AM-BATS

Advanced Modular Battery System

ELECOMP Capstone Design Project 2020-2021

Sponsoring Company:

EaglePicher Technologies
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https://www.eaglepicher.com/

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, aviation and medical 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, life-saving medical implants and more than 85 percent of U.S. missile platforms.

Technical Directors:

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Project Motivation :

Performance and lifetime are major factors in designing battery powered products. Lithium Ion batteries in particular are vulnerable to stresses experienced throughout their service life. Additionally, the circuits responsible for controlling and monitoring cells in a battery must be capable of performing under the same stresses. In a complete battery design, the cells, monitor circuits, and control schemes must work together seamlessly. Many aspects of battery design and performance are well understood. However, there are some persistent topics that plague the ability to accurately predict and track the performance of Li-Ion batteries. EaglePicher specializes in providing solutions to very demanding applications that expose batteries to extremes in temperature, vibrations, power delivery and service life. These are not your cordless drill batteries. Some of our batteries are on their way to Mars as you read this. New approaches to design and reliability modeling are needed. How long will a charge last? How many cycles can the battery survive while enduring temperature extremes? Will the Battery Management System (BMS) perform as expected? Is accuracy maintained over the service life? Will the system tolerate faults? If a fault occurs, will the system adapt or fail?

Anticipated Best Outcome:

A) Identify methods that improve the correlation between the design intent of a battery system and the actual observed performance.
B) Develop predictive models to compensate for natural cell degradation over time and exogenous events. Validate the models with a purpose built proof of concept design.

Project Details:

EaglePicher Technologies has a significant portfolio of battery designs based on a variety of electronic hardware platforms and battery cells. With new batteries in development the portfolio is growing. One of the key objectives for this project is to establish baseline modules of both hardware and software. These modules will integrate into new and unique products. The goal is to create reliable, adaptable building blocks to facilitate rapid software development in concert with new battery hardware development. The objectives of this effort are not necessarily to develop plug and play solutions but to develop solutions that stand up to a high degree of rigor. With applications that must withstand multiple layers of review, having confidence in the baseline at the start of a new program will accelerate our development efforts and create a competitive advantage. There are some key areas of software development that have historically lagged in our new products. Predictive models and algorithms that accurately track the natural wear and capacity loss of our batteries over time are a high priority. Synchronizing modular hardware concepts with software is also a high priority.

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Hardware/Electrical Tasks:

- Identify Battery Management System (BMS) components that support EaglePicher design requirements. Consider power management, temperature measurement, communications, processing, data storage
- Develop a selection matrix of suitable devices or parametric tool
- Compile reliability data, Failure-In-Time (FIT) / MTBF for available devices.
- Identify reliability prediction tools or methods
- Develop a redundancy model utilizing the configurations and reliability previously determined. This could be a tool or utility with the above information.
- Propose fail safe design topologies for various configurations.
- Propose a Battery Management System design based on TBD battery cells and configuration. Team to make preliminary design review presentation
- Perform detail design of BMS electronics with EaglePicher support
- Team to present design for critical review with EaglePicher support
- Upon approval, build the proposed design
- Validate the design and objectives with correlation to the predictive models
- Present findings

Firmware/Software/Computer Tasks:

- Review battery management software requirements
- Develop supporting firmware code to interface with proof-of-concept BMS
  - Microcontrollers
  - IC's
- If necessary, develop system for analyzing BMS performance
- Algorithm Design
  - Identify filter algorithms for:
    - State of Charge (SOC)
    - State of Health (SOH)
    - Remaining Capacity
    - Cell Resistance Growth
    - Limits as set by peak load, temperature, or energy requirement

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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:

- Analog circuit design
- Digital circuit design
- Power circuit design
- Circuit simulation
- Data analysis
- Electrical Safety knowledge and awareness
- Knowledge and use of common lab equipment
- PCB layout
- Soldering, Troubleshooting, Repair

Computer Engineering Skills Required:

- Embedded software development
- IDEs / Debuggers
- Algorithm development
- Analog Signal processing
- Digital Signal processing and Filters
- Test, Debug and Validate code

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

If successful, this project will help establish the framework for the next generation of EaglePicher Technology batteries and systems.

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

With an efficient and robust process in developing reliable high-performance batteries, EaglePicher Technologies will set the standard for providing solutions for critical applications.

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Additional Comments from Brenden Smerbeck (Acumentrics Inc)

Firstly, I would like to share my excitement about this project sponsored by EaglePicher. Battery management systems are an exciting technology that affects everyone across almost every industry. When we look at our phone, it reports its state-of-charge and even state-of-health. Electric vehicles are of the fastest selling group of automobiles and aim to offset our carbon debt and help repair our environment while also providing top-of-the-line performance. In Australia, a 129Mwh battery facility was installed that reduced the costs of maintaining power grid stability by 90%.

All these advancements, however, would be impossible without research into not only the performance of these battery systems, but the safety and control of them through monitoring. Remember the Galaxy Note 7 and its particular tendency to…get a bit too hot? In extreme environments like those seen by EaglePicher's products, this level of scrutiny in design and consideration is of the utmost important.

So what does this mean for capstone? In 2018, Acumentrics sponsored a project titles, "AcuBMS", in hopes of developing a custom battery management system. The project was, to that point, one of the more challenging projects we had ever sponsored. This was partly due to Acumentrics' focuses being the science behind uninterruptible power supplies, and partly due to restrictions we had placed on the students – they could not use an off-the-shelf IC to perform any of the measurements or protections typically seen in battery management systems. BMS projects are underline perfectly aligned with the electrical and computer engineering majors. If you enjoy circuit design and theory, getting your hands dirty with building and testing PCBs, writing firmware to drive electronics, developing algorithms to solve real-world questions; give this project a look.

EaglePicher, in contrast to Acumentrics, is one of America's leading battery manufacturers. Their battery cells have run for over 2.8 billion hours **in space** (with some batteries on their way to Mars right now – no really, their batteries were used in Spirit, Opportunity, Curiosity, and the new 2020 Mars Rover!).

Project AM-BATS does differ from many of our ELECOMP projects. It still – however - meets our core project requirements: What problems are you facing or questions seeking answers for, and how could URI engineers help?

To this year's students: Give the AcuBMS project a look here and give both EaglePicher and BMS technology a quick search online. If you have a question, don't hesitate to email Professor sunak (sunak@ele.uri.edu) or myself (bsmerbeck@uri.edu). ELECOMP is about enabling students to advance the technologies around them and this project is a perfect opportunity.

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