Automated Lithium-Ion Battery Characterizer

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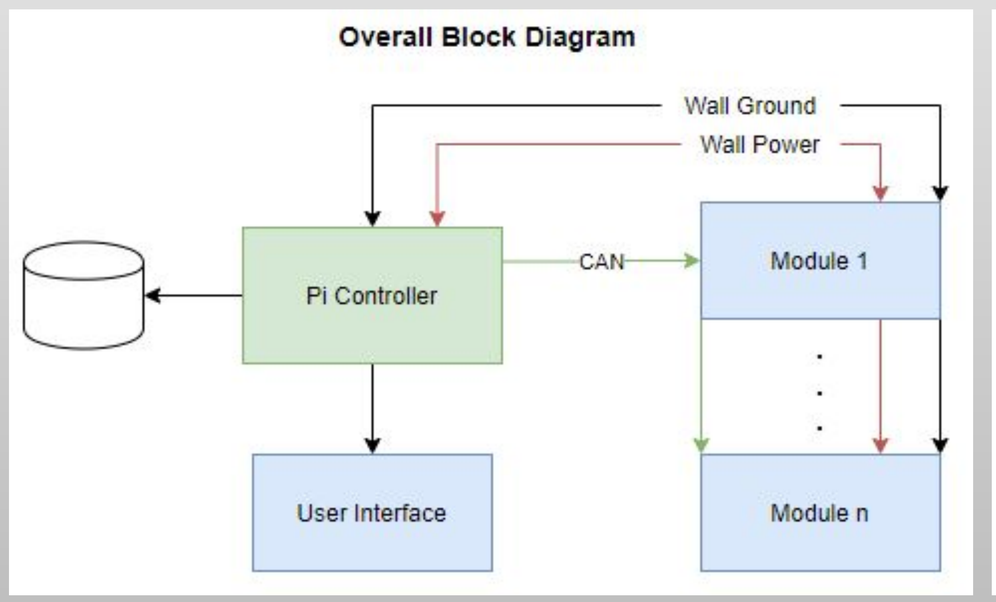
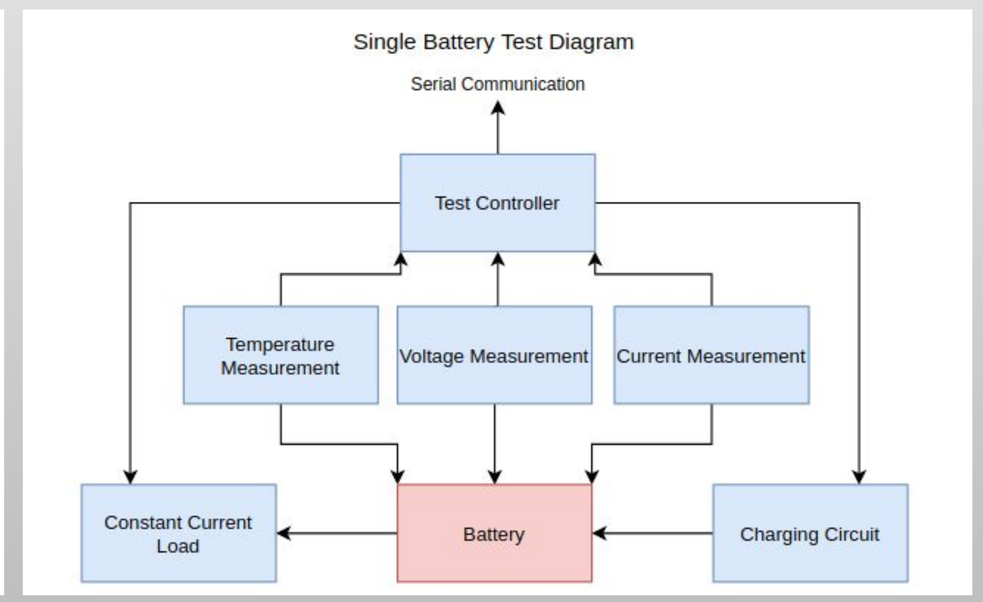
Problem & Need Statement:

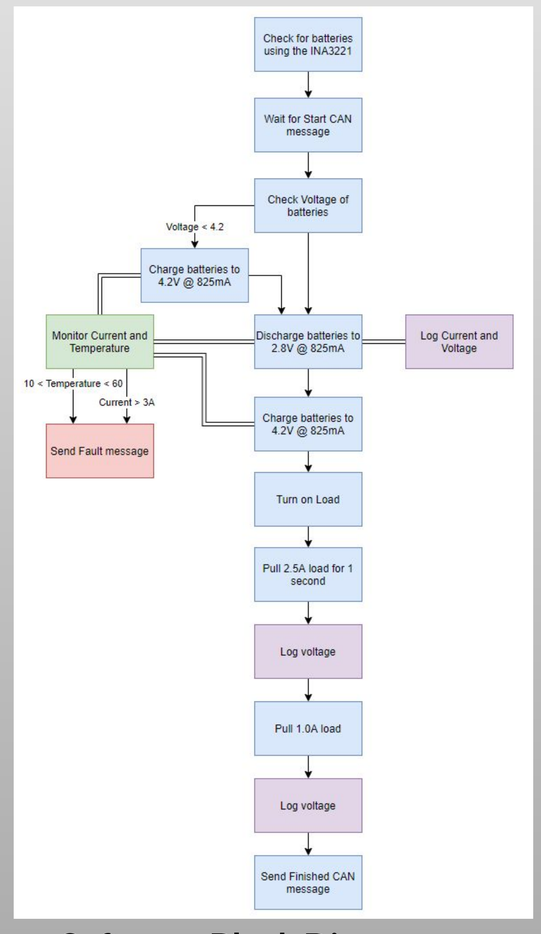
An important step in lithium-ion battery pack manufacturing is to have an accurate characterization of the charging and discharging curves for every battery cell before it goes into a parallel module. This allows for the grouping of similar performing batteries into each module, which ensures that the batteries in a module will charge and discharge at similar rates, improving the efficiency of the pack. PrISUm Solar Car currently does not have a reliable method for performing this characterization and is proposing that we develop a system that can address this need. Our proposed solution to this problem would be making a device that would charge and discharge the batteries and graph the current and voltage characteristics. To help group battery cells, the device would also be able to remember which cells were characterized and store that information somewhere accessible.

