Control Theory Intro: Home Assignment #8

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Introduction

The purpose of this home assignment is to base your understanding in full state and partial state feedback control.

Your solutions should be presented in a PDF (not Word!) file. You should submit also a **.m** file. The first line should print your ID.

>> disp('ID_STUDENT_1 ID_STUDENT_2') % disp('ID_STUDENT_1') if only one student is submitting.

For clarity of the script, you can separate the different sections of the script with a **%%**. This will automatically create a block in your script. In order to run specifically this block of code press 'Ctrl+Enter'. To run the entire script press 'F5'.

1 Manipulator control

A manipulator control system has a loop transfer function of

$$\mathrm{G(s)}=\frac{1}{s(s+0.4)} \tag{1}$$

and negative unity feedback.

1. Represent this system by a block diagram and a vector differential equation (i.e., state-space representation).
2. Plot the response of the closed-loop system to a step input.
3. Use state variable feedback so that the overshoot is 5% and the settling time (with a 2% criterion) is 1.35 seconds.
4. Plot the response of the state variable feedback system to a step input.

2 Pole-placement full-state feedback control

A system has the model

$$\dot{x} = \begin{bmatrix} -2 & -3 & 1 \\ 5 & 0 & 0 \\ 0 & 1 & 0 \end{bmatrix} x + \begin{bmatrix} 5 \\ 0 \\ 0 \end{bmatrix} u.$$

Add state variable feedback so that the closed-loop poles are $s = -6, -7, -8$.

3 Observer design

Consider the system depicted in Figure 1.

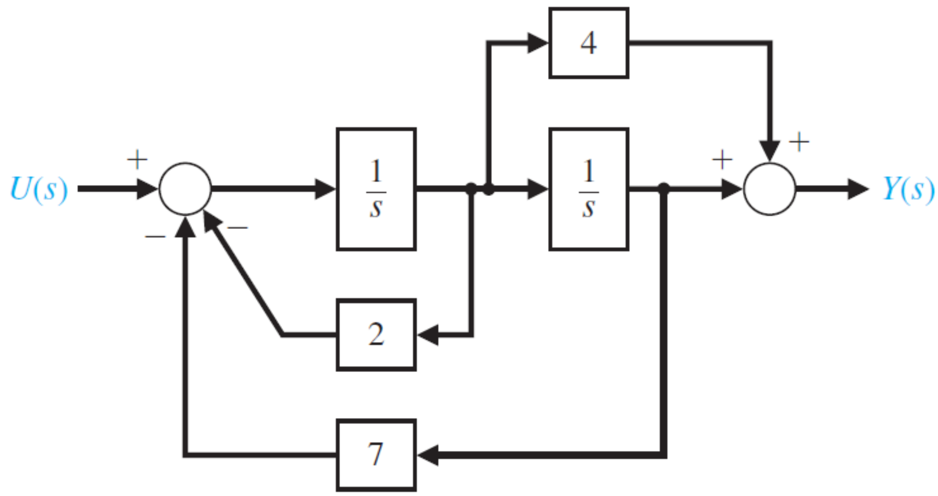

Figure 1: A second-order system block diagram.

Design a full-state observer for the system. Determine the observer gain matrix L to place the observer poles at $s_{1,2} = -10 \pm 10j$.

4 PD control

The goal is to design an elevator control system so that the elevator will move from floor to floor rapidly and stop accurately at the selected floor. The elevator will contain from one to three occupants. However, the weight of the elevator should be greater than the weight of the occupants; you may assume that the elevator weighs 1000 pounds and each occupant weighs 150 pounds. Design a system to accurately control the elevator to within one centimeter. Assume that the large DC motor is field-controlled. Also, assume that the time constant of the motor and load is one second, the time constant of the power amplifier driving the motor is one-half second, and the time constant of the field is negligible. We seek an overshoot less than 6% and a settling time (with a 2% criterion) less than 4 seconds.

