Low Power Magnetic Attitude Control System for a CubeSat

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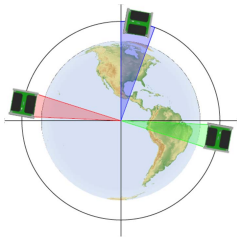
Concept

Nadir Pointing CubeSat with low power magnetic control

Low Power Magnetic Torquers

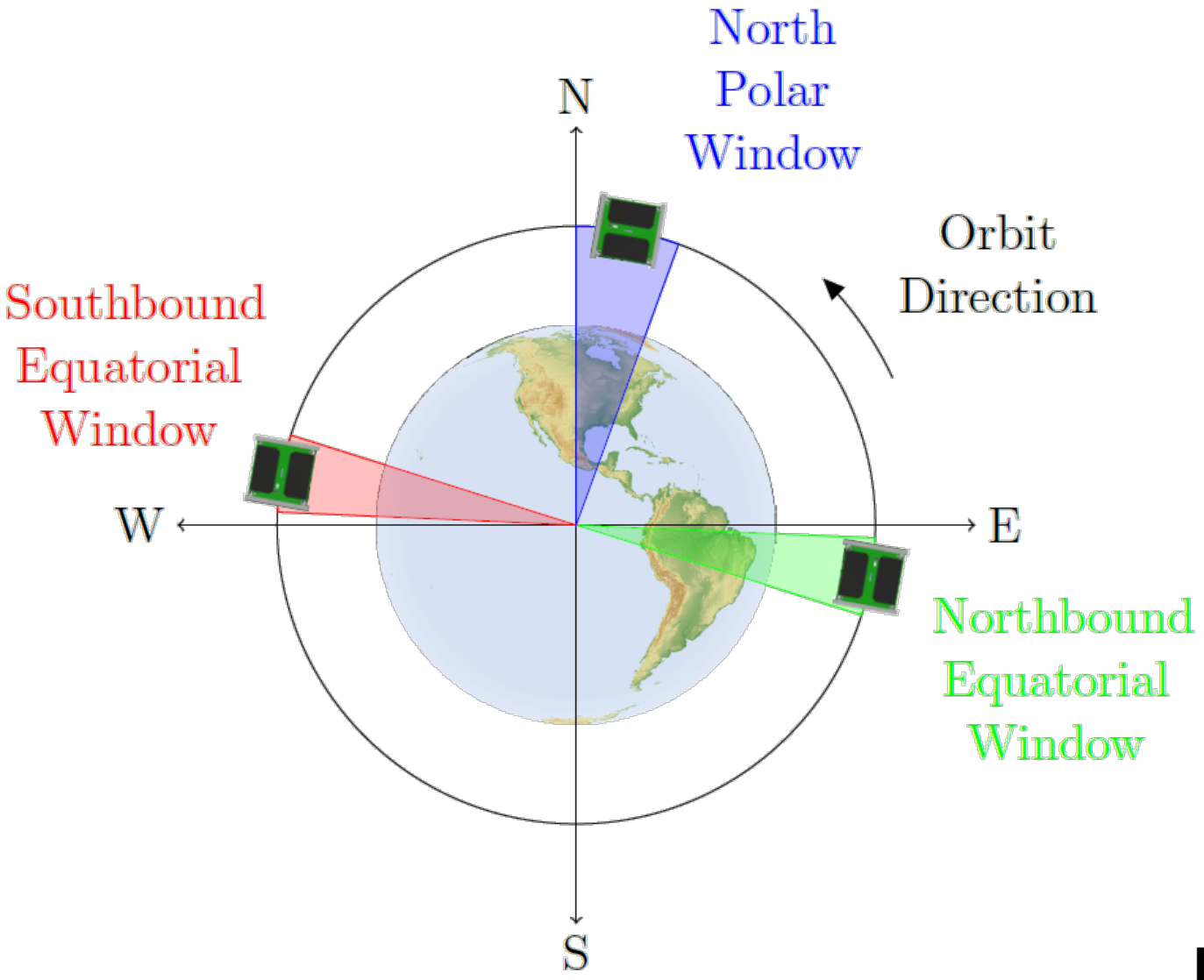
- Hard magnetic material reduces power consumption
- Allows bias with no power penalty



