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Design and Development of an Active Magnetic Actuator for Attitude Control System of Nanosatellites

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Universidade de Brasília

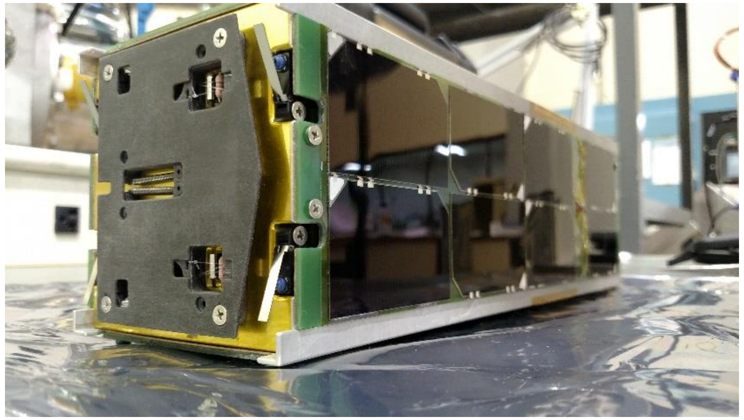
UnB Gama
O novo endereço da tecnologia

LAICA

1. Introduction

1.1 Context

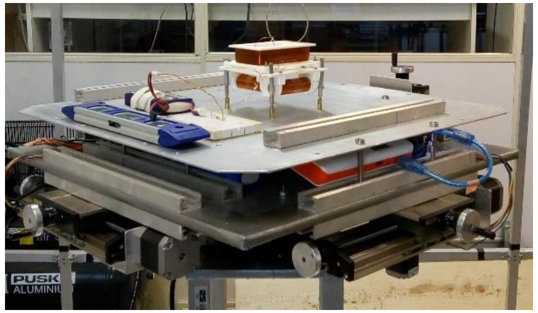
- Work conducted in the Laboratory of Aerospace Science and Innovation (LAICA) of University of Brasília (UnB), Brazil.



SERPENS Nanosatellite - Credits: Brazilian Space Agency (AEB)

- LAICA groups several research activities on aerospace engineering of UnB.

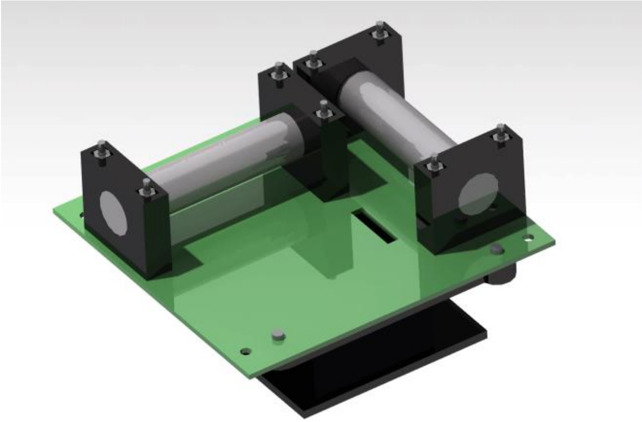
- Equiped with an ADCS testbed and a Helmholtz cage.



ADCS Testbed - Credits: LAICA

1. Introduction

1.2 The magnetic actuator



- A **3-axis** system, composed of three coils assembled in a Printed Circuit Board (PCB).
- 2 cylindrical and 1 rectangular coil.
- Use of 3D printed components in Polylactic Acid (PLA).

2. Design of the actuator

2.1 The choice of the magnetic core for the cylindrical coil

- EFI Alloy 79, chosen due to its high relative magnetic permeability, increasing the magnetic moment and the torque τ.

