FINAL EXAMINATIONS – DECEMBER 2012

ELEC 360 – CONTROL THEORY AND SYSTEMS I

SECTIONS A01/CRN 10522, A02/CRN 10171

TO BE ANSWERED IN BOOKLETS

DURATION: 3 hours

INSTRUCTOR: Dr. P. Agathoklis

STUDENTS MUST COUNT THE NUMBER OF PAGES IN THIS EXAMINATION PAPER BEFORE BEGINNING TO WRITE, AND REPORT ANY DISCREPANCY IMMEDIATELY TO THE INVIGILATOR.

THIS QUESTION PAPER HAS 5 PAGES, INCLUDING THIS COVER PAGE AND TWO ATTACHED FIGURES.

FOUR (4) PAGES OF NOTES AND PHOTOCOPIES OF LAPLACE TRANSFORMS ARE PERMITTED.

DETACH PAGE 5 FROM THE EXAMINATION PAPER AND HAND IN WITH YOUR ANSWER BOOKLET.

Marks

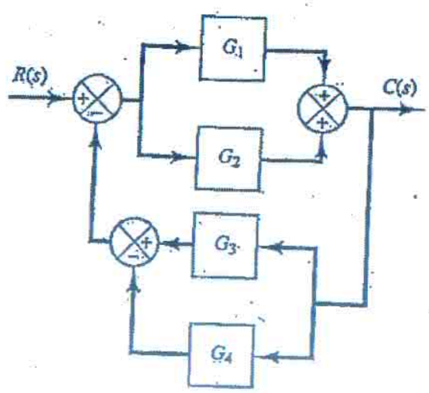
(4) 1. Consider a system described by:

$$\ddot{y} + 4\dot{y} + 3y = u + 2\dot{u}$$

Find $y(t)$ for $y(0)=1$, $\dot{y}(0)=0$ and an input signal $u(t)$ given by:

$$u(t) = \begin{cases} 1 & for\ \ 1 < t < 2 \\ 0 & else \end{cases}$$

(4) 2. Find the transfer function G(s)=C(s)/R(s) for the block diagram:



(4) 3. Consider the unity negative feedback system with open-loop transfer function given by:

$$G(s)H(s) = \frac{K}{s^3 + 4s^2 + 2s}$$

(a) Find for what values of K is the closed-loop system stable
(b) Find if and for what values of K does the closed-loop system have a steady state error of less than 0.2 for unit step and unit ramp inputs.

(3) 4. Consider a system given by:

$$\dot{\underline{x}} = \begin{bmatrix} 1 & 0 \\ a & b \end{bmatrix} x + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u$$
$$y = \begin{bmatrix} 1 & 0 \end{bmatrix} \underline{x}$$

Find values for α and b so that the response $y(t)$ to a step input $u(t)$ has a settling time of 4 sec and a damping ratio ζ of 0.5.

(5) 5. Consider the negative unity feedback system with open-loop transfer function given gy:

$B=1 \quad B'=0$

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

$A = s^3 + 6s^2 + 9s$

$A' = 3s^2 + 12s + 9 \Rightarrow s^2 + 6s + 3$

a) Sketch the root-locus of the system in for K between 0 and infinity.

b) Discuss the transient response performance of the closed-loop system when K goes from 0 to ∞.

(8) 6. Consider the transfer functions given by:

(i) $$G_1(s) = \frac{K(s+1)}{(s+2)(s+3)(s+5)}$$

(ii) $$G_2(s) = \frac{K(s-1)}{(s+2)(s+3)(s+5)}$$

(a) Sketch the Bode and Polar plots for $G_1(s)$ and $G_2(s)$

(b) Evaluate the stability of the two closed-loop systems with negative unity feedback, with Proportional Control (i.e variable gain K changing from 0 to infinity in the numerator) and feedforward transfer function $G_1(s)$ and $G_2(s)$ respectively using the Nyquist Stability Criterion.

(6) 7. The Bode plots of the open loop compensated and uncompensated system are given in page 6.

From the plot of the uncompensated system, determine:

a) The stability of the closed-loop system

b) The type of open-loop system and the value of the corresponding static error constant.

c) The phase and gain margins.

From the plot of the compensated system, determine:

a) The compensator used

b) The new phase and gain margins

c) Discuss the effects of using a compensator – what has been improved and how?

Justify your answers and indicate in the attached figure (page 6) the corresponding quantities.

END

Name: ______________________ **Student No.:** ______________

Figure for Question 7

Solid line: Uncompensated system
Dashed line: Compensated system