Bias algorithm

- No required attitude knowledge
- Three axis magnetic control

Bias Algorithm



Motivation

Active Magnetic

- Moderate power usage
- More control of attitude
- More complex algorithm

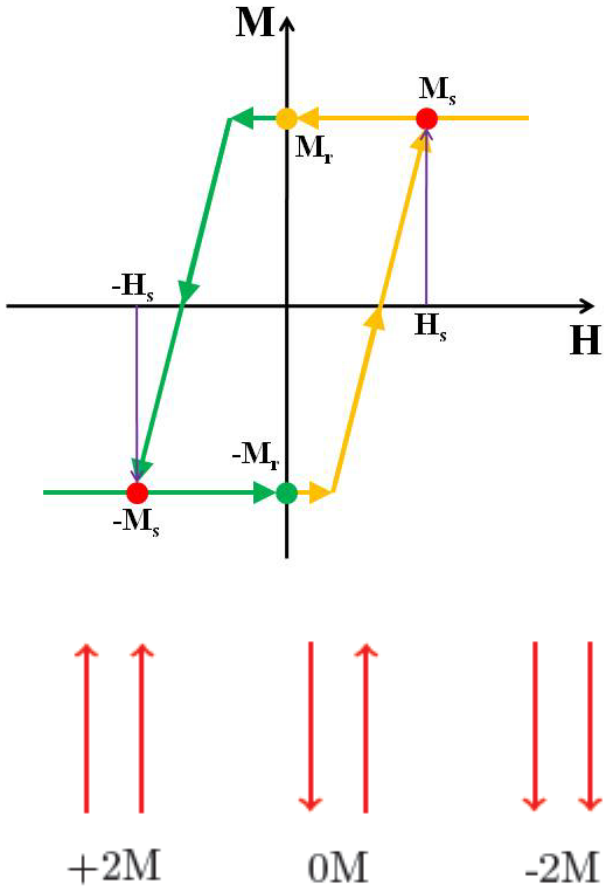
LPMT

- Low power usage
- Simple algorithm
- Allows for nadir pointing

Passive Magnetic

- No electric power usage
- Attitude relative to local magnetic field

Low-power Magnetic Torquer



History

Initial Concept

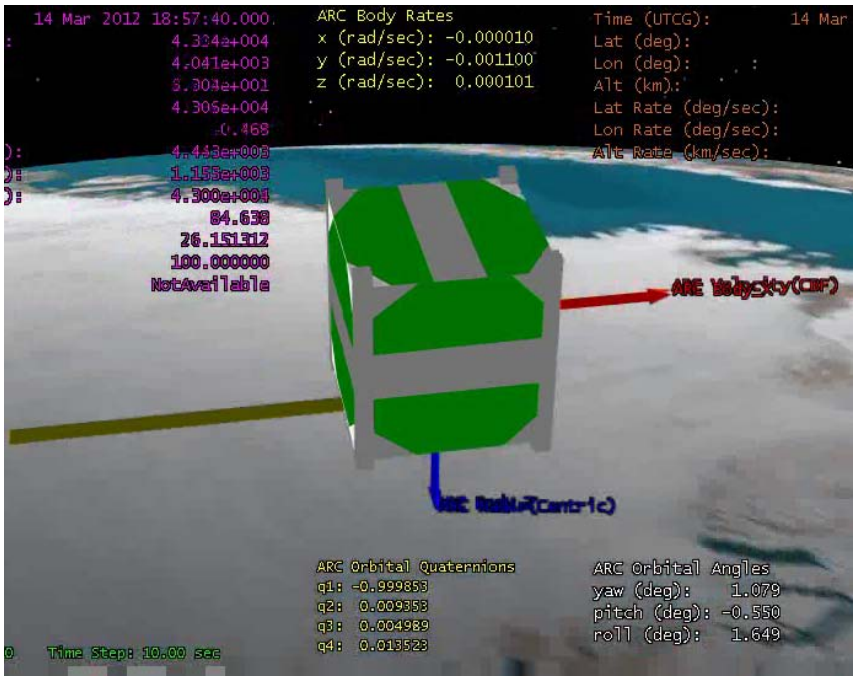
- Originally conceived to dump momentum from reaction wheels on larger spacecraft
- Used remendur for torquer cores

CubeSat Adaptation

- Primary Torquers with Alnico 1 for detumble.
- Vernier Torquers with inert core coated with magnetic material for alignment

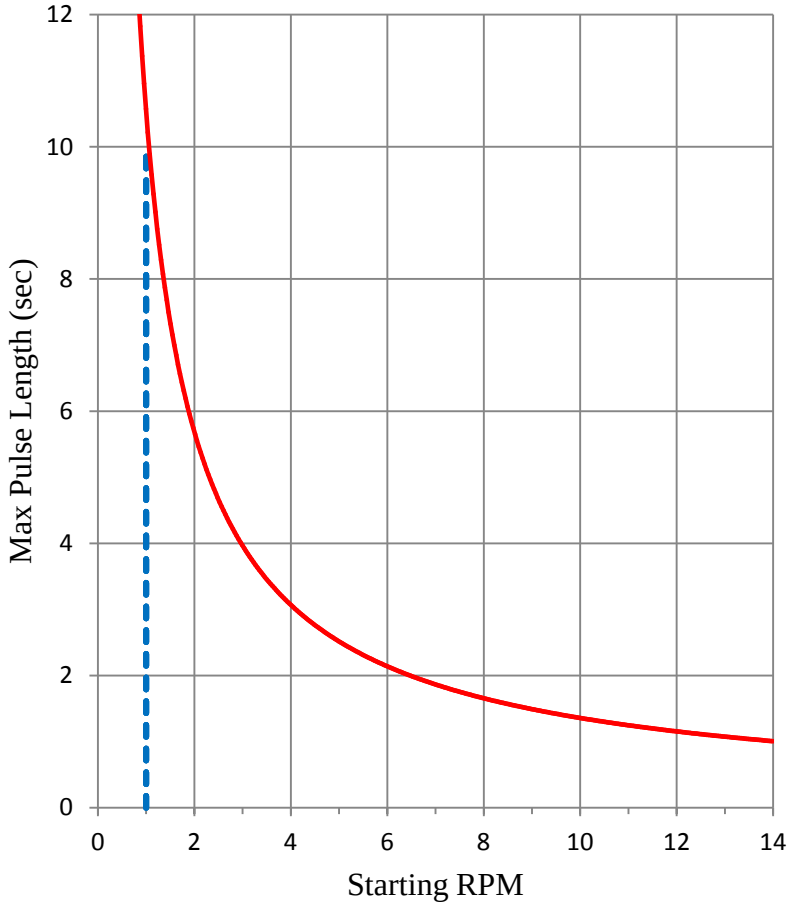
Algorithm Overview

- 3 modes
  - 1 for detumble
  - 2 for alignment
- dual axis bias for three-axis attitude alignment
- No direct attitude knowledge necessary
- Latitude information required for alignment

