THE OPEN UNIVERSITY OF SRI LANKA
FACULTY OF ENGINEERING TECHNOLOGY
DIPLOMA IN TECHNOLOGY – LEVEL 4
FINAL EXAMINATION – ACADEMIC YEAR 2008/2009
MEX4243 - CONTROL SYSTEMS ENGINEERING/
ECX4242 - CONTROL SYSTEMS

Date : April 04, 2009 **Time: 0930 - 1230 hrs**

Important:

1. This question paper consists of **eight** questions.
2. Write the answers for the **Section A** and **Section B** in **separate answer books.**
3. Answer **Q1, which is compulsory,** and FOUR other questions selecting at least ONE from SECTION A and TWO from SECTION B.
4. Present important but relevant facts and information briefly. Any missing information can be sensibly and reasonably assumed provided that you state them clearly. Wherever necessary, use neatly drawn sketches to explain answers.

SECTION A

Q1 An antenna azimuth position control system is shown in Figure Q1. The purpose of the system is to adjust the azimuth angle of the antenna.

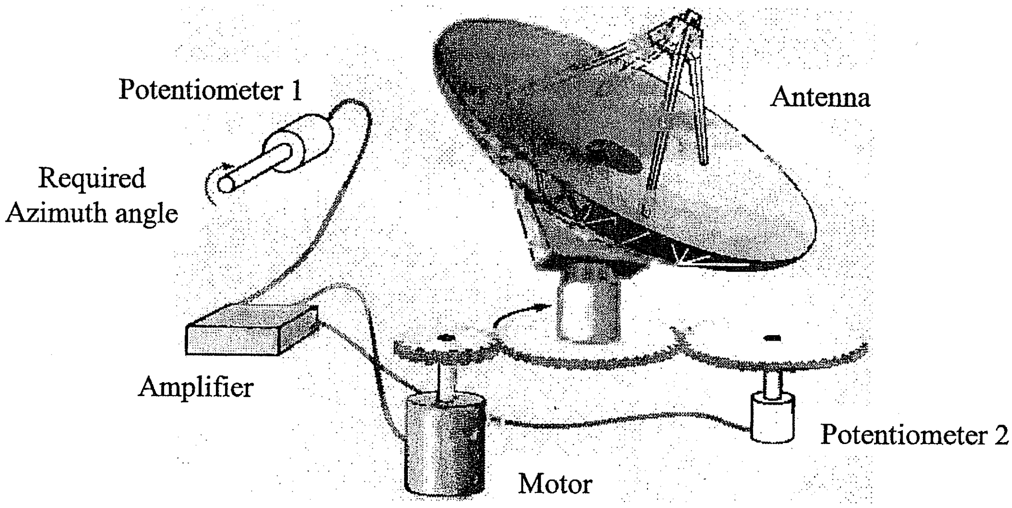

Figure Q1

(a) What is the system output? What type of transducer is used for measuring the output?

(b) What is the system Actuator? What type of transducer is used here?

(c) Describe the functions of each physical component of this system.

(d) Explain briefly the operation of this control system.

(e) Draw a complete block diagram of this control system.

(f) What are the external disturbances for this kind of control system? Indicate them on the block diagram you have drawn.

Q2 Figure Q2 represents a multivariable control system in the Laplace domain.

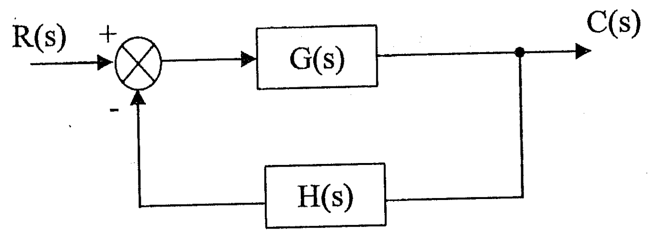

Figure Q2

(a) If C(s) is a vector of order ($p \times 1$) and R(s) is a vector of order ($q \times 1$), find the orders of G(S) and H(s).

(b) Write down the following transfer functions:

(i) Feed Forward path
(ii) Open Loop
(iii) Error
(iv) Closed Loop

(c) (i) What is the condition that should be satisfied for the closed loop transfer Function to exist.

