CAPSTONE, IMAGING, AND ASTRIONICS (CIA) BOARD FOR CONTROLLING CUBESAT MAGNETORQUERS

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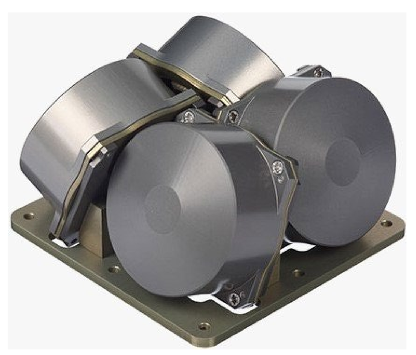
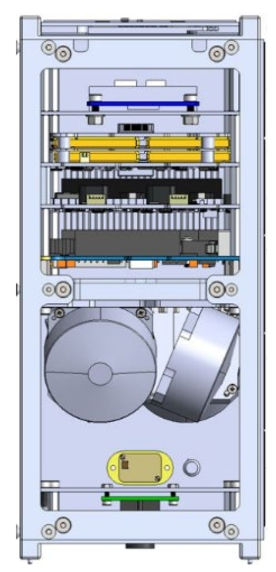
Attitude Control

- Attitude (orientation) control of the CubeSat is necessary in order to point the camera towards Earth to take pictures.
- Attitude control is achieved using commercial off the shelf reaction wheels.
- As the reaction wheels spin up, the satellite begins to spin in the opposite direction.
- In order to keep the satellite at a particular orientation, the reaction wheels need to maintain a constant speed.



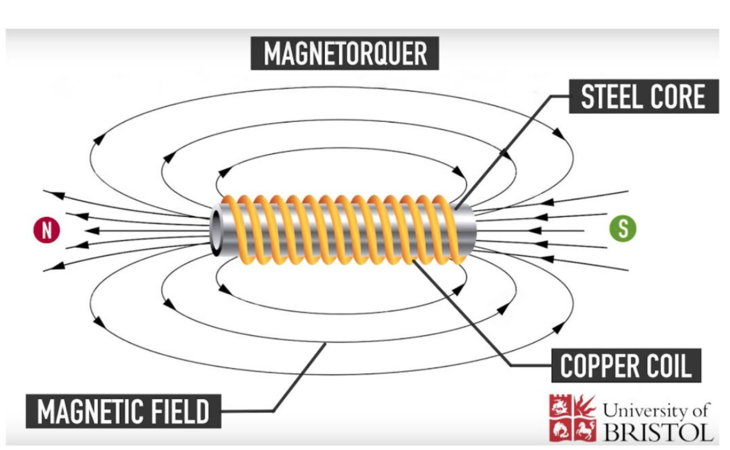


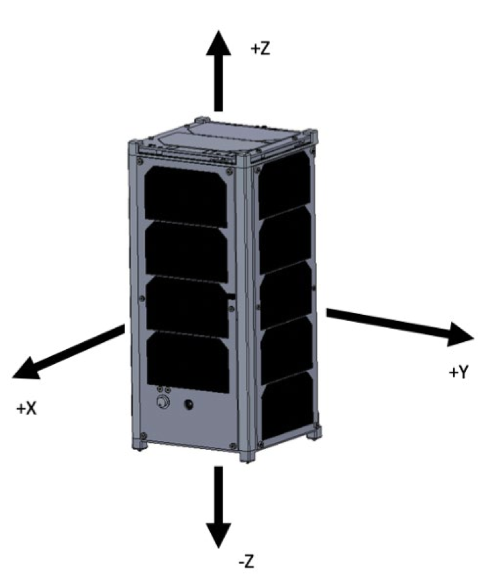
Desaturation

- Once the reaction wheels saturate, or reach their maximum speed, they are no longer able to effectively control the attitude of the satellite.
- Simply slowing down the reaction wheels isn't an option, because doing so would add unwanted spin to the satellite.
- In order to desaturate these reaction wheels while maintaining a desired attitude, the satellite needs a way to produce a torque that resists the spin caused by slowing down the reaction wheels.

Magnetorquers

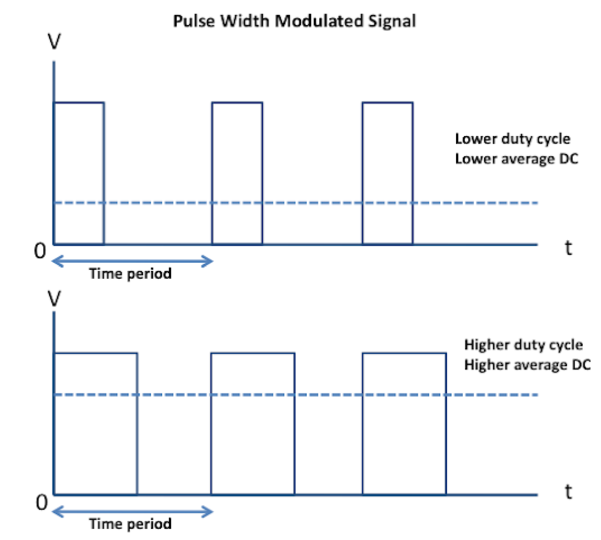
- Magnetorquers are little coils of wire that produce a directed magnetic field called a magnetic dipole moment.
- In order to generate a torque, the magnetic dipole moment generated by the magnetorquer must interact with the magnetic field of the earth.
- With multiple magnetorquers placed on various sides of the CubeSat, a very specific magnetic dipole moment can be used to generate the desired torque, keeping the CubeSat from rotating.



