EMI Filtered Switched Mode Power Supplies for Sounding Rocket Applications + SPEID CubeSats

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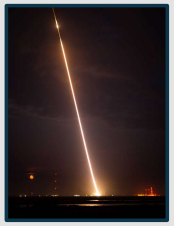
1. Introduction/Overview

Background:

- **Switched-mode power supplies** are an integral part of electronic systems on-board **sounding rocket missions** and are one of the most efficient methods of power conversion, but they are prone to **EMI** issues
- **Communication systems and ground operations** are also important for sounding rocket and CubeSat missions alike
- With the **SPEID CubeSats** being intended to aid the OSAM-1 satellite servicing mission by providing imagery for 3D reconstruction, creating reliable communications and ground subsystems is crucial



Overview:

- Tested and made changes to the hardware of a space-grade EMI filtered 28V to ±15V switched-mode power supply of my design so that it can be improved upon
- Made schematic drafts for a 28V to ±28V converter with ±18V and ±8V regulation using LTSPICE
- Created a preliminary ground system architecture and conducted a communications hardware trade study for SPEID's CubeSats

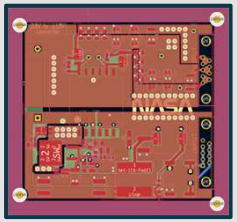
2. Methodology

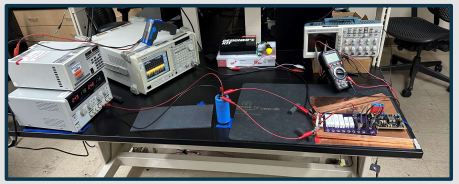
Circuit Design and Testing Methods

- **LTpowerCAD and LTspice** were used to design and simulate the circuits under various input and loading conditions, which helped predict efficiency, output ripple, component stresses, and overall performance
- **KiCAD** was used to produce the PCB layouts of the designs, which use footprints of commercial off-the-shelf (COTS) parts acquired from Mouser and Digikey
- EMI noise levels were measured using conducted emissions testing for **differential and common mode noise**, which **Goddard's General Environmental Verification Standard (GEVS)** document covers in detail. The recommended testing setup implementation is shown below (spectrum analyzer operated in accordance with **MIL-STD-461G**)

Comms & Ground System Design

- Design of the communication and ground subsystems was accomplished through the guidance of my mentors and by consulting **NASA's State of the Art Small Spacecraft Technology Report**
- Trade study influenced by heritage designs
- **MIT's Beaverworks Build a CubeSat program** provided necessary background knowledge

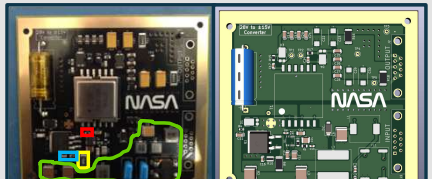




3. Results

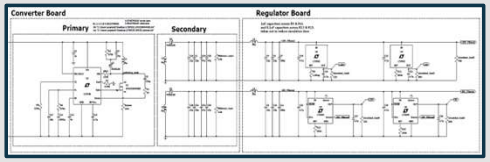
Changes made to 28V to ±15V Converter:

- Reduced feedback resistor (red) to **improve accuracy**
- Reduced current sense resistor (yellow) to **increase power capacity**
- Redesigned snubber filter (blue) by increasing capacitance and reducing resistance to **reduce voltage ringing** across transistor
- Redesigned EMI (green) filter due to the design not meeting **conducted emission requirements** for common mode noise at higher loads (needed a larger common mode choke)



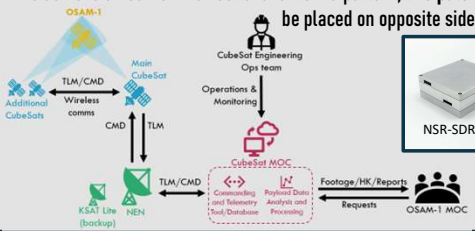
28V to ±28V Converter with ±18V and ±8V Regulation:

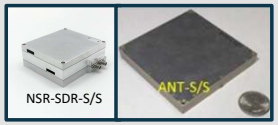
- Borrows from previous converter design
- Regulator section features **easily adjustable voltage regulators** for positive and negative voltages while also providing **additional filtering** for the ±28V lines



Ground System Architecture and CubeSat Communications Trade Study

- The commands sent by the **CubeSat Mission Operations Center (MOC)** will be primarily dependent on the needs of the OSAM-1 MOC, so both MOCs are included
- CubeSat projects at Goddard typically use **Vulcan Wireless hardware** for communication
- To achieve a near-omnidirectional antenna pattern, two **patch antennas** would need to be placed on opposite sides of the CubeSat





4. Conclusions

Common mode chokes hundreds of micro-Henries large must be used to successfully filter **common mode noise**, which can appear much earlier on in the frequency spectrum than had been previously assumed. Future work would involve **testing** the new EMI filter designs and moving onto the **layout** of the new converter and regulator boards.

Furthermore, **Near Earth Network (NEN)** ground stations would be the most appropriate choice to support LEO, and the **Vulcan Wireless** products selected in the trade study give the team a wide range of NEN to choose from due to their S-band compatibility. Future work would see the development of the CubeSat MOC and CubeSat transmit mode of operation, which would be determined by data rate requirements.

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