COMPUTATIONALLY EFFICIENT STOCHASTIC MODEL PREDICTIVE CONTROLLER FOR BATTERY THERMAL MANAGEMENT OF ELECTRIC VEHICLE

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ABSTRACT

The temperature of the battery in an electric car is too low or too high, its performance and health go down. The gadget that controls the temperature of the battery uses a lot of electricity, especially to cool the battery. So that the car can go as far as possible, the way the battery temperature is controlled should use as little energy as possible. In this project, the battery controller is cooled with the help of a probabilistic model prediction controller. Model predictive control works best when you have a good, easy model of the system and a good way to predict what will happen in the near future. Part of the cooling system of the battery is shown to explain how energy is used and heat is moved, but some theory has been left out to make things clearer. People can get a rough idea of what will happen next by looking at how people have driven in the past. A random model of future heat production for real-time use includes a chance distribution with gaps that aren't the same size. The suggested control method keeps the temperature in a comfortable range while using much less energy than other temperature controllers, like thermostats or model prediction controllers that just guess what will happen in the future. The suggested prescient regulator beats other regulators because it uses an irregular way to predict what will happen in the future.

INTRODUCTION

Extreme temperature fluctuations pose significant challenges to the safe and efficient operation of electric vehicle (EV) batteries. Such extreme temperatures not only impact the battery's efficiency and durability but also jeopardize its safety and resistance to thermal runaway, while compromising long-term performance. The research has been conducted to understand the effects of temperature on operation battery. Notably, Yang's electrothermal battery model considers the temperature-dependent behavior of internal components, including capacity, open-circuit voltage, and resistance, highlighting the degradation and imbalance risks caused by temperature variations in lithium-ion battery cells. Wang further emphasizes the criticality of temperature control, as an uncontrolled rise in temperature could lead to battery explosions. Jarman, in his investigation, combines the drag model with the battery electric warm-up model to assess how temperature influences the range of EVs. These studies demonstrate that neglecting temperature effects can result in suboptimal range performance, leading to either excessively short or long ranges. As EVs rely on battery power for propulsion and charging while stationary, the battery undergoes Joule heating during vehicle operation, necessitating effective temperature control mechanisms. Furthermore, limited range remains a concern for many EV drivers, primarily due to the lower energy density of the power source, longer charging times, and inadequate charging infrastructure compared to conventional vehicles. The energy required to maintain optimal battery temperatures further reduces the overall range of EVs. According to the Argonne National Laboratory, the heating, ventilation, and air conditioning (HVAC) systems in EVs can reduce mileage by up to 40%. In order to improve the safety and range of electric vehicles, it is essential to reduce the amount of energy required for battery thermal management.

OBJECTIVE AND PROBLEM STATEMENT

OBJECTIVES

The primary objective of this master's thesis is to develop a BTMS model for harmonising the various cooling and heating circuits within the battery pack to meet performance standards. Before starting the modelling, the needs of the battery pack will be looked into through a review of the books. Then, an idea selection matrix will be made with a list of several possible BTMSs, both in the commercial stage and the research phase, along with their pros and cons. For the next simulation, two of them will be put forward as applicants. After the models have been built with the help of the simulation tool Simulink, they will be tried in a variety of starting situations. Last but not least, the systems' performance factors will be looked at and compared.

PROBLEM STATEMENT

While hybrid electric vehicles (EVs) are currently gaining popularity, this thesis specifically focuses on battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs), which are equipped with larger battery packs compared to other EVs. To develop a computer model dedicated to regulating the temperature of the battery pack. Because of this, we don't go into depth about how battery cells make heat, and this model comes from a different place. Also, the wiring for the fridge, radiator, heater, and other systems for cooling and warming will be made easy to use. It doesn't matter if the conversation is put off, changed, or called back. We'll talk about what happened before and after, but the main points of this thesis are about how the system works and what it does during test driving rounds. They are the most important parts, so they will be closely looked at and compared.