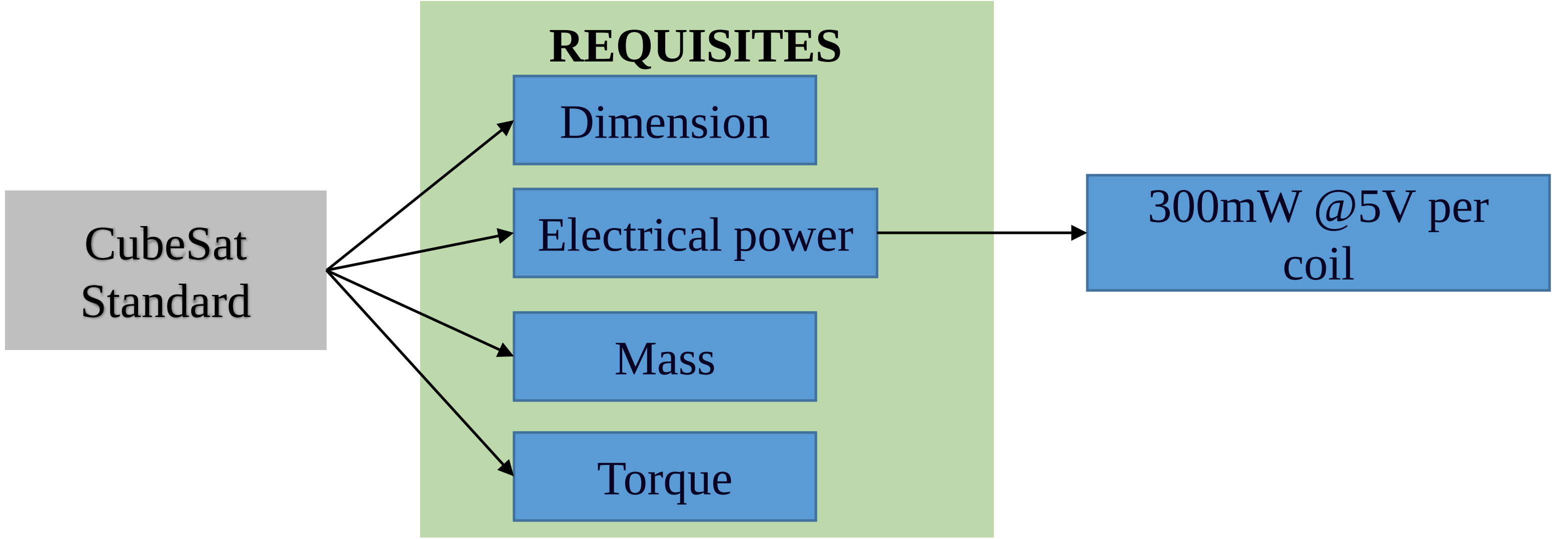
$$\mu_{r;max} = \frac{\mu}{\mu_o} = 230{,}000$$

Increases the core's magnetization ($\vec{M}$) → Increases the magnetic moment of the coil ($\vec{m}$) → Increases the torque $\tau = \vec{m} \times \vec{B}$

2. Design of the actuator

2.2 Definition of the requisites of the system

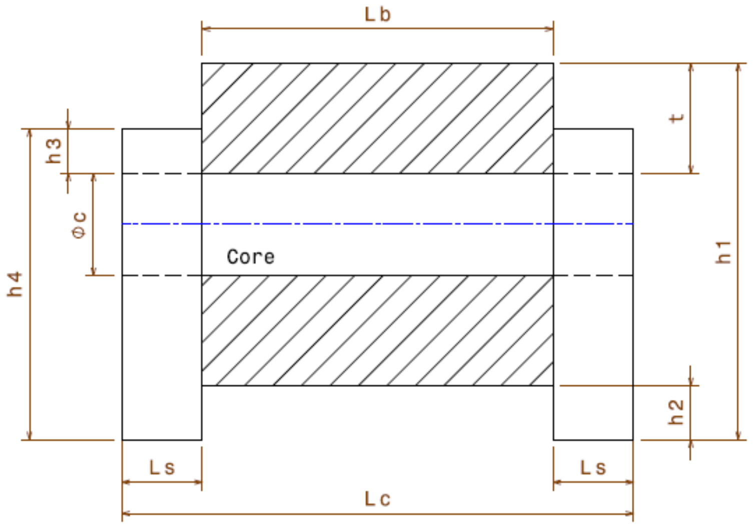
- The CubeSat standard imposes constraints of dimension, electrical power, mass and torque.



2. Design of the actuator

2.3 Design of the coils

- Use of an algorithm on Matlab, **its inputs** are the requisites of the system and the range of the available conductors (AWG 19-44).



Outputs of the algorithm

Parameter	Detail
$\|\|\vec{m}\|\|$	Magnetic moment
AWG	Wire gauge
N_e	Number of turns
N_c	Number of layers
$L_{conductor}$	Length of conductor
$M_{conductor}$	Mass of conductor
R_{series}	Resistor to be associated in series

2. Design of the actuator

2.4 Design of the coils

- Cylindrical and rectangular coils designed.

Cylindrical coil

Parameter	Detail	Value
$\|\|\vec{m}\|\|$	Magnetic moment	$0.3585 Am^2$
AWG	Wire gauge	31
N_e	Number of turns	171
N_c	Number of layers	20
...	...	...

