UNIVERSITY OF VICTORIA

FINAL EXAMINATIONS – DECEMBER 2002

ELEC 360 – CONTROL THEORY AND SYSTEMS I

SECTION F 01

TO BE ANSWERED IN BOOKLETS AND ON THE PAPER

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 6 PAGES, INCLUDING THIS COVER PAGE AND TWO ATTACHED FIGURES.

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

DETACH PAGES 5 & 6 FROM THE EXAMINATION PAPER AND HAND IN WITH YOUR ANSWER BOOKLET.

Marks

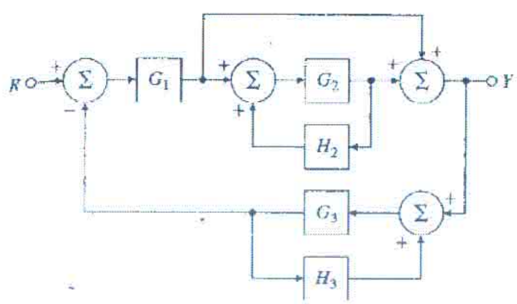
(4) 1. Find the output of a system given by:

$$\underline{\dot{x}} = \begin{bmatrix} -0.5 & 2 \\ 0 & -2 \end{bmatrix} \underline{x} + \begin{bmatrix} 3 \\ 1 \end{bmatrix} u$$

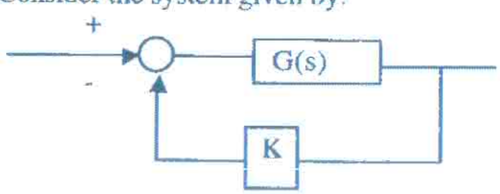
$$y = \begin{bmatrix} 0 & 1 \end{bmatrix} \underline{x}$$

to an input signal given by:

(4) 2. Find the transfer function of Y(s) / R(s)



(5) 3. Consider the system given by:

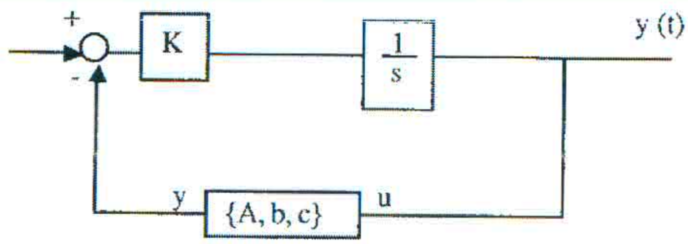


where $G(s) = \dfrac{1}{s(s^3 + 5s^2 + 8s + 6)}$

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

(b) What is the smallest steady state error for a unit ramp input you can obtain by changing K? Justify your answer.

(4) 4. Find a state-space description for a system given by:

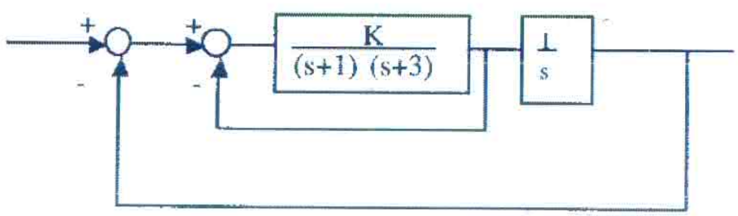


where {A, b, c} is given by:

$$\dot{x} = \begin{bmatrix} -1 & 1 \\ 0.5 & -3 \end{bmatrix} \underline{x} + \begin{bmatrix} 1 \\ 2 \end{bmatrix} u \qquad \Rightarrow \dot{x} = Ax + bu$$

$$y = \begin{bmatrix} 0 & 1 \end{bmatrix} \underline{x} \qquad y = cx + du$$

(6) 5. Sketch the root locus of:



And discuss the step response of the closed-loop system when K goes from 0 to ∞.

(6) 6. Consider a system with negative unity feedback and a feedforward transfer function G(s). The polar plot of G(s) is given in page 5. Find:

a) The type of the system

b) Phase and gain margins

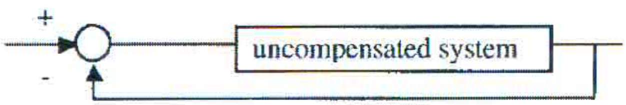
c) Discuss the stability of the system when the gain of G(s) changes.

