ASEN 5014 Final Project

Assigned 12/5/2024

Due 12/16/2024 at Noon

The final project will build on the first project, applying control system analysis and design concepts and techniques discussed in class to a representative model of a physical system. As before, you may work on the project in groups, with a single file submitted. Be sure to include the names of all group members and a short description of member contributions to the project report. Otherwise, credit cannot be given. Each write-up should be typeset, and should include diagrams, equations, and figures as appropriate to explain your approach and results in each of the sections below. Simply providing the answer is not sufficient; your methods and results must be explained. Explanations using the terminology discussed in class is expected. It is expected that results are checked explained using the tools and methods discussed in class.

1. (20 Pts) Examine the observability of the plant by determining the un-observable subspace of the state space. Determine the energy in the output over a suitable time interval (appropriate for your system) resulting from unit magnitude initial conditions in each of the plant modal spaces, and discuss the implications on the degree of observability of each of the plant real modes. Which of the modes can be changed in an observer designed around your plant dynamics?
2. (20 pts) Design a Luenberger observer for your system for three different performance objectives as follows:
    a. Slow observer: place observer eigenvalues (that can be moved) at locations that are 0.2 times as fast as the corresponding closed loop plant eigenvalues.
    b. Equal observer: place observer eigenvalues at the same locations as the corresponding plant closed loop plant eigenvalues.
    c. Fast observer: place observer eigenvalues at locations that are 5 times as fast as the corresponding closed loop plant eigenvalues.
3. (20 pts) For each case in part 2., simulate the closed loop observer/controller response to a step at each reference input, (one at a time, with zero initial conditions in both the plant state and the observer state). Comment on the difference between the three observer designs in these responses.
4. (20 pts) For each case in part 2., simulate the closed loop system response to non-zero initial conditions (with zero reference input). Use zero initial conditions in the observer, with non-zero initial conditions in the plant (one state vector component at a time, with unit size). Comment on the difference between the three observer designs in these responses. Are any of these responses likely to be objectionable in the presence of the step responses from part 3?
5. (20 pts) Use LQR to deisgn an optimal state feedback gain K for the plant such that closed loop plant eigenvalues have time constants at least as short as the slowest closed-loop mode designed in Project 1, and redesign the input matrix F (if necessary) to preserve accurate DC tracking of the reference inputs by the plant outputs. Implement this design along with the preferred observer design from above and evaluate the closed loop step reference tracking

behavior, using zero initial conditions. Compare the energy in the control signal (plant input), over a time period of 3 closed loop time constants, between the LQR control and the pole placement controller used in Project 1. Comment on any other differences between these two feedback control signals.