SpaceLab ADCS Module - PDR

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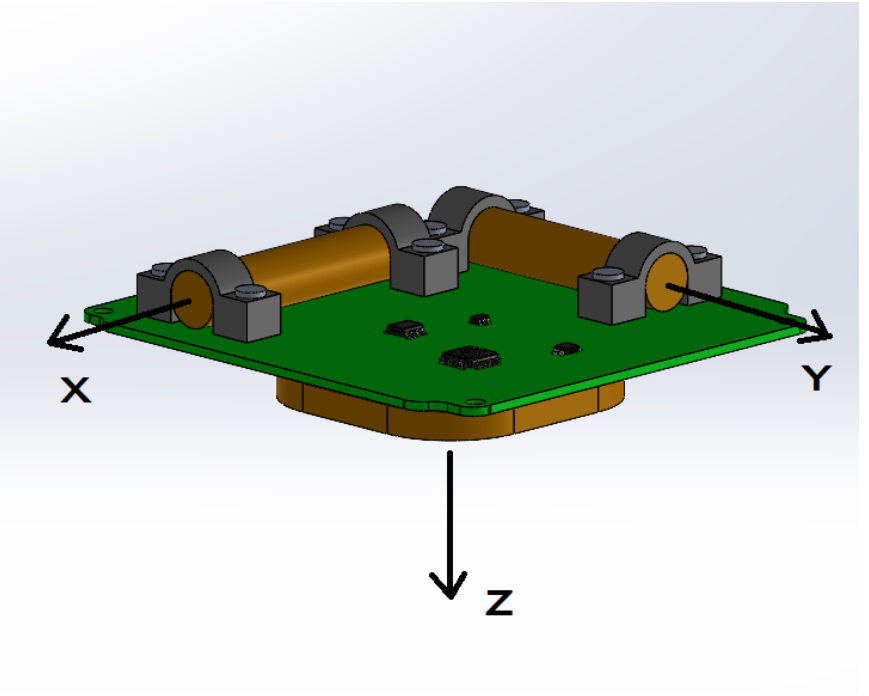
SpaceLab - UFSC

Summary

Project Overview

Overview

- Attitude Determination and Control System (ADCS) module for small satellites (Cubesat)
- Custom made project
- Fully open source



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Overview

- Main objective: Create a module with basic instrumentation for an active magnetic ADCS
- Three-axis actuators: two magnetorquers with magnetic core and one with air core; Nominal dipole strength: $0.2 Am^2$ TBC.
- Current, Voltage and Temperature sensors for each magnetorquer;

Related Projects and References

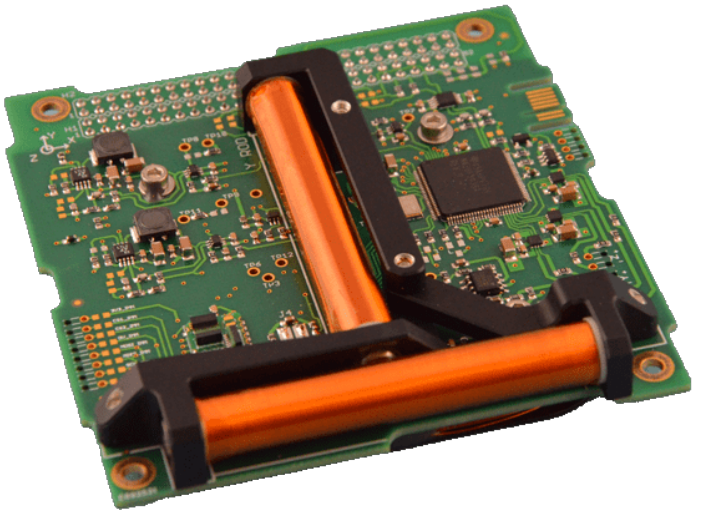
Comercial ADCS modules for CubeSats

A few commercial ADCS modules for CubeSats are available in the market:

- ISIS - iMTQ Magnetorquer Board
- GomSpace - NanoTorque GST-600
- NanoAvionics - CubeSat Magnetorquer SatBus MTQ
- ...

Comercial ADCS: ISIS - iMTQ Magnetorquer Board

- Three-axis actuators: two magnetorquers with magnetic core and one with air core; Nominal dipole strength: $0.2 Am^2$;
- Current and temperature sensors for each magnetorquer;
- Suitable to detumble up to 12U (24kg) CubeSats.



