

2.14/2.140 Analysis and Design of Feedback Control Systems

Laboratory Assignment 7: Servomotor Position Control

Assigned: Week of April 14, 2014

Due: Week of April 21, in either Wed. or Thurs. lab sessions. (Monday 4/21 and Tuesday 4/22 are MIT holidays. There will also be no new lab assignments after this one, so you really only need to show up to lab to hand in your report, and be sure that we have back from you the myDAQ, thermal plant, and any other hardware.)

Position control

Position control is in some sense more difficult than velocity control, due to the additional integrator in the transfer function. In position control, feedback is taken from the potentiometer. We use a one-turn 5 k Ω servo potentiometer in this setup. The term servo potentiometer means that it is specified for continuous rotation with a reasonable life time. Conventional pots will have a rotation stop at the extreme of rotation, and also will not endure continuous mechanical operation. Given the selected 1.5 k series resistors, and for the ± 15 V supplies, the potentiometer voltage output varies from -9.4 to $+9.4$ volts. There is a discontinuity at the end of the range as the voltage transitions from the maximum negative to the maximum positive.

We have used the above information when developing the relationship between potentiometer output voltage and motor shaft angle. This also depends upon the gear ratio of the drive train. Due to the way the potentiometer is connected, the motor angle is 6 times the potentiometer angle, which is what you measure. In the model, we refer all variables to the motor shaft.

A lead-lag compensator with its lag pole at $s = 0$ can be written as

$$G_3(s) = K \frac{(\tau_1 s + 1)(\alpha \tau_2 s + 1)}{\tau_1 s (\tau_2 s + 1)} \quad (1)$$

The compensator parameters are to be chosen to satisfy the system requirements.

- a) Design a lead-lag compensator as given above to implement a position controller which achieves a crossover frequency of 50 rad/s and a phase margin of 45 degrees. Implement this controller on the real-time hardware. Record the system step response and compare with that predicted in your paper analysis.
- b) Use the supplied Dynamic Signal Analyzer (DSA) in Labview to experimentally measure the loop return ratio Bode plot, and include this plot in your report. What are the experimentally-measured loop crossover frequency and phase margin? How do the loop shape and crossover frequency and phase margin compare with your design from part a)?
- b) With the controller running, notice the effect of increasing the gain K on the servo stiffness. Do you notice any deterioration of position stability with increasing loop bandwidth? What might this be due to?
- c) With the controller running, and with a fixed reference position, try manually rotating the potentiometer shaft away from a fixed reference point. Notice the restoring torque of the servo increases with time due to the integral control term. Record the transient response of

recovery from this induced position error. Can you see the rather large overshoots caused by integral windup? Turn on anti-windup in your controller and repeat this experiment. Comment on the difference with anti-windup in place.

MIT OpenCourseWare
<http://ocw.mit.edu>

2.14 / 2.140 Analysis and Design of Feedback Control Systems
Spring 2014

For information about citing these materials or our Terms of Use, visit: <http://ocw.mit.edu/terms>.