ELECTRIC VEHICLE BATTERY MANAGEMENT SYSTEM (CEIES PROJECT)

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TEAM NO.: 18 **SPRING 2025 INTAKE**

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EE 499 SENIOR DESIGN PROJECT
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JEDDAH – SAUDI ARABIA

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A senior design project report submitted in partial fulfillment of the requirements for the degree of

Bachelor of Science
in
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King Abdulaziz University, Jeddah, Saudi Arabia

Checked and Approved by the Advisor:

Advisor Name: Prof. Khalid Munawar

Signature: Khalid Munawar

Date: 20/2/2025

ABSTRACT

Electric Vehicle Battery Management System (CEIES Project)

Because of their high energy-to-mass ratio and resilience to demanding cycles of charging and discharging, lithium-ion (Li-Ion) batteries are the most widely used energy storage technology in electric vehicles (EVs), which have emerged as a key component of sustainable transportation. However, improper management of (Li-Ion) batteries can lead to rapid deterioration and safety hazards such as thermal runaway. This emphasizes how important it is to have a smart Battery Management System (BMS) to guarantee safe, effective, and optimal battery functioning. Thus, an electronic device that controls a rechargeable battery is called a Battery Management System (BMS). By keeping an eye on the battery's voltage, current, temperature, and charge level, it guarantees safe functioning.

Through the design and implementation of a comprehensive (BMS) that incorporates cutting-edge functions, this project tackles the difficulties associated with managing (Li-Ion) batteries. The technology integrates regenerative braking energy recovery to improve total energy consumption in addition to controlling charging and discharging cycles to optimize efficiency and prolong battery life. Predictive models are created to forecast battery health, longevity, and efficiency, and intelligent algorithms are used to monitor important characteristics like the State of Health (SoH) and State of Charge (SoC).

The process entails creating a comprehensive simulation model to reproduce different charging and discharging stages using simulating programs such as MATLAB/Simulink. Furthermore, power electronics are managed by intelligent control algorithms that guarantee exact switching times for peak performance. Both software and hardware implementations are included in the finished product, which has an effective embedded system with real-time monitoring and control capabilities. This project's distinctive accomplishments are found in the way it combines intelligent control, energy recovery, and predictive analytics into a unified (BMS) platform. In addition to satisfying the technical specifications of contemporary EVs, this system establishes a standard for upcoming developments in battery management technology.

Index Terms — Battery Management System (BMS), Lithium-Ion Batteries, State of Charge (SoC), State of Health (SoH), Regenerative Braking, Energy Recovery, Predictive Analytics,

ACKNOWLEDGEMENT

To everyone who helped us finish this project successfully, we would like to extend our sincere gratitude. Above all, we would want to express our profound gratitude to our project adviser for their essential advice, knowledge, and unwavering support during the development process. Their advice and observations were very helpful in determining the course of this effort.

We also want to express our gratitude to our family members for their constant support and patience over the many hours spent on this endeavor. Their encouragement gave us the drive to overcome obstacles and accomplish our objectives. We are especially grateful to the lab engineers and teachers that offered technical support, resource access, and a supportive environment for development and testing. Their assistance was essential to the hardware and software components' effective deployment. Lastly, we thank organizations and businesses whose platforms and technologies, like MATLAB/Simulink, allowed us to create and verify our simulation models. This initiative has benefited greatly from their contributions to the field of electric car technology. This achievement would not have been possible without the collective efforts of all those mentioned above, and we are deeply appreciative of their support.