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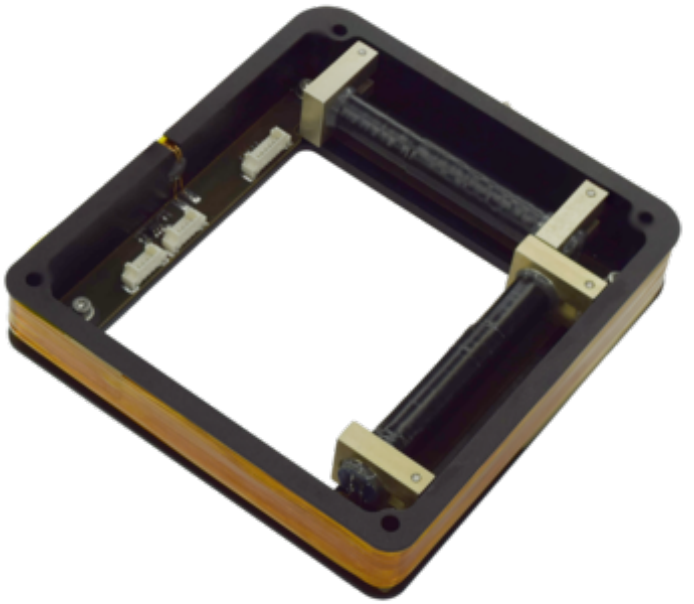
Comercial Coils: GomSpace - NanoTorque GST-600

- 3-axis magnetorquer;
- Torque $> 0.3Am^2$ per axis;
- Build-in temperature sensor;
- High torque and low residual dipole.



Comercial Coils: NanoAvionics - CubeSat Magnetorquer MTQ

- 2 magnetorquer rods with soft magnetic cores and 1 coil with air core;
- Dipole magnetic moment strength: $0.3Am^2$ (X/Y axis), $0.34Am^2$ (Z axis);
- Supply voltage: up to 5 V;
