Eagle-Li

Battery Management Research System (BMRS)

ELECOMP Capstone Design Project 2022-2023

Sponsoring Company:

EaglePicher Technologies
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Company Overview:

EaglePicher Technologies is a leading producer of batteries and energetic devices. For more than 75 years, we have been serving the mission-critical aerospace, defense and aviation battery markets. EaglePicher's batteries are a key component of the U.S. space program; our batteries provided the emergency power that successfully brought the Apollo 13 crew home. Today, EaglePicher batteries power the International Space Station, Mars Rovers, commercial jets and helicopters and more than 85 percent of U.S. missile platforms.

Technical Directors:

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Project Motivation:

Under water, over land, in the air and out in space; EaglePicher batteries are providing power to the most extreme applications ever conceived. Our batteries are commonly required to deliver high power and energy while exposed to dynamic conditions and over a long service life. While advancements in battery performance develop at a rapid rate, Improvements in battery management systems have consistently lagged behind. Leveraging the success of AMBATS-part deux, this project seeks to improve on the AMBATS investigative platform, illuminating the performance dynamics of Lithium Ion batteries, and the Battery Management Systems that monitor and protect them. The Eagle-Li system will merge battery performance and BMS design elements to Machine Learning algorithms which will predict and influence the ultimate life, utility and safety of future battery designs.

Anticipated Best Outcome:

A. Develop an improved Eagle-Li BMS laboratory platform, applying the lessons learned from the AMBATS program.
B. Using Eagle-Li, perform live battery experiments, simulating the conditions found in electric bikes, electric vehicles, directed energy weapons, and more.
C. Generate imperical data to identify the most sensitive indicators of battery degradation and performance changes that impact product safety and longevity using BMS data

Project Details:

The objective of this project is to design and build an investigational platform that integrates a typical battery management system with a high-fidelity data acquisition system. EaglePicher Technologies develops Li-Ion battery cells with a wide range of characteristics. The successful outcome of this project will facilitate the characterization of these battery cells in concert with the battery management functions necessary to protect the cells and the applications for which they are intended, from catastrophic failure. The envisioned outcome will feature a functional hardware and software platform capable of monitoring a fixed number of battery cells (e.g.: 4-12) while providing well correlated telemetry data for analysis.

Summary: Detection of faults using BMS data, individually and in combination. Followed by suggestions for improvements in the type and accuracy of the hardware to improve fault detection.

Faults to be detected include:

- OverCharge
- OverDischarge
- Internal Short
- Li-plating
- Overheating Cells
- Overheated cells

Discipline #1: Hardware/Sensor/Electrical Tasks:

1. Along with the other Eagle Li discipline group, draft a requirements specification for the Eagle-Li BMS platform to evaluate high performance battery cells
2. Evaluate and Propose design concepts in accordance with the specification document. High prioritization on minimizing hardware induced data variation from cell position to cell position. Strength in statistics would be beneficial.
3. Create a preliminary design based on the selected concept. Present a block diagram design and description for review and approval
4. Perform a detailed design of the Eagle-Li platform with a detailed hardware design description and supporting analysis.
5. Present the BMS design for critical review with EaglePicher support
6. Build and test the Eagle-Li platform
7. Using the Eagle-Li platform, collect synchronized BMS and DAQ battery cell performance data for a variety of use case profiles.
8. Present findings

Discipline #2: Firmware/Software/Statistical/Computer Tasks:

1. Collaborate with the other Eagle Li discipline group in proposing and evaluating design improvement proposals for the Eagle-Li platform
2. Draft a software requirements specification for the Eagle-Li platform to evaluate battery cell performance.
3. Develop a Software Design Description based on improving the platform interface (for operation and load changes) and data collection.
4. Present the SDD for critical review with EaglePicher support
5. Develop functional software in accordance with the SDD
6. Test and validate the operational software on the Eagle-Li platform
1. Using the Eagle-Li platform, collect synchronized BMS and DAQ battery cell performance data for a variety of use case profiles.
    a. Identify which sensors can first identify a critical fault.
    b. Quantify possible improvements in the sensor type
    c. Identify alternative options for that sensor and/or hardware.
7. Present findings
8. Stretch Goal: Look at opportunities for combinations of sensors.

Composition of the Team:

1-2 Electrical Engineers & 1-2 Computer Engineers.

US Citizenship Required; Background Checks will also be conducted before the first kick-off meeting with the Technical Director.

Skills Required:

Electrical Engineering Skills Required:

- Organization and Documentation
- Circuit simulation
- Electrical Safety knowledge and awareness
- Analog circuit design
- Digital circuit design
- Power circuit design
- Knowledge and use of common lab equipment
- PCB layout
- Soldering, Troubleshooting, Repair
- Statistics (MiniTab or equivalent needed)

Computer Engineering Skills Required:

- Organization and Documentation
- Embedded software development
- User interface design
- IDEs / Debuggers
- Analog Signal processing
- Digital Signal processing and Filters
- Test, Debug and Validate code
- Statistics (MiniTab or equivalent needed)

Anticipated Best Outcome's Impact on Company's Business, and Economic Impact

If successful, this project will accelerate the evaluation and validation of next generation EaglePicher Technology battery cells and systems for demanding applications.

Broader Implications of the Best Outcome on the Company's Industry:

This project creates an efficient and robust process in developing reliable high-performance battery management systems. By optimizing the BMS around the most important parameters to measure, for both safety and state of health/charge, EaglePicher Technologies will set the standard for providing rapid solutions for critical applications.