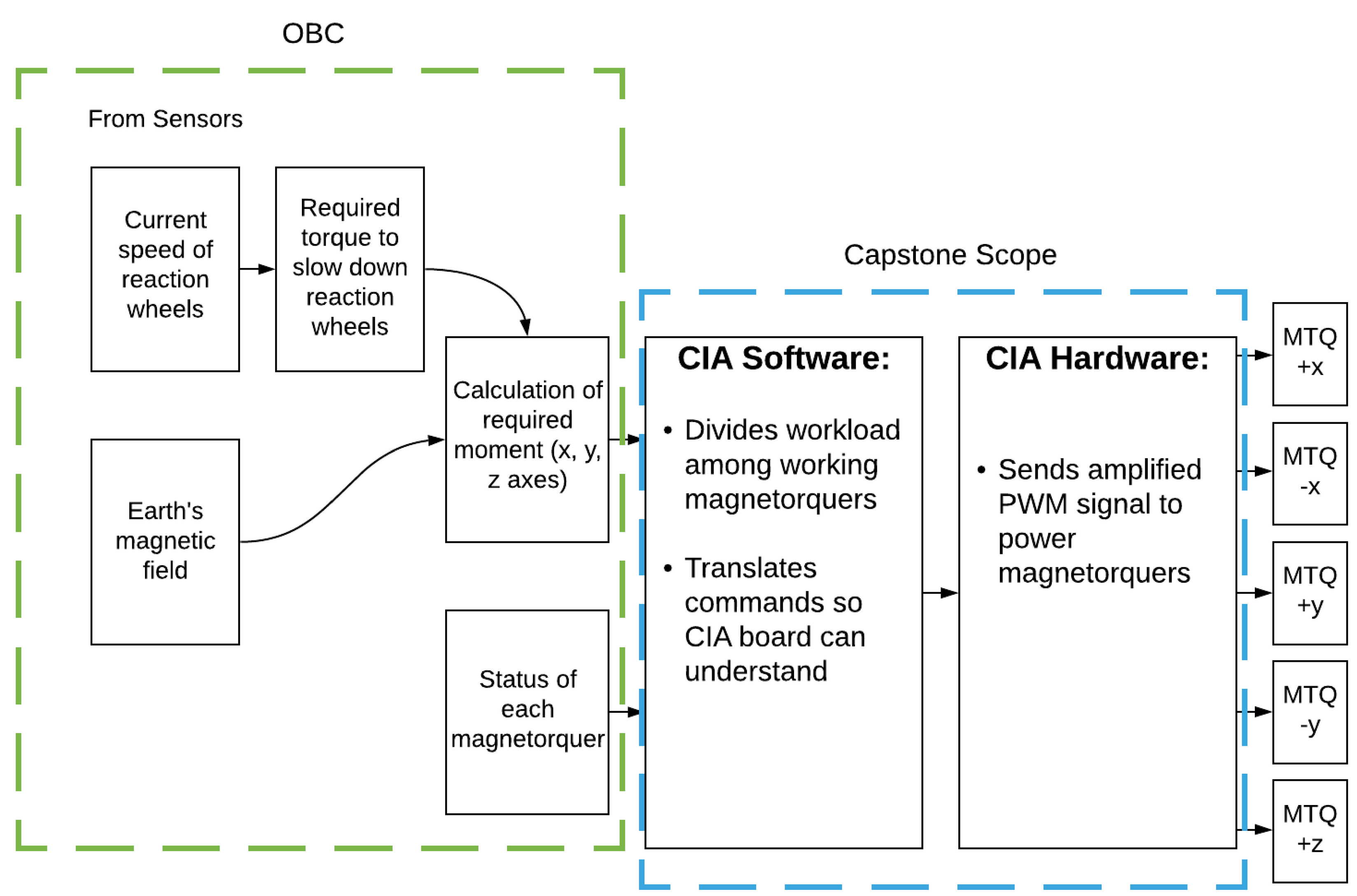


Capstone Mission

- Our mission is to take in this specific magnetic dipole moment that the Guidance, Navigation, and Control (GNC) algorithm generates and translate it to commands our hardware can use.
- Our hardware must supply each of the 5 magnetorquers with pulse width modulated (PWM) signals to generate the desired dipole moment.
- In addition, we must also house the Imaging team's hardware on our circuit board.