- Power consumption: 0.4 W.

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Preliminary Design

Specifications

- Microcontroller: STM32F303RCT6
- Sensors:
  - Voltage sensor (4x)
  - Current sensor (4x)
  - Temperature sensor (4x)
  - Gyroscope (3-axis)
  - Magnetometer (3-axis)
  - Sun sensors (?x)
- H-bridge (3x)
- Interfaces: CAN and SPI TBC
- Mass: TBD
- PC-104 compatible

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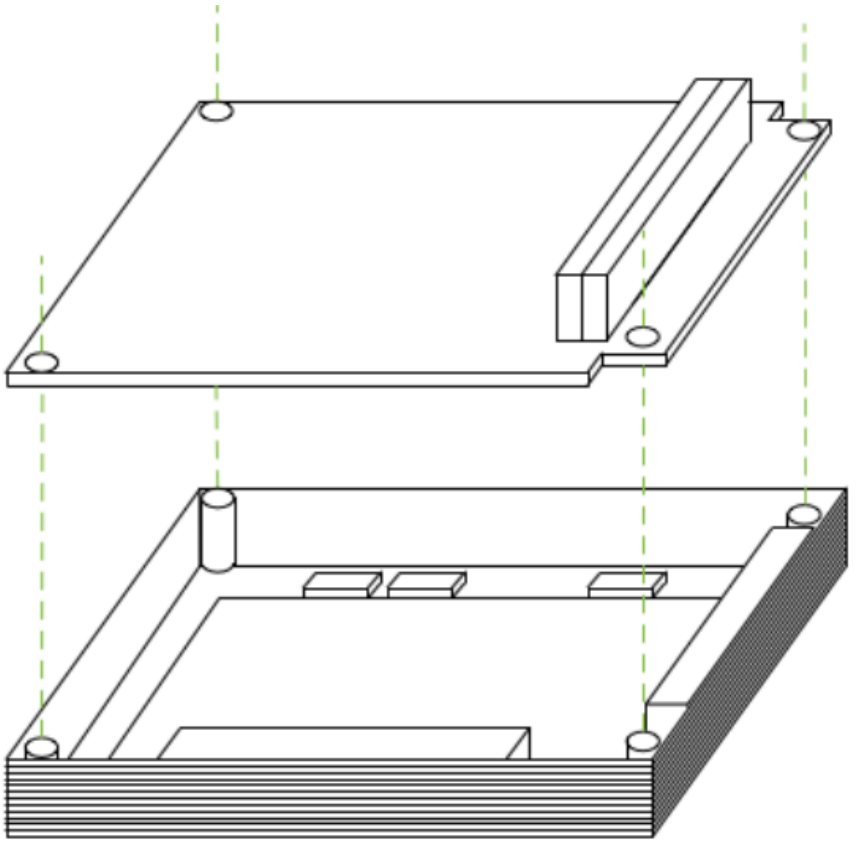
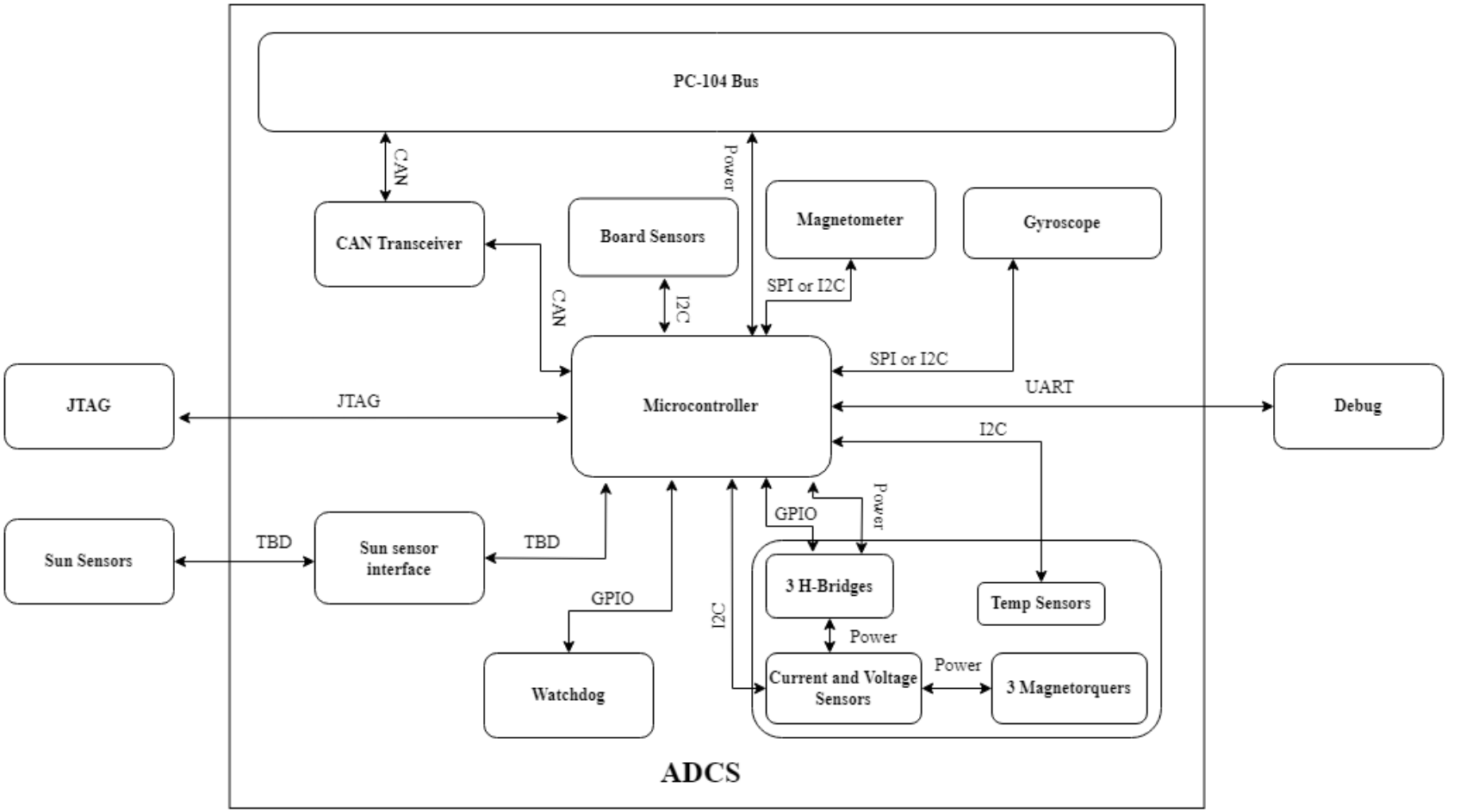
Features