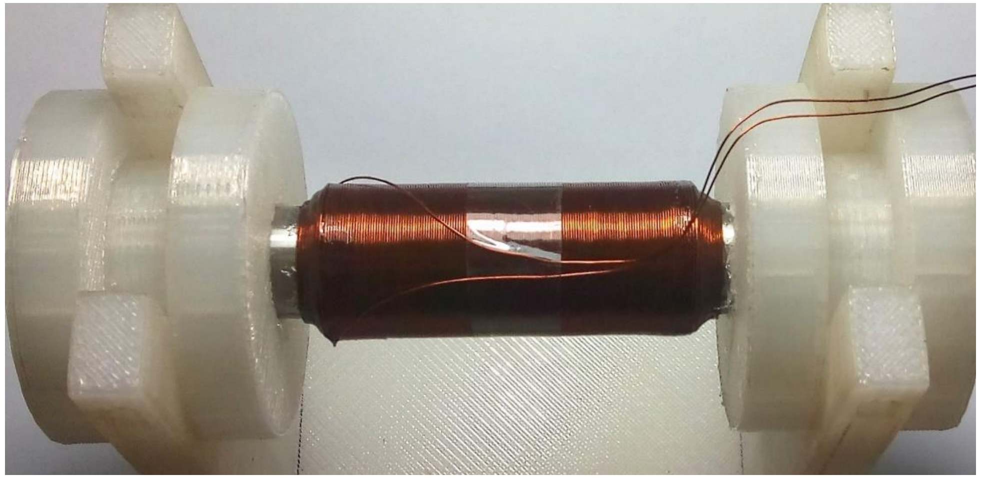
Rectagular coil

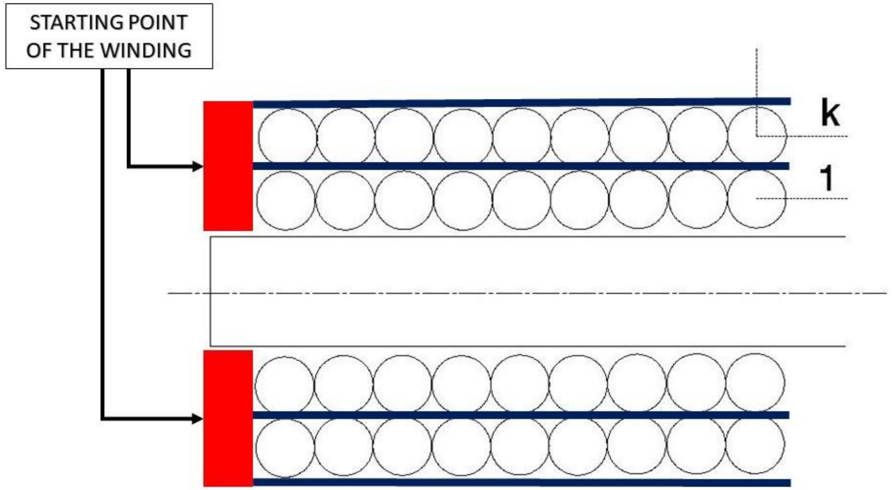
Parameter	Detail	Value
$\|\|\vec{m}\|\|$	Magnetic moment	$0.1672 Am^2$
AWG	Wire gauge	31
N_e	Number of turns	65
N_c	Number of layers	12
...	...	...

3. Development of the actuator

3.1 Development of the coils

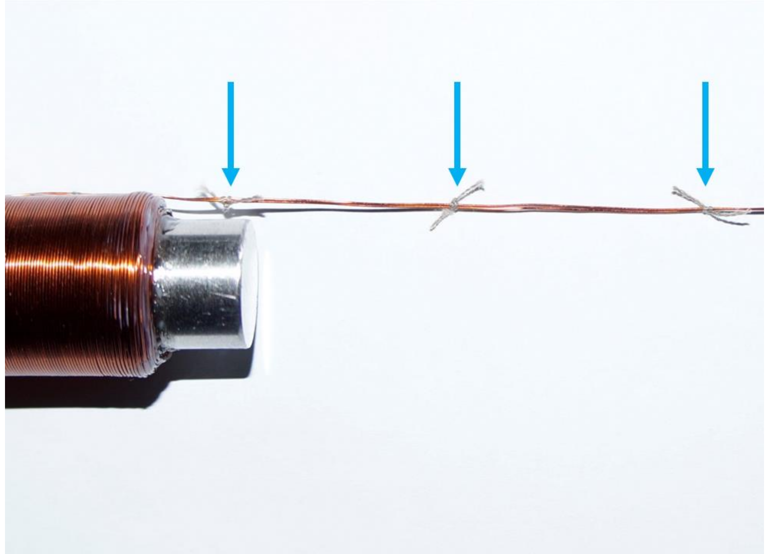
- More perfection obtained by applying glue in some regions of the windings.

