



Electrical Engineering Department
Faculty of Engineering
Alexandria University
Egypt

Year: 4th Communications

SEMESTER: II, 2022/2023

Course: Automatic Control Systems

Code: EE 391

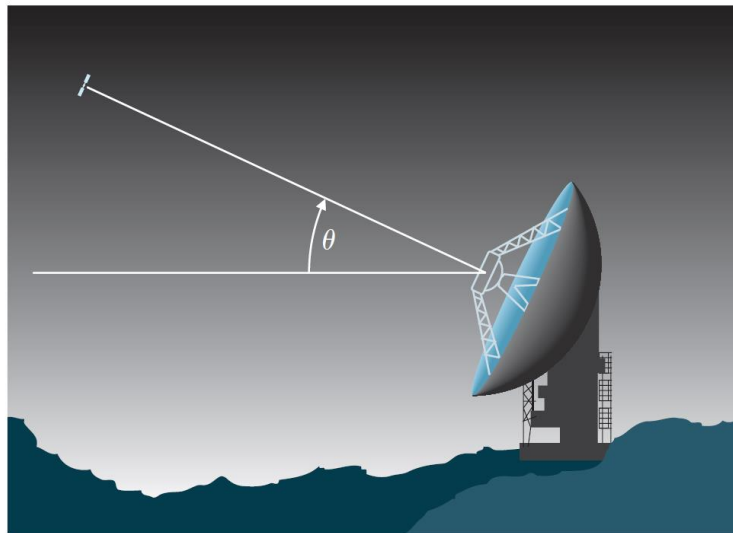
Lab Assignment 02: Design of Satellite-Tracking Antenna

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

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

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.

Submission rules

Deadline Date	29 th November 2022 23:59
Submission e-mail	control.systems.alexedu.2022@gmail.com subject of the email is your Name & ID
Submission files	<ul style="list-style-type: none">- MATLAB (.m file)- Simulink (.slx file)- A Report that includes screenshots for all the requirements
Note	Write your full name in ARABIC in the body of your email and your ID