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This document explains the function of the ADCS, its schematic level design, its board level design, and its functional testing

ADCS

Attitude Determination and Control System Design

Revision: 1.0.1



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# Introduction

This document explains how the ADCS will fulfill the following Functions and conform to the following Requirements. This document refers to the Avionics Board version 1.1.

## Function

The ADCS is responsible for the following:

* Operating the magnetorquer coils
* Collecting data on the position and orientation of the satellite

## Requirements

The requirements and design requirements for the ADCS can be found on GitHub.

# Detailed Description

This section references the Avionics Board schematic. Page numbers will be listed and may have coordinates listed (number and letter combination found around the frame).

## Functional Block Diagram

The block diagram can be found on the first page of the schematic.

### Magnetorquer Coils

The ADCS operates three magnetorquer coils in order to rotate the satellite while in orbit. Each coil is positioned on a different axis. three H-bridges provide a varying current to each coil, producing a magnetic field that’s strength can be controlled. The resultant magnetic field of all three coils interacting with the magnetic field of the earth will produced the desired rotation.[[1]](#footnote-1)

### Monitoring and Changing Orientation

The ADCS receives data from six photodiodes, each positioned on a different face of the satellite. Each sensor provides a signal dependent upon its exposure to the sun. By monitoring these signals, an estimate of the sun’s direction can be made. Knowing the sun’s direction and satellite’s current position above the earth[[2]](#footnote-2), the ADCS knows the satellite’s orientation[[3]](#footnote-3) and what rotations need to be made in order to point at the desired target/angle.[[4]](#footnote-4) The rotations will be monitored using the three Inertial Measurement Units. These sensors provide the changes in acceleration and rotation.

## Schematic

### Power Rails

Page 2 of the schematic illustrates the power rails the Avionics Board draws from. The ADCS subsystem draws power from 3.3V-2 and BATT-5.

### ADCS Microcontroller

The ADCS Microcontroller[[5]](#footnote-5) (page 3) handles the data received by the various sensors in the ADCS subsystem as well as operated the three magnetorquer coils. It was chosen for its ease of programming, and lower power consumption. The ADCS Microcontroller communicates with the sensors through two I2C Buses and a UART bus.

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### EEPROM

The

### IMUs

The three Inertial Measurement Units[[7]](#footnote-7), or IMUs, (page 4, A2, B5, & C2) sense changes in the satellite’s linear acceleration, rotation, and gravity. This information is transmitted to the ADCS Microcontroller through the I2C buses.

### H-Bridges

The H-Bridges[[8]](#footnote-8) (page 5, A3, B3, & C3) provide a PWM signal to the magnetorquer coils. Varying the signal increases and decreases the current passing through each coil, changing the strength of the resultant magnetic field.

### Magnetorquer Coils

The

### ADCs & Amplifiers

The Analog to Digital Converters[[9]](#footnote-9), or ADCs, (page 6, A3, B3, C3, & D3) monitor the temperatures of the components in the ADCS subsystem as well as the current passing through the magnetorquers.

### GPS

The GPS[[10]](#footnote-10) (page 7, B2, B3) sends the satellite’s coordinated above earth via UART to the ADCS microprocessor.

### Power & ADCS Jacks

The six Picolock jacks (page 11, A1, A2, A3, A4, B1, B2, B3, & B4) provide the I2C connections for the six ADCs not on the Avionics board. The +X and -Z jacks also provide power to the ADCs they connect to. The power inputs (page 11, C1, C2, D1, & D2) come from the backplane (from the Electrical Power Subsystem). The ADCS uses the 3.3V-2 power source.

