AcuBMS

Battery Management System for Rechargeable Lithium-Based Batteries

ELECOMP Capstone Design Project 2018-2019

Sponsoring Company:

Acumentrics, Inc
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Acumentrics is continuing support of the Program they initiated in 2016. 2017 Project Details available here: https://web.uri.edu/elecomp-capstone/project-details-by-team/acumentrics/

Team Acumentrics won 1st prize at the 2017 ELECOMP Capstone Summit and 2nd prize at the 2018 ELECOMP Capstone Summit

Company Overview:

Acumentrics, Inc., headquartered in Walpole, Massachusetts, has been a trusted market leader in RUPS™ (rugged AC and DC uninterruptible power sources) for harsh and combat environments as well as heavy-duty industrial applications, since 1994. Acumentrics products provide clean power conditioning and battery backup when reliability is mission-critical. Acumentrics, is a preferred supplier of US-made power electronics to many of the world's largest prime defense contractors.

The modern military relies on computers and other sophisticated electronic equipment and relies on Acumentrics' products to keep that equipment online in harsh environments. Electrical variance, surges, spikes, sags, and interruptions can cause communication breakdown and data loss, especially during the rigors of active duty.

Acumentrics technology is based on over 20 years of experience in delivering trusted, reliable and rugged backup power solutions to military specifications.

Technical Directors:

Peter Upczak
Senior Firmware Engineer
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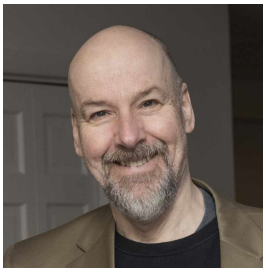
Peter Upczak has lead Team Acumentrics for two years, with teams placing first and second place at the ELECOMP Capstone Summit.



Brenden Smerbeck (URI College of Engineering Class of 2017)
ELECOMP Capstone Graduate 2017
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Brenden Smerbeck has lead Team Acumentrics for one year, with the team placing second place at the ELECOMP Capstone Summit.

Project Motivation:

As technology advances, so does the overwhelming need for its users to be able to monitor, control, and manage it; regardless of location. It is because of this demand that the internet of things (IoT) and the presence of embedded systems in both consumer and industrial electronics has grown exponentially in recent years. Rapid charging battery technologies and smart batteries have grown in usage along medical devices and autonomous systems. Compared to standard batteries, smart batteries are more viable for any modern application.

Smart batteries contain both a rechargeable battery pack and a built in battery management system (BMS). BMS are capable of monitoring the state of charge, voltage and current, temperature, and additionally control the charging and balancing of the cells therein. In applications where runtime estimations and fast charge times (<20 min.) are critical, there is an immense value and pressure to implement these technologies. However, prices of adequate systems are priced too high to secure an adequate profit margin. To counter this, a retrofit package capable of converting a normal battery to a smart battery is proposed.

Anticipated Best Outcome:

The team will construct a package prototype capable of transforming a traditional rechargeable battery to a smart battery. The system will be able to measure the voltage, current, state of charge, and temperature of the battery while providing control of the rate at which the cells are charged and discharged. The system will include a communication interface through which the developer - and therefore the user - can retrieve and monitor the status of the battery.

Project Details:

