ELECOMP CAPSTONE
VIRTUAL SUMMIT
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THE UNIVERSITY OF RHODE ISLAND

THINK BIG WE DO™

AM-BATS Part Deux

Investigating battery cell performance and health

EAGLEPICHER TECHNOLOGIES

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Project Motivation

EaglePicher specializes in providing battery solutions for very demanding applications. Their batteries are frequently required to perform at extremes in temperature, vibrations, power delivery and service life. Achieving the performance that their customers demand requires advancements in the tools and methods used to evaluate battery cell designs, integrated with the battery management systems to control them. Tradeoffs typical in BMS product designs create limitations that make laboratory instrumentation challenging. A battery management system with the ability to collect high fidelity performance telemetry could prove invaluable in evaluating battery cell designs. Illuminating the unique characteristics of candidate battery cells will aid in establishing the minimum requirements for a deliverable BMS design. Ultimately, a better understanding of cell characteristics, and how those characteristics can be observed and interpreted by the BMS, is the next step in optimizing the use of the batteries in both first and second life applications.

Key Accomplishments

Key Component Selection: Researched and selected components within power specifications dictated by the design. Completed a bill of materials for the majority of the components needed to run data collection with an electronic load supply.

Data Collection Systems: Our project's main objective is to be able to compare the data collected from a commercial off the shelf (COTS) BMS system to a real time data acquisition system. We researched data collection systems and chose the National Instruments DAQ due to its high 24-bit resolution and high sampling rate. The Orion BMS 2 was chosen over the foxBMS as a good representation of a widely available COTS BMS.

Temperature and Current Measurement: Designed circuitry to allow us to measure the temperature of the battery cells and the current going in or out of the battery pack. This circuitry includes the necessary signal conditioning required to put the measured output voltages in a readable range. We designed a buffer amplifier and voltage divider circuit to read the temperature. We designed signal conditioning for the current sensor to operate on a 10V scale to represent the range of current (0-10A) from the battery pack.

Programmable Load Design: Designed a programmable load with eight channels that is capable of creating 256 different current levels between 0 amps and 10.24 amps. Simulated a working load profile circuit with non-ideal components.

Test Fixture Design and Assembly: Created battery testing system fixture **(Fig 1).** that has allowed us to house 12 18650 cells and run rigorous tests on them using multiple load profiles. This Test fixture consists of a BMS, DAQ, battery cells, a load supply, multiple Power supplies, contacter, fuse and current sensor, all of which are connected through our PCB.

PCB Design: Designed a printed circuit board that houses the battery cells and all necessary circuitry required to measure the cell voltages, temperatures, and the pack current. The PCB also allows for clean wire management as all external connections are routed through headers, including all the connections needed to the DAQ and BMS.

Data Organization: As our data collecting system has yet to be fully developed and running, a Fake Battery Data Set was created to allow us to begin our Machine learning efforts. Data was organized and normalized in a way that would allow us to use Starting State of Charge and Ambient Temperature to calculate damage on battery cells through different load cycles..

Machine Learning (ML) Model Selection: Our goal is to utilize Starting State of Charge and Ambient Temperature to predict optimized values to output the least damage on battery cells. This was planned to be achieved by creating a Stochastic Gradient Descent optimization Model that will allow us to find the global minimum pointing us in the direction of the most optimized SOC and Temperature values.

ML Model Training, Calculating accurate loss and Fitting Equations: Implemented Stochastic gradient descent methods to create a model. Compiled and trained model, and the loss was calculated using mean squared error. Loss was on average with what SOC and Ambient loss is. This allowed multiple accurate fitting models to be produced **(Fig 2.).**

Orion BMS: Created a block diagram and documented all connections between the BMS, Thermistor Expansion Module(TEM), PCB and PC. Wired all connectors for the BMS and soldered the termination for the CAN bus. Configured BMS software to read and collect live data **(Fig 3.).**

National Instruments DAQ: Connected National Instruments modules to PCB Test fixtures and made sure all channels were running tests correctly. The DAQ was made up of two voltage modules one used to record cell voltages and the other to measure cell temperature and current.

Anticipated Best Outcome

Our Anticipated Best Outcome for AM-BATS Part Deux, is to design and build a battery management system platform to investigate battery cell performance for demanding applications. This will include the ability to synthesize the charge and load characteristics for a variety of applications. Using the AM-BATS platform, demonstrate the safety protocols and performance of Li-Ion batteries in various applications. EaglePicher will provide usage profiles ranging from electric bikes, to vehicles, to directed energy weapons and hybrid load conditioners. Identify the correlation between BMS measurements and the prediction of aging for various cells and usage profiles.

