A

Examples

In this appendix we describe five control problems which are used to illustrate the analysis and design techniques developed in the text. These are collected here in order to permit references to them at a number of places in the text without the need to repeat the derivation of the model or discuss the specifications each time the example is used.

A.1 Single-Axis Satellite Attitude Control

Satellites often require attitude control for proper orientation of antennas and sensors with respect to the earth. Figure A.1 shows a communications satellite with a three-axis attitude-control system. To gain insight into the three-axis problem we often consider one axis at a time. Figure A.2 depicts this case where motion is allowed only about an axis perpendicular to the page. The equations of motion of the system are given by

$$I\ddot{\theta} = M_C + M_D, \tag{A.1}$$

where I is the moment of inertia of the satellite about its mass center, M_C is the control torque applied by the thrusters, M_D are the disturbance torques, and θ is the angle of the satellite axis with respect to an "inertial" reference. The inertial reference must have no angular acceleration. Normalizing, we define

$$u = M_C/I, \quad w_d = M_D/I \tag{A.2}$$

and obtain

$$\ddot{\theta} = u + w_d. \tag{A.3}$$

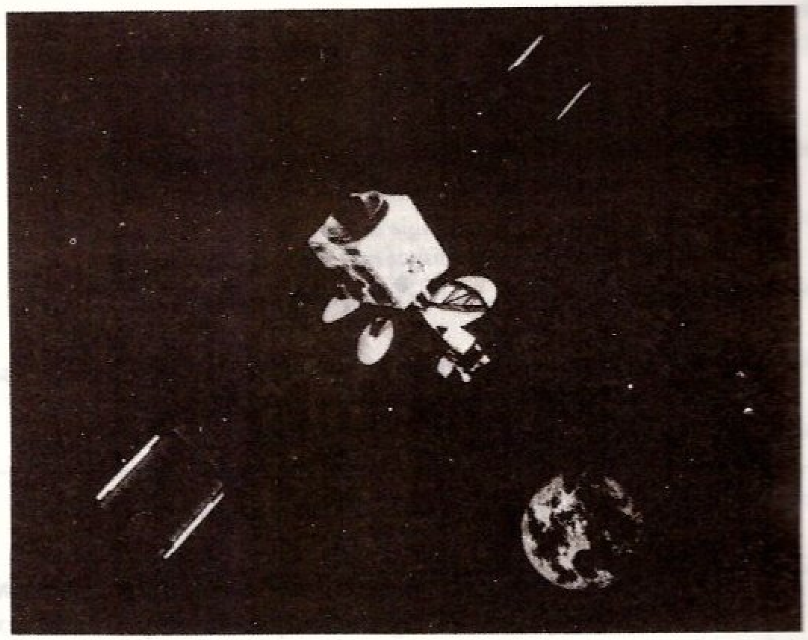

Figure A.1 Communications satellite (courtesy Space Systems-Loral)

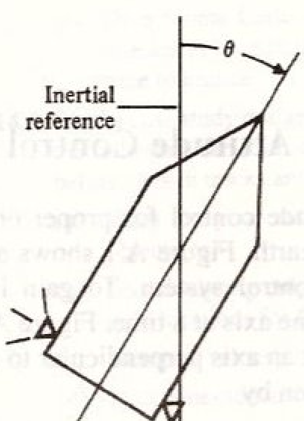

Figure A.2 Satellite-control schematic

Taking the Laplace transform

$$\theta(s) = \frac{1}{s^2}[u(s) + w_d(s)],$$

which becomes, with no disturbance

$$\frac{\theta(s)}{u(s)} = \frac{1}{s^2} = G_1(s).$$