Module Capabilities

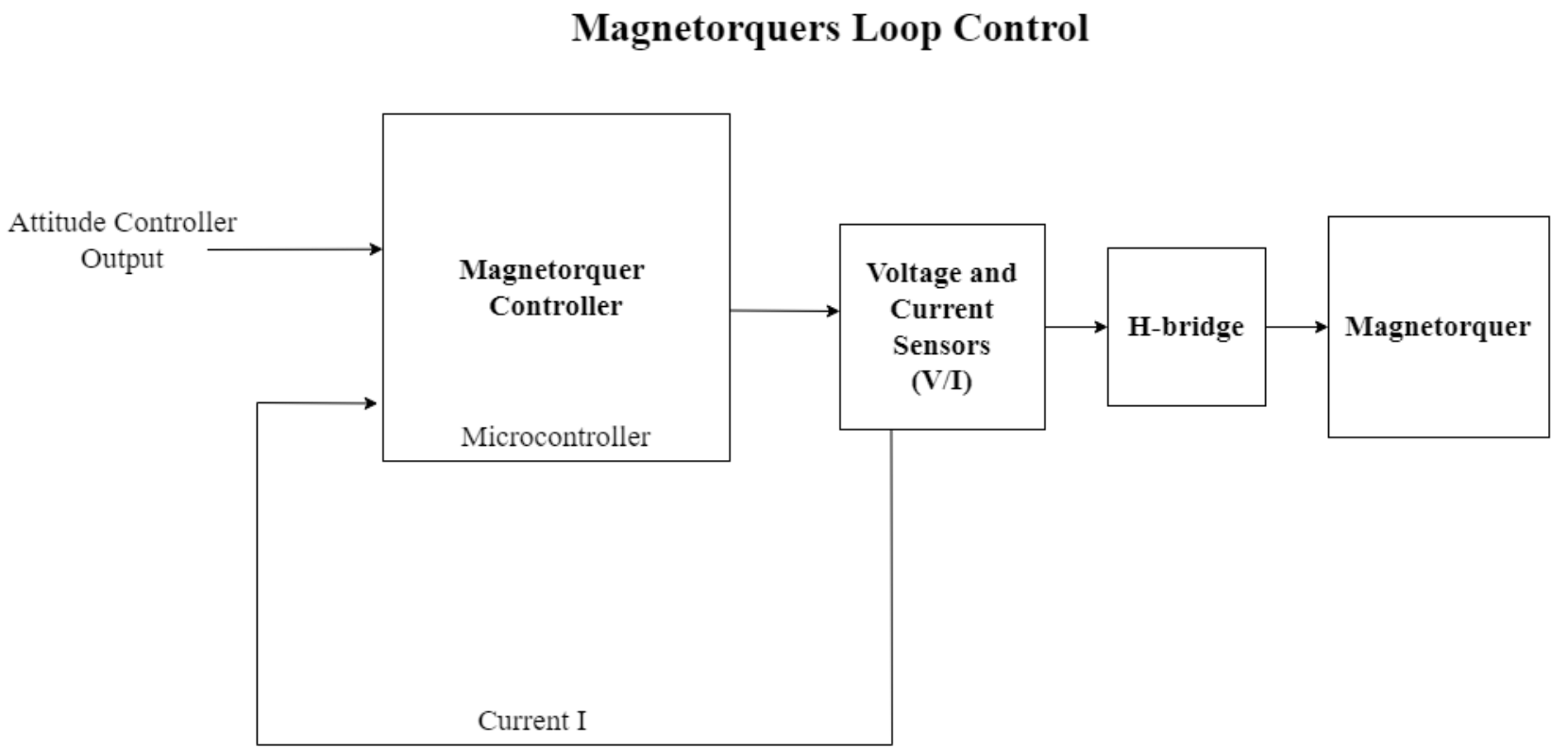
- Detumbling
- Pointing
- Idle



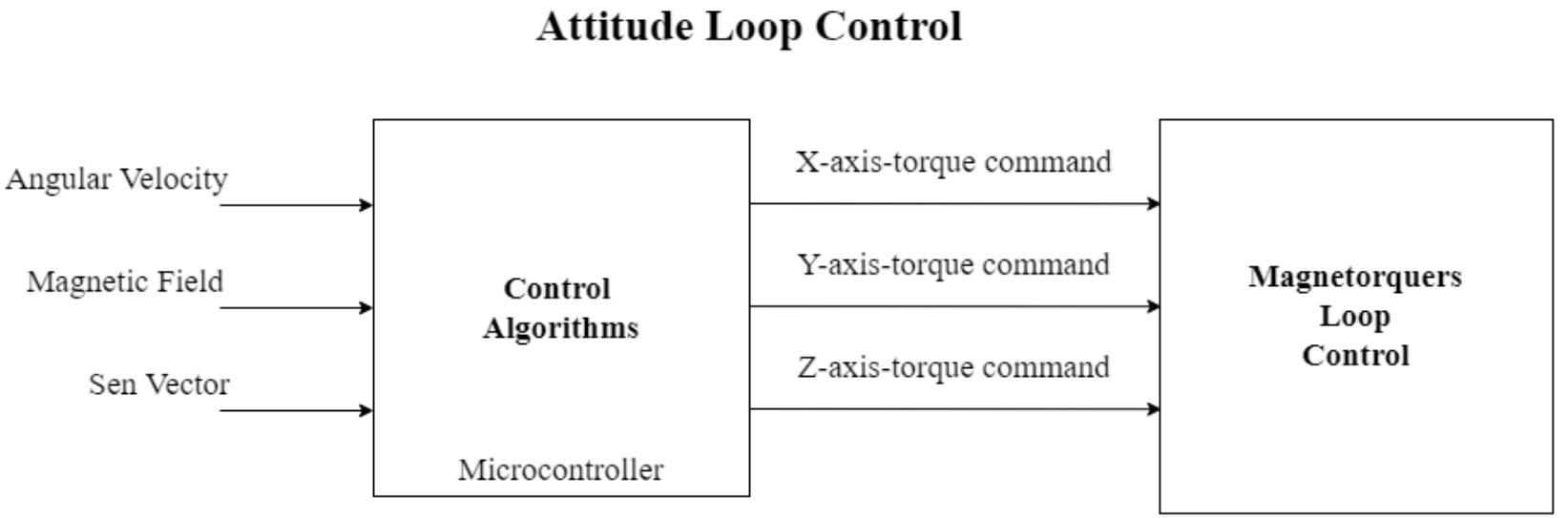
Electrical Block Diagram



Magnetorquer Loop Control Diagram



Detumbling Loop Control Diagram



Possible Hardware for the mission

- Voltage and current sensor - ina226 (4x)
- Temperature sensor - TMP100 (4x)
- Gyroscope (3-axis) - I3G4250DTR (1x)
- Magnetometer (3-axis) - MMC5983MA (1x)
- H-bridge - DRV8834PWP (3x) TBC
- Sun sensors - (?x) TBC