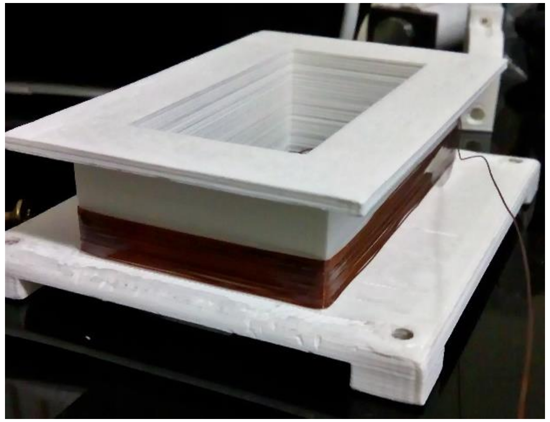




3. Development of the actuator

3.2 Cylindrical coils developed and production of the rectangular coil

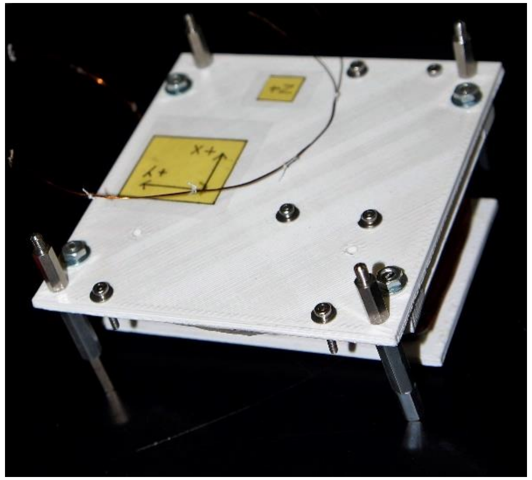


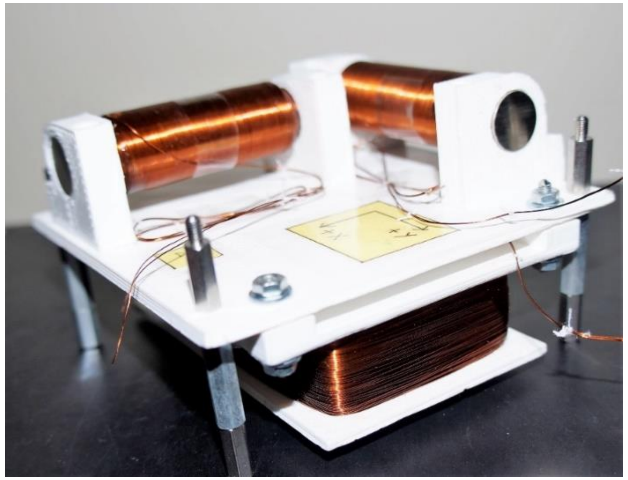


3. Development of the actuator

3.3 Coils assembled in the actuator's 3D printed structure

- A PLA structure substituted the PCB in this version of the actuator.





3. Development of the actuator

3.4 Measured properties of the developed coils

Cylindrical coils

Parameter	Detail	Value
R_1	Resistance of the coil 1	34.5Ω
R_2	Resistance of the coil 2	37.1Ω
M_1	Mass of the coil 1	100g
M_2	Mass of the coil 2	102g

Resistance expected=41.66Ω

Rectangular coil

Parameter	Detail	Value
R	Resistance	72.8Ω
M	Mass	118g

Resistance expected=83.33Ω

4. Magnetic field measurement

4.1 Magnetic field

- The magnetic field of each coil was measured using the Honeywell HMR2300 3-axis magnetometer.

Coil	$\|\vec{\beta}_x\|$ (μT)	$\|\vec{\beta}_y\|$ (μT)	$\|\vec{\beta}_z\|$ (μT)
Cylindrical coil 1	-26.69	20.24	103.2
Cylindrical coil 2	-15.15	-1.36	140.8
Rectangular coil	-211.3	-74.85	156.5

- The Earth's magnetic field intensity measures $50\mu T$ in average.

5. Conclusion

- The first version of the 3-axis actuator was designed and developed, allowing the conduction of the tests in the ADCS testbed of the laboratory.

- The testing of the actuator will contribute for the improvement of the testbed.

- Beyond the testing of the actuator, in the next step of the work the PCB will be developed and the possibility of optimizations will be considered.

Thank you

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