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CHAPTER – 1 INTRODUCTION

1.1 BACKGROUND

Electric vehicles (EVs) are the forefront of the global innovation effort to transition toward sustainable transportation, driven by the need to reduce greenhouse gasses which petrol vehicles represent a big percentage of the total emissions, and dependence on fossil fuels. Lithium-ion (Li-Ion) batteries have been adopted as the preferred energy storage solution for EVs due to their high energy density, long cycle life, and ability to deliver high power output. However, despite their advantages, (Li-Ion) batteries present significant challenges, including safety risks, performance degradation, and complex controlling mechanisms.[1]

The physics and chemistry of (Li-Ion) batteries involve intricate electrochemical processes that require precise control to ensure optimal performance and longevity. Controlling parameters such as State of Charge (SoC), temperature, current, and voltage is key in preventing overcharging, deep discharging, or thermal runaway, which can lead to catastrophic failures.[2] However, the monitoring of such parameters can't be done without an assembly of battery cells electrically arranged to enable the delivery of an intended spectrum of voltage and current that is called a battery management system (BMS).[3] As illustrated in Figure 1

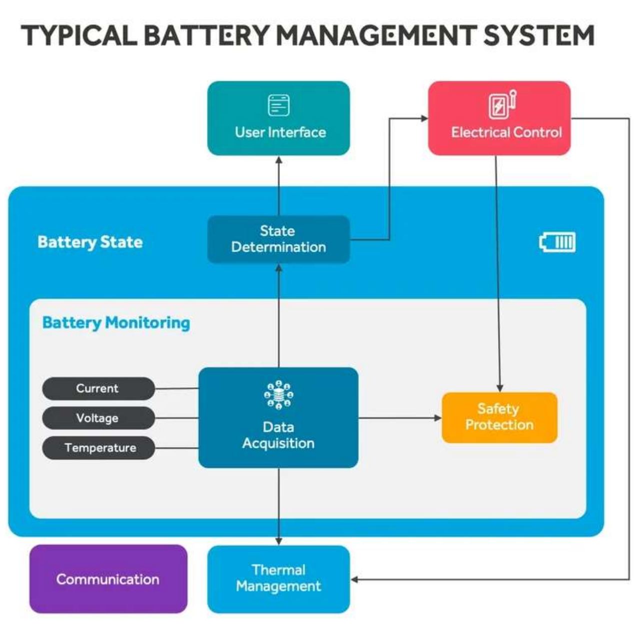

Figure 1: Visual conception of a BMS Device

Furthermore, the integration of regenerative braking systems, which convert kinetic energy during deceleration into electrical energy, adds another layer of complexity to the (BMS).[4]

Recent statistics highlight the growing adoption of EVs, with global sales surpassing 14 million units in 2023 alone with 35% sales growth with each year.[5] This rapid growth indicates the need for an advanced (BMS) that can ensure the safety, efficiency, and reliability of EV batteries.

1.2 PROBLEM STATEMENT

(Li-Ion) batteries are highly sensitive to improper charging and discharging cycles, so a system is needed to help in preventing deterioration and thermal runaway of the battery. Additionally, the integration of regenerative braking systems, while beneficial for energy recovery, introduces further complexity to battery management.

1.3 PROJECT OBJECTIVES

High-Level Objectives:

1. Enhance the Safety and Reliability of Electric Vehicles By developing an intelligent (BMS) that mitigates the risks associated with (Li-Ion) batteries, such as thermal runaway and premature degradation.
2. Promote Sustainable Transportation By improving the efficiency and lifespan of EV batteries and powertrain, thereby reducing waste and supporting the global transition to clean energy.
3. Advancing the EV technology in the Kingdom becoming a leading country in the industry

Lower-Level Objectives:

1. Design and implement a hardware and software system capable of real-time monitoring and control of battery parameters (SoC, SoH, temperature, voltage etc.).
2. Develop a simulation model using MATLAB/Simulink to replicate various charging and discharging states, including regenerative braking energy recovery.
3. Implement intelligent control algorithms to manage power electronics and optimize switching timings for charging, discharging, and energy recovery.
4. The (BMS) system should be able to withstand High voltage, High current (280v to 1000v)/ (10A to 100A).

