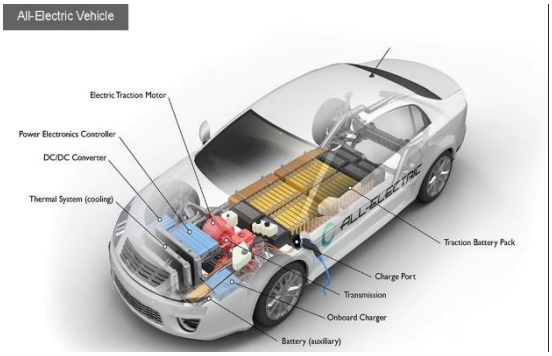
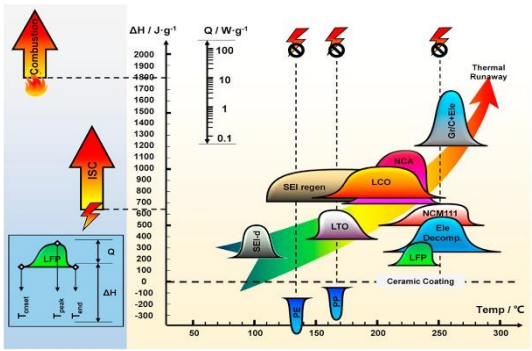
Project Title:

Battery Life Predictions and Lifespan Improvements for Electric Vehicle Batteries

Introduction:

Regarding the environment and sustainability, the world has increasingly turned to electric vehicles (EVs) as an alternative to traditional internal combustion vehicles. EVs have become a significant focus in the automotive market in recent years. Globally, there has been a significant shift towards sustainable transportation, and India is also gearing up with ambitious targets to reduce carbon emissions and transition towards a cleaner and more sustainable future. The country's mobility mission aims to achieve 100% EVs on the road by 2030, a crucial step towards realizing this vision. The Indian EV market has historically faced challenges such as high costs, limited model availability, and a scarcity of charging stations. Reports indicate that the battery alone constitutes nearly 20% of the total vehicle cost. Additionally, thermal runaway and fire incidents involving batteries pose significant risks for EV users. Addressing these challenges is essential to enhance battery safety and improve user experience. Accurate prediction of the battery life cycle from its early stages of usage is critical for user safety and reliability. Moreover, it can be economically beneficial for users and suitable for reuse purposes. This initiative is expected to attract more customers and boost EV sales in India.





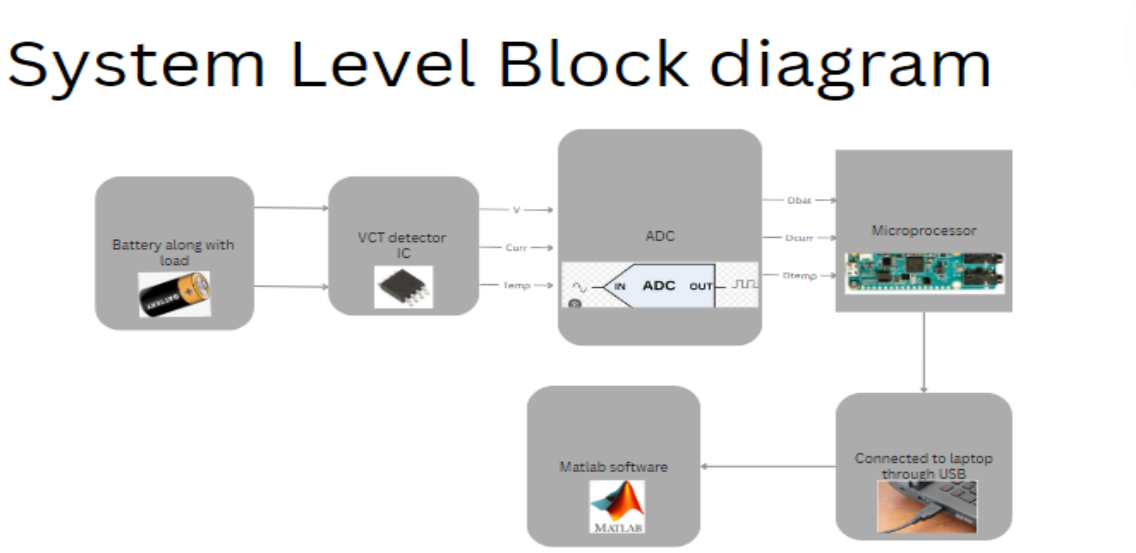
Problem Statement:

In today's EV market, both cost and safety are critical factors for success. The primary energy source for EVs, the battery pack, represents a significant portion of the vehicle's overall cost and poses major risks for thermal runaway. Optimizing these issues is a considerable challenge for the EV industry. This project explores how current technology can be used to optimize these issues and predict battery degradation early, allowing for proactive safety measures.

