conditions. The following are common BMS responsibilities:

1. Battery Monitoring
2. Battery protection
3. Estimating the operational state of the battery
4. Constantly improving battery performance
5. Reporting operational status to other devices

In this situation, the term "battery" refers to the entire pack; nevertheless, in the overall battery pack assembly, individual

cells or clusters of cells known as modules are subjected to monitoring and control activities. Rechargeable lithium-ion cells have the highest energy density and are used in computer and electric car battery packs. They operate well, but if used outside of a relatively small safe operating area, they can be harsh, resulting in everything from battery degeneration to outright danger. The BMS does have a difficult job profile, and the complete complexity and oversight it requires may include digital, control, electrical, hydraulic, and thermal domains.

1.3 BATTERY SWAPPING STATION

Electric vehicles majorly face the problem of range anxiety and long charging period time which can be overcome by implementing a Battery Swapping Station. In this concept, when the vehicle is scheduled to come to a station, then the discharged battery pack is replaced by the charged one. The battery can be replaced in one of two ways:

- i. **Automated Robots-** This is a method of replacing the battery pack that does not require the use of human workers.
- ii. **Manually-** In this procedure, a battery which is not charged i.e. a discharged battery is removed and a new charged battery is placed with the help of man available at station. This process will take longer than the previous one, and because manpower is involved, the cost will go up.

II. LITERATURE REVIEW

I. Title: "Battery Health Monitoring for Commercialized Electric Vehicle Batteries: Lithium-Ion"

Author: Fawad Ali Shah, Shehzad Shahzad Sheikh, Umar Iftikhar

Description: Batteries are widely utilized to power electric vehicles, hybrid electric vehicles (HEVs), and many other high-power applications. The battery is critical to their efficiency, safety, and reliability. Initially, numerous types of batteries are discussed in this paper. According to the research, utilized in EVs and HEVs are explored. The most recent battery management methods (BMS). Lithium-ion batteries due to their extended life, a preferred source of EVs and HEVs high power density, and good charging and charging efficiency performance. However, there are still some concerns. Li-ion batteries are used in a variety of applications, including complicated electrochemistry, battery deterioration, and battery accuracy health assessment. Vehicle electrification is a global trend that includes Asia and Pakistan. Following that, the article considers the economic, environmental, and energy efficiency implications of increased use of electric vehicles.

II. Title: "Battery Swapping Technology"

Author: Shubham Jain, Azures Ahmad, Mohammad Saad Allam

Description: The transportation industry contributes significantly to carbon emissions and pollutes the environment globally. Electric vehicles (EVs) have a significant promise for reducing carbon emissions. A

Battery Swapping Station (BSS) is a promising mechanism for providing power to EVs while reducing long charging times at a Battery Charging Station. Swapping Technology is an excellent option for completing a long-distance interstate journey. This study investigates the advantages of establishing the BSS from many perspectives, and as a result, a methodology for swapping out batteries in significantly less time is given, taking into account the position of the battery to be fixed. This new approach can be used as a source of inspiration for a future framework that provides EVs with sensible and dependable charging.

III. Title: "Scalable and Decentralized Battery Management System for Parallel Operation Multiple Battery Packs"

Author: Shreyas Maitreyan, Himani Jain, Priyanka Pallial

Description: Multiple lithium-ion battery packs operating in parallel are required for large-scale energy storage applications. Renewable energy storage systems, batterypacks for large-scale automobiles such as electric trucks, tanks, armoured vehicles, diesel-electric submarines, and so on are examples of such uses. The existing method for parallel operation of numerous battery packs is highly hardware intensive. It necessitates a distinct pack management system acting as a master, as well as battery management systems in each of the battery packs deployed as slaves. This has a huge impact on the scalability of such systems because the number of battery packs that can be connected in parallel is entirely reliant on the capacity of the master. A decentralized pack management system is presented as an alternative in this study. Thus suggested technique eliminates the need for master-slave battery pack configurations and eliminates the need for centralised hardware to manage the battery packs. Instead, this system allows individual Battery packs to communicate with one another on their own, allowing for decentralized pack administration.

IV. Title: Battery Management System in Electric Vehicle

Author: Ananthraj C R, Arnab Ghosh

Description: The most crucial component of any electric vehicle (EV) is battery storage, which stores the energy required for the vehicle's operation. So, in order to get the most out of a battery while also ensuring its safety, it is vital to have an effective battery management system in place. It monitors the parameters, calculates SOC, and provides the services required to ensure the battery's safe functioning. As a result,

BMS are a crucial component of any electric vehicle, and more research is being done in the field to build more capable BMS. System for Managing Batteries.

A. Comparison: Conventional BMS vs Digital Twin-Based BMS

Feature	Conventional BMS	Digital Twin-Based BMS
Modeling approach	Static / rule-based	Dynamic, data-driven
SOC estimation	Coulomb counting, ECM	Adaptive hybrid models
SOH estimation	Periodic / offline	Continuous, real-time
Degradation awareness	Limited	Explicit and predictive
Scalability	Limited	High (fleet-level possible)
Fault detection	Reactive	Predictive
Battery swapping support	Minimal	Strong
Integration with smart grid	Limited	Seamless
Lifecycle optimization	Not supported	Fully supported

III. HARDWARE AND RESULTS

Hardware Implementation

We took a conventional bicycle. After this we took BLDC chain motor of 250 W. We fixed that BLDC motor into our bicycle to make it an electric bicycle. We made a batterypack of 24 V and 10.4 A. We took Lb27 Controller box for controlling the motor. After mounting it to our bicycle had to make a battery health card where we can see the various aspects of the battery. For monitoring different aspects we took a current sensor (ACS 712), voltage sensor, Temperature sensor (DH11) and NodeMCU (ESP8266). We made 3 different modules for measuring each component. In current module we used ACS712 current sensor that can measure maximum 30 Am. We connected it to Arduino IOT cloud to monitor it live. Now we made separate module for measuring voltage and we can determine voltage less than 25 V. In the same way we are sending data to Arduino IOT cloud to determine voltage. We are also monitoring Battery percentage. For the last part we are using temperature sensor DH11 to monitor battery Temperature. We can monitor battery voltage up to 50 degree

Celsius and we are also monitoring humidity. We are connecting it to Arduino IOT cloud to monitor same.

IV. CONCLUSION

The proposed system is useful in monitoring and tracking the properties of the battery in real time. The battery plays a vital role in an Electric vehicle. Therefore monitoring of the Battery is very important. The project proposed a new way monitoring the battery with the help IOT. The sensors incorporated in the proposed system can collect the data of battery such as voltage, temperature and current, these data is then sent to Arduino IOT Cloud. Thus the real time data collection, storage and monitoring of the battery of an electric vehicle is possible with the system. By tracking these variables, it will be easier to determine the battery's health or longevity, and pricing will be adjusted accordingly, as a less efficient battery with a shorter life cycle will cost more than a more efficient battery with a longer life cycle. This helps in identifying and solving a problem before a failure without human dependency. In addition measured data helps to develop a battery swapping station and its price fixing.

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