System Overview

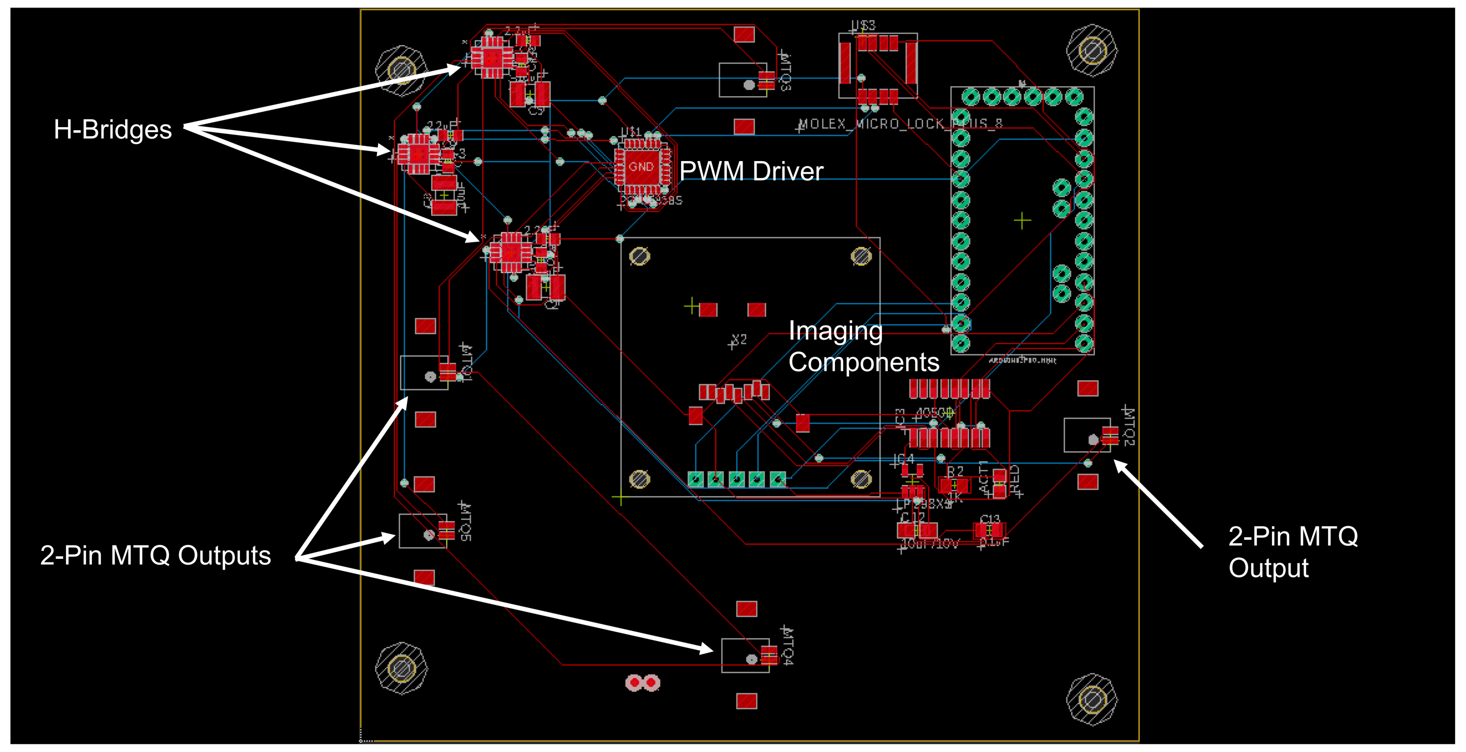


- All of the sensor readings and calculations in the green box are done by the on-board computer (OBC) and are outside the scope of the capstone project.
- The OBC provides the required magnetic dipole moment and the health status of each magnetorquer to our software function.
- Our function divides the workload of the required dipole moment among the operational magnetorquers. The function also translates the dipole moment for each of the magnetorquers into commands that the CIA board can understand.
- Those commands are sent to the CIA board, and the board generates and amplifies PWM signals that power the magnetorquers.

Software

- The first input to our software function is the three-dimensional magnetic dipole moment as an array of floating point numbers. The second input is the operational status of each of the magnetorquers, where status can either be functional or not functional.
- The output of the function is the commands to produce the PWM signals on our board, according to the PCA9685 data sheet.
- Our code is composed of two C functions, a C header file, and a unit test file. The primary function, setMags.c, determines the signals to be sent to the magnetorquers using the helper function, allocation.c. The header file contains the definitions of these functions, making it more convenient for the on-board computer to use.
- These functions are verified using unit tests, which run the functions with test inputs to ensure the outputs are reasonable. These unit tests are stored in ciaAllocationUnitTests.c.

CIA Board Design



- Above is the CIA board that was designed by the capstone team and sent out for fabrication and assembly by third party companies.
- The PWM driver communicates with the OBC and sends out the PWM signals.
- The h-bridges amplify the current of the PWM signals in order to power the magnetorquers.
- The 2-pin magnetorquer outs are the wires that connect our board to the magnetorquers.
- The Imaging team's components include an Arduino, SD card holder, and a camera.

Future Work and Acknowledgments

- Addition of a checkStatus.c file for determining the status of each magnetorquer
- Development of testing procedures for validation and verification of the CIA board
- Improvements on overall board design

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