UNIVERSITY OF VICTORIA

FINAL EXAMINATIONS – DECEMBER 2014

ELEC 360 – CONTROL THEORY AND SYSTEMS I

SECTIONS A01 (CRN:11203), A02 (CRN:11204)

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 7 PAGES, INCLUDING THIS COVER PAGE.

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

DETACH PAGE 7 FROM THE EXAMINATION PAPER AND HAND IN WITH YOUR ANSWER BOOKLET.

Marks

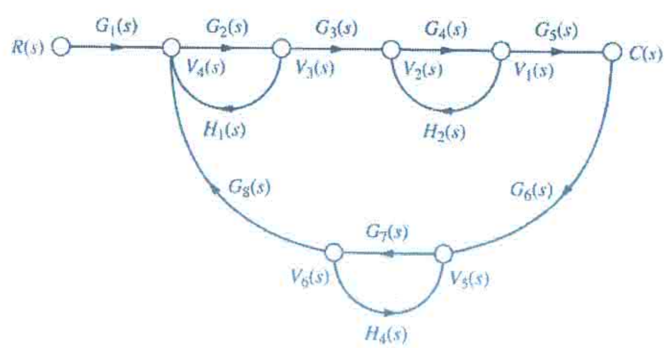
(4) 1. Consider a system G(s), where G(s) has

- a pole at -1
- a pole at -2 and
- a gain cross-over frequency of 3 rad/sec

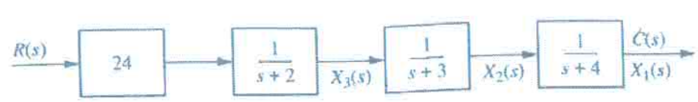
Find the response of a closed-loop system with G(s) in the feed forward path and a negative unity feedback to the following input signal:

$$u(t) = \begin{cases} 0.5t & for\ 0 < t < 2 \\ 0 & else \end{cases}$$

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



(4) 3. Find a state-space description for the following system using x_1, x_2, x_3 as states:



(10) 4. Consider the closed-loop system with unity negative feedback and the following system in the feed forward path:

$$\dot{\underline{x}} = A\underline{x} + \underline{b}u$$
$$y = \underline{c}\underline{x}$$

with

$$A = \begin{bmatrix} 0 & 0 & 0 \\ 1 & 0 & -2 \\ 0 & 1 & -3 \end{bmatrix} \quad \underline{b} = \begin{bmatrix} 1 \\ 0 \\ 0 \end{bmatrix} \quad \underline{c} = [0, \quad 0, \quad K]$$

(a) Sketch the root-locus for the above system.

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

(c) For what values of K is the closed-loop system stable

(d) Find for what values of K does the closed-loop system have a steady state error of less than 0.7 for unit step and unit ramp inputs.

(e) Sketch the Bode plot for the open-loop system.

(6) 5. Sketch the Bode plots and the polar plots for the following transfer functions:

(a) $$G(s) = \frac{10(s+1)}{s(s+2)(s+10))}$$

(b) $$G(s) = \frac{(s-1)}{s(s+2)(s+10)}$$

(6) 6. Consider the unity negative feedback system with the feed forward transfer function given by:

$$G(s) = \frac{10K}{s(s+2)(s+3))}$$

(a) Use the polar plot of G(s) and evaluate the stability of the closed-loop system with Proportional Control (i.e variable gain K changing from 0 to infinity in the numerator) using the Nyquist Stability Criterion.

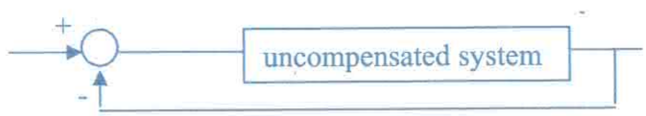
(b) Replace Proportional Control K with Proportional-Derivative Control so that

$$G(s) = \frac{10K(s+1)}{s(s+2)(s+3)}$$

and use the Nyquist Stability Criterion to evaluate the stability of the closed-loop system when K is changing from 0 to infinity.

(6) 7. The Bode plots of the open loop compensated and open loop uncompensated systems are given in page 7 (both are minimum phase).

From the plot of the uncompensated system, determine:



a) The stability of the closed-loop system

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

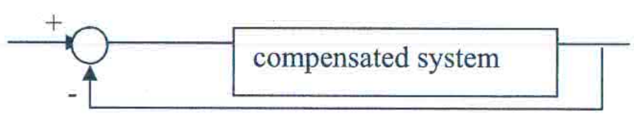
c) The phase and gain margins.

From the plot of the compensated system, determine:

a) The type of compensator used

b) The new phase and gain margins

c) Discuss the effects of using this compensator on the response of the closed-loop system, i.e, what has been improved (with respect to the uncompensated system) and why?



Justify your answers and indicate in the attached figure (page 5) the corresponding quantities.

END

This page is intentionally left blank

Name: ______________________________ **Student No.:** __________________

Figure for Question 7

1. Compensated system: solid line
2. Uncompensated system: dashed '- - ' line