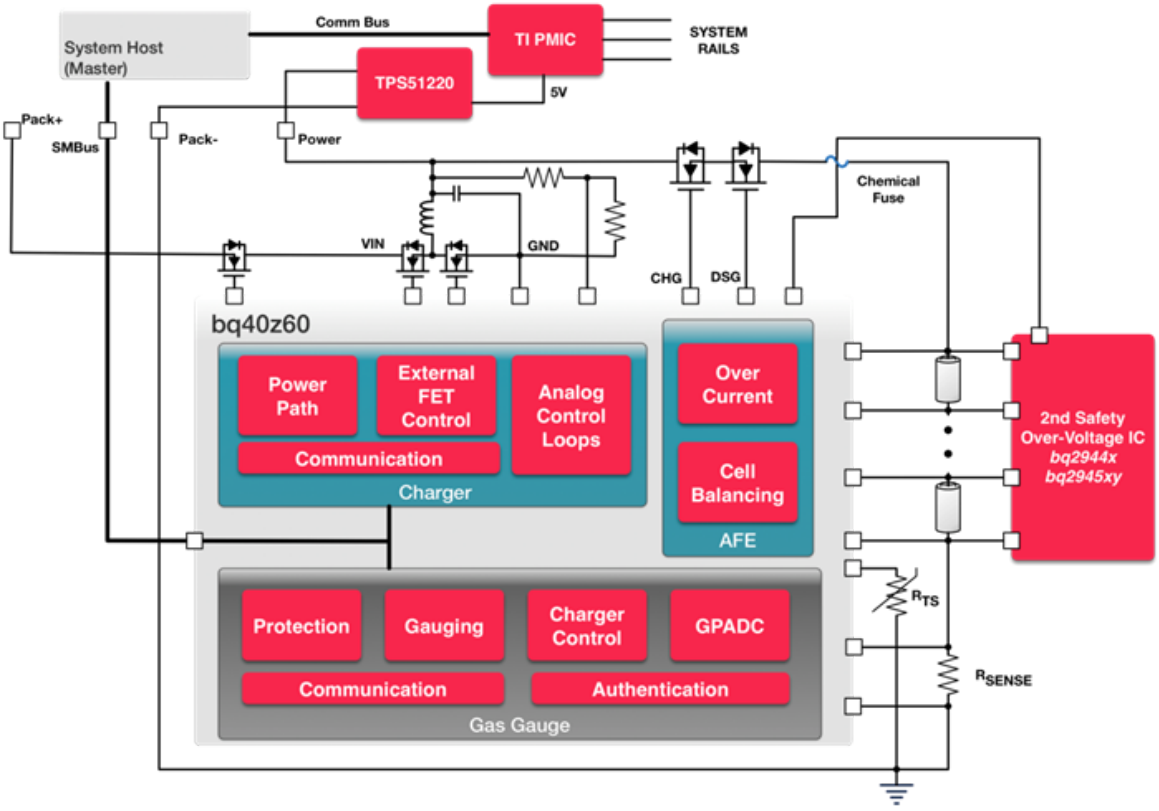
Overall system concept

The general design of the BMS is standardized within the industry. The key functionality of the system is the ability to control the charging of the device and provide cell balancing, employ protection systems to the battery, and additionally monitor and report on the battery state.

The functionality of the system will parallel those provided by turnkey smart battery solutions. This includes high and low voltage and temperature cut-off, charge control, and state monitoring. State monitoring includes voltage, current, state of charge, and temperature. Additional metrics may be monitored including: watt hour charged/discharged at temperature, total watt hours charged/discharged, state of health, and known battery events.

The system must employ a communication interface through which recorded data may be retrieved. While SMBUS Smart Battery Specification is noted, it is not a requirement. The system will either employ the use of available BMS components or components of the team's design.

Block Diagram



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Electrical Tasks

- Lean basic principles of lithium-based rechargeable batteries and their charging characteristics.
- Learn component breakdown of a BMS including charger, AFE, gas gauge, and controller.
- Research and determine the viability of BMS IC's available from manufacturers.
- If viable, select and implement available IC to construct a BMS proof of concept; including a detailed characteristic document and configuration guide. If not, determine subcircuits necessary to provide BMS functionality.
- Design a schematic for the prototype BMS.
- From the schematic, construct a bill of materials (BOM) that meet the operational and environmental requirements of the product.
- Design a PCB supporting all required components
- From the fabricated PCB, construct the SmartBatt prototype

Firmware

- Gain experience with a Raspberry Pi, GPIO programming, and controlling devices using the GPIO pins.
- Research communication protocols and determine the best choice to accomplish product requirements.
- Test and ensure that BMS subcomponents are functionally properly and are implemented with minimal errors.
- Based on the hardware design by the electric engineers, develop a proof of concept capable of interfacing with the BMS and retrieving information.
- If necessary, develop firmware to gather information from the BMS and present the data in a queryable format for software development.
- If necessary, implement a smart charging and cell balancing algorithm capable of high and low voltage/temperature/current shutoff.

Software Tasks

- Research application design architectures like MVC, MVVM, and unidirectional flows.
- Determine an application architecture based on product requirements capable of presenting the data from the BMS to a user.
- Design a mockup graphical user interface using available software to draft the initial software design.
- From the design mockup, develop a front end UI capable of displaying data retrieved by the backend.
- Design and develop a backend capable of initializing connection with BMS and querying the system from data.
- Design a proof of concept application with the purpose of demonstrating the functionality of the BMS.

Composition of Team:

1 Computer Engineer and 1 Electrical Engineer. It is preferred that one or more engineers have an interest in both disciplines.

Skills Required:

Electrical Engineering Skills Required:

- Analog and digital circuits and signals
- Interest in rechargeable battery technologies
- Printed circuit board design and layout

Computer Engineering Skills Required:

- Low level programming experience
- Firmware
- Embedded MPU or CPU programming knowledge and/or experience
- Networking
- GUI development experience
- Experience with Linux

Anticipated Best Outcome's Impact on Company's Business:

The inclusion of smart battery technologies will expand Acumentrics' competitive offering, improve our existing product line available to our customers, and assure that we remain at the forefront of total power solutions and their associated technologies. Additionally, the technology will allow Acumentrics to explore new markets with cutting-edge products.

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

In order to satisfy the need for data monitoring and analytics at all levels of technology, smart batteries are an absolute need. Improving the intelligence of these systems will pave the path towards faster charging and more diverse applications. Soldiers utilizing smart batteries will be able to mobilize faster and have greater knowledge of the state of their numerous appliances. Operations stations will have enhanced insight as to the health of their systems and their power budget at a more granular and physical level.