LITERATURE SURVEY

The application of battery thermal management in electric vehicles

Guodong Xia, Lei Gao and Guanglong bi, Member, Elesiver, The battery temperature management (BTM) system is the focus of this investigation. Battery thermal management can effectively resolve this issue. Three crucial parts receive special attention in a single battery: heat production, heat transfer, and heat elimination for large cells, models with multiple scales and dimensions have been developed.

Advantages

- The ones that use forced air are easy to make, an
- The ones that use liquid are perfect at keeping the battery pack in the right temperature range.

Disadvantages

- It's hard to get the temperature of each cell to be the same.
- Systems that use liquids may have leakage problems.
- Took up space in liquid-based devices and increased their complexity.

Predictive energy management for hybrid electric vehicles

Ronghu Du, Xiaosong Hu, Shaobo Xie,Lin Hu, Zhiyong Zhang,Xiankle Linresearchdemonstrates a predictive energy management system for hybrid electric vehicles that takes battery age and temperature into consideration. On the basis of model predictive control, this method was developed and applied to urban bus service. First, because speed changes during real-world travelling are random to do.

Research directions for next-generation battery management solutions in automotive application

Xiasong Hu, Zhongwei Deng, Xianke Lin, Yi Xie Presents the researchResearch directions for the next iteration of automotive battery management solutions. This research aims to develop viable solutions for these three problems. First, the concept of multi-physics battery demonstrating is introduced, highlighting the significance of integrating mechanical, electrochemical, thermal, and ageing elements into the design of novel BMS calculations. Electrothermal modelling, advanced optimisation techniques, and predictive control enable dynamic hysteresis-sensitive, heat transfer for ultrafast charging, and preheating model in conjunction with vehicle autonomy and connectivity. Thirdly, battery models and AI effectively collaborate to predict battery life, identify its fragile components, and offer effective preventive support.

SYSTEM ANALYSIS

EXISTING SYSTEM

A stochastic model prediction controller is used to cool the battery controller in this case. A basic but dependable model of the system and a method to predict changes in the near future are required for model predictive control. Some concepts are reduced to keep things simple, but the components of the battery's cooling system are demonstrated to demonstrate how energy is used and heat is transported. People can predict what will happen next by looking at how others have driven in the past. A real-time random model of how heat will be produced in the future employs a chance distribution with varying gap sizes.

Drawbacks

Finally, stochastic models can be computationally fairly complex to implement, necessitating more in-depth statistical and computing abilities than some of the simpler deterministic models. As a result, the conclusions may be more difficult to express than in the case of simpler deterministic models.

PROPOSED SYSTEM

In this project, the suggested control method uses much less energy than an indoor regulator or a model-based regulator that just guesses what will happen in the future. But it does a good job of keeping the temperature steady no matter what. Most controllers don't work as well as the suggested prediction controller because it makes random guesses about what will happen in the future.

Advantages of proposed system

• One of the main advantages of probabilistic models is that the assumptions made are completely explicit.

• Additionally, these assumptions can be tested using a variety of techniques.

