Project N-Plus

Optimization of Parallel UPS Operation

ELECOMP Capstone Design Project 2020-2021

Acumentrics is continuing their support of the Program for the 5th consecutive year:

2019-2020: ***FaultLine – Power Signature Analysis for Fault Detection and Predictive Maintenance***

2019-2020: ***Volta – Automated Variable Load Testing of HV DC Output Boards***

2018-2019: ***AcuBMS – Battery Management System for Rechargeable Lithium-Based Batteries***

2017-2018: ***AcuPDU – Network Managed Power Distribution Unit for Military Application***

2016-2017: ***AESA – Acumentrics Easy Simple Network Management Protocol Application***

Team Acumentrics won 2nd Prize at the 2019 ELECOMP Symposium with Project FaultLine, 2nd Prize at the 2018 ELECOMP Summit with Project AcuPDU, and 1st Prize at the 2017 ELECOMP Summit with Project AESA

Sponsoring Company:

Acumentrics, Inc.

10 Walpole Park South,
Walpole, MA 02081
https://www.acumentrics.com

Company Overview:

Acumentrics, Inc., headquartered in Walpole, Massachusetts, has been a trusted market leader in RUPS™ (rugged AC and DC uninterruptible power supplies) for harsh and combat environments as well as autonomous power and 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. With new autonomous power systems, these products can range from rack-mounted units to carry-on luggage, backpacks, and even handheld devices.

Technical Director:

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ELECOMP Capstone Graduate 2017
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Brenden Smerbeck has lead Team Acumentrics for three consecutive years

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ELECOMP Capstone Graduate 2018
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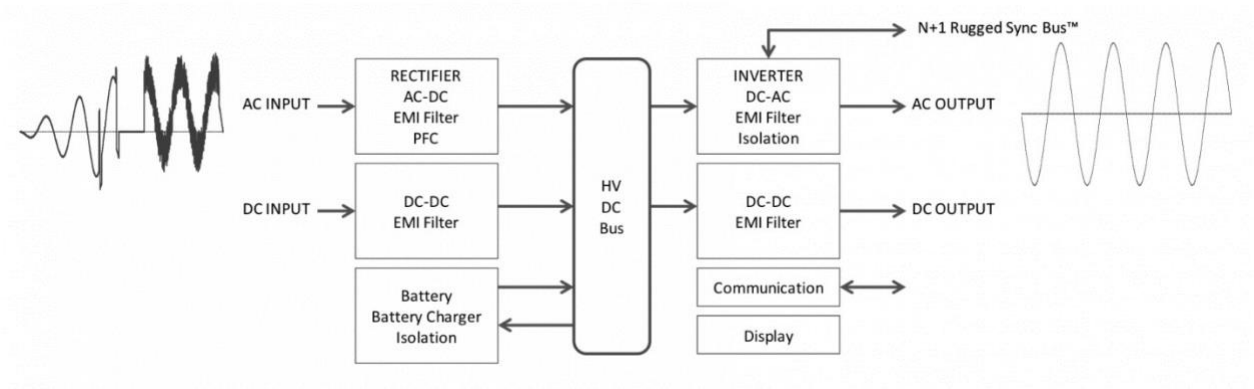
Project Motivation:

The Acumentrics Rugged-UPS™ 2500 (RUPS) is specifically designed for worldwide deployment in harsh physical and electrical environments. The Rugged-UPS™ 2500 provides 2500VA of nominal 115VAC output from an input of 80-265VAC 47-440Hz or 22-32 VDC.



To achieve greater amounts of output power, the Acumentrics Rugged-UPS™ 2500 has the capability to be connected in parallel with N+1 redundancy.

A parallel-redundant UPS system is one in which two or more modules are installed on the same system in what is termed an N+X arrangement (N being the power capacity required by the connected loads and X being the number of modules in addition to that capacity). Parallel redundancy allows for the failure of one single UPS module in the configuration without the need

for the protected load to be transferred to mains power. In such an event, the other UPS modules can take over the total load.

Control of parallel UPS is normally managed using a primary/secondary arrangement whereby a primary controller acts as the brains of the system and determines operating parameters: how UPS modules synchronize their outputs, how they share loads, and where their control information comes from. It does, however, requires complicated control wiring between UPS modules. Inconsistencies in manufacturing and assembly result in parallel load failures. To reduce the occurrence of faulty cables and to reduce the cost of manufacturing, a simplification and design revision is proposed.

