UNIVERSITY OF VICTORIA

FINAL EXAMINATIONS – DECEMBER 2015

ELEC 360 – CONTROL THEORY AND SYSTEMS I

SECTIONS A01 (CRN: 11255), A02 (CRN: 11256)

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.

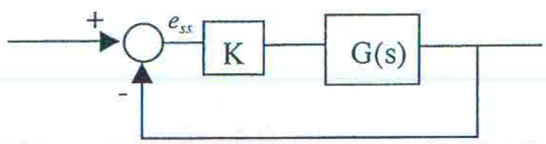
THIS QUESTION PAPER HAS 5 PAGES, INCLUDING THIS COVER PAGE.

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

(5) 1. Consider a negative unity feedback system with feedforward transfer function KG(s):



where G(s) has

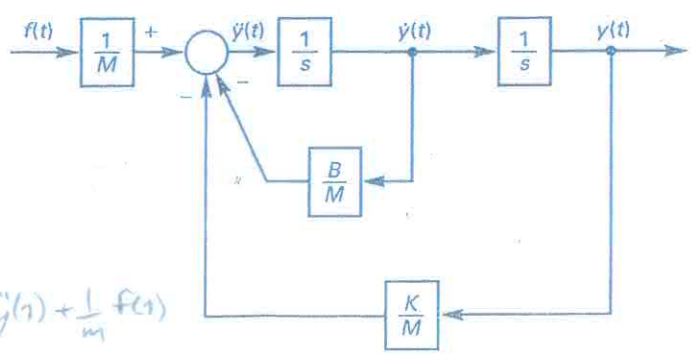
- an integrator
- a pole at -2

and e_{ss} , the steady state error to a unity ramp is 0.5

Find the response of the closed-loop system to the following input signal:

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

(4) 2. Find a state-space description for the following system :



$y(t) = \frac{1}{s}\dot{y}(t)$
$\dot{y}(t) = \frac{1}{s}\ddot{y}(t)$
$\ddot{y}(t) = -\frac{B}{m}\dot{y}(t) - \frac{K}{m}y(t) + \frac{1}{m}f(t)$

$y(s) = y(s)$
$s\dot{y}(s) = s y(s)$
$y(t) = y(t)$
$\dot{y}(t) = \dot{y}(t)$
$\ddot{y}(t) = -B\dot{y}(t) - K y(t) + \frac{1}{m}f(t)$

$y(t) = \frac{1}{s}\dot{y}(t)$
$\dot{y}(t) = \frac{1}{s}\ddot{y}(t)$
$\ddot{y}(t) = \frac{B}{m} - \frac{K}{m} - 1$

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

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

$s^2 - 1$
$(s-1)(s+1)$
$s^2 + s - s - 1$

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

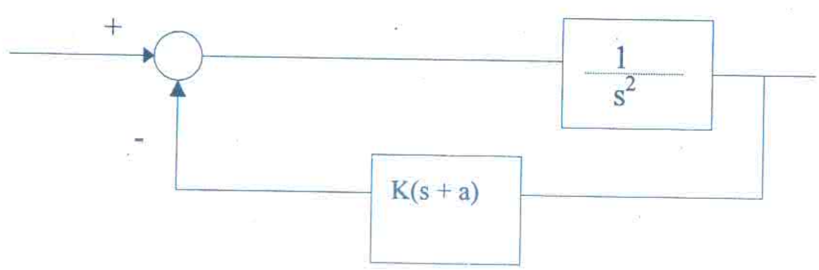
(b) Discuss the transient response performance of the closed-loop system when K goes from 0 to ∞.

$(s+1)(s-1)$
$s^2 - s + s - 1$

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

(d) Sketch the Bode plot and the polar plot for the open-loop system.

(5) 4. Consider the system given by:



Find K and a so that the closed-loop unit step response has a settling time of 4 sec and an overshoot of 0.13.

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

(a) $$G_1(s) = \frac{10(s+0.5)}{s(s+2)(s^2+2s+5))}$$

$\frac{1}{s^2} \cdot k(s+a)$

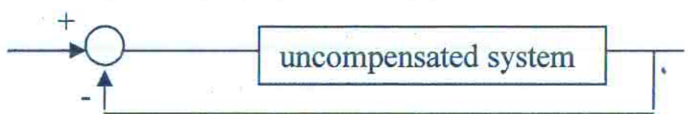
$\frac{3.57(s+a)}{s^2}$

(b) $$G_2(s) = \frac{K(s+1)}{s(s+2)(s+4)}$$

Using the Nyquist Stability Criterion, evaluate the stability of the negative unity feedback closed loop system with $G_2(s)$ as the feedforward transfer function. Consider a variable gain K changing from 0 to infinity.

(6) 6. The Bode plots of the open loop compensated and open loop uncompensated systems are given in page 5 (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