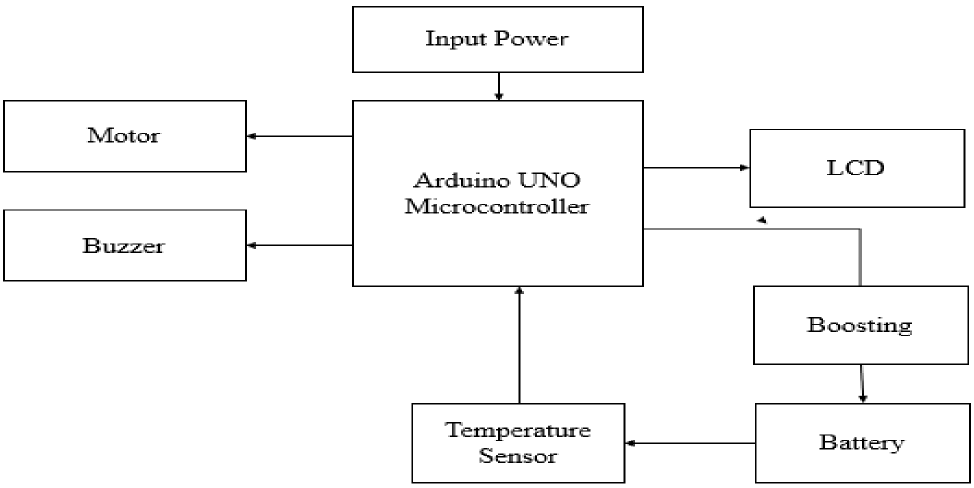
HARDWARE REQUIREMENTS

ARDUINO MICROCONTROLLER

Microcontrollers are miniature circuits designed to conduct clear functions in implanted medical devices. A typical microcontroller is a singular device containing a processor, memory, and I/O peripherals. In addition to a minuscule amount of RAM, chips typically include programmed memory in the form of ferroelectric RAM, NOR Flash, or OTP ROM. In contrast to the microchips used in PCs and other universally useful devices, which comprise of multiple discrete circuits, microcontrollers are designed for implanted applications. A microcontroller is comparable to a system-on-a-chip (SoC) in modern applications, but it lacks intelligence. SoCs can connect external microcontroller processors to the motherboard, but their internal microcontroller unit circuitry is composed of advanced peripherals like WLAN-Fi interface controllers and graphics processing units (GPUs).

CONTROLLER DESIGN

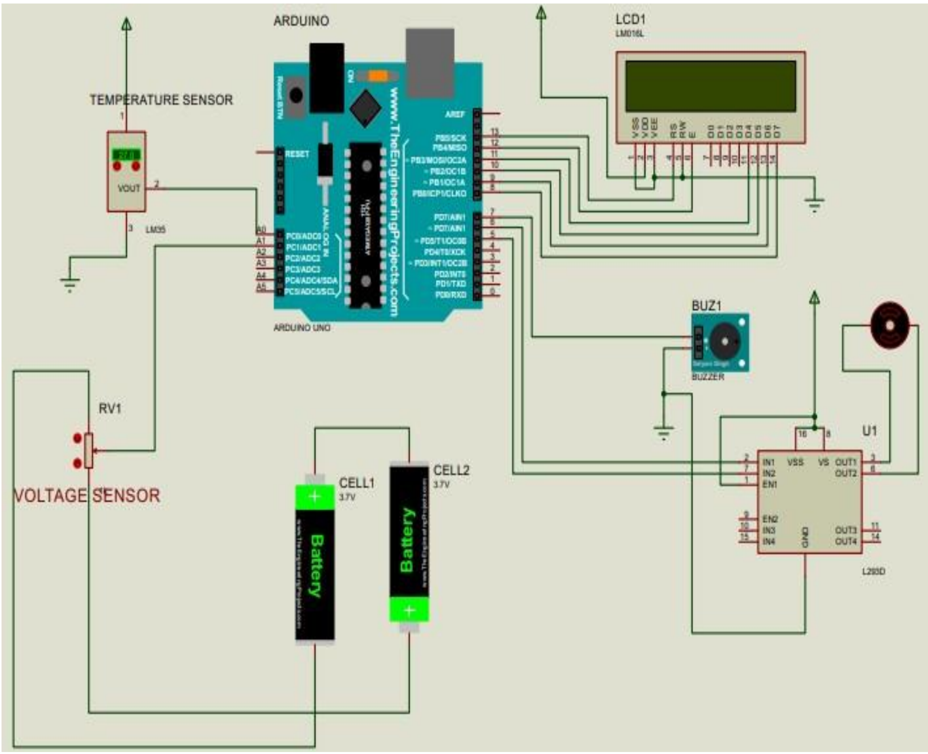
SYSTEM BLOCK DIAGRAM



EXPLANATION

The micro controller's job is to watch and control the data from the temperature gauge and switch the battery source at the same time. Once the battery is charged, the voltage stabilizer will show what temperatures are normal and what temps are not normal. Increasing the power of the battery will make the task of heat If the temperature is going to be different than usual, the battery is used. Switching frequency is stopped

CIRCUIT DIAGRAM



EXPLANATION

In the circuit diagram, the voltage sensor is connected across a subset of the battery cells, and the temperature sensor is placed near the battery pack. Both sensors are connected to the microcontroller's analog input pins. The buzzer and LCD are connected to the microcontroller's digital output pins. The microcontroller continuously reads the voltage and temperature data, processes it, and controls the buzzer and LCD based on predefined thresholds or algorithms. Additional circuitry, such as voltage level shifters, amplifiers, or signal conditioning circuits, may be required depending on the specific sensors and microcontroller used. Safety features like overvoltage protection and temperature monitoring for the microcontroller and other components may also be included to ensure safe operation of the battery thermal management system.