Anticipated Best Outcome:

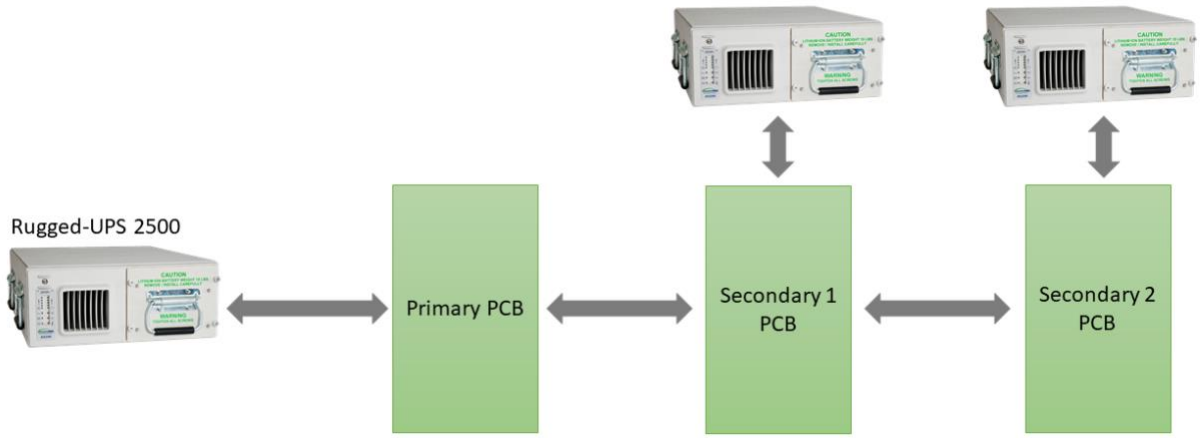
The team will combine the current two PCB modules that are built into the cable and integrate the newly designed PCB module inside the Rugged-UPS™ 2500. The PCB module will be capable of acting as either primary or secondary. To accommodate the integration of the PCB module within the Rugged-UPS™ 2500, the original parallel cable will be redesigned.

Project Details:

Overall System Concept:

Students will first need to understand both electrically and digitally how the current parallel cable module works. The module is comprised 1 primary board and up to 4 secondary boards. These boards facilitate digital signaling between each other and the UPSs, while also managing the primary-secondary connection. This task combines both knowledge of digital circuits and digital signals/communication.

Current Parallel Cable Configuration:



Once a foundational knowledge of the current system is obtained, the next task will be designing a single prototype combining the functionality of the two original PCBs found in the parallel cable. Combining these two boards will help improve build quality and reduce points of failure during assembly.

