NEW SCHEME

EE43

USN

Fourth Semester B.E. Degree Examination, July/August 2005

EE / EC / IT / TE / BM/ ML

Control Systems

Time: 3 hrs.] [Max.Marks : 100

Note: *Answer any FIVE full questions.*

1. (a) For what purpose feedback is used in control systems? Mention the effects of feedback on i) stability ii) overall gain iii) disturbance and iv) sensitivity of control systems. (10 Marks)

   (b) Draw the F-V analogous mechanical system for the electrical circuit shown in fig.1, writing the loop equations for the electrical circuit, then transforming them to their mechanical analog. (10 Marks)

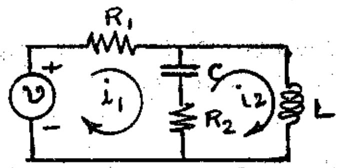


FIG 1

2. (a) Illustrate how to perform the following in connection with block diagram reduction techniques:

   i) moving a summing point ahead of a block and behind a block

   ii) moving a take off point ahead of a block and behind a block

   iii) Transforming a non unity feedback to a unity feedback. (10 Marks)

   (b) Explain Masons gain formula. Use it to determine the transmittance of the flow graph shown in Fig.2. (10 Marks)

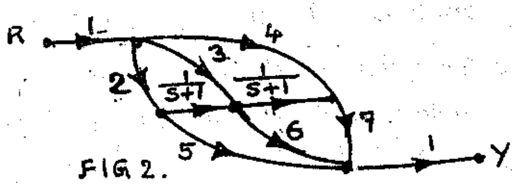
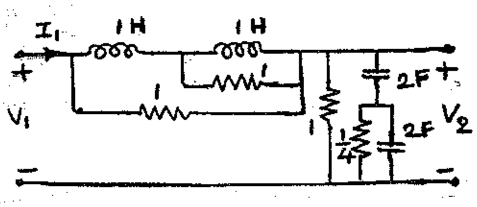


FIG 2.

3. (a) For the two port network shown in Fig.3, obtain the transfer functions

   i) $\frac{V_2(s)}{V_1(s)}$ and ii) $\frac{V_1(s)}{I_1(s)}$ (10 Marks)



(b) For a unity feedback control system with $G(s) = \frac{64}{S(S+9.6)}$ write the output response to a unit step input. Determine:

i) The response at t = 0.1 sec

ii) Maximum value of the response and the time at which it occurs

iii) Setting time. (10 Marks)

4. (a) Obtain expressions for i) peak resonance ii) resonance frequency and iii) band width of a proto type second order system. (10 Marks)

(b) For the flow graph shown in fig.4, mention the type number and order of the system and determine the steady state errors for step and ramp inputs $e(t) = r(t) - y(t)$. (10 Marks)

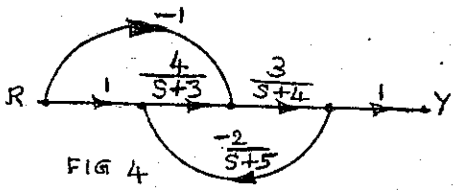


FIG 4

5. (a) The polynomial $P(S) = S^4 + 2S^3 + 3S^2 + S + 1$ has all its roots in LHS of a plane. Use R-H criterion to determine the number of roots of P(S) lying between $S = -\frac{1}{2}$ and $S = -1$. (10 Marks)

(b) The block diagram of a feedback control system is shown in fig.5. Apply RH criterion to determine the range of K for stability if $G(S) = \frac{K}{(S+4))(S+5)}$ (10 Marks)

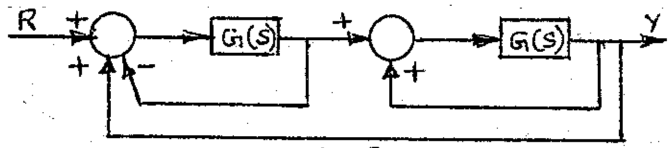


FIG 5

6. (a) For a unity feed back system $G(S) = \frac{K(1+S)^2}{S^3}$, determine the range of K for the system to be stable using Nyquist criterion. (10 Marks)

