Design of a Low Consumption Magnetic Coil Assembly for the Attitude Control System of a CubeSat 6U

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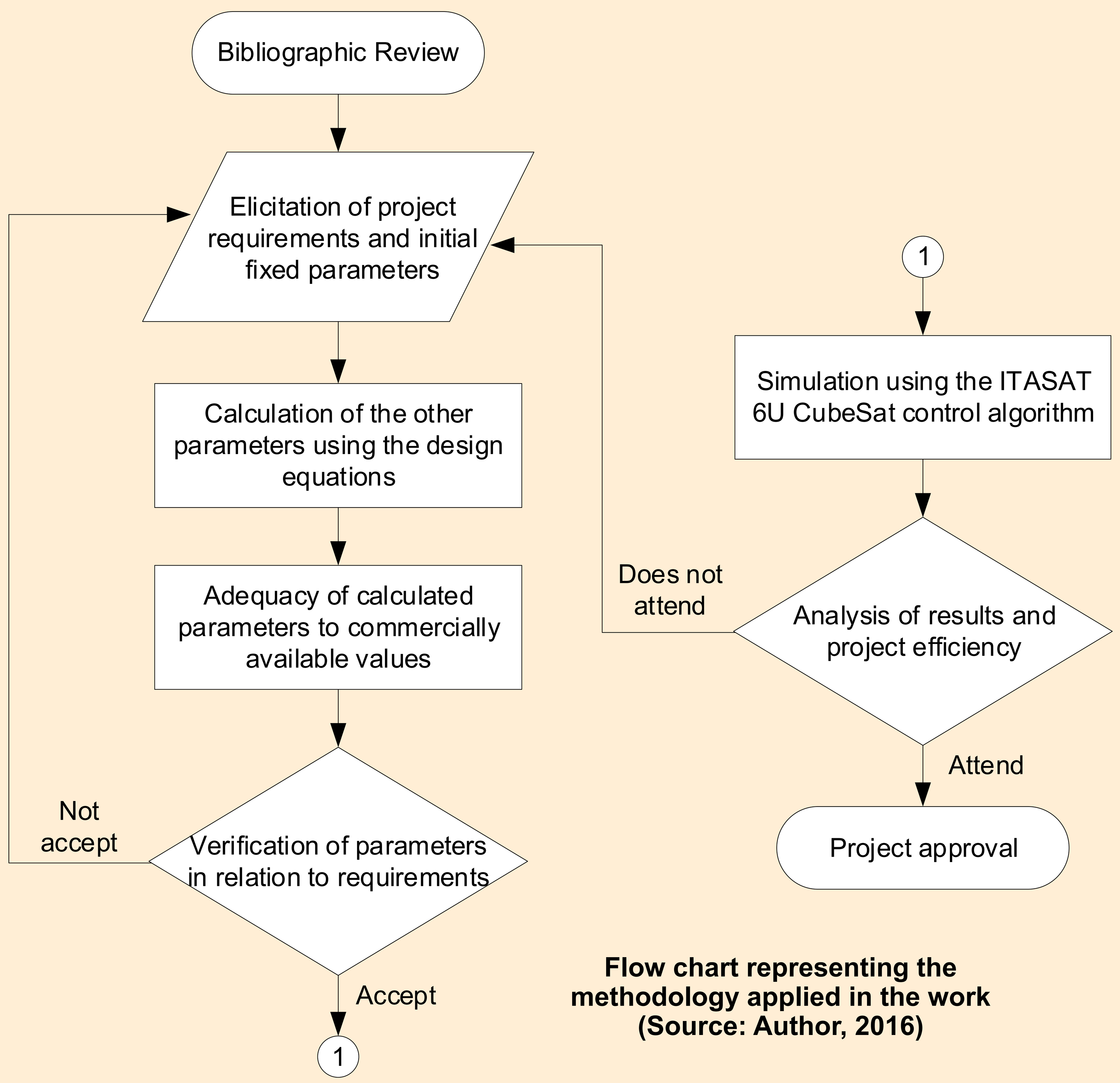
The satellite attitude and orbit control subsystem (AOCS) is responsible for maintaining it in a specific orbit, and constantly performs vehicle orientation maneuvers, regardless of external disturbances. AOCSs are made up of sensors, actuators and on-board computer. Magnetic coils are one of actuators types used in AOCSs, whose electrical currents generate magnetic moments, which interact with the Earth's magnetic field producing the torques needed to maintain the nominal attitude specified. In operation, the coils consume power, which can cause the satellite's batteries to be discharged. In an attempt to minimize this problem this work presents the design of a set of three magnetic coils, which has a lower power consumption than those presented commercially and that can be used as actuator in nanosatellite AOCSs. The performance of this work involves the areas of nanosatellite attitude control, orbital dynamics, mechanics and magnetism. Security, performance, integration, and manufacturing requirements determine project implementation and must ensure functionality, without interfering in costs and risks to the mission as a whole. The coils will be developed from design and functional requirements, and equations that characterize them. The results obtained are simulations in MATLAB® that compare the performance of a set consisting of two coils with ferromagnetic core and one with air core, to a market model, for the stabilization of a CubeSat 6U.