Design Approach:

The design was divided into several main components. This included the web app that served as a user interface, the data base for all battery test data, the main controller which consisted of a raspberry pi, and the test board that took battery measurements during testing. The test board itself was broken down into several components such as charging, the load circuit, power distribution, and measurement.
The Pi controller initiates tests conducted by the test modules and receives data via CAN communication it is then sent to an SQL database to be viewed in the web app. Below are diagrams showing this system level functionality as well as hardware and software block diagrams.





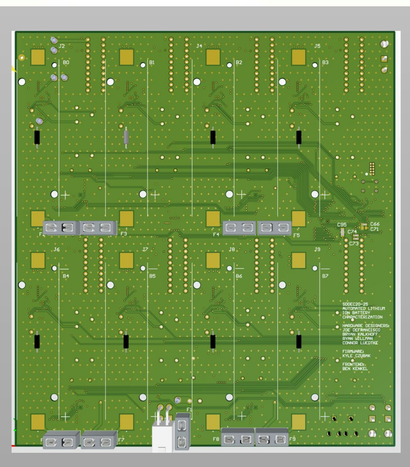


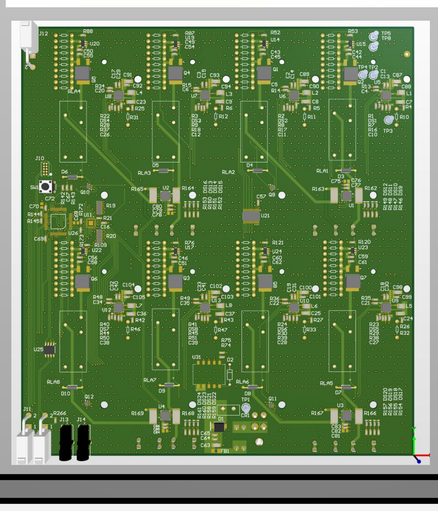
Software Block Diagram

System Block Diagram(Top)

Hardware Block Diagram(Top)

PCB Design Top View(Right)





PCB Design Bottom View(Left)

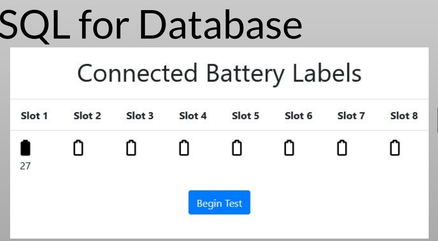
Design Requirements:

- ***Functional***
  - Characterize 8 lithium-ion batteries safely
  - Store the battery information and a way to analyze data in the future
  - Safely operate unsupervised
- ***Non-Functional***
  - Compute the capacity and internal resistance of each of the batteries
  - Batteries should not operate outside of temperature specifications as listed in JEITA guidelines
  - Must finish battery characterization in under 24 hours
- ***Environmental Requirements***
  - Room temperatures between 10 C and 30 C
  - Humidity between 20% and 80%

Technical Details:

Software and Libraries

- Gitlab
- C and Python programming languages
- Altium Designer
- SQL for Database



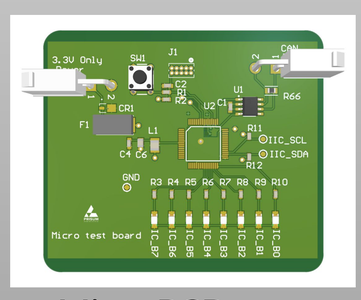
Python GUI

Project Resources and Standards:

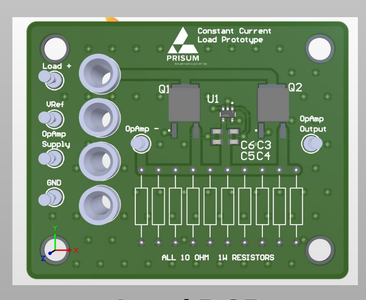
- Agile Development
- IEEE 1679.1-2017: IEEE Guide for the Characterization and Evaluation of Lithium-Based Batteries in Stationary Applications
- JEITA Battery Guidelines
- Total Cost : $400

Testing:

- Run Testing in Coover Lab
  - Oscilloscope
  - Multimeter
- Measure Voltages and Waveforms
  - I2C
  - Can Bus
  - Various PCB Test Points
- Prototype PCBs
  - Microcontroller
  - Load Circuit



Micro PCB



Load PCB

Intended Users and Uses:

- The project is intended to provide the ability to characterize batteries to optimize Lithium-Ion battery packs' efficiency and longevity
- Non-Professionals: Most people that are not in industry skip the characterization part of designing a battery pack due to no viable market solution. As larger-scale battery pack design is becoming more feasible due to declining lithium battery costs, it is becoming increasingly feasible to make large battery packs, which results in an increasing need for proper battery characterizing methods.