(ii) Check the validity of the above (c)(i) if,

$$G(s) = \begin{bmatrix} \frac{1}{s+1} & 1 \\ 1 & \frac{2}{s} \end{bmatrix} \text{ and } H(s) = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$$

(iii) Find the closed loop transfer function.

Q3 The block diagram of a feedback control system is shown in Figure Q3.

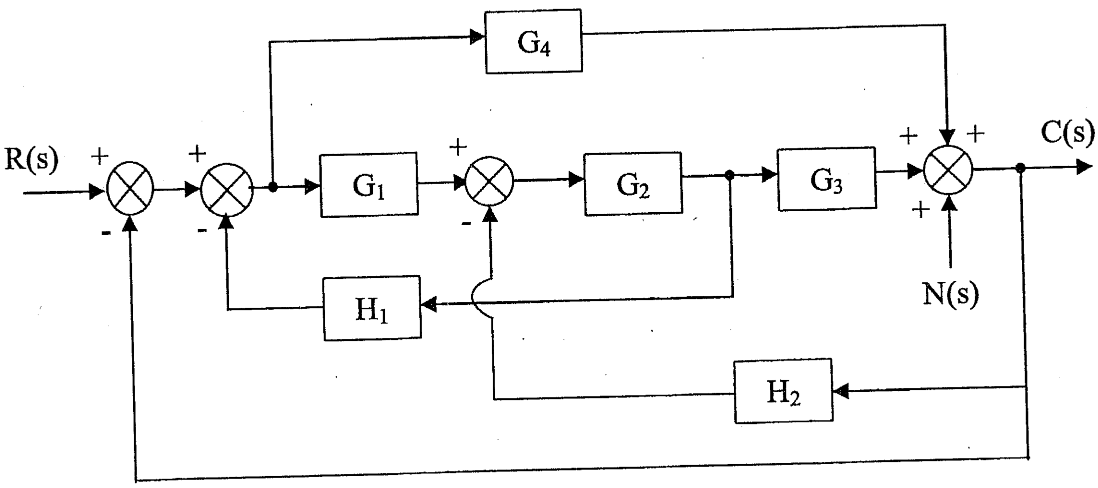

Figure Q3

(a) Draw the signal flow graph for the system given in figure Q3.

(b) Apply the SFG gain formula to find the transfer functions.

(i) $\left.\dfrac{C(s)}{R(s)}\right|_{N=0}$ (ii) $\left.\dfrac{C(s)}{N(s)}\right|_{R=0}$

(c) Express C(*s*) in terms of *R*(*s*) and *N*(*s*) when both inputs are applied simultaneously.

Q4 Refer the system shown in figure Q4.

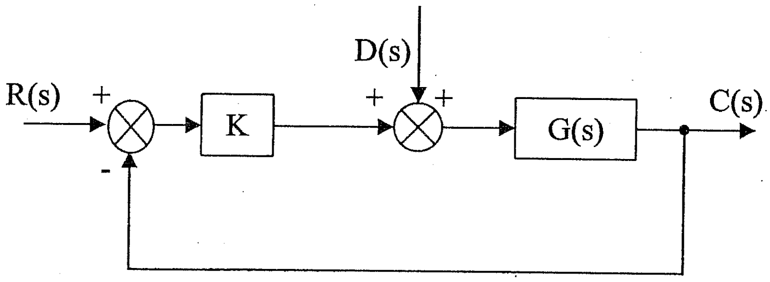

Figure Q4

(a) Derive the expression of the output, C(s), in terms of the input, R(s), and the disturbance, D(s).

(b) Suppose that

$$G(s) = \frac{1}{(1+sT_1)(1+sT_2)}$$

(i) The r(t) is unit step input and d(t) is a negative unit step input. When both r(t) and d(t) are present find the steady state error.

(ii) Supporting your argument with analysis, comment on the desirable setting for the proportional control (K), to give good disturbance rejection.

(iii) If it is impossible to achieve zero steady state error by using the K, propose an improved scheme and support your comments with necessary calculations.