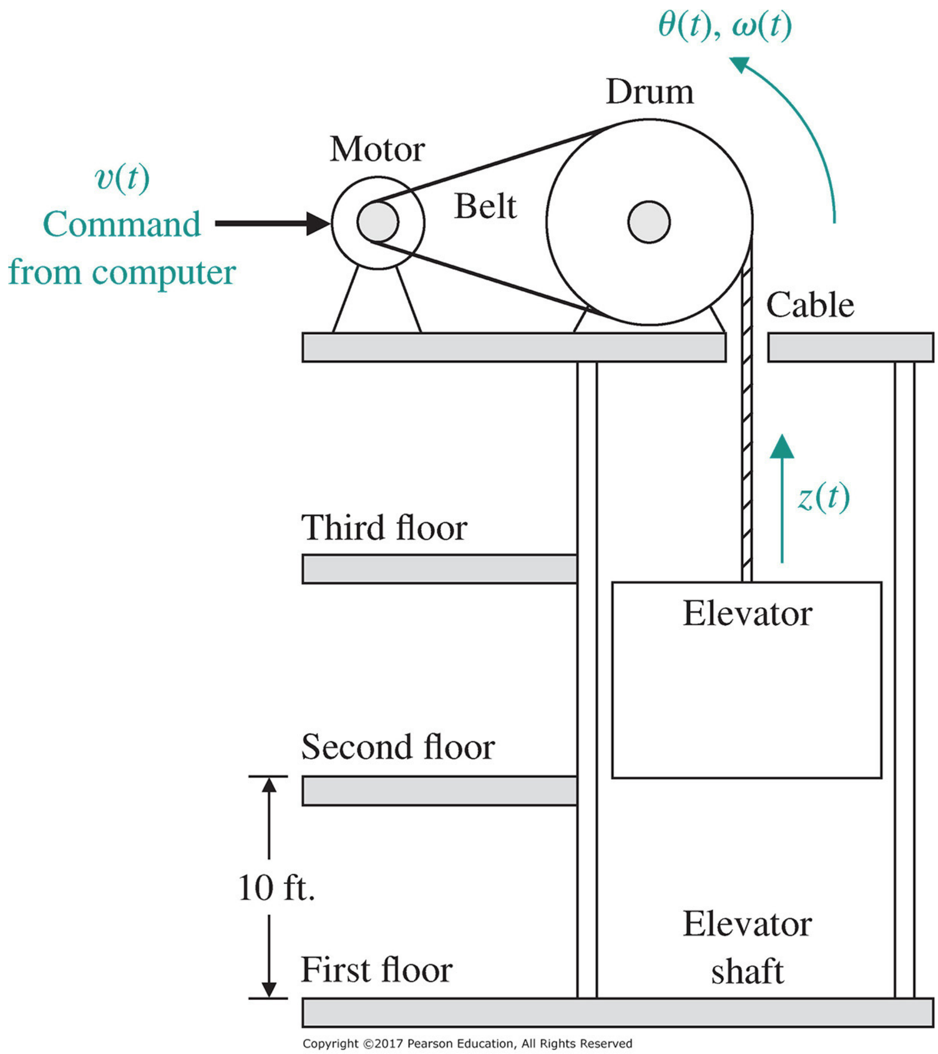

Figure 2: Magnetically levitated telescope position control system.

Hint - You can assume the transfer function $G = \frac{2}{s(s+1)(s+2)}$. Find the location of the poles which satisfy the requirements, and use a PD controller (technically an additional zero) to negate one of the poles. Use Root Locus to design the PD controller.

5 Pole-placement algorithm for state-space model

Write an m-file function that given the state-space model matrices A and B, and a vector of poles, p, the function returns the full-state controller, K, such that the poles of the closed loop system will be at p.

Test your function on the following inputs: myPolePlacement(magic(5), [1;2;3;4;5], [-1, -2, -3, -4, -5]).

Compare your result with the place function:

K=place(magic(5), [1;2;3;4;5], [-1, -2, -3, -4, -5]) % K=[10.5062 10.6291 3.5642 -2.7071 9.6742].