Project Outcome

The Anticipated Best Outcome was achieved. Our battery testing system was built and fully functional and the Machine Learning Models trained and outputting the correct outcomes. This will allow next year's team to start with collecting data and a great starting point to advance with the ML efforts.

Figures

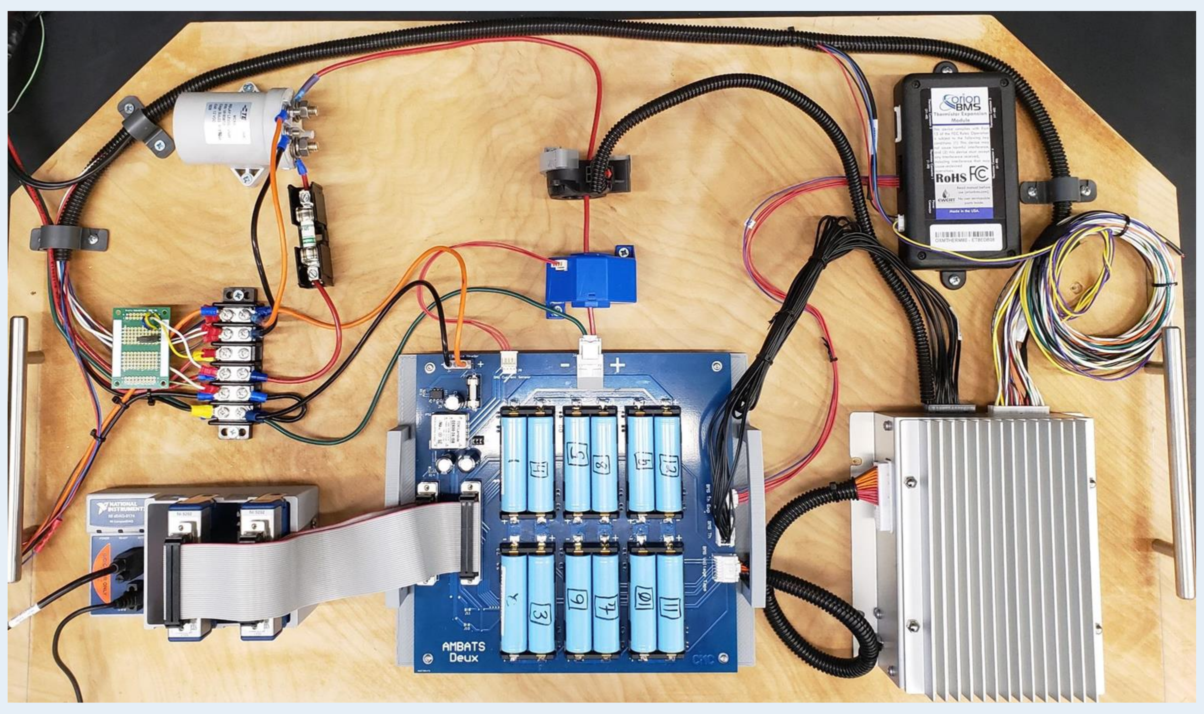

Fig 1: Battery Testing Fixture

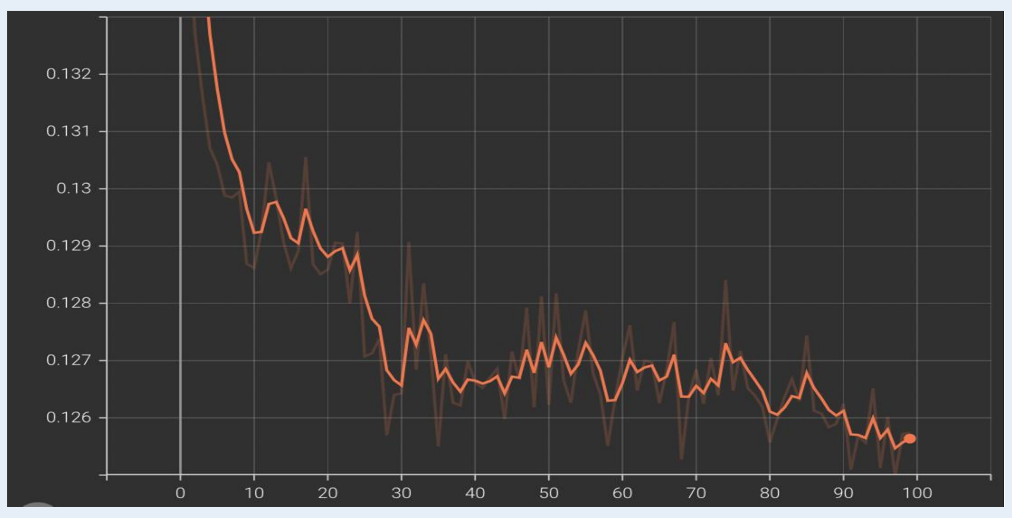

Fig 2: Trained SGD Model Improving Loss Calculations

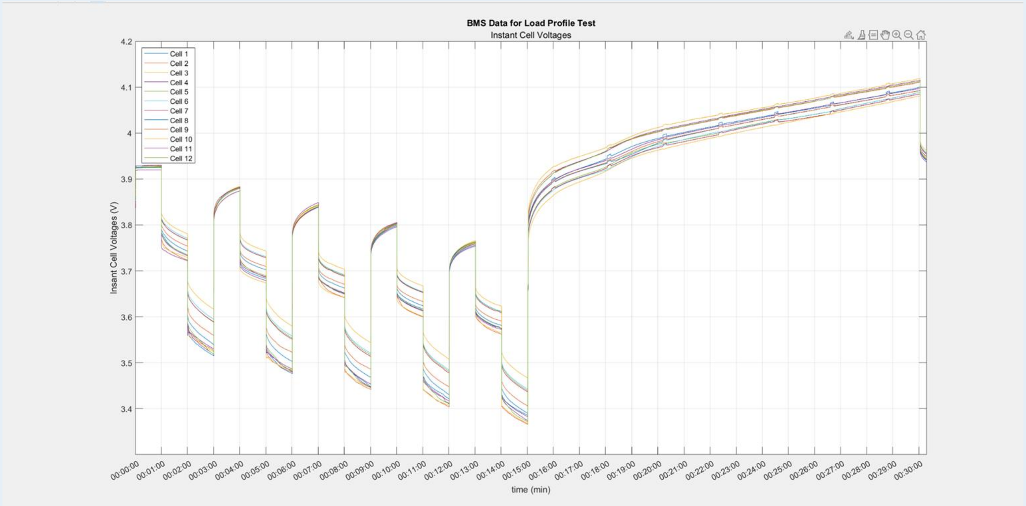

Fig 3: BMS Data Collection

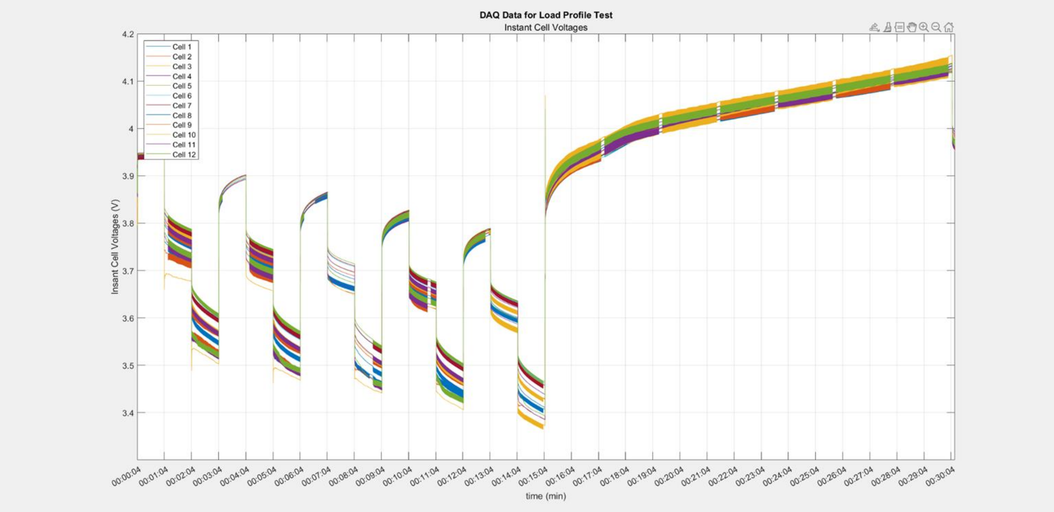

Fig 4: DAQ Data Collection

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