Solution:

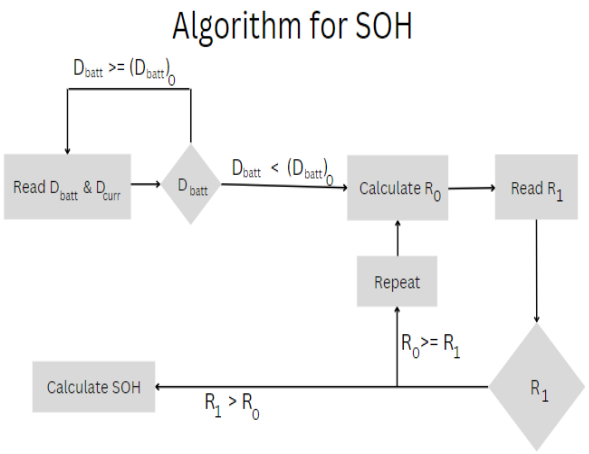
Predicting State-of-Health (SOH) of a Battery

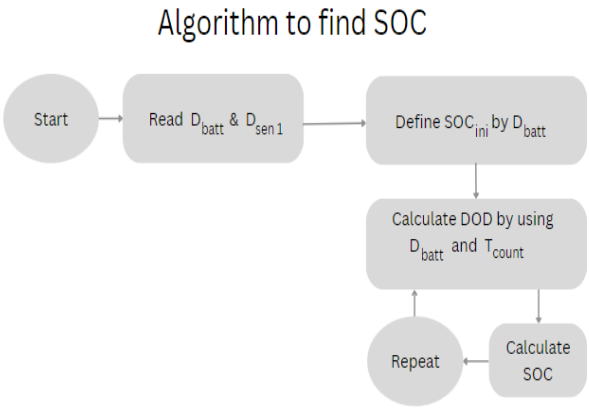
The State-of-Health (SOH) is a critical criterion for battery life prediction. It indicates how much a battery has degraded and its current condition. We propose developing an algorithm to measure the SOH of the battery and indicate a maximum SOH threshold below which the battery should not be used (typically 80% for most EV batteries).



Explanation of Each Block:

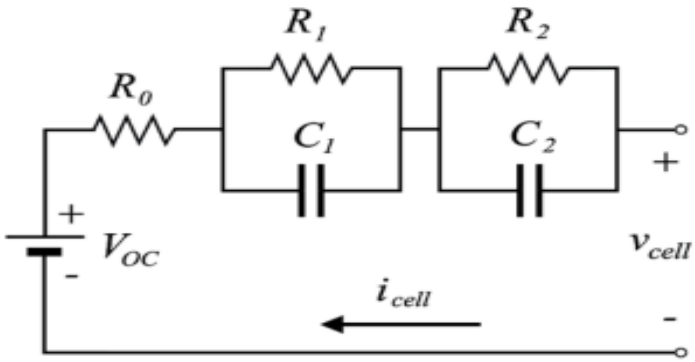
- **Battery with Load:** A known chemistry battery is used and connected to a load for discharging. The terminals are connected to an integrated circuit (IC).
- **VCT Detector IC**: An IC that can detect voltage, current, and temperature with inbuilt sensors is chosen. It outputs analog signals for voltage, current, and temperature.
- **Analog to Digital Converter (ADC):** The analog signals are converted to digital signals for higher precision, resulting in digital voltage, digital current, and digital temperature readings.
- **Microprocessor:** The digital data is fed to a microprocessor.
- **Data Transfer:** The data is transferred for simulation using a USB connection.
- **MATLAB Software:** The data is read and processed in MATLAB to develop a Simulink model that takes voltage, current, and temperature as inputs. Using the algorithm, we can predict the state of the battery.





