DALHOUSIE UNIVERSITY
FACULTY OF ENGINEERING
Department of Electrical and Computer Engineering

Dalhousie Space Systems Lab

Low-Orbit Satellite EPS Design and Manufacturing

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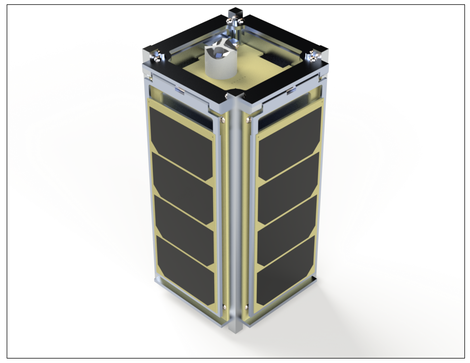
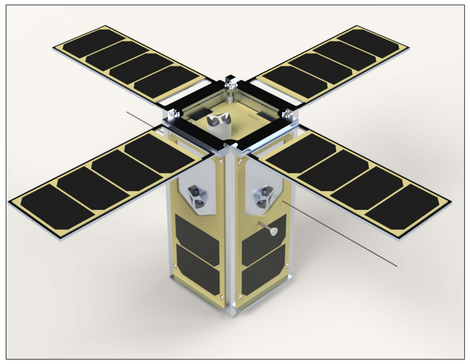
Introduction

The Dalhousie Space Systems Lab was granted $200,000 by the Canadian Space Agency to create and build a CubeSat satellite that will be launched from the International Space Station in late 2021 (Nanosats Database, 2020), and we were tasked with designing the deployment board for the satellite. This board would contain the burn wire circuit, which will receive a signal from the Attitude Determination and Control System (ADCS) board, and once activated the burn wire will turn on, cutting through the tie downs that will then release the deployable panels with the solar arrays attached.





Design Process

The following was required for the design:

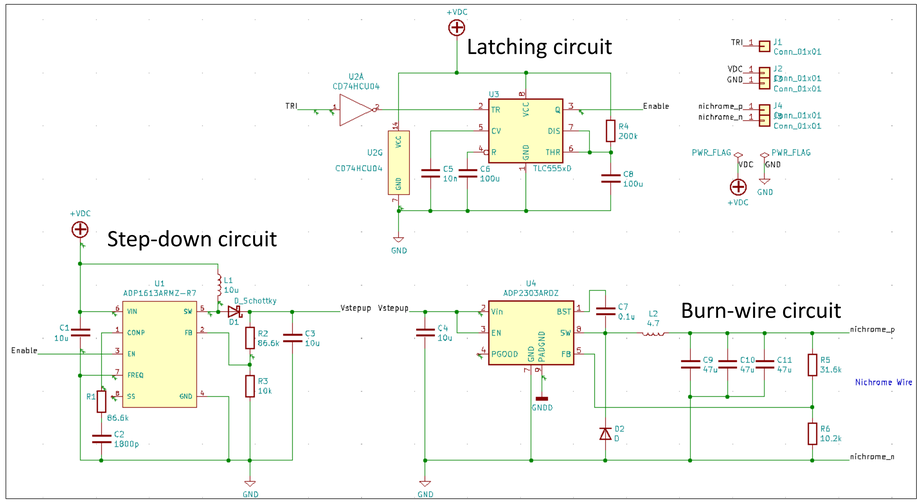
- A circuit that would receive the signal from the ADCS board and turn on the burn wire long enough to cut through the Vectren rope that is holding down the panels.
- The circuit would shut off after the rope has been cut.
- The circuit can turn on again after getting another signal should the first attempt not work.
- The circuit needs to be powered from about 4.2V that will come from the battery after being dormant.

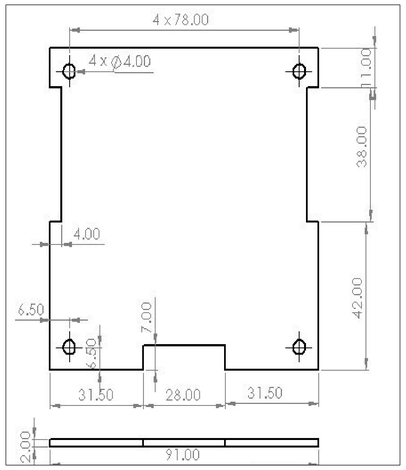
The following was done during the design process to accommodate the above:

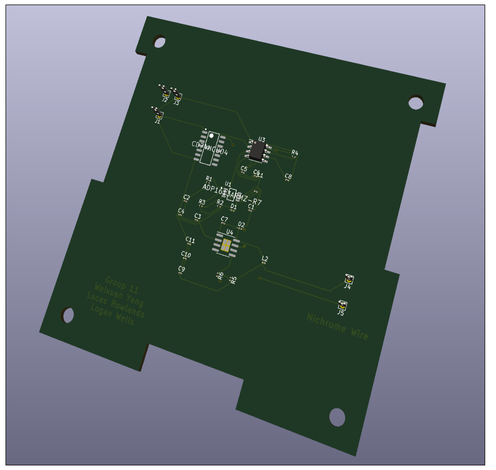
- The circuit would use a timer that would receive the signal and turn on the burn wire for a given time. This time can vary; however, it would be anywhere from 2-6 seconds.
- A step-up regulator will be used to ramp the voltage up to the required voltage needed, and then a step-down regulator will be used to convert that voltage into a high enough current to heat up the burn wire to the required temperature.

Details of Design

The entire circuit includes three major parts, which are the latching circuit, the step-down circuit, and the burn-wire circuit, as the figure shows. The critical component of the latching circuit is the 555 Timer, which can generate a pulse with exact duration when it is triggered. This sub-circuit helps to avoid any noise or unstable signal from the ADCS board to affect the burn-wire circuit and makes the power-on time of the circuit to be configurable by changing the resistance value of the resistor connected with the pin 6 and 7. The purpose of the step-down circuit is to utilize its step-down regulator to enlarge the voltage from the satellite battery to feed the burn-wire circuit, so it can step-up the voltage to output sufficient current to make a successful cut. The burn-wire circuit includes a step-up regulator, which is used to enlarge the line current by reducing the input voltage. Theoretically, the burn-wire needs 1.60-Amps to pass through to generate enough heat to cut the tie-down cable (Thurn. A et al, 2012). In our case, we use a 50mm 30AWG nichrome wire, which has 2-ohm resistance, to test the circuit.







Recommendations & Conclusion

- Both regulators still draw power after the enable is turned off. A possible solution is to use the timer circuit to control a relay which will isolate the regulators from the battery after operation.
- To reduce the operating temperature of the regulators, it is recommended to use a thermal ground plane on the final PCB design.
- Overall testing shows that the prototype circuit was able to produce the target current of 1.6 A and successfully cut through the string using the supply voltage of 5V.

References

[1] Nanosats Database. (2020, December). *LORIS (DUCS, Dalhousie University Cubesat).* Retrieved from https://www.nanosats.eu/sat/loris

[2] A. Thurn, S. Huynh, S. Koss, P. Oppenheimer, S. Butcher, J. Schlater, and P. Hagan. (2012, May). *A nichrome burn wire release mechanism for CubeSats.* The 41st Aerospace Mechanisms Symposium.