### I2C Bus

The ADCS has three I2C buses (page 3 B2, B3, & B5). Two are for communicating with sensors and ADCs, and one is to communicate with C&DH. On the ADCS buses, the ADCS Microcontroller is the master served by the attached devices

#### IMUs

There are three IMUs connected to the ADCS Microcontroller. All IMUs are located on the Avionics Board. The list of addresses follows:

|  |  |  |  |
| --- | --- | --- | --- |
| **IMU** | **I2C Bus** | **I2C Address** | **COM3** |
| IMU0 | ADCS\_I2C0 | 0x28 | L |
| IMU1 | ADCS\_I2C0 | 0x29 | H |
| IMU2 | ADCS\_I2C1 | 0x28 | L |

Note: Redundancies in addresses is are accounted for by being on different busses

#### ADCs

There are eight IMUs connected to the ADCS Microcontroller. Two ADCs are located on the Avionics Board. The remaining 6 are each located on a different panel of the satellite. The list of addresses follows:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **ADC** | **I2C Bus** | **I2C Address** | **AS1** | **AS0** |
| ADCS0 | ADCS\_I2C0 | 0x20 | H | H |
| ADCS1 | ADCS\_I2C0 | 0x22 | H | NC |
| +X | ADCS\_I2C1 | 0x20 | H | H |
| -X | ADCS\_I2C1 | 0x22 | H | NC |
| +Y | ADCS\_I2C1 | 0x23 | H | L |
| -Y | ADCS\_I2C1 | 0x2A | NC | NC |
| +Z | ADCS\_I2C1 | 0x2B | NC | L |
| -Z | ADCS\_I2C1 | 0x2C | L | H |

Note: Redundancies in addresses is are accounted for by being on different busses

## Board

The board shall be double layered with copper and ENIG finish. The board shall also conform to the dimensions specified by the [CougSat Module Standard](https://github.com/CougsInSpace/CougSat1-Hardware/blob/master/CougSat1-Backplane/Documentation/CougSatModuleStandard.pdf).

### Layout Constraints

Unless specified in the following subsections, all signals shall use the default parameters below. Signals in the following subsections do not include their sense signals unless otherwise specified. Trace width can be broken if a trace needs to bottleneck down to a pin, the bottleneck shall be minimized.

Trace width:

Vias: , unlimited count

Separation:

Length: unlimited

Devices with specific placement and routing considerations are called out on the schematic, see “CAD Note:”

#### JTAG – ADCS\_[JTCK, JTDI, JTDO, JTMS]

Length: Each node shall be length matched

Stubs:

#### I2C – ADCS\_I2C0\_[SDA, SCL], ADCS\_I2C1\_[SDA, SCL], BUS\_I2C0\_[SDA, SCL, IRQ]

Length: Each node shall be length matched

Stubs:

#### Power Traces – VBATT-5

PGND applies to between the H-bridges and the backplane

Length: Each node shall be length matched

Stubs:

1. Requirement ADCS-009 [↑](#footnote-ref-1)
2. Requirement ADCS-004 [↑](#footnote-ref-2)
3. Requirement ADCS-003 [↑](#footnote-ref-3)
4. Requirement ADCS-009 [↑](#footnote-ref-4)
5. [STM32L476RG](https://github.com/CougsInSpace/Resources/blob/master/SupplierDocuments/ST/STM32L476.pdf) [↑](#footnote-ref-5)
6. [STM32L476RG](https://github.com/CougsInSpace/Resources/blob/master/SupplierDocuments/ST/STM32L476.pdf) [↑](#footnote-ref-6)
7. [BNO055](https://github.com/CougsInSpace/Resources/blob/master/SupplierDocuments/Bosch/BNO055.pdf) [↑](#footnote-ref-7)
8. [DRV883x](https://github.com/CougsInSpace/Resources/blob/master/SupplierDocuments/Ti/DRV8837_HBridge.pdf) [↑](#footnote-ref-8)
9. [AD7291](https://github.com/CougsInSpace/Resources/blob/cad-libraries/SupplierDocuments/27%20-%20Conversion%20IC/27-0003/ANALOG_AD7291.pdf) [↑](#footnote-ref-9)
10. [Venus838FLPx-L](https://github.com/CougsInSpace/Resources/blob/master/SupplierDocuments/SkyTraq/Venus838FLPx-SPC_CubeSatGPS.pdf) [↑](#footnote-ref-10)