Panel Deployment

Problem 1

The satellite depicted in Fig. 1 is powered by solar panels. Initially, the three articulated solar panels are in the stowed configuration indicated on the figure. To become operational, these panels are deployed by means of motors located at points A, B and C. These motors provide torques that will deploy the system in such a way that the time schedule for angle θ is

$$\theta(t) = \frac{\pi}{4}[1.0 - \cos(\pi\,\bar{t})];$$

where the normalized time is $\bar{t} = t/T$, and T the total time required for the deployment.

1. Plot θ, $\dot{\theta}$ and $\ddot{\theta}$ versus time $\bar{t}$.

2. Draw free body diagrams for each of the three panels and the corresponding dynamic equations of motion.

3. Let M_A, M_B and M_C be the torques that the motors at points A, B and C, respectively, must apply to complete the desired schedule of deployment. Let H_A, H_B and H_C be the horizontal components of force for the joint at points A, B and C, respectively. V_A, V_B, V_C are the corresponding vertical force components. Finally, F_A, F_B, F_C are the magnitudes of the force at each joint.

4. Plot M_A, M_B and M_C versus $\bar{t}$. Find the instant at which each torque is maximum. Which motor will have to produce the highest torque? Why?

5. Plot H_A, H_B and H_C versus $\bar{t}$.

6. Plot V_A, V_B and V_C versus $\bar{t}$.

7. Plot F_A, F_B and F_C versus $\bar{t}$. Find the instant at which each force component is maximum. Which joint is the most heavily loaded? Why?

8. If the maximum torque the motors can produce is $M_{\text{MAX}} = 100.0$ N.m, what is the minimum time in which the deployment can be completed.

Each panel of the solar array is uniform, has a mass $m_P = 120$ kg and a length $\ell_P = 5$ m. The total time to complete the deployment is $T = 5$ sec.

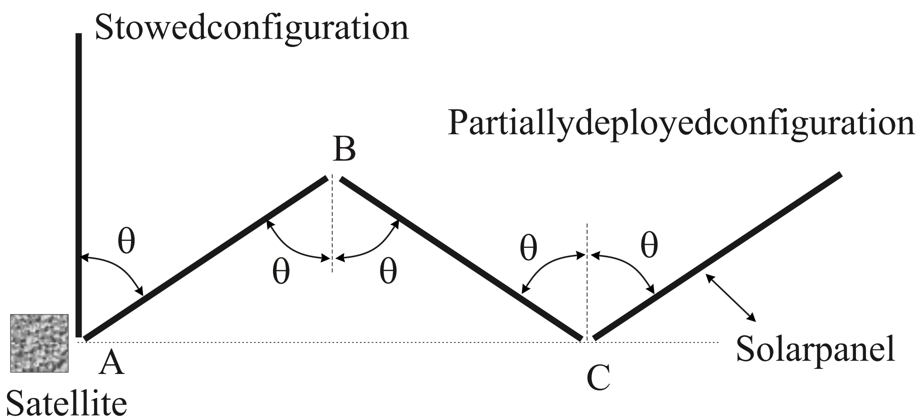

Figure 1: Satellite in stowed and deployed configurations