RESULT AND DISCUSSION

Implementing an EV battery Thermal monitoring system, you can increase the reliability, safety, and lifespan of the battery while optimizing its performance. This enables better management of electric vehicles, reduces maintenance costs, and enhances the overall user experience.. Battery thermal management systems play a crucial role in ensuring the safe and efficient operation of batteries. By actively managing the temperature of batteries, these systems offer several benefits and outcomes, including:

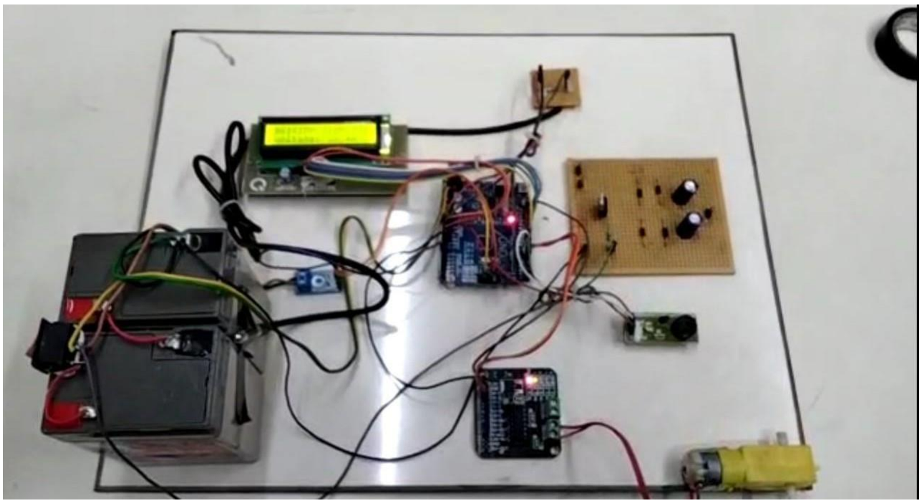


Figure (1) : Hardware module

Electric vehicle battery monitoring which displayed im LCD.

Figure (2) : EV Battery moniter

In electric vehicle battery temperature level at 29 ℃ in normal condition .

Figure (3) : Temperature level at 29℃

In electric vehicle battery temperature level at 33 ℃ in normal condition .

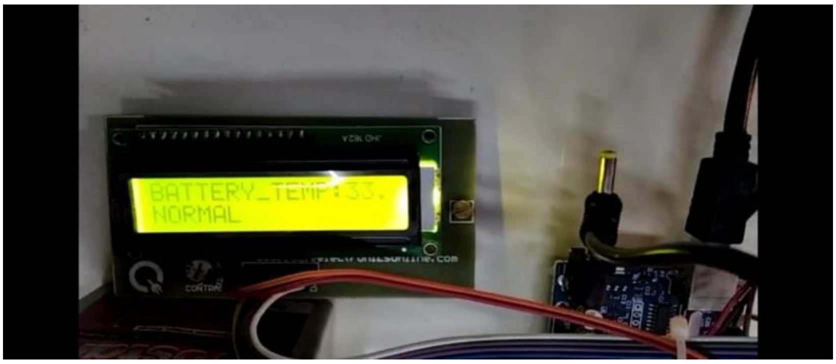


Figure (4) Temperature level at 33℃

In electric vehicle the battery temperature level increase above 33 ℃ it turn to abnormal condition.