Sensors

Characteristic	ina226	TPM100	MMC5983MA
Manufacturer	Texas Instruments	Texas Instruments	MEMSIC
Partnumber	INA226AIDGSR	TMP100MDBVREP	MMC5983MA
Interface	I2C	I2C	SPI or I2C
Temperature range	–40°C a 125°C	–55°C to 125°C	-40°C to +105°C

Sensors

Characteristic	I3G4250D	Sun sensor
Manufacturer	MEMSIC	-
Partnumber	I3G4250DTR	-
Interface	SPI or I2C	-
Temperature range	-40 °C to +85 °C	-

External Watchdog

- IC: Texas Instruments TPS3823
- Voltage monitor with a watchdog timer feature
- Timeout period: 1600 *ms*

Bill of Materials[1]

Component	Description	Partnumber	Quantity
Microcontroller	-	STM32F303RCT6	2
CAN Transceiver	-	TCAN330GD	2
Voltage and Current Sensors	-	ina226	8
Temperature Sensors	-	TMP100	8
Gyroscope	-	I3G4250DTR	2
Magnetometer	-	MMC5983MA	2
Sun sensors	-	TBD	TBD
H-Bridge	-	TBD	6
Copper wire	TBD	-	1
Magnetic core	TBD	-	4
Watchdog	-	TPS3823	2

[1] 2 units.

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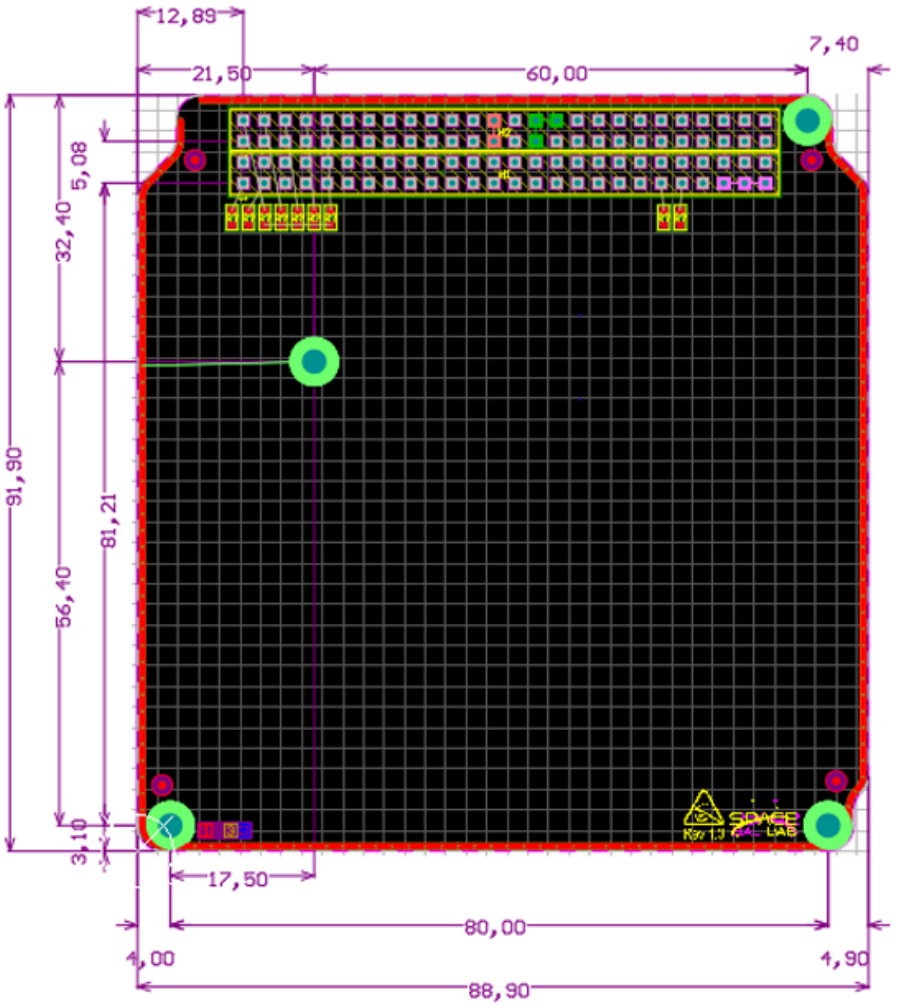
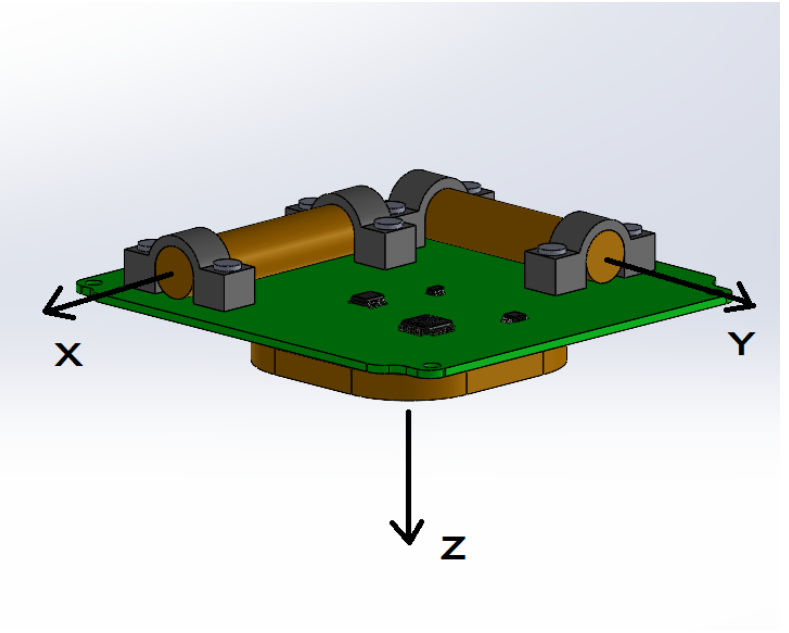
Dimensions