(b) For the polar plot shown in fig. 6

i) determine the gain margins in dB and the phase margins if $OA = -0.5, OB = -1, OC = -2, OD = -2.5\ OE = -0.866 + J0.5$ and $OF = -0.643 - J0.766$.

ii) Complete the Nyquist, plot and determine whether the system is stable, if all poles are in LH of s plane. (10 Marks)

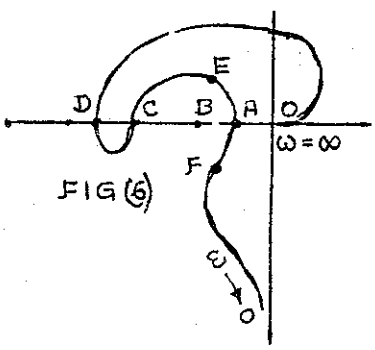


FIG (6)

7. (a) As applied to root locus, explain how to
   i) determine angle of departure or arrival from a complex pole or zero
   ii) determine the breakaway or breakin points if they are present
   iii) calculate K on a given point on the root locus. (10 Marks)

   (b) The root locus for $G(S)H(S)$ is shown in Fig. 7.
   i) What value of K gives a damping ratio $\delta = 0.707$ for the two poles nearest the JW axis when the system is operated closed loop?
   ii) What is the setting time for the closed loop system with the two poles adjusted to have $\delta = 0.707$?
   iii) What K makes the closed loop system go unstable? (10 Marks)

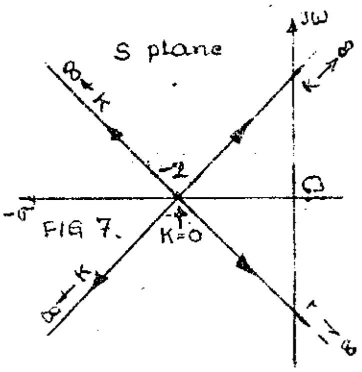


FIG 7.

8. (a) Draw bode plot for the system shown in fig.8. Determine gain margin and phase margin. (10 Marks)

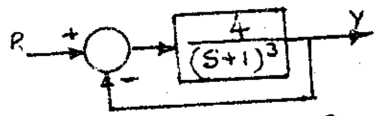


FIG 8

(b) Estimate the transfer function from the bode plot shown in fig.9. Digits on line indicate slope in dB/dec. (10 Marks)

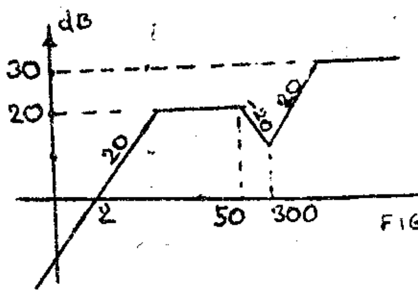


FIG 9

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NEW SCHEME

EE43

Reg. No.

Fourth Semester B.E. Degree Examination, January/February 2006

Common to EC, TE, EE, IT, ML and BM

Control Systems

Time: 3 hrs.) (Max.Marks : 100

Note: ***Answer any FIVE full questions.***

1. **(a)** List the merits and demerits of open loop and closed loop control systems. Give at least one example for each. **(6 Marks)**

(b) For the mechanical system shown in Fig. 1.

i) Draw the mechanical network

ii) Write the differential equations governing its dynamic behaviour

iii) Write the Force - Current (F-I) and Force - Voltage (F-V) analogous electric networks

iv) List all the analogous quantities **(2+3+(3+4)+2=14 Marks)**

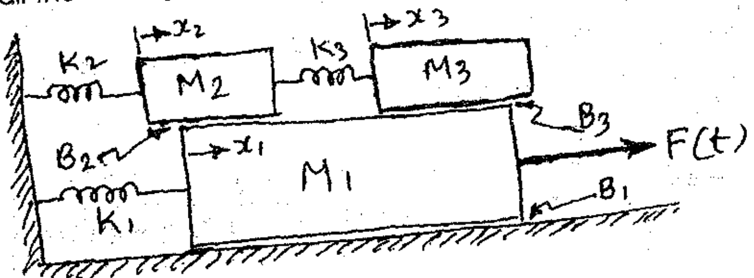


FIG. 1

2. **(a)** Define 'Transfer function' of a system
For a single loop unity feed back system the unit step response is given by

