Homework 4

Instructions

1) You are free to discuss the questions with your classmates, but if I notice the same answer is copied all the copiers will get “0” for that question.
2) I prefer typed reports (MS Word, LaTeX etc.) Please be consistent in notations. You can use the following notations:
   - lower case bold for vector ($\boldsymbol{q} = \begin{bmatrix} 0 & 0 & 0 & 1 \end{bmatrix}^T$)
   - lower case regular for scalar (q_1),
   - capital letter for matrix (C)
   - lower case right subscript/superscript for the reference frame notations (C_{ab}, $\boldsymbol{\omega}_{ab}^{b}$).
3) Provide the algorithms that you coded in the submitted package.
4) Due date is 17th December (Sunday) until the midnight (23:59).
5) Submit your reports on ODTUClass.
6) Title of your report file (or zipped package) should be: AE486_2023_Name_Surname_HW4

Questions

1) (**40pts**) You are going to use the magnetic B-dot control law (refer to the lecture notes or Fundamentals of S/C Attitude Determination and Control by Markley and Crassidis, § 7.5.1) to de-tumble a spacecraft.
   Use the MOI tensor of

$$J = \begin{bmatrix} 6.9 & 0 & 0 \\ 0 & 7.5 & 0 \\ 0 & 0 & 8.4 \end{bmatrix} \text{kgm}^2$$

   which is for a satellite appoximately the size of RASAT.
   You can use the shared data with your previous homeworks to get the magnetic field in body frame. The inital quaternion is given by $\boldsymbol{q}(0) = \sqrt{2}/2\begin{bmatrix} 1 & 0 & 0 & 1 \end{bmatrix}^T$ and the initial angular velocity is given by $\boldsymbol{\omega}_{bi}^{b}(0) = \begin{bmatrix} 0.2 & 0.1 & 1.5 \end{bmatrix}^T$ rad/s . Give the angular velocity components vs. time and the dipole moment vs time plots.

   What happens if you set a limit for maximum magnetic moment (same for all three axes) as $\pm 3\text{A}\cdot\text{m}^2$?

2) (**60pts**) For the same satellite in Q1, this time you are going to control the attitude using the reaction wheels. The initial conditions are given as $\boldsymbol{q}(0) = \begin{bmatrix} 0.6853 & 0.6953 & 0.1531 & 0.1531 \end{bmatrix}^T$ for quaternions and $\boldsymbol{\omega}_{bi}^{b}(0) = \begin{bmatrix} 0.53 & 0.53 & 0.053 \end{bmatrix}^T$ deg/s for angular velocities (be careful, angular velocity terms

are in deg/s this time). You must put the spacecraft in Sun pointing mode by pointing the body Z axis through Sun. Other two axes can be pointing at a random direction. The initial wheel angular momentum is set as $\boldsymbol{h}(0) = 0$ in all three axes. For the Sun direction in the inertial frame you can use the data in your previous HWs.

Use the control laws of Eq.7.7 and Eq.7.12 from Fundamentals of S/C Attitude Determination and Control by Markley and Crassidis, § 7.2. Observe if there is any difference in the response of the spacecraft in terms of quaternions and angular velocities.

Plot also the wheel angular momentum for 4 RWs on the spacecraft if the distribution matrix is given as

$$W_4 = \frac{1}{\sqrt{2}} \begin{bmatrix} 1 & -1 & 0 & 0 \\ 1 & 1 & 1 & 1 \\ 0 & 0 & 1 & -1 \end{bmatrix}$$

Use the pseidoinverse law to get the inverse of the distribution matrix.

Bonus (**20pts**) Using again the RWs as in Q2, can you make your spacecraft point its body Z axis through the Sun and spin around that axis with an angular rate of 3rpm? You may need to alter the control laws slightly to do so. I would suggest you to search the literature a little bit.

Good luck!
H.E. Soken