METHODOLOGY



Flow chart representing the methodology applied in the work (Source: Author, 2016)

Magnetic moment of the coil (a) with air core and (b) with ferromagnetic core equations (CARRARA; VAROTTO, 1995):

(a) $$M = A\, n_{espiras}\, i$$

(b) $$M \cong \frac{B}{\mu_0} V\, R_S$$

Power consumption of the coil (a) with air core and (b) with ferromagnetic core equations (CARRARA; VAROTTO, 1995):

(a) $$P = \frac{P_{ext}}{A} v\, K\, M$$

(b) $$P = Ui$$

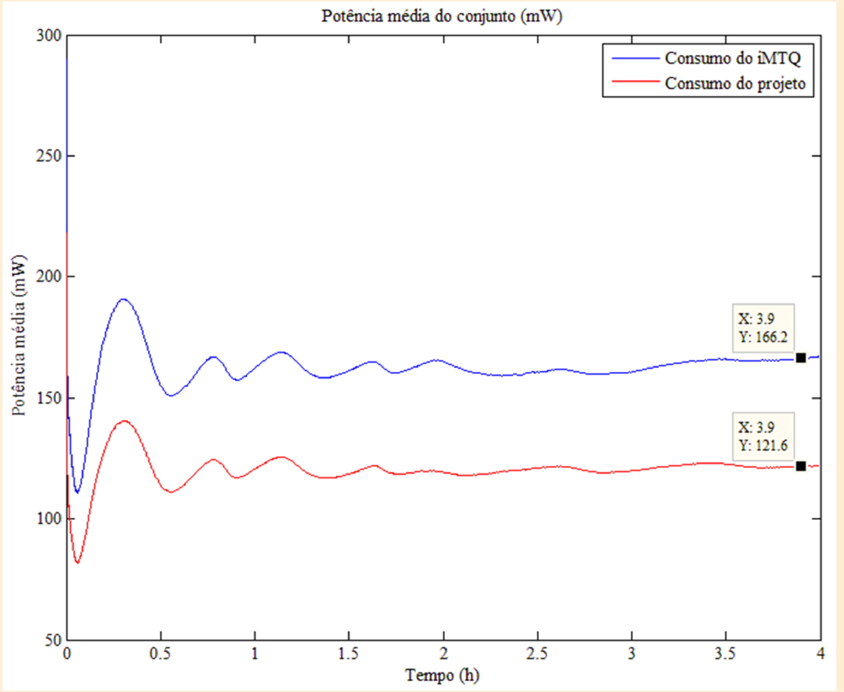
PROJECT

Comparison between the design parameters and the reference model (Source: Author, 2016)

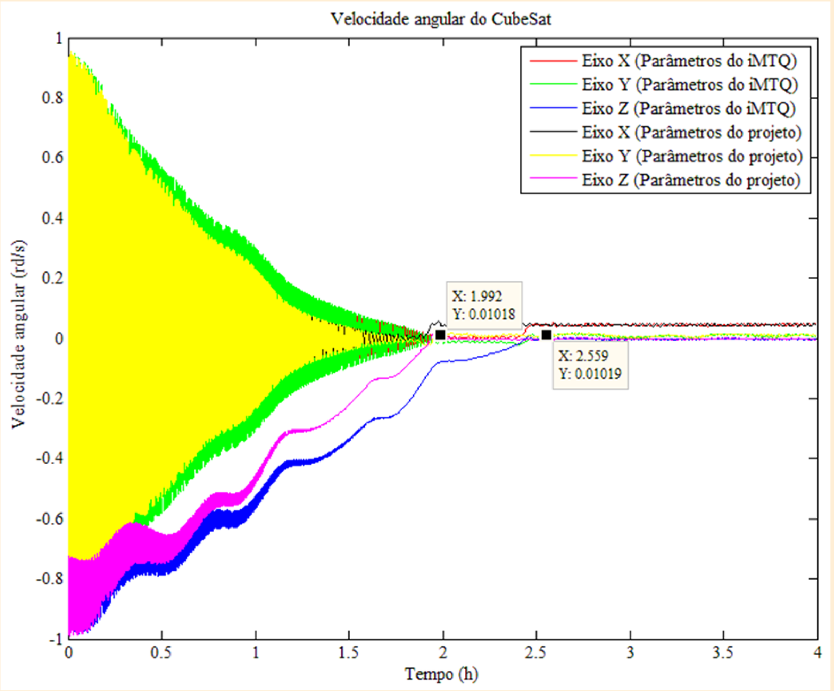
Principal parameters	Model	Voltage [V]	Nominal magnetic moment [Am²]	Power consumption [W]	Current consumption [A]
Coil with Ferromagnetic Core	ISIS iMTQ	5,0	0,20	0,20	0,040
	Project 1	**5,0**	**0,24**	**0,12**	**0,024**
	Project 2	3,3	0,16	0,05	0,016
Coil with Air Core	ISIS iMTQ	5,0	0,20	0,57	0,110
	Project 1	**5,0**	**0,22**	**0,47**	**0,095**
	Project 2	3,3	0,15	0,2	0,063