12,89
21,50
60,00
7,40
5,08
32,40
91,90
81,21
56,40
3,10
17,50
80,00
4,00
4,90
88,90

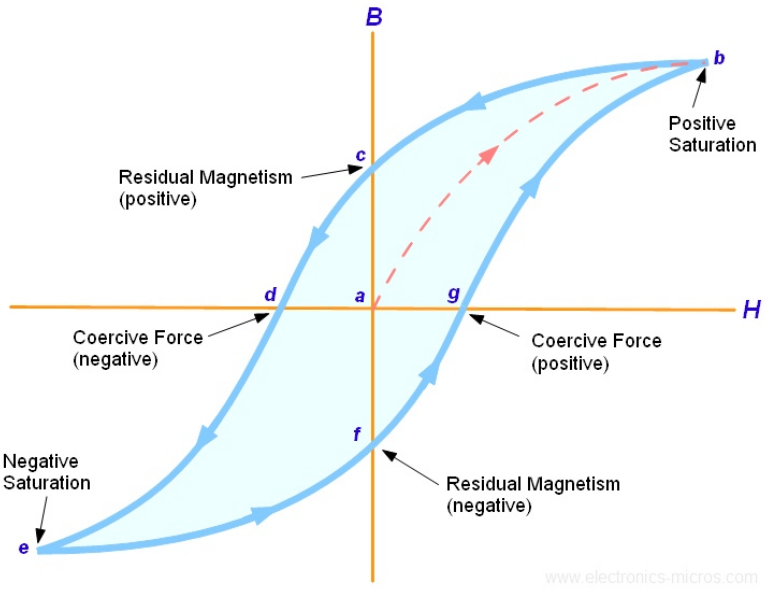
Dimensioning: ADCS structure

- Limiting factors:
- 3U cubesat
- The sizing must take in account the Z axle for the dimensioning limits
- Estimated space available: (90x90x40mm)



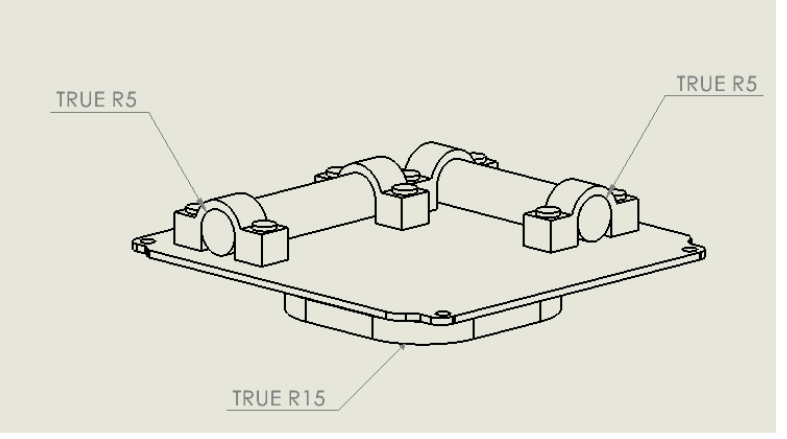
Dimensioning: Magnetic Core

- Only two coils with magnetic core
- Magnetic core with low coercive force and high relative permeability (>2000).
- Torque = $0.2Am^2$ TBC.



