hw 5 Solutions

5.2 For the axis of interest, the s/c intertia is 6000 kg-m^2. The effectors are reaction wheels and a thruster pair located at a 1.52m radius. Each thruster is rated at .89N and is pulsed for .025s. (a) determine the reaction wheel momentum necessary to cause a s/c maneuver rater of .004rad/s. (b) for some mission segments, control will be with the thrusters alone. What pointing accuracy can be achieved if the dead band is .001 radians and there are no external torques?

$I_{sc} := 6000\,kg\cdot m^2 \quad r_{thrust} := 1.52\,m \quad F_{thrust} := .89\,N \quad t_{thrust} := .025\,s \quad \omega_{sc} := .004\,\frac{rad}{s}$

$\theta_{db} := .001\,rad$

(a)

$T_{thrust} := 2\cdot F_{thrust}\cdot r_{thrust} \qquad T_{wheel} = I_{wheel}\cdot \alpha_{wheel}$

$$\alpha_{sc} = \frac{T_{thrust} + T_{wheel}}{I_{sc}}$$

$\omega_{sc} = \alpha_{sc}\cdot t_{thrust} \qquad \frac{\omega_{sc}}{t_{thrust}} = 0.16\,\frac{1}{s^2}$

$$T_{wheel} := \frac{\omega_{sc}\cdot I_{sc}}{t_{thrust}} - T_{thrust} \qquad T_{wheel} = 957.294\,kg\cdot\frac{m^2}{s^2}$$

(b)

$$\Delta\theta := \frac{2\cdot F_{thrust}\cdot r_{thrust}\cdot t_{thrust}^{\,2}}{8\cdot I_{sc}} \qquad \Delta\theta = 3.523\times 10^{-8}\,rad$$

$\theta_p := 2\cdot\theta_{db} + 2\Delta\theta \qquad \theta_p = 2\times 10^{-3}\,rad$

5.5 How frequently will a 20Nm wheel require unloading if the unbalanced torque on the s/c, about the axis of interest, is 5.43*10^-6 Nm? Assume that the wheel is allowed to saturate.

There is a typo in this question, it should say a 20Nms wheel

$H_{wheel} := 20\,N\cdot m\cdot s \qquad T_{ub} := 5.43\cdot 10^{-6}\,N\cdot m$

$$t_{ub} := \frac{H_{wheel}}{T_{ub}} \qquad t_{ub} = 3.683\times 10^{6}\,s$$

$t_{ub} = 42.63\,day$

6.6 How many 22 A-h batteries are required to power an eclipse load of 462 W at 28 V, for a duration of 46 min, with a maximum depth of discharge of 38%, and a loss, battery to load of 4.2%?

$C_{bat} := 22A \cdot hr \quad P_{ec} := 462W \quad V_{ec} := 28V \quad t_{ec} := 46min \quad DOD := 38\% \quad X_{b\_1} := 4.2\%$

$$C_{req} := \frac{P_{ec} \cdot t_{ec}}{\left(1 - X_{b\_1}\right) \cdot DOD \cdot V_{ec}} \qquad C_{req} = 34.749\, A \cdot hr$$

6.9 A new design communication s/c has a payload power requirement of 647 W. What is the predicted total power requirement for the s/c? What power margin would you reccomend?

$P_{req} := 647W$

$$P_t := 1.17 \cdot P_{req} + 56W \qquad P_t = 812.99\, W$$

Margin := 90%

7.1 A spherical s/c is used for a near solar mission. The outer skin of the s/c is made of a material that has a high thermal conductivity, and the s/c is spin stabalized. These two conditions cause the temperature of the s/c's outer skin to be uniform. THe emmisivity and absorptivity of the outer skin are .85 and .1, respectively. If the SS conditions are assumed and there is no heat generation within the s/c, what is the skin temperature, in C, is the solar constant is 8? This means that the solar flux is 8*1371 W/m^2.

$\varepsilon_{IR} := .85 \quad \alpha_s := .1 \quad G_s := 8 \cdot 1371 \frac{W}{m^2} \quad \sigma := 5.67 \cdot 10^{-8} \frac{W}{m^2 K^4}$

$$T_{sc} := \left(\frac{G_s \cdot \alpha_s}{\varepsilon_{IR} \cdot \sigma}\right)^{\frac{1}{4}} \qquad T_{sc} = 388.402\, K$$

7.5 A flat space radiator is mounted on the surface of a s/c and perfectly insulated on the inside. The area of the radiator is .6x.6m with a solar absorptivity of .15 and an IR emmisivity of .8. If the solar vector is at an angle of 45 deg relative to the normal to the radiator, the incident solar flux is 1371 W/m^2m and the radiator temperature is 93.7 C, what is the power rejected by the radiator? Neglect albedo and Earth IR radiation.

$\varepsilon_{IR} := .8 \quad \alpha_s := .15 \quad A_{rad} := .6^2 m^2 \quad G_s := 1371 \frac{W}{m^2} \quad T_{rad} := (93.7 + 273.15)K$

$$Q_w := \left(\sigma \cdot \varepsilon_{IR} \cdot T_{rad}{}^4 - G_s \cdot \alpha_s\right) \cdot A_{rad} \qquad Q_w = 221.719\, W$$