ME399 - Reaction Wheel Project

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1 Introduction

Last spring, due to COVID-19, the NUSTARS Foundation Rocketry team was unable to complete the competition. One subsystem of our rocket was a reaction wheel. We were only able to get as far as manufacturing the required components to make the reaction wheel, but developing the electronics and code needed to make it operational was not finished. I would like to work on developing this system this quarter (Fall 2020) with the goal of having a fully operational reaction wheel, and documentation to support it, so that the design can be utilized in future NUSTARS projects and competitions.

2 Motivation

The aim of the reaction wheel is to control the roll(rotation about the roll axis shown in Figure 1) of a rocket during ascent. This is achieved by spinning a mass inside the rocket, and by conservation of angular momentum, inducing a roll in the desired direction. The reaction wheel is controlled by an on-board flight computer (typically an Arduino). Commonly, we may want to eliminate roll all together, often for the purpose of obtaining clear photo and video during the rocket's ascent. Other reasons to control roll can be to increase stability, or simply to fulfill rocket competition requirements.

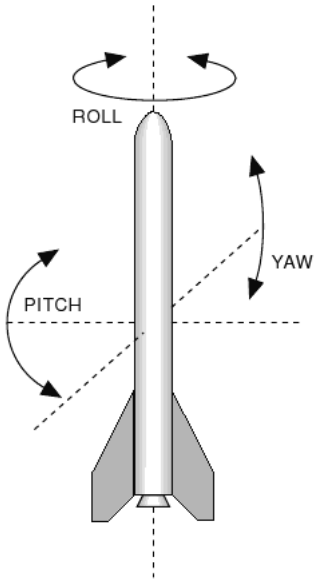

Figure 1: Axes of a rocket

3 Plan

Since last year we only completed the mechanical design, which was fairly simple(Figure 2), the majority of the work left for this project is still left for me to do now.

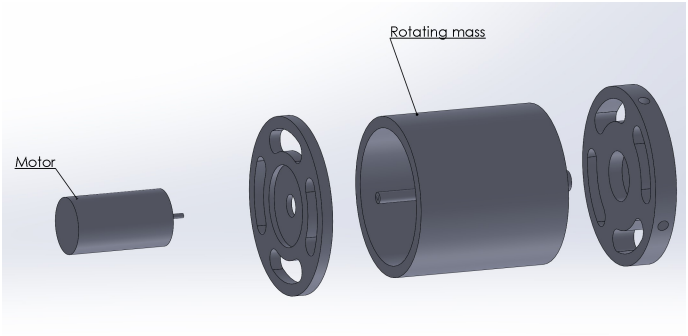

Figure 2: Reaction wheel design

3.1 Control system

The majority of the project will consist of setting up a control system for the reaction wheel with an Arduino, an Adafruit BNO055 Absolute Orientation sensor, and DC motor. The goal of my project now is to create a feedback system that will actively try and eliminate any rolling the rocket experiences during flight. The plan is to read orientation data from the BNO066 sensor to determine the rolling of the rocket in which the reaction wheel is situated, then to trigger the motor to turn the reaction wheel in such a way to counteract this roll. A PID controller will most likely be utilized in this control system.

3.2 Testing and Further Development

Testing To test the reaction wheel, I would hang a small section of a rocket from a string, mount the reaction wheel inside, turn it on, and rotate the rocket section by hand to see if the reaction wheel can properly correct for the roll. Then I would measure the time it takes to correct for rolling through different angles. For example, I could make a plot of roll angle versus correction time to see how effective my system is and how I could improve on it.

Further Development After creating a functioning active roll control system with the reaction wheel, I would like to tweak the system to allow for rocket masses to be variable. That is, a different rocket mass can be specified in the reaction wheel code and then the reaction wheel will still be able to function. I would then like to determine, based on the mass of the reaction wheel, what the most effective mass range that the rocket could have for the roll control to work effectively. Lastly, time permitting, I would like to tweak the system again to allow for the mass of the reaction wheel to also be variable. Therefore, if a larger rocket is used I can choose a reaction wheel mass so that the roll control will be most effective.