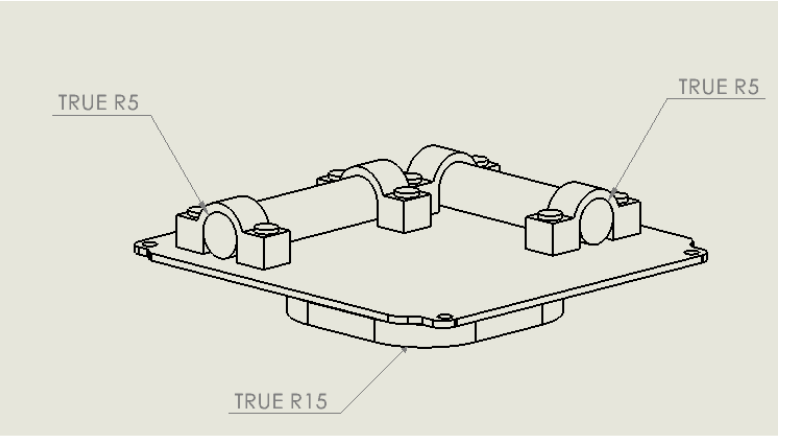
Dimensioning: Magnetorquer Material

- Magnetorquer core Material
  TBD

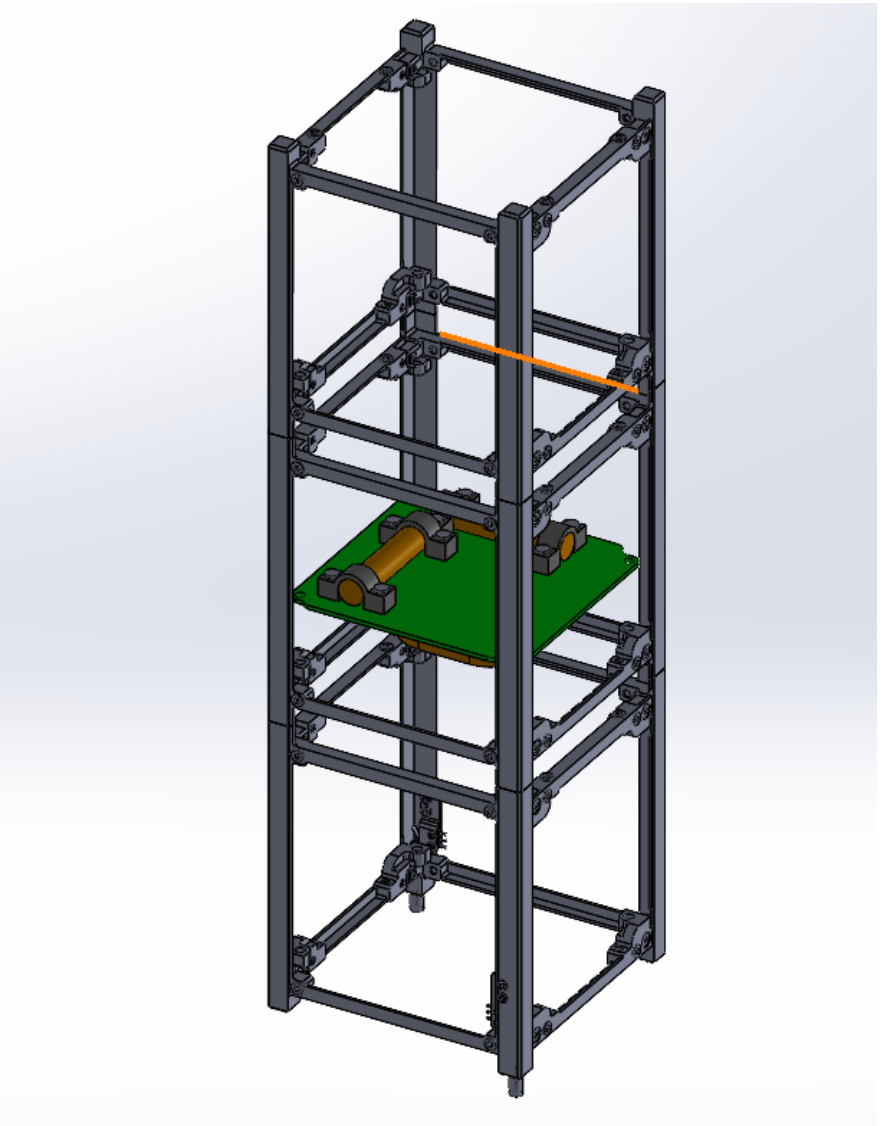


Dimensioning: Magnetorquer Sizing (X; Y; Z)

- Coil in axle X: D: TBD L: TBD
- Coil in axle Y: D: TBD L: TBD
- Coil in axle Z: D: TBD L: TBD