SIMULATION AND ANALYSIS OF RESULTS

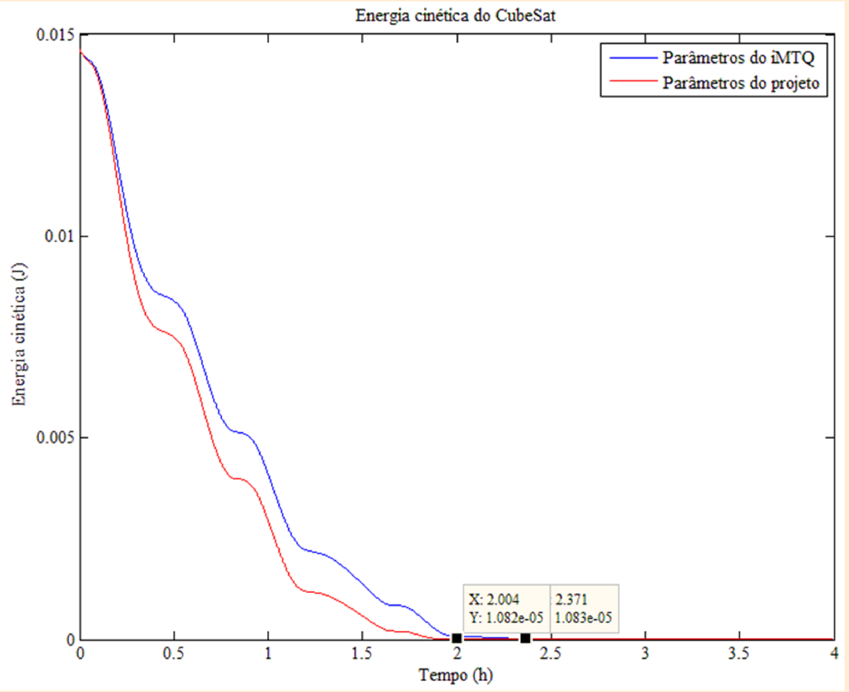
Simulation using the ITASAT Project control software, in B-dot mode, to stabilize and reduce the speed of CubeSat in the orbitalization phase.



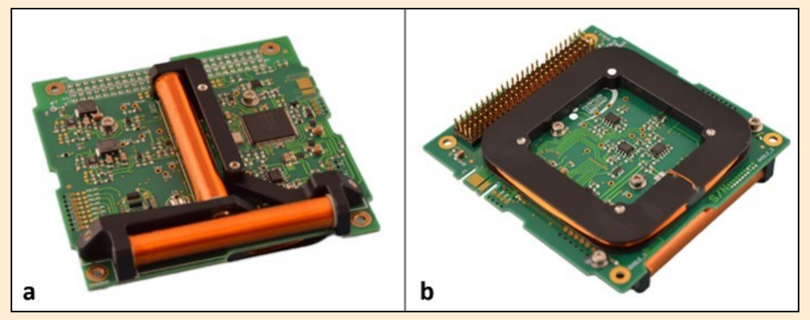
Average power of the set (Source: Author, 2016)



Angular velocity of the CubeSat (Source: Author, 2016)



Kinect energy of the CubeSat (Source: Author, 2016)



Reference Model - ISIS iMTQ: side of the coils with (a)ferromagnetic core (b) air core (Source: www.cubesatshop.com, 2016)

Percentage data of the results (Source: Author, 2016)

Parameter	Coil with Ferromagnetic Core	Coil with Air Core
Dipole or nominal magnetic moment	Increase of 20 %	Increase of 10 %
Power consumed	Reduction of 40 %	Reduction of 17,55 %
Current consumed	Reduction of 40 %	Reduction of 13,64 %
Average power of the set	Reduction of 26,83 %	
Time to the angular velocity to go to zero	Reduction of 22,16 %	
Time to the kinect energy to go to zero	Reduction of 26,62 %	

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