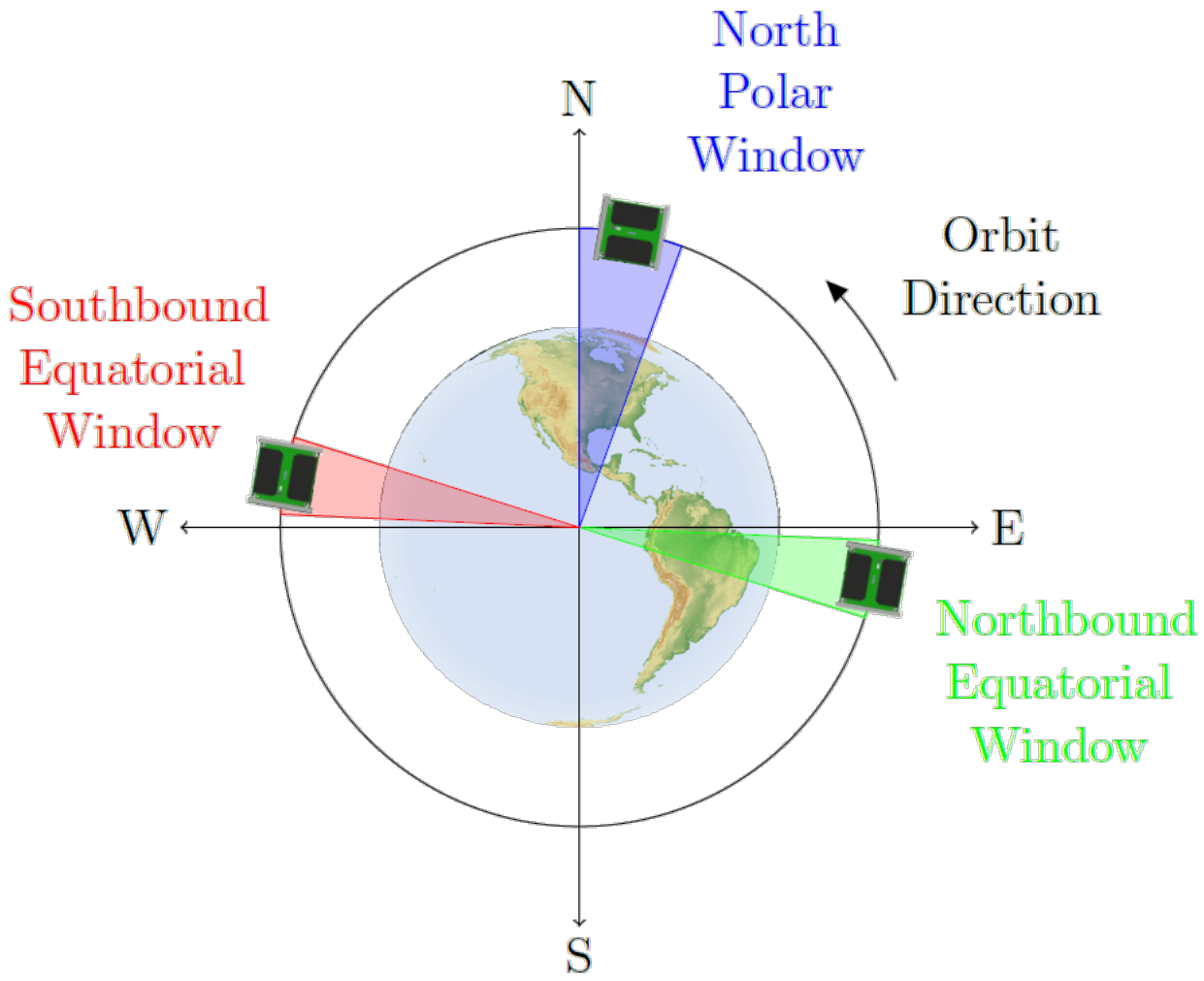


Mode 1 (Detumble) Algorithm

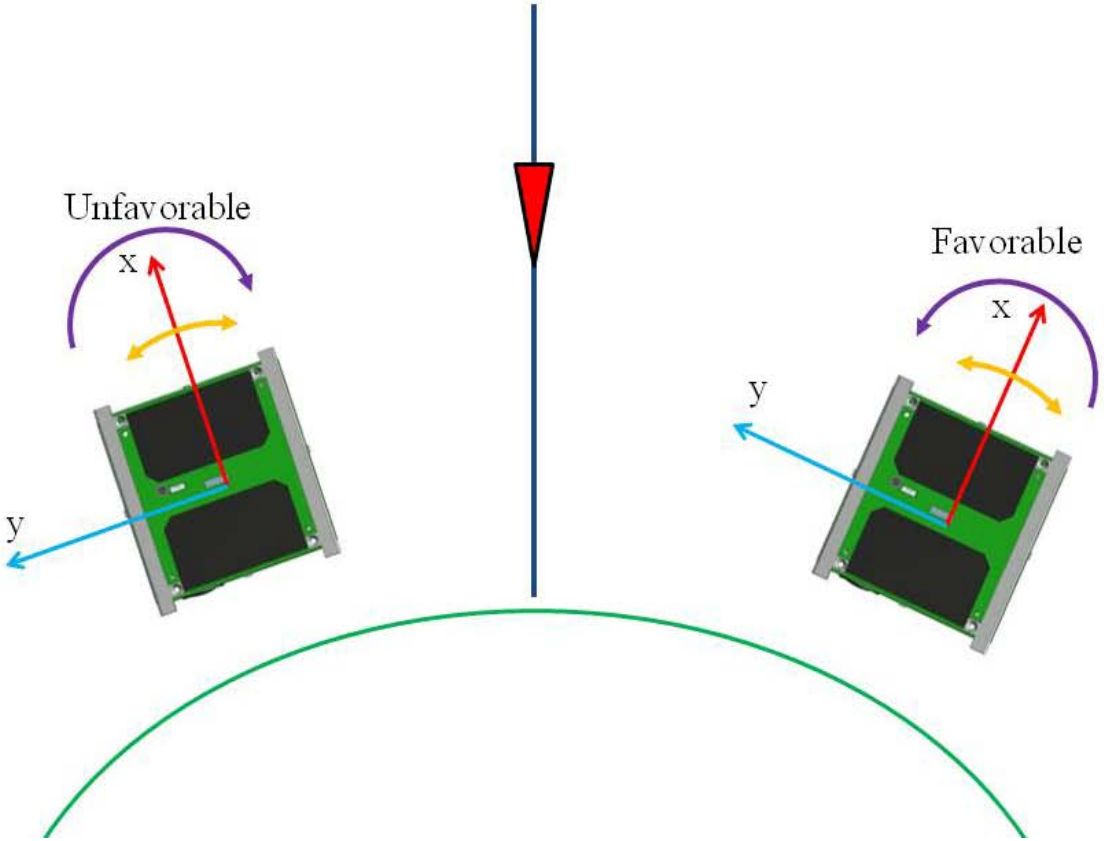
- Detumble is the only use of the ALNICO1 torquers
- The detumble algorithm can arrest a maximum rate of 5°/s
