University of British Columbia
Department of Electrical & Computer Engineering
ELEC341 – Jan. - Apr. 2020

Matlab Project Assignments
Due day: Apr. 13, 2020

Mark distribution:
10+20+15+20+10+15+10 +10 +10+ 20 +20+25=185 points

Computer/Design Problems from the textbook (13th Edition)

1. CP7.10
2. DP 7.12
3. DP8.1
4. DP8.3
5. CP8.6
6. DP10.1
7. CP10.2
8. CP10.4
9. CP11.3
10. DP11.7

Problem 11:

Consider a unity feedback system with loop transfer function

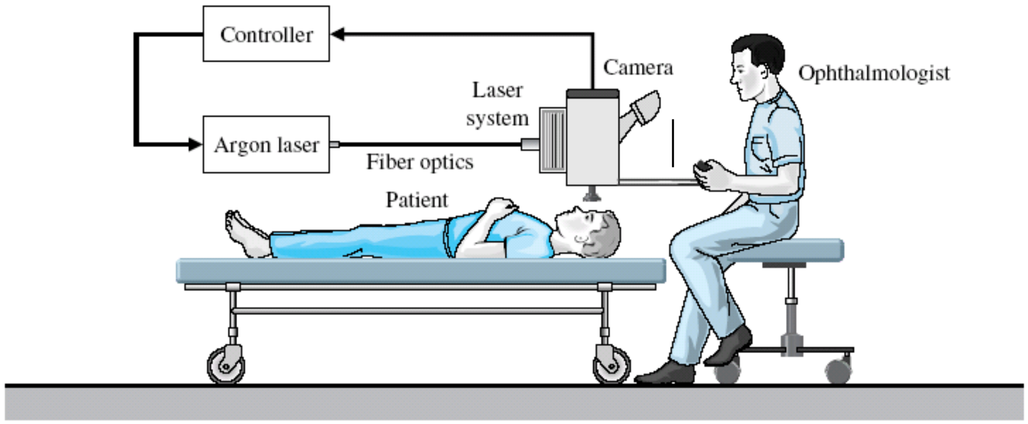
$$G_c(s)G(s) = \frac{s+\alpha}{s^3 + (1+\alpha)s^2 + (\alpha - 1)s + (1-\alpha)} \tag{1}$$

The magnitude of the steady-state error of the closed-loop system to a step input should be less than or equal to 10%.

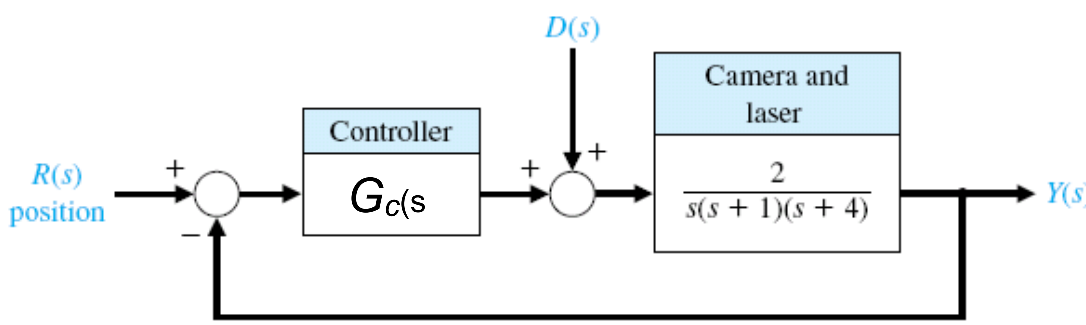
1. Using Matlab commends, plot the root locus as a function of the parameter α.
2. Use the Routh-Hurwitz criterion to determine α for which the closed-loop system is stable.
3. Determine all α that will achieve the desired steady-state error.
4. On a single plot, plot the roots of the closed-loop system for 3 values of α that achieve the required steady-state error. The Matlab commands **roots** and **pzmap** may be useful. Where do the 3 sets of poles on this plot lay in relation to the root locus in part (1)? What about the 3 sets of zeros?
5. Use Matlab to simulate the step response of the closed-loop system for 3 chosen values of α that satisfy the steady-state error constraint, and overlay them on the same plot, such that the 3 responses can be distinguished on a black-and-white printout. The Matlab command **legend** may be useful. Which of the 3 values of α is “best"? Justify your answer in terms of transient performance characteristics.

Problem 12:

The position-control procedure in the laser eye surgery system:



Since the laser allows the ophthalmologist to apply heat to a location in the eye in a controlled manner, lasers have been very useful in eye surgery, as shown in the above figure. Automated control of position enables the ophthalmologist to indicate to the controller where lesions should be inserted. The controller then monitors the retina (i.e. the thin sensory tissue that rests on the inner surface of the back of the eye) and controls the laser's position so that each lesion is placed at the proper location. A wide-angle video-camera is used to monitor the movement of the retina. Such a position-control system can be represented by the following block diagram, where D(s) represents the disturbance due to noise in the system:



1.) Suppose the controller is an ideal amplifier, i.e. $G_c(s)=K_a$. In Matlab, simulate the system to:

a. For several selected values of the amplifier gain K_a, show the response to step changes in the desired position and the disturbance noise. Determine the corresponding steady-state error.

b. Determine the value of K_a required for stability. And select an appropriate gain K_a so that the system is stable and the effect of the disturbance D(s) is minimized.

c. Sketch the root locus for this system as K_a varies and determine a K_a so that the damping ratio ζ of the closed-loop roots is 0.5.

d. For the K_a obtained in c.), plot the Bode diagram for the system.

2.) Modify your model accordingly. Design and simulate an alternative controller (e.g. a PD controller or a PID controller) so that

a. Suppose we wish to use a PD controller such that $G_c(s) = K(s+2)$. Plot the root locus for this system as K varies. What are your major observations and conclusions?
b. Determine the value of K in (a.) such that the resulting 2% settling time will be around 4 seconds.
c. Plot the response, y(t), for a unit step input r(t) and a unit step disturbance d(t) simultaneously with the controller designed as in (b.).
d. Plot the Bode diagram for the system with the controller designed as in (b.).

Please report your results/figures in a clear way, and also discuss your findings when applicable.