Electrical Engineering Department
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Year:	4^{th} Communications	**SEMESTER:**	II, 2022/2023
Course:	Automatic Control Systems	**Code:**	EE 391

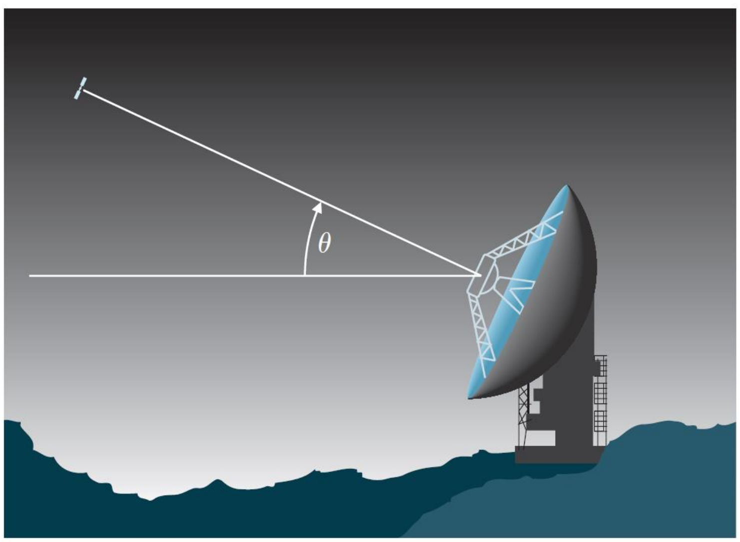
Lab Assignment 02: Design of Satellite-Tracking Antenna

Objectives

- To learn to use MATLAB to generate an LTI state-space representation of a system
- To evaluate the effect of additional poles and zeros upon the time response of second-order systems

Assignment

You wish to control the elevation of the satellite-tracking antenna shown in Fig. The antenna and drive parts have a moment of inertia *J* and a damping *B*; these arise to some extent from bearing and aerodynamic friction, but mostly from the back emf of the DC drive motor.



The equations of motion are

$$J\ddot{\theta} + B\dot{\theta} = T_c,$$

where T_c is the torque from the drive motor. Assume that

$$J = 600{,}000\ kg \cdot m^2\ , B = 20{,}000\ N \cdot m \cdot sec.$$

Suppose the applied torque is computed so that θ tracks a reference command θ_r according to the feedback law

$$T_c = K(\theta_r - \theta),$$

where K is the feedback gain.

a. Evaluate the closed loop transfer function

b. Use MATLAB to generate the state-space representation for the closed loop system for $K = 1$

c. What is the maximum value of K that can be used if you wish to have a stable closed loop system?

d. What is the maximum value of K that can be used if you wish to have an overshoot $M_p <$ 10%?

e. What values of K will provide a rise time of less than 80 sec? (Ignore the M_p constraint.)

f. Use MATLAB to plot the step response of the antenna system for K = 200, 400, 1000, and 2000. Find the overshoot and rise time of the four step responses by examining your plots. Do the plots to confirm your calculations in previous parts?

g. Use MATLAB to plot the zeros and poles locations for each value of K in part (e). comment on the effect of K on the closed loop zeros and poles

h. for each value of K in part (e). find the steady state error.

i. Using Simulink, add a pole to the second-order system and plot the step responses of the system when the higher-order pole is nonexistent, at $-200; -20; -10,$ and -2. Make your plots on a single graph, using the Simulink LTI Viewer. Normalize all plots to a steady-state value of unity. Record percent overshoot, settling time, peak time, and rise time for each response.

j. Discuss the effect upon the transient response of the proximity of a higher-order pole to the second-order system.

k. Using Simulink, add a zero to the second-order system and plot the step responses of the system when the zero is nonexistent, at $-200; -50; -20; -10; -5,$ and -2. Make your plots on a single graph, using the Simulink LTI Viewer. Normalize all plots to a steady-state value of unity. Record percent overshoot, settling time, peak time, and rise time for each response

l. Discuss the effect upon the transient response of the proximity of a zero to the dominant second-order pole pair.