- For a 64° inclination the detumble procedure will take 2 orbits



Bias Windows



Alignment Window Offsets



Alignment Modes

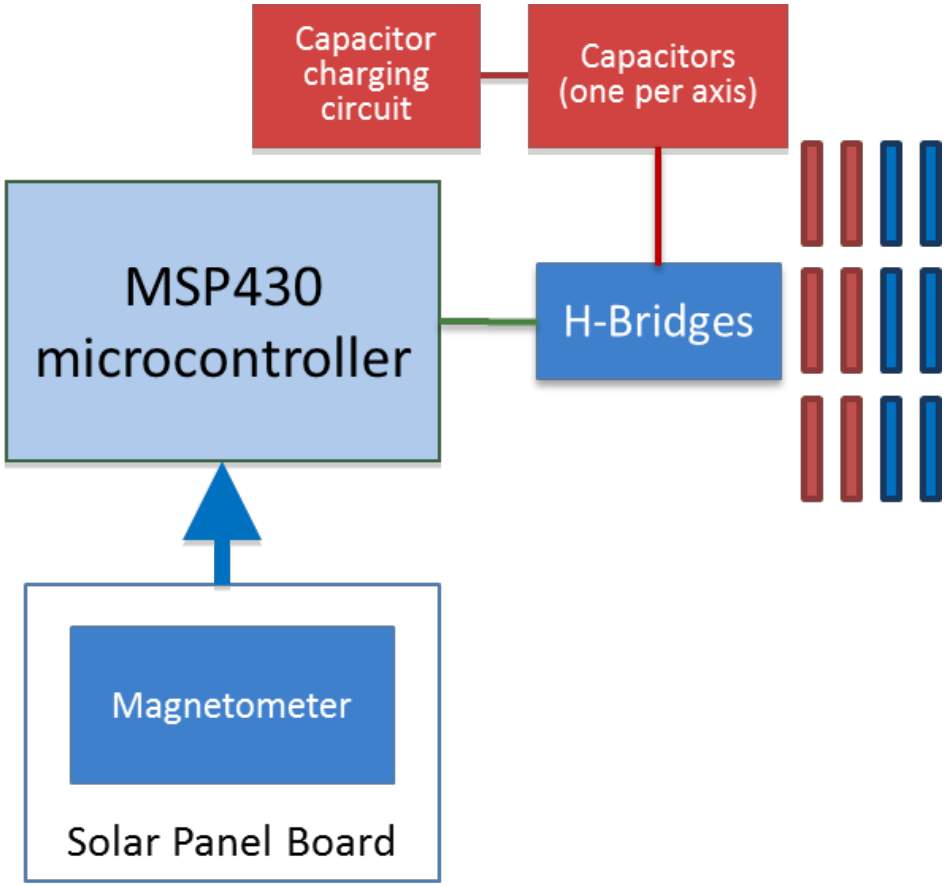
Mode 2

- Apply bias in equatorial and north polar windows
- Outside windows coast
- Run for 10 orbits

