From Concept to Implementation: CubeSat Power Supply Design Using GaN FET Technology & Testing To TRL 5 Standards

Hisham Mannaa, Hector Valencia, Luis Rendon - University of Nevada, Las Vegas
In collaboration with Courtney Copenhagen and Thomas Schotik - University of Nevada Las Vegas
Dr. Ke-Xun Sun - University of Nevada, Las Vegas
This material is based upon work supported by the NASA NVSGC Under Grant No. 80NSSC25M7094

Abstract

Design a resilient buck-style voltage converter that accepts both Solar and DC power as Vin voltage sources while driving GaN FETs to increase reliability and maintain a steady output branch to charge a 3-S LiFePO4 battery arrangement that is designated as the main source of power for the downstream Main Processor Unit (MPU) and additional peripheral loads. In the event of onboard battery failure, a secondary 5V Vout voltage branch will provide redundancy (serving as a secondary source) to the MPU. Once successfully designed and manufactured, the voltage converter will undergo strenuous testing such as high heat and Ultra High Vacuum (UHV) testing. The results produced will serve as the benchmark for future design.

Introduction

CubeSats demand many systems and subsystems to be integrated together to produce a working nanosatellite. The study of these systems can be in-depth and require meticulous efforts to ensure the systems are properly designed. Throughout ECG 615/L, students explored these efforts and worked together to conclude the concept/design phase of a 1U CubeSat design with potential for the same systems to be integrated into the future planned 3U CubeSat design. The CubeSats utilize the PC/104 design standard with stackable PCBs to provide a completely autonomous optical and navigation flight package with the ability to monitor from multiple ground stations on Earth. Ultimately to function, these systems rely on resilient power supplies that will not fail them during their critical missions. Upon completion of all TR levels, UNLV seeks to be the first University to launch a CubeSat in the state of Nevada

Methods/Analysis

Through a newly offered course at UNLV titled "ECG 615: Spacecraft and Payload Engineering", students were granted the opportunity to study spacecraft and payload engineering with a corequisite lab class to implement the concepts learned during the course while also allowing them exposure to component and system failures, emphasizing the importance of proper planning and system design. The course was held In conjunction with a graduate student course to allow coordination between undergraduate space enthusiasts and graduate students seeking postgraduate degrees. Through ECG 615, calculations were taken into account for total spacecraft and payload energy consumption. Using Altium Designer and ISim: PE, schematics were drafted and simulated prior to fabrication of power supply PCBs.

The manufactured PCBs are undergoing the TRL 5 testing requirements as of 03/22/2026. Testing will be completed within the upcoming weeks. Testing will include UHV testing for the span of 2-2.5 hr. Increments. Testing will not include LiFePO4 until secondary boards are tested and proven to function properly after the first round of UHV testing. Total testing will consist of three rounds.

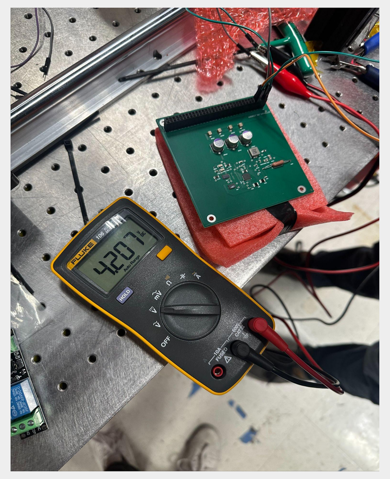

Figure 1: Vout of Secondary PCB

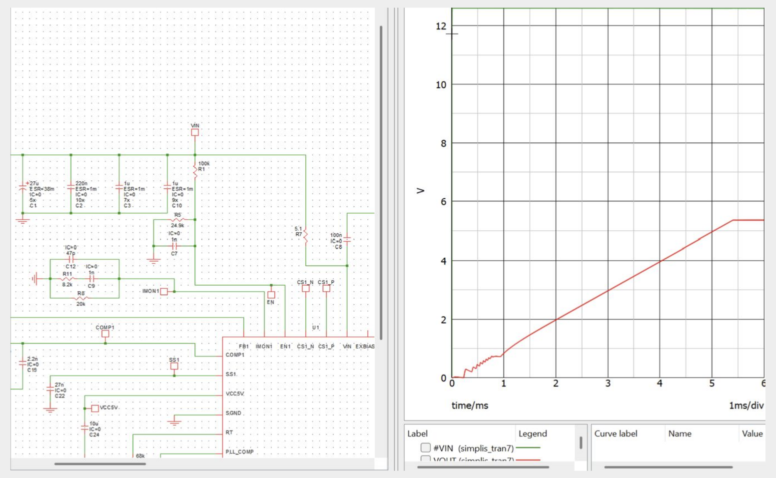

Figure 2: Schematic Simulation Vout

Figure 3: UHV System

Anticipated Results

While the results from the testing are not available at this time, the anticipated results include the following:

- Voltage stability In high heat environments and pressures beyond 10^-9 Torr.
- Component Resilience in advertised ranges such as -50 through +150°C
- Assessment of solder joint reliability pre and post UHV testing.
- Voltage output to reflect simulated voltage output of 5V.
- Assessment of GaN technology for proposed delivery of CubeSat system to MEO, traveling beyond the Van Allen Radiation Belts
- *While x-ray tests are not required, such tests will be highly encouraged if afforded to report on the Gan FET hardness in comparison to standard silicon based components.*

Conclusion

Following the completion of ECG 615/L, space research has grown tremendously among our group as three new students have opted to pursue space-focused research. Once testing of the PSU is complete and the accumulated data is analyzed and determined sufficient to designate the PSU as a TRL 5 component, the PSU will be used to benchmark future designs such as the addition of the LIFePO4 batteries. If proven to be effective under TRL 5 testing, GaN technology will be proposed for the next step of space exploration beyond standard LEO. Lastly, While designing a satellite ground up may take many years, we must not forget to recognize the accomplishments that occur each day, internally to our research, and externally, to the world of engineering that make our progresses more consistent and more efficient.

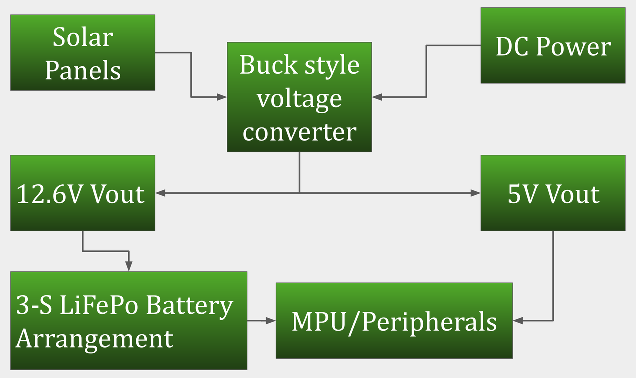

Figure 4: System Design

References

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Acknowledgements

We would like to express our gratefulness to NASA for funding our group research and courses and thank you to Dr. Ke-Xun Sun for affording us the opportunity to partake in space research.