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

(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 coefficient.

(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

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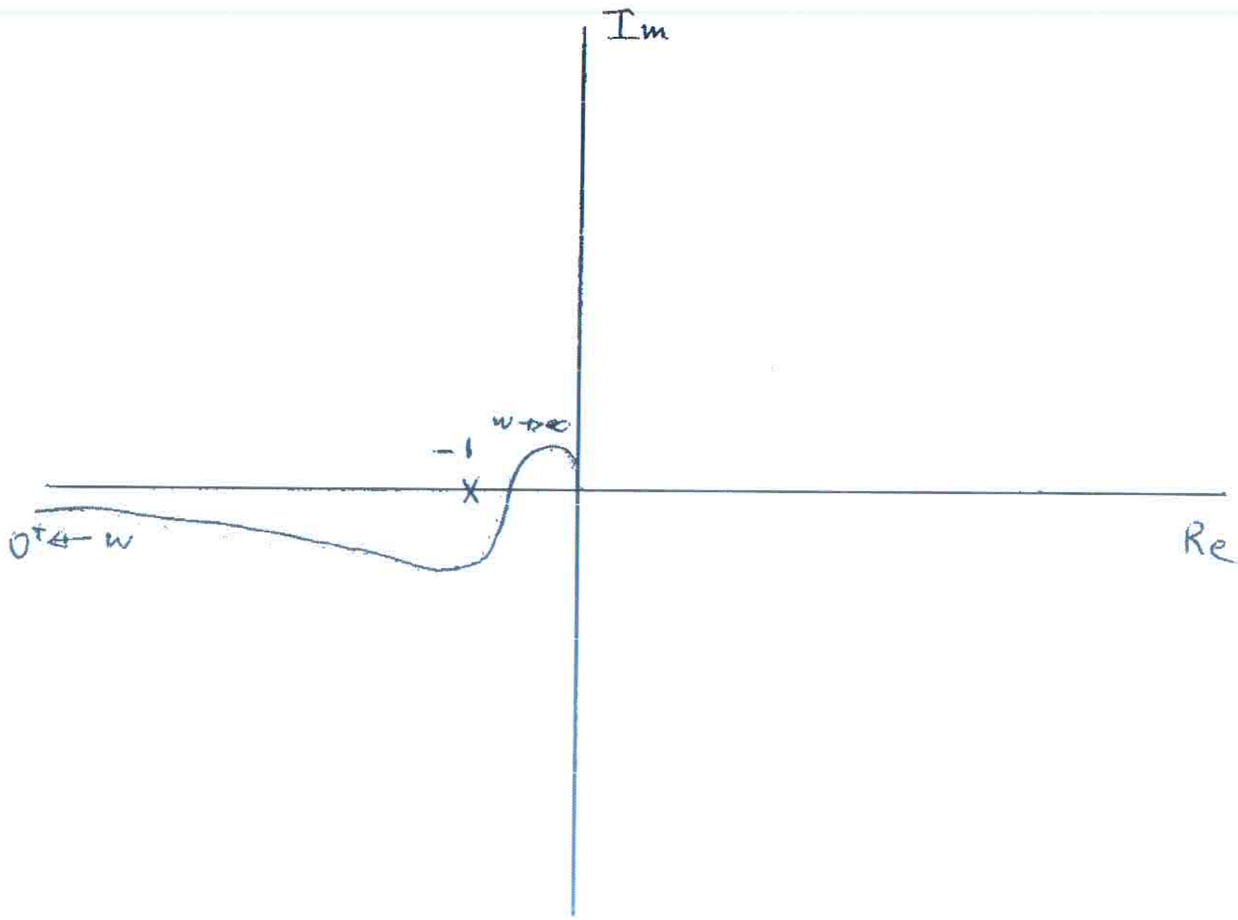

