Midterm in
Control Engineering
MECH 435
Spring 2012

Duration: 90 minutes

Family name:	
First name:	
Student Id:	

	achieved points	max. points		
P1		20		
P2		20		
P3		20		
Total		**60**		

1 **20 Pts (33%)**

Given is a DC motor control system with cascaded position and velocity feedback:

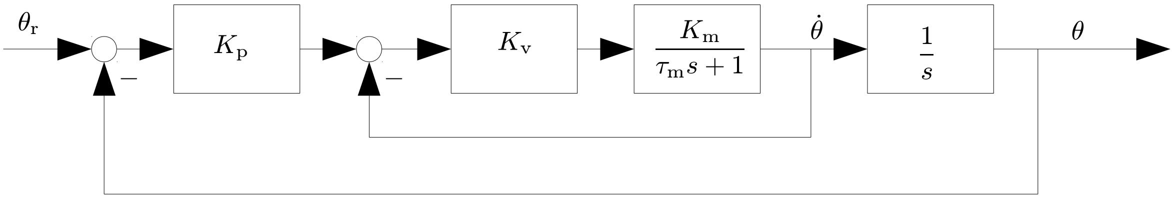

Figure 1: DC motor control block diagram

The following parameters are given: $K_m = 1$, $\tau_m = 0.5$

a) What is the steady state error of the system to a step input?

b) Determine the velocity error constant. What is the condition on K_p and K_v to ensure a steady state error of $e_{ss} = 0.01$ of the closed loop to a unit ramp input?

c) Determine K_p and K_v such that the settling time is around 4 seconds (for the 2% criterion) and the steady state error is $e_{ss} = 0.01$.

d) What effect would it have, if K_v was negative?

2 **20 Pts (33%)**

Given the plant:

$$G(s) = \frac{s^2 - s + 1}{s(s+1)}$$

Construct the root-locus while following the steps below:

a) Locate poles and zeros in the complex plane

b) Determine the part of the real axis included in the root-locus

c) Construct the asymptotes (if any) and determine their angles and their intersection with the real axis

d) Determine the break-away/break-in points (if any)

e) Determine the angles of departure/arrival (if any)

f) Determine the gain K above which the system becomes unstable (if applicable)

g) Determine the intersection of the root-locus with the imaginary axis (if any)

3 **20 Pts (33%)**

In this exercise we would like to control the plant $G(s)$ using the controller $G_c(s)$ and a unity feedback. The setup is as shown in Figure 2 below:

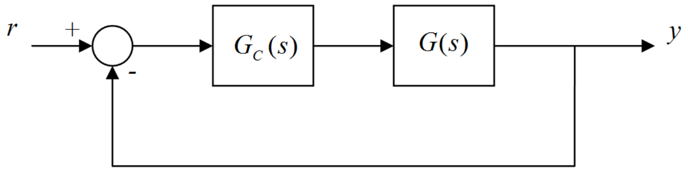

Figure 2: Control Scheme of the plant G(s)

The transfer function of the plant $G(s)$ is given by:

$$G(s) = \frac{s+2}{s(s+1)(s+3)}$$

The root locus of the plant $G(s)$ is given in Figure 3. We would like to design a controller that achieves a settling time $T_s = 2$ seconds and a damping ratio $\xi = \sqrt(2)/2$.

a) Based on the root locus, show that it is not possible to satisfy the requirements stated above using **only** a gain in the controller, i.e., $G_c(s) = K$

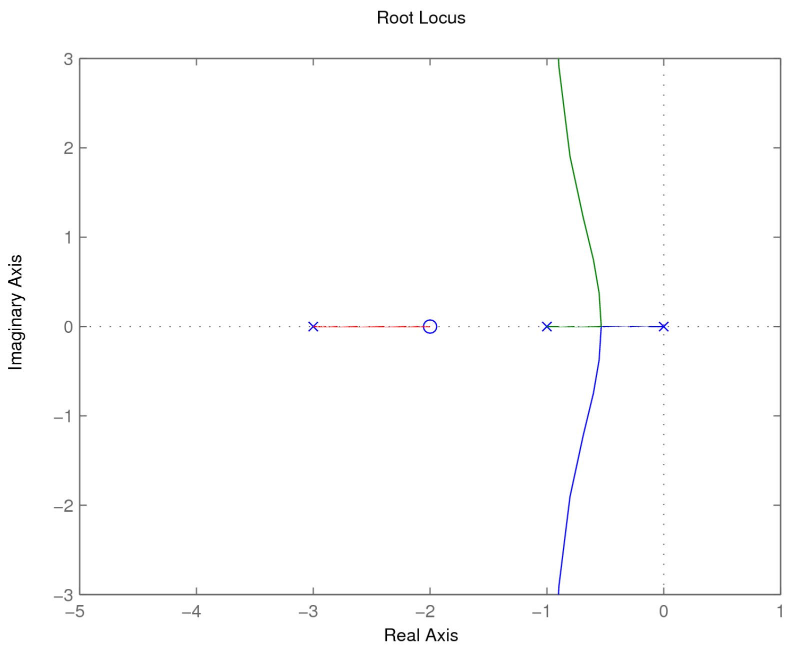

Figure 3: Root Locus of the plant G(s)

b) Design a lead controller that achieves the requirements stated above

c) Design a PD controller that achieves these same specifications