Final result



Management

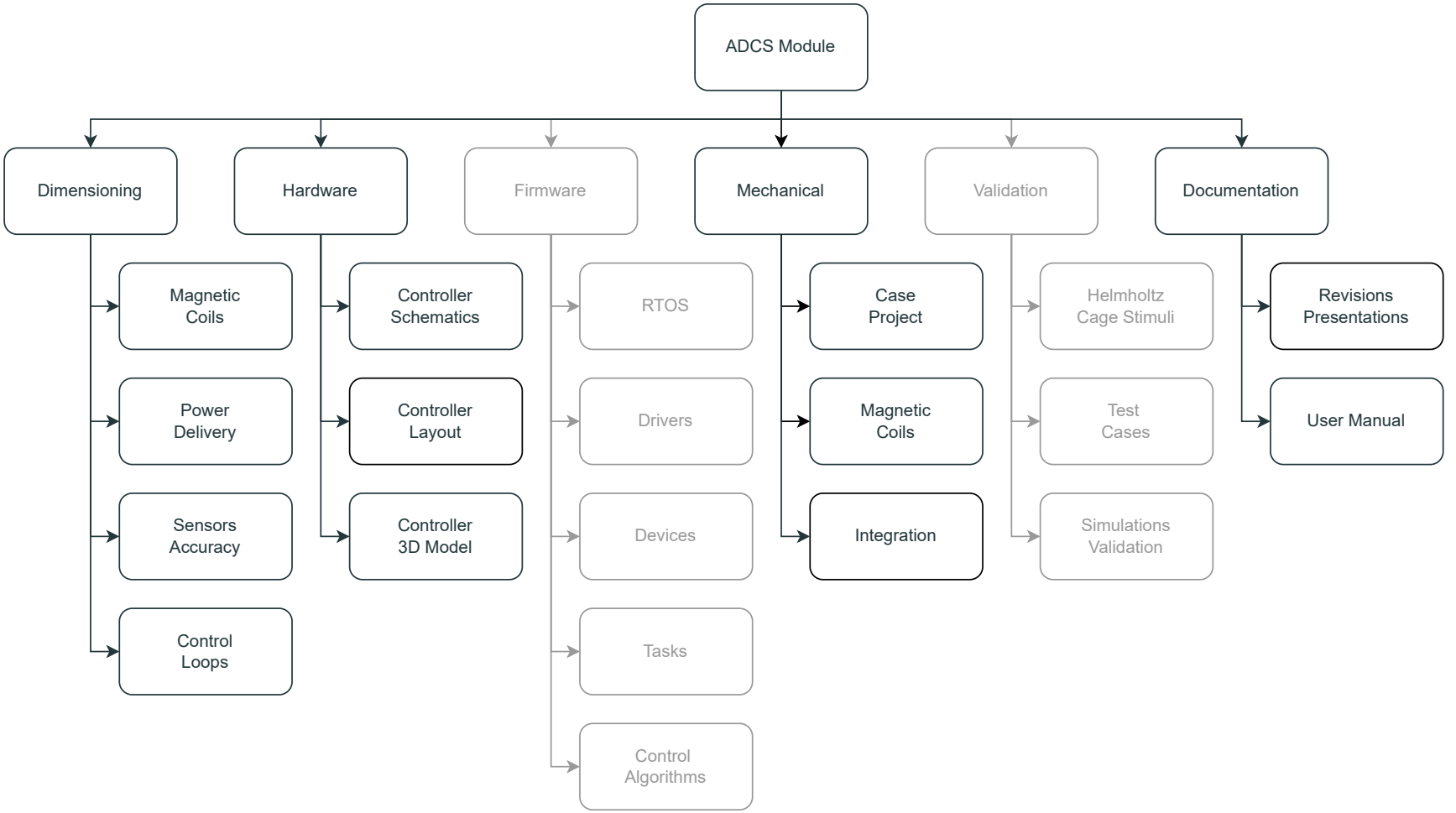
Project Management

- Activities and tasks: GitHub issues/project
- Periodic meetings
- Source files and versioning control: Git/GitHub repository (https://github.com/spacelab-ufsc/adcs) with five development branches:
  - *dev_doc*: Documentation
  - *dev_hardware*: Hardware project
  - *dev_firmware*: Firmware project
  - *dev_mechanical*: Mechanical project

Documentation

- User manual (PDF)
- This presentation
- Schematics

Product Tree



Schedule

Activity	Week											
	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12
Project definition	X											
Bibliographical review	X											
Project dimensioning		X	X									
Component selection		X	X									
PDR			**X**									
Mechanical design			X	X								
Controller schematics			X	X	X							
Components aquisiton				X	X	X	X	X				
Controller PCB layout				X	X	X	X					
Mockup fabrication							X					
CDR							**X**					
Controller PCB fabrication								X	X	X	X	
Case fabrication								X	X			
User manual preparation									X	X	X	
Preliminary Electrical tests											X	
Mechanical integration											X	
AR												**X**

Schedule changes from the original presentation (besides PDR, CDR, and AR):

5.3:W2, 5.5:W5, 5.7:W9, 5.9:W13

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Team

Role	Name
Management/Support	André M. P. de Mattos Gabriel M. Marcelino
Dimensioning	Matheus Wagner
Hardware design	Rebecca Q. Do Ó Bruno Benedetti Caique S. de M. Gomes
Mechanical design	Caique S. de M. Gomes

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Cost Estimation[3]

Item	Unit (US$)	Quantity	Total (US$)
STM32F303RCT6	8.86	2	17.72
TCAN330GD	3.89	2	7.78
ina226	9.24	8	73.92
TMP100	2.68	8	21.44
I3G4250DTR	10.98	2	21.96
MMC5983MA	4.44	2	8.88
DRV8834PWP	3.62	6	28.96
Copper wire	-	1	-
Magnetic core	-	4	-
Passive components	5.00	1	5.00
PCB	0.50	10	5.00
TPS3823-50DBVR	1.59	2	3.18
Total		193.84[2]	

[2]Prices in August 2022, without delivery rates or taxes.

[3]2 units.

Thanks!