Mode 3

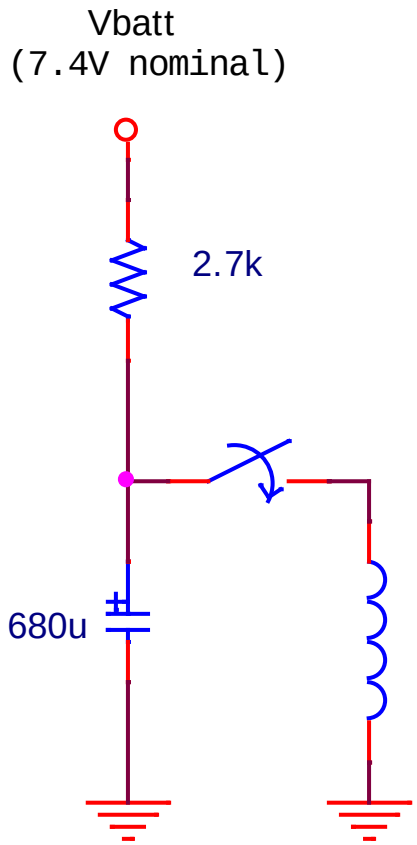
- Apply bias in north polar window
- Outside window run detumble algorithm with small torquers

CubeSat System Overview

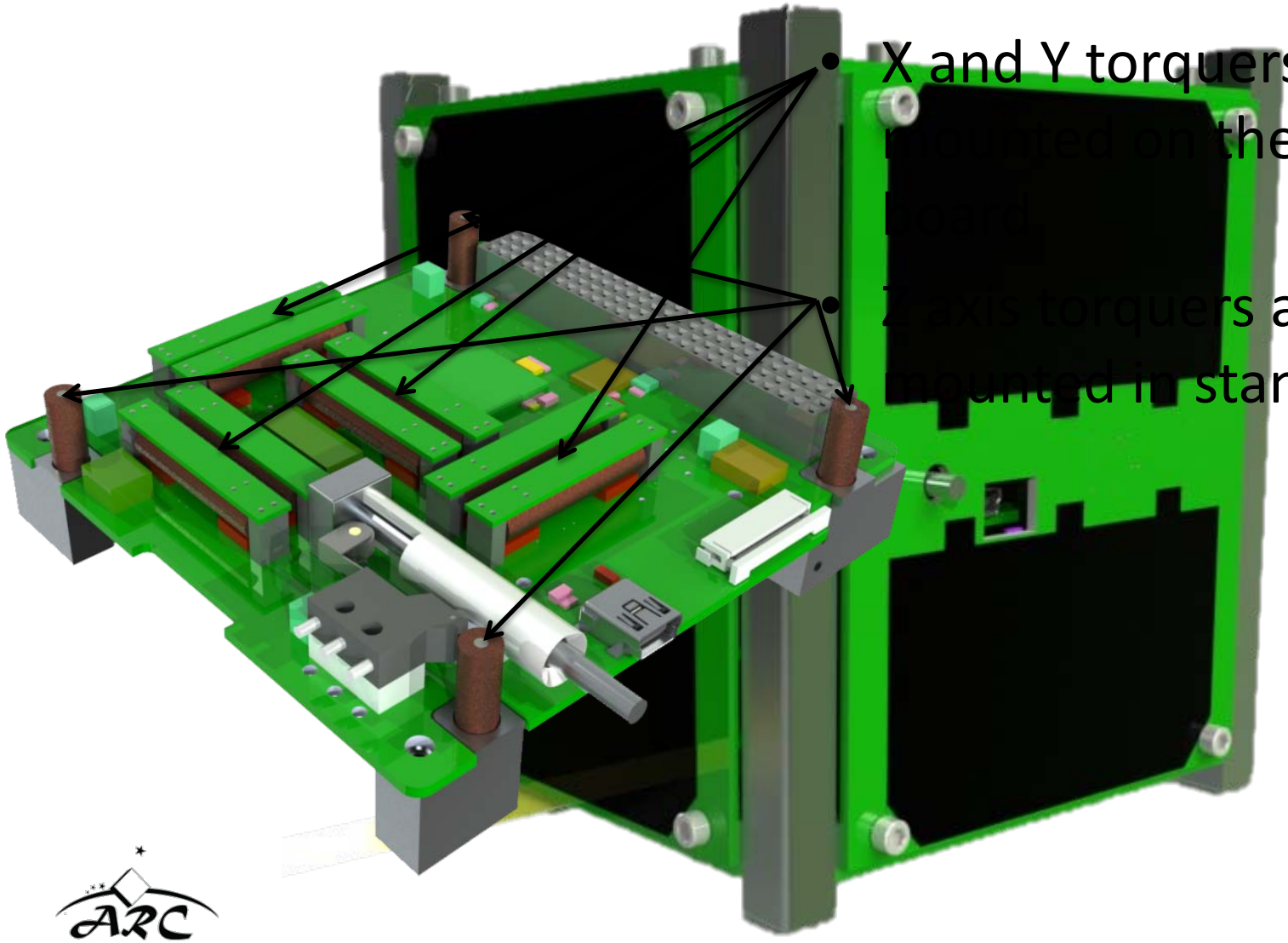


Torquer Driver Schematic (Simplified)