SECTION B

Q5 (a) The open-loop transfer function of a unity feedback control system is given by

$$G(s) = \frac{K}{(s+2)(s+4)(s^2+6s+25)}$$

By applying Routh criterion, discuss the stability of the closed-loop system. Determine the values of ***K*** which will cause sustained oscillations in the closed-loop system. What are the corresponding oscillation frequencies?

(b) A feedback system has an open-loop transfer function of

$$G(s)H(s) = \frac{Ke^{-s}}{s(s^2+5s+9)}$$

Determine by use of the Routh criterion, the maximum value of ***K*** for the closed-loop system to be stable.

Q6 (a) Sketch the root locus plot of a unity feedback control system with the open loop transfer function

$$G(s) = \frac{K}{s(s+1)(s+8)}$$

Determine the values of K for which the system is stable.

(b) If a zero at s = -2 is introduced into the function of part (a), obtain the modified root locus. Describe the effect that the introduction of the zero has upon the performance.

Q7 (a) The asymptotic Bode magnitude plot of a system is sketched in Figure Q7. Write the expression for its transfer function in frequency domain. Draw its asymptotic phase plot.

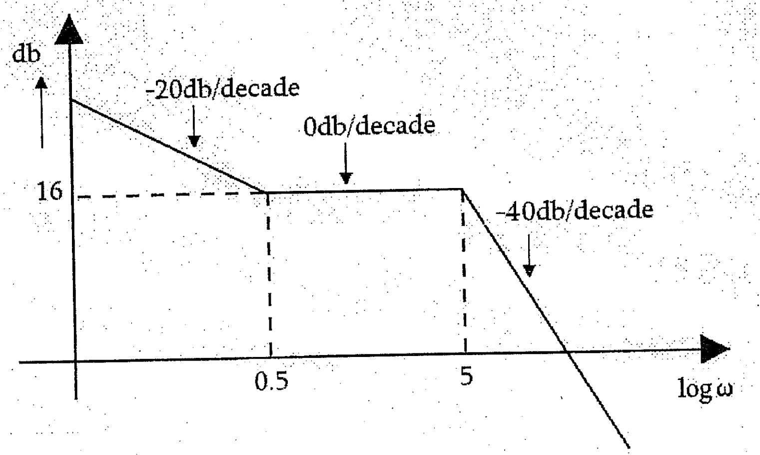

Figure Q7

(b) A unity negative feedback system has an open loop transfer function of

$$G(s) = \frac{K}{(s+4)}$$

Consider a cascade compensator

$$G_C(s) = \frac{s+\alpha}{s}$$

(i) Select the values of $\boldsymbol{K}$ and $\boldsymbol{\alpha}$ to achieve
   a. Peak overshoot of about 20%, and
   b. Settling time =1sec

(ii) For the values of $\boldsymbol{K}$ and $\boldsymbol{\alpha}$ found in Part (i) calculate the unit ramp input steady-state error.

Q8 (a) Describe and compare the characteristics of

(i) Proportional Controller.
(ii) Proportional plus Integral Controller.
(iii) Proportional plus Integral plus Derivative Controller.

(c) Figure Q8(i) represents control system and Figure Q8(ii) represents control system with the PD Controller ($G_c(s)$). The forward path transfer function of the system in figure Q8(i) is given by

$$G(s) = \frac{16}{s^2 + 1.6s} \quad \text{and}$$

The transfer function of the PD controller is given by $G_c(s) = 1 + K_t s$

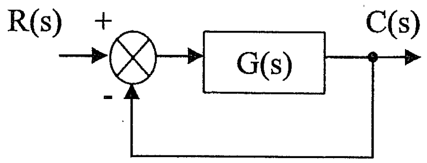

Figure Q8(i): without PD controller

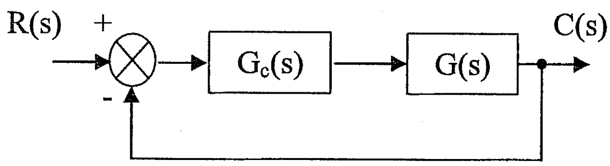

Figure Q8(ii): with PD controller

Determine the derivative feedback constant K_t and compare the rise time, peak time, maximum overshoot and steady state error for unit ramp input with and without derivative feedback control, if it is desired to have the damping ratio as 0.8.

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