1.4 PRODUCT DESIGN SPECIFICATIONS (PDS)

Musts:

- Hardware and software implementation of the complete system with an efficient embedded system with these features: Cell balancing, Real-time monitoring of battery SoC, SoH, temperature, and voltage.
- Complete simulation model on MATLAB/Simulink or some other platform.
- Be able to extract energy from regenerative braking

Wants:

- LCD Display showing SoH, SoC and other parameters
- Integration with vehicle-to-grid (V2G) systems for bidirectional energy flow.
- Remote monitoring and control through a mobile application.
- This (BMS) is to be installed in a real-world commercial vehicle.
- Implementation of machine learning algorithms for intelligent battery management.
- Custom PCB

Constraints:

- Simulation may not be exactly proportional to the real system
- SAR5000 budget for hardware components and testing equipment.

Engineering Standards:

1. ISO 26262: Functional safety for road vehicles.
2. SAE J2929: Safety standard for lithium-based rechargeable batteries.
3. SASO 02-04-18-166: Technical Regulation of Electrical Batteries

Assumptions:

1. A battery should be provided with the availability of high-fidelity battery data for model training and specifications.
2. The simulation model may not represent real-world operating conditions.
3. The embedded system has sufficient computational power to run control algorithms and predictive models in real-time.
4. EV charging unit

Project Deliverables:

1. A fully functional hardware and software system of the (BMS).
2. A complete simulation model on MATLAB/Simulink.
3. Documentation including design specifications, test results.
4. A final report detailing the project's methodology, achievements, and recommendations for future work.

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APPENDIX – A: EVALUATION COMMENTS

Insert the evaluators' comments for each of the evaluation stages.

A.1 IDENTIFYING THE PROBLEM AND DESIGN REQUIREMENTS

A.2 CONCEPTUAL DESIGNS

A.3 TERM 1 REPORT AND PRESENTATION

A.4 PROGRESS UPDATE

A.5 FINAL REPORT AND PRESENTATION

APPENDIX – B: EFFECTIVE TEAM INTERACTIONS

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Meeting Minutes

Date:	10/2/2025
Team:	18
Project Title:	ELECTRIC VEHICLE BATTERY MANAGEMENT SYSTEM (CEIES PROJECT)

Attendees:

Member 1:	Mohammed Alsaiari	Signature:	Present
Member 2:	Mohammed Samkari	Signature:	Present
Member 3:	Mohammed Baaboud	Signature:	Present
Advisor:	Prof. Khaled Munawar	Signature:	Khalid Munawar
Customer:	Prof. Khaled Munawar	Signature:	

Agenda:

- What is the project about?
- How can we implement the project?
- What are the specifications of the project?

Discussion Points:

- Musts/Wants alongside constraints.
- CEIES Funding the project.
- How electric vehicles work.
- What types of batteries are to be used and considered.

Follow-up of the Last Meeting:

-

Decisions Taken:

- Do the report with the notes considered in mind and after meeting up together.

Actions to do before next meeting:

- Write down all the components that we are going to use for the project.

Date:	17/2/2025
Team:	18
Project Title:	ELECTRIC VEHICLE BATTERY MANAGEMENT SYSTEM (CEIES PROJECT)

Attendees:

Member 1:	Mohammed Alsaiari	Signature:	Present
Member 2:	Mohammed Samkari	Signature:	Present
Member 3:	Mohammed Baaboud	Signature:	Present
Advisor:	Prof. Khaled Munawar	Signature:	Khalid Munawar
Customer:	Prof. Khaled Munawar	Signature:	

Agenda:

- Report #1 Advisor notes.
- Derivable product.
- Components needed.
- Standards to be considered.

Discussion Points:

- Taking advisor notes regarding Report #1.
- Discussion about the implementation components and requirements.
- What type of nationwide standards are to be considered and is there a number of standards to achieve?

Follow-up of the Last Meeting:

- Implementation of brainstorming for Musts/Wants, Objectives to be achieved and Constraints.

Decisions Taken:

- Finalise the report with the notes taken.

Actions to do before next meeting:

- Write down all the components that we are going to use for the project.