Astronautics (SESA2024)

Section 10: Thermal Control – Exercises.

1. Why is thermal control necessary for spacecraft?

2. What is the general definition of spectral absorptance and what is it a function of? What has an absorptance value of 1?

3. How is the emittance of a real material defined?

4. What are the main inputs and outputs which governs the spacecraft equilibrium temperature?

5. How can the thermal balance be rearranged to show that the spacecraft temperature is a function of absorptance and emittance?

6. When would active thermal control be necessary, and what are the issues associated with this?

7. A spacecraft is injected into a circular, equatorial orbit of radius 18,000 km about the Earth, at a time of Northern hemisphere summer as shown in Figure Q7. The spacecraft is 3-axis stabilised and has two planar solar array panels each of 6 m^2 area and of negligible thickness, deployed symmetrically on either side of a central body. The array panels are rotated about an axis normal to the orbit plane to maintain near-Sun pointing. The Sun facing surfaces of the arrays have an emittance of 0.80 and a solar absorptance of 0.67, and the emittance and solar absorptance of the anti-Sun surfaces are both 0.70. The power raising function of the arrays has been allowed for in the stated thermal properties.

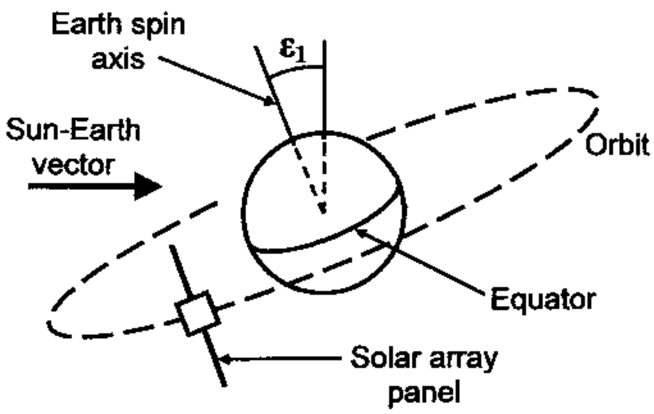

Figure Q7

Determine whether the spacecraft enters the Earth's shadow during this phase of the mission.

Plot an approximate temperature profile of one of the array panels as a function of the true anomaly, assuming it to be thermally decoupled from the spacecraft, by evaluating the array equilibrium temperature when the spacecraft is above:

- the noon meridian
- the midnight meridian
- the terminator

Data:
Obliquity of the ecliptic (see Figure Q7), $\varepsilon_1 = 23.5^o$
Solar radiation flux, q_s = 1,400 W/m^2
Earth radiation flux, q_E = 240 W/m^2
Earth albedo, a = 0.34
Earth radius, R_E = 6,378 km
Stefan-Boltzmann constant, $\sigma = 5.67 \times 10^{-8}$ W/m^2/K^4.