- Core driven to saturation by a 7A current pulse
- Capacitor stores charge for current pulse to smooth current spikes and prevent supply overdraw
- Resistor charges capacitor from supply rail

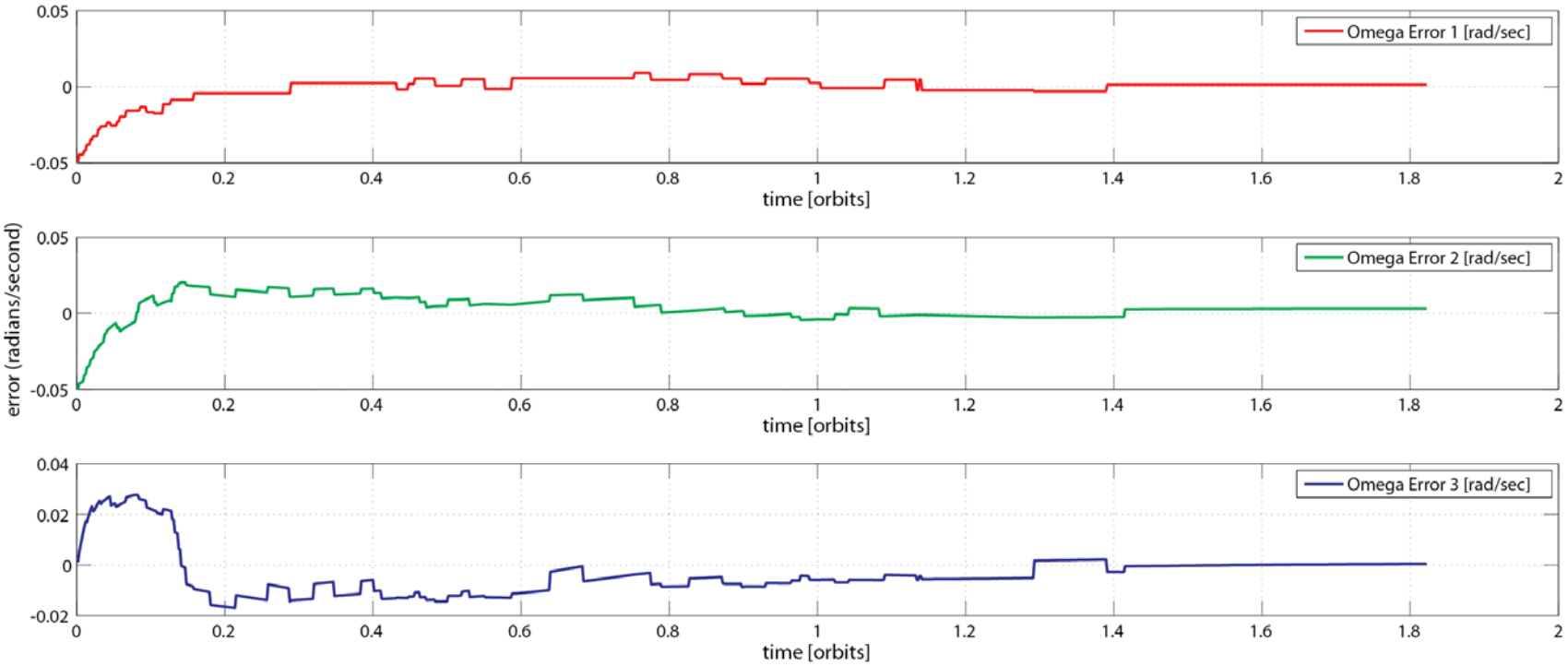


Torquer Placement

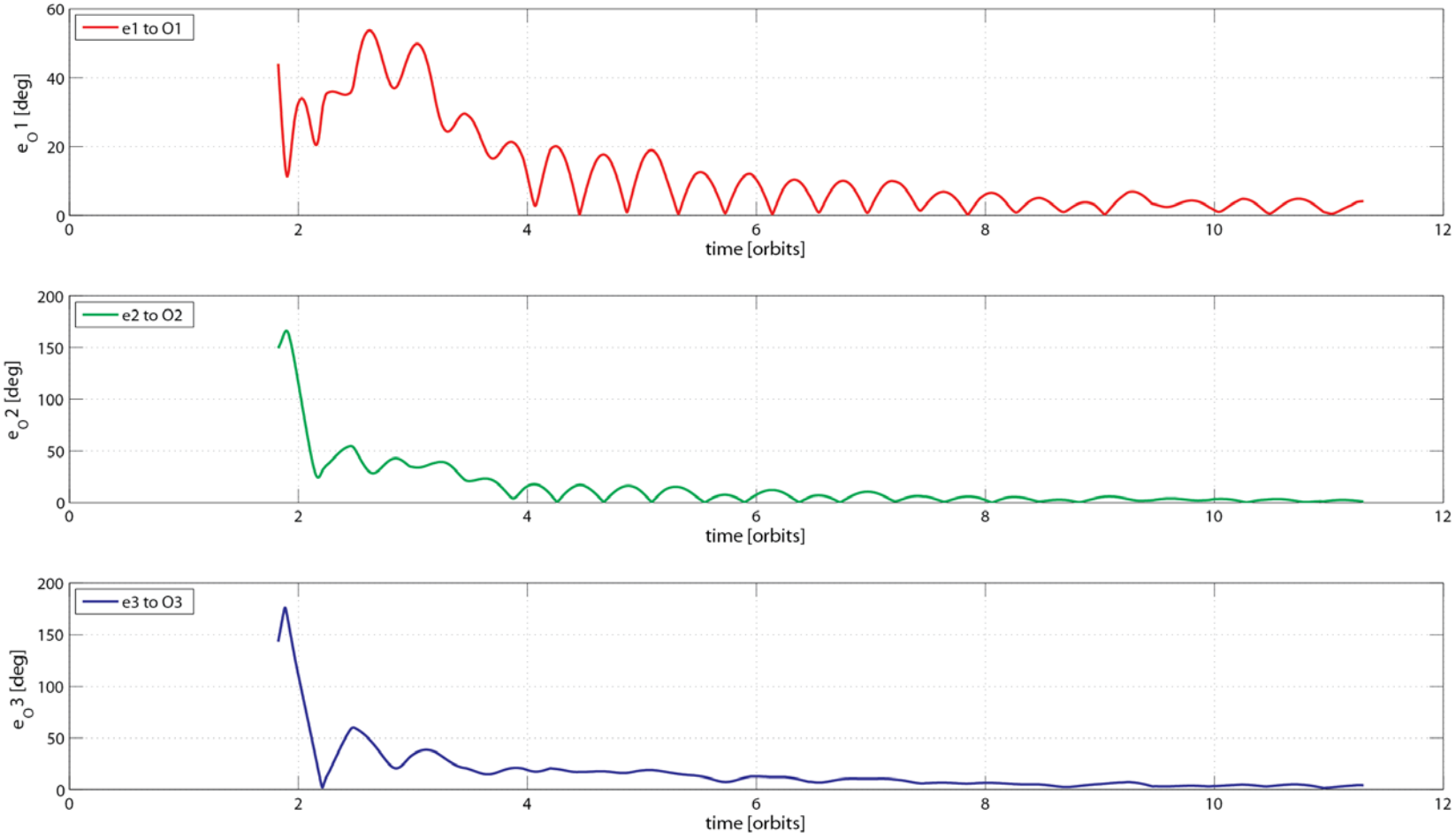


- X and Y torquers are mounted on the ADCS board
- Z axis torquers are mounted in standoffs