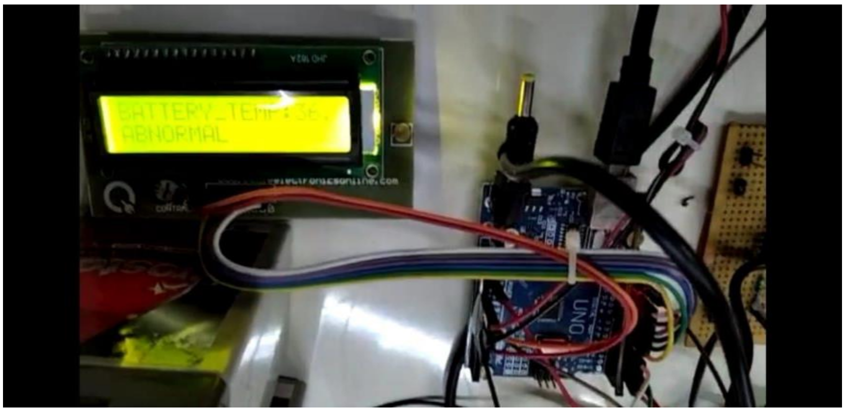


Figure (5) : Battery temperature at abnormal condition .

Enhanced Safety: Battery thermal management helps prevent overheating and thermal runaway, which can lead to battery failures, fires, or explosions. By maintaining the battery within a safe temperature range, the risk of thermal-related accidents is significantly reduced.

Extended Battery Life: Operating batteries within the recommended temperature range helps extend their lifespan. High temperatures can accelerate the degradation of battery materials, reducing capacity and overall performance. Effective thermal management minimizes the impact of temperature on battery health, leading to longer-lasting batteries.

Improved Performance: Batteries perform better at optimal temperatures. Cold temperatures can increase internal resistance, reducing the battery's ability to deliver power. On the other hand, excessive heat can cause voltage drops and power loss. Battery thermal management ensures that the battery operates at the ideal temperature, maximizing its performance.

Fast Charging and Discharging: Proper thermal management enables faster charging and discharging rates. By controlling the temperature, the battery can be kept within the optimal range for efficient charge acceptance and power delivery. This is particularly crucial for electric vehicles and portable electronics, where quick charging is desired.

Consistent Operation: Battery performance can be affected by temperature fluctuations. Thermal management systems help maintain a stable temperature, ensuring consistent operation and reliable performance of the battery over time and in varying environmental conditions.

Increased Capacity and Power Output: Optimal temperature control allows batteries to utilize their maximum capacity and power output. By preventing overheating or cold-induced performance limitations, thermal management systems enable batteries to deliver their rated capacity and power consistently.

It's important to note that the effectiveness of battery thermal management depends on various factors, including the design and implementation of the system, the specific battery chemistry, and the operating conditions. Proper engineering, monitoring, and control are essential to achieve the desired outcomes and maximize the benefits of battery thermal management.

CONCLUSION

In this work, we told the best way to make a probabilistic model prescient regulator for battery cooling that functions admirably with PCs. The cooling system for the battery had to keep the battery at the right temperature while using as little energy as possible. As a result, an effective control-based approach was required. With only a slight increase in PC load, the proposed control strategy improved performance significantly. There are numerous benefits to these systems, including more power and storage, quicker charging and discharging, improved performance, a longer battery life, and improved safety To avoid thermal runaway, overheating, and the associated dangers to safety, a thermal management system actively regulates the temperature of the battery. By maintaining the battery within the recommended temperature range, minimizing the effect of temperature on battery health and maximizing energy efficiency, it also helps optimize battery performance.

Applications like electric vehicles, renewable energy storage systems, consumer electronics, and industrial processes all require effective battery thermal management. To get the best results and get the most out of battery thermal management, a thermal management system needs to be designed, built, monitored, and controlled correctly.

Thermal management technologies like integrated battery management systems, intelligent and adaptive systems, advanced cooling solutions, and active thermal control will continue to improve battery thermal management's effectiveness and efficiency in the future. expected to get to the next level. Overall, battery thermal management is essential for maximizing battery performance, extending battery life, ensuring safe and dependable operation, and advancing and promoting battery-powered applications in a variety of industries.

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