ADCS RECRUITMENT CHALLENGE

Context :

Our satellite orbits around the Earth at an altitude of around 500 Km from the surface of the Earth. The satellite is completely autonomous meaning, the satellite has to perceive itself (i.e., its own position , velocity with respect to both the Earth, other celestial bodies and its own body frame) and this perception is aided by the onboard set of sensors. Next, it has to take actions based on this perception through the onboard actuators whether it means pointing towards the earth to take pictures or point towards the sun to gather electrical power. This becomes an orbital physics, control systems, and a hardware problem all at the same time. Therefore, all your solutions should reflect the above context, it should be realistic, efficient and mathematically sound.

Tools required : MATLAB, SIMULINK (preferably); Python or any other language works as well

Documentation of the answers is a must as we are not only looking for the answer but the method of solving and understanding. Documentation can be in any format – hand-written or digital. There is no restriction on using ChatGPT or any other such tools.

Timeline : 2-3 weeks

Questions :

Attempt any number of questions. The questions have hints which if followed can lead you the final answer itself. Answers need not be perfect or complete, but it must show your approach to the questions.

The numbers in the brackets, [123], are the weightage given to the questions based on the difficulty.

1. Given an initial velocity and position vectors of a satellite in orbit, determine the velocity and position after x seconds, consider various effects on the orbit (perturbations). [3.14]
    a. Compute the Keplerian elements
    b. Find the anomalies associated with these elements
    c. Propagate these anomalies for the given time period
    d. Compute the final vectors in the Perifocal frame.

2. Given an attitude in ORF(orbital reference Frame) and initial angular velocity of 30 rad/s design a controller to achieve final angular velocity of 0.5 rad/s post exit from the launch vehicle only using solenoid-based actuators. [9.81]
    a. Model a magnetic actuation device.
    b. Realise a control law based on magnetic actuation.
    c. Compute the necessary frame conversions.
    d. Combine the above computations with a suitable controller.

3. Select a reaction wheel configuration best suited for our Cubesat (10x10x20 cm). Based on mass constraints (available mass : 200-300g) and torque requirements, research and find a suitable reaction wheel for procurement. Actuator Modelling needs to be done, along with a simulation model with a controller which has to be implemented as well. Your model should account for key sensor characteristics and error sources. [6378]

   This is an advanced problem, and it is expected that the solution may not be complete. We want to see your approach and way of thinking for such problems

   Bonus : Explore different Controller schemes and select the appropriate controller for the system

   a. Come up with the Torque requirements based on the disturbances in LEO.
   b. Identify key parameters and control Torque parameters
   c. Assume true angular velocities (0.5 rad/s - 1 rad/s) to sensor readings and include scale factor and bias errors
   d. Incorporate random noise based on the noise density.
   e. Produce angular velocity readings at 1 kHz sampling rate.
   f. Design an appropriate controller.

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