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

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### 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).

2.1 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  $\tau$ .



2.2 Definition of the requisites of the system

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



#### 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
<i>m</i>	Magnetic moment
AWG	Wire gauge
N <sub>e</sub>	Number of turns
N <sub>c</sub>	Number of layers
L <sub>conductor</sub>	Length of conductor
M <sub>conductor</sub>	Mass of conductor
R <sub>series</sub>	Resistor to be associated in series

#### 2.4 Design of the coils

• Cylindrical and rectangular coils designed.

Parameter	Detail	Value
$  \vec{m}  $	Magnetic moment	$0.3585Am^2$
AWG	Wire gauge	31
N <sub>e</sub>	Number of turns	171
N <sub>c</sub>	Number of layers	20

#### Cylindrical coil

#### **Rectagular coil**

Parameter	Detail	Value	
$\vec{m}$	Magnetic moment	$0.1672Am^2$	
AWG	Wire gauge	31	
N <sub>e</sub>	Number of turns	65	
N <sub>c</sub>	Number of layers	12	

#### 3.1 Development of the coils

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





3.2 Cylindrical coils developed and production of the rectangular coil







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

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





3.4 Measured properties of the developed coils

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Parameter	Detail	Value	
$R_1$	Resistance of the coil 1	34.5Ω	
<i>R</i> <sub>2</sub>	Resistance of the coil 2	37.1Ω	
<i>M</i> <sub>1</sub>	Mass of the coil 1	100g	
$M_2$	Mass of the coil 2	102g	

#### Cylindrical coils

Resistance expected= $41.66\Omega$ 

#### **Rectangular coil**

Parameter	Detail	Value
R	Resistance	72.8Ω
М	Mass	118g

Resistance expected= $83.33\Omega$ 

## 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  (\mu T)$	$ \vec{\beta}_{y}  (\mu T)$	$ \vec{\beta}_z  (\mu T)$
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.

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