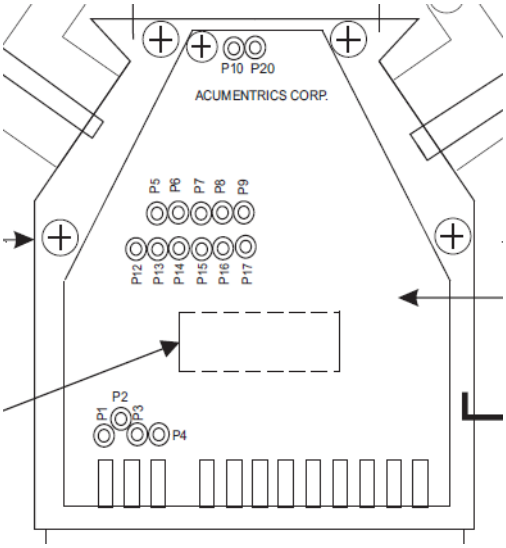


Diagram of primary module

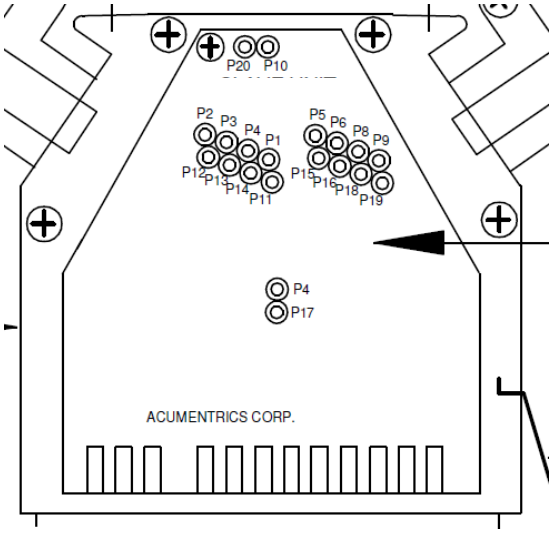
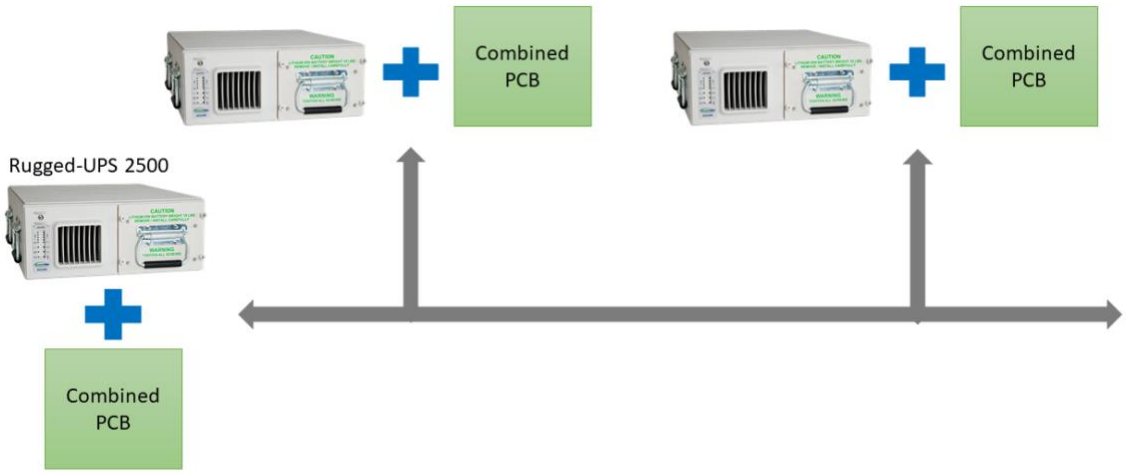


Diagram of secondary module

Having created a single prototype capable of performing the duties of the original parallel cable module, the system must be converted to a printed circuit board capable of being housed internally inside the UPS. By internally housing the parallel module, we can ensure a higher level of ruggedness while also removing hardware from the parallel cable itself.

New Proposed Parallel Configuration:



The proposed configuration differs in that the module – originally part of the cable itself – now resides in the UPS. The original cable is now modified so that it serves only to transfer data. Each UPS contains a "parallel module", and through some mechanism distinguishes itself as a primary or secondary device.

Electrical Tasks:

- Familiarize selves with current parallel cable configuration
- Familiarize selves with both the primary and secondary PCB circuitry
- Determine if improvements can be made to current circuitry
- Combine primary and secondary PCB circuitry
- Revise cabling to exclude the original PCB modules
- Prove cable logic can be used to determine primary or secondary for any unit
- Create functional prototype to establish proof-of-concept (PoC)
- Design new prototype schematic based on PoC
- Design new PCB Layout
    - Size restrictions
    - Noise/EMI
    - Rugged
- Test and validate parallel functionality with new module and cabling

Composition of Team:

2 Electrical Engineers (ELE)

Skills Required:

As the University of Rhode Island lacks courses in the discipline of Power Engineering, it is not expected of students to have a background in the subject matter. Nonetheless, students considering the project should be confident in their computer and electrical engineering skills and be comfortable in the field of mathematics. The proposed project is non-trivial, and requires motivated students to meet its Anticipated Best Outcome

Electrical Engineering Skills Required:

- Analog and Digital Circuit Design
- Digital Signal Processing
- Linear Systems and Signals (e.g. ELE 313+314)
- Calculus, Linear Algebra (MTH 362, MTH 242 + MTH 243)

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

As Acumentrics' products are built to last in normally inoperable environments, integrity is an absolute requirement. There is a growing concern for harsh environments that need specific cables made of different materials. As this happens, the process for manufacturing can get even more difficult due to size restrictions. As the company improves these processes there will be both a reduction to inconsistencies in manufacturing and assembly, and an increase in Acumentrics' offering for cables made of other materials. This will continue onto all of Acumentrics' products and will increase the stability of these systems even further.

Should the project succeed, Acumentrics' will be able to provide a simpler cable solution that can be made with a larger selection of materials. Therefore, the economic impact is large. For new and existing customers in Acumentrics core market, the project will allow for a larger offering of customization, optimization, and control of parallel units. Additionally, cost savings can be reinvested into developing new technologies.

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

Power systems are a necessity often overlooked by the typical consumer. Yet power systems can be found behind every startup tech company and telecommunications firm, every first responder, every family, every military operation, and – frankly – every modern business. As technology advances, so too does the energy requirement of the world. In order to provide clean and reliable energy in every environment, companies within the industry of power systems must evolve as well. Today, machine learning and artificial intelligences have opened a gateway to medical innovations, seemingly impossible designs, and otherwise limitless opportunity. Yet these opportunities are equally matched by a demand for enhancement and improvement at every stage. It is because of this ever-growing demand that the innovations of the next generation are possible, and why projects like this are necessary.