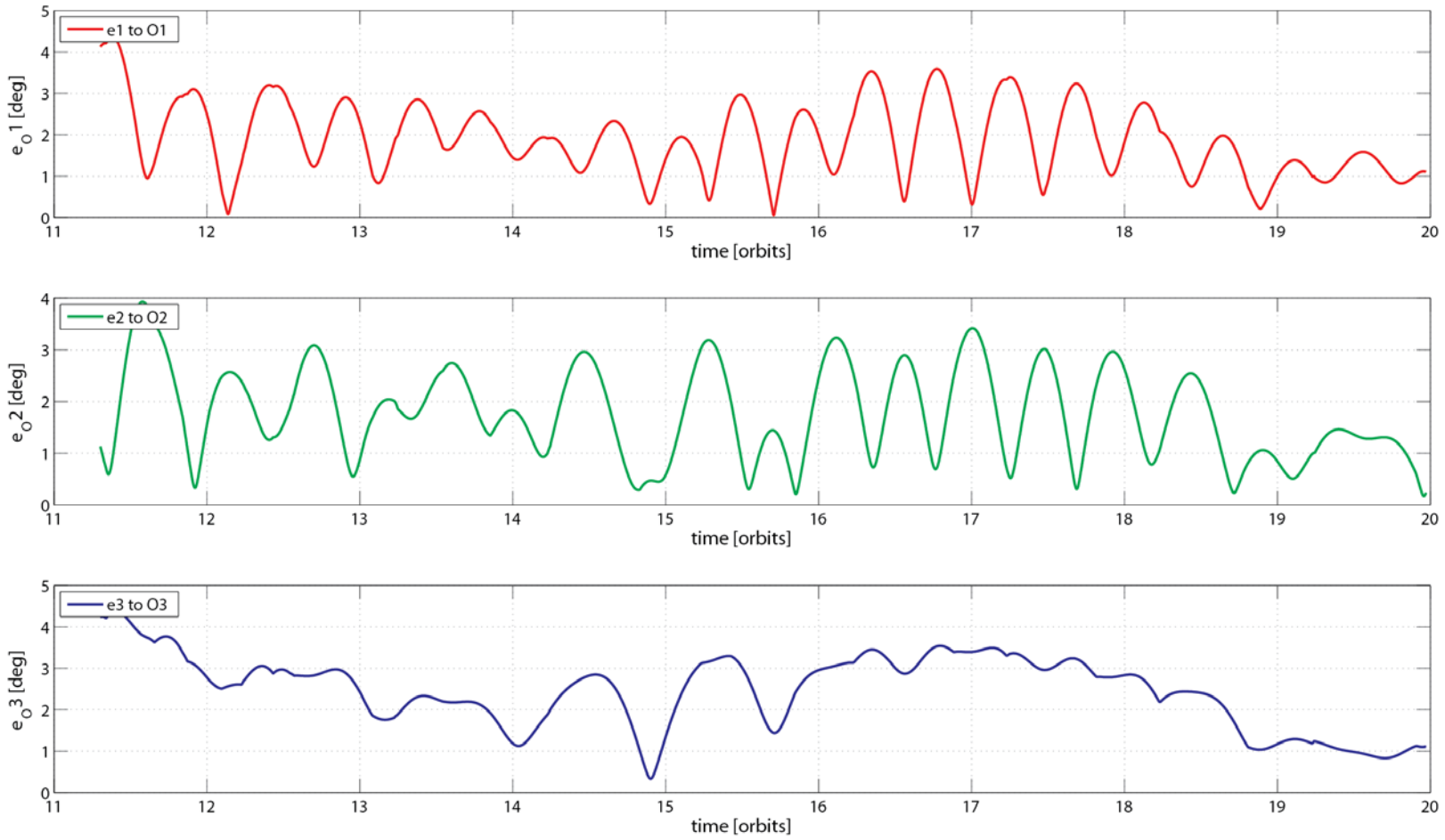
Simulation Results : Detumble



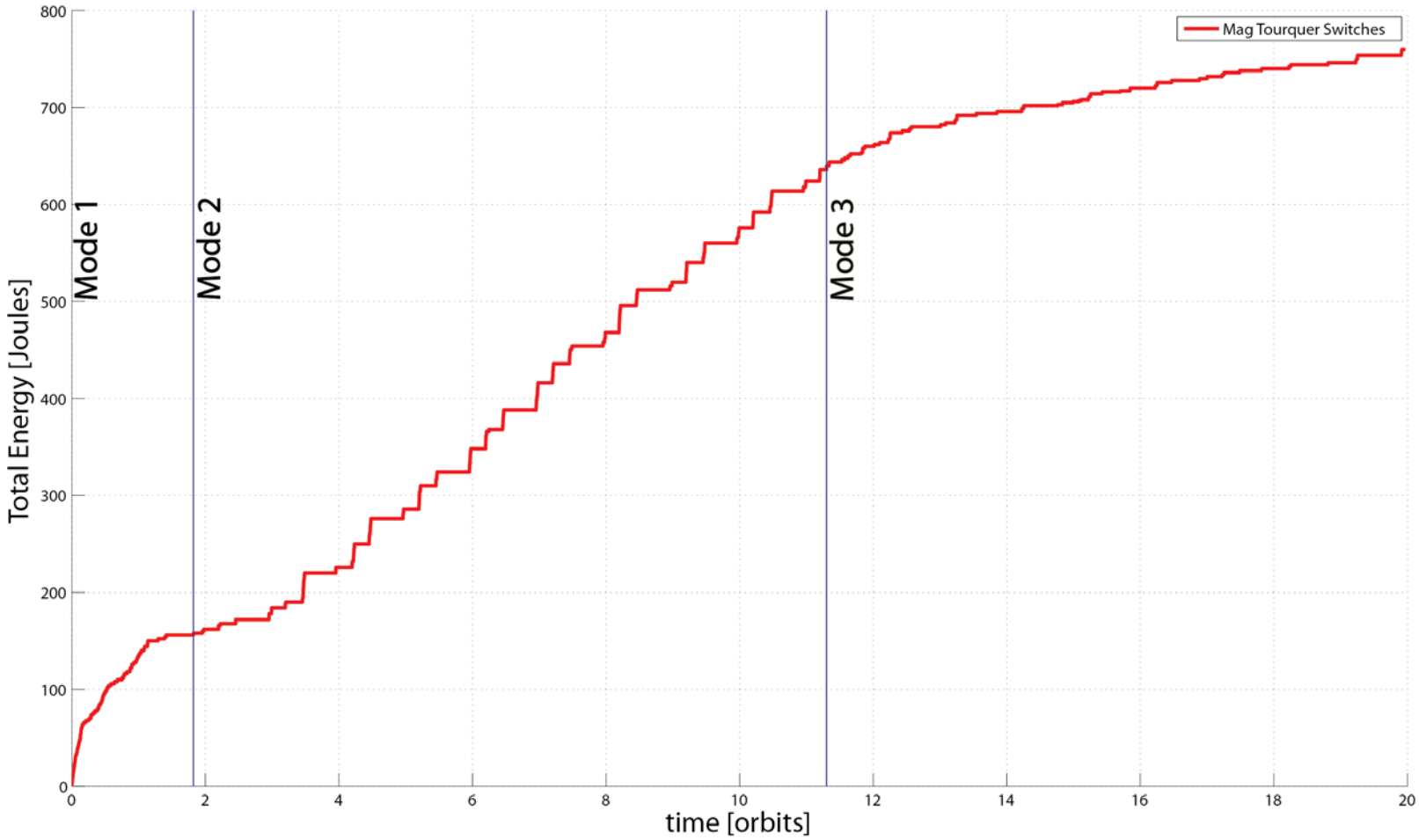
Simulation Results : Mode 2 Establish Alignment



Simulation Results : Mode 3 Maintain Alignment



Joules of Energy Consumption



Future Work

- Need to balance magnetic dipole moments
- Correct magnetometer data for locally generated magnetic fields
- Validate Control Algorithm

Conclusion

Low power for nadir pointing CubeSat applications

Designed for high inclination orbits

Alignment accuracy depends on balance of torque rods

Questions

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