Improving Battery Lifespan

This solution allows us to identify degradation in specific parameters of the cell. We consider an equivalent circuit model and observe changes in waveforms of R_o, R_1, and R_2 to conclude which parameter has degraded.



Changes in Equivalent Circuit Model (ECM) Parameters:

- **Increase in R_o**: Indicates reduction of two charge transfer constants (i_{oon} & i_{oop}).
- **Increase in R_1,C_1**: Indicates a decrease in catalytic properties.
- **Increase in R_2,C_2**: Indicates degradation of solid-phase diffusivities (D_{sn}, D_{sp}). The main advantage is early detection of battery degradation, preventing further damage.

Uniqueness of the Project:

- **Partial Battery Pack Analysis**: The project does not require a complete battery pack for analysis; a single battery can be analyzed.
- **Interchangeable Batteries:** The battery can be replaced with another battery of different chemistry for a comparative study to select a better battery pack.
- **Deep Learning:** We aim to use deep learning for state estimation of the battery, which will provide more precise and accurate results.

Objectives / Our Agenda:

- **Detect Early Battery Degradation:** Estimate the state of the battery and improve its lifespan by identifying causes of degradation.
- **Enhance EV Usage:** Minimize the disadvantages of EVs to enhance their usage and contribute to sustainable development in India.

Deliverables:

- **Algorithm Development:** Create an algorithm to measure the SOH of batteries.
- **SOH Threshold Indication:** Implement a mechanism to indicate the SOH threshold below which batteries should not be used.
- **MATLAB Simulink Model:** Develop a Simulink model for battery state prediction.
- **Degradation Analysis:** Identify degradation in battery parameters using an equivalent circuit model.
- **Deep Learning Integration:** Incorporate deep learning for more precise state estimation.

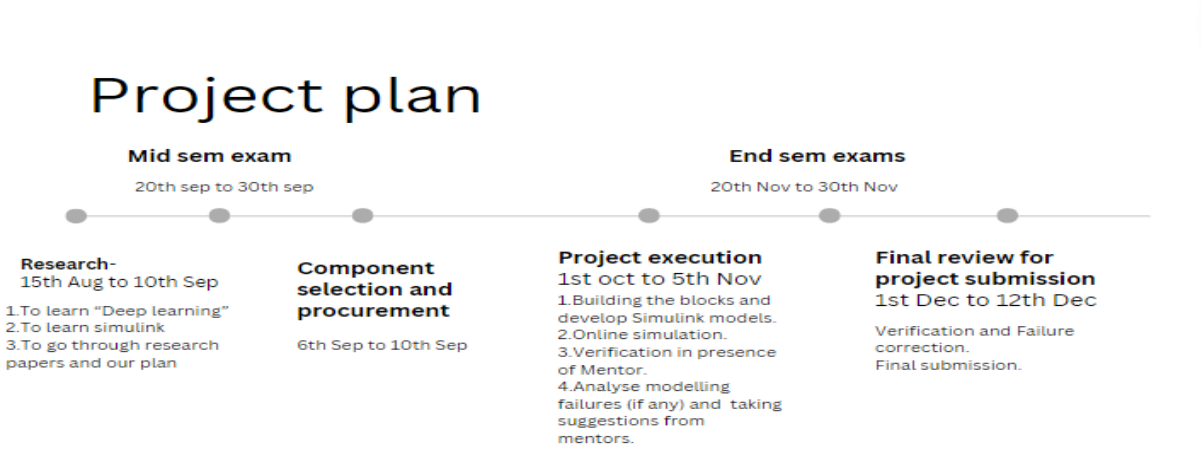
Limitations:

Data Requirements: Deep learning requires extensive data related to batteries and their datasheets of many cells.

Hardware and Software Used

- Li-ion Battery
- VCT Detector IC (e.g., BQ40Z50-R2)
- 3-Channel 10-bit ADC
- Microprocessor
- MATLAB Software
- Arduino
- Deep Learning

Plan to take this project ahead:



Note- our college exam dates are tentative.

References:

1.Link To Reference 1

2.Link To Reference 2

About Our Team:

Our team consists of five passionate pre-final year undergraduate students from Electrical, Electronics, and Mechanical branches, along with a faculty mentor with EV industry knowledge.