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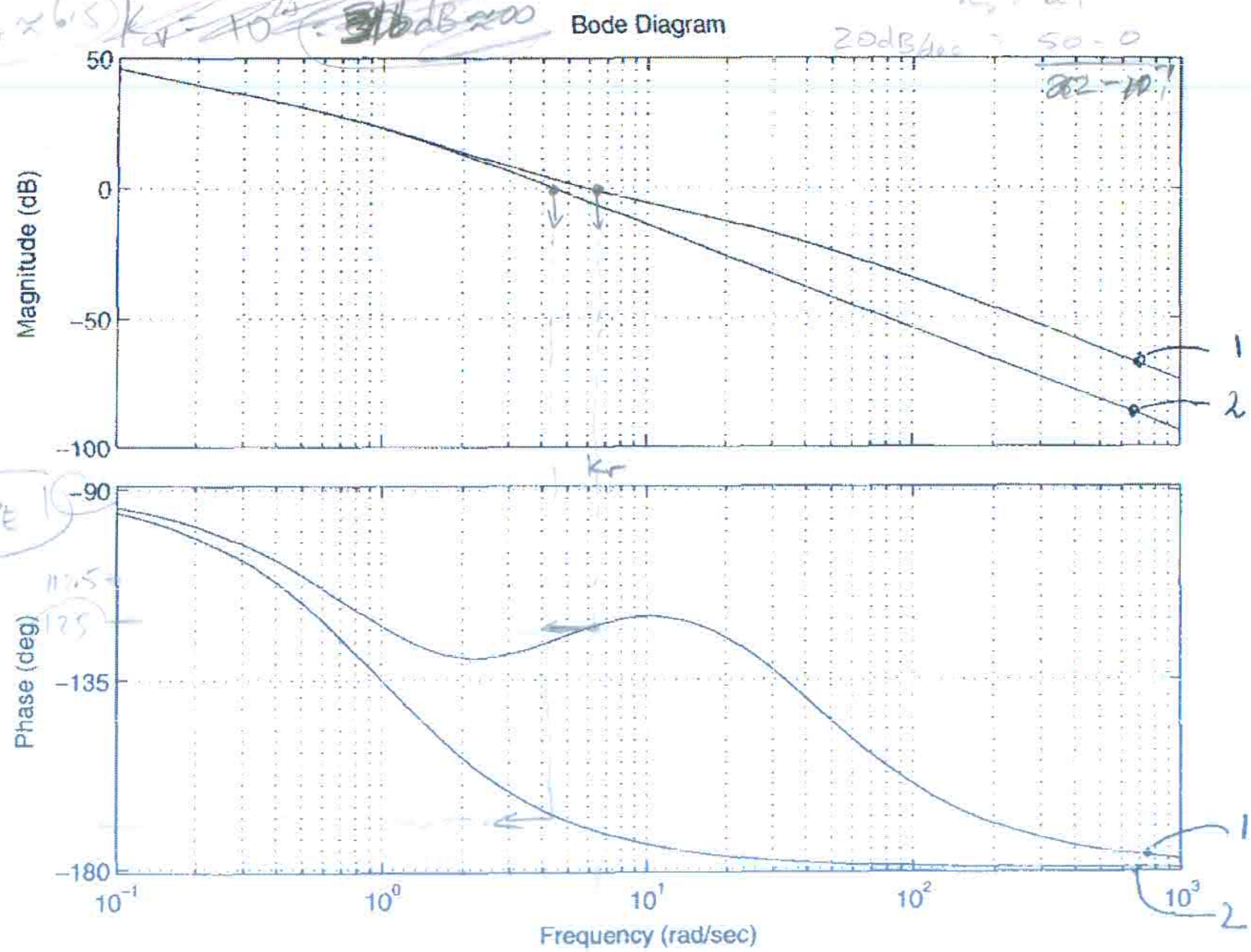
(1) PM: 180 − 125 ≈ 55
GM: > 50dB

(2) PM:
GM:

$m = \frac{y_2 - y_1}{x_2 - x_1}$

$K_v \approx 6.5$



$K_v = \lim_{\omega \to 0} (j\omega)(G(j\omega))$ $\quad \frac{Z_2}{s P_1 P_3}$

$= j\omega \left(\frac{\quad}{j\omega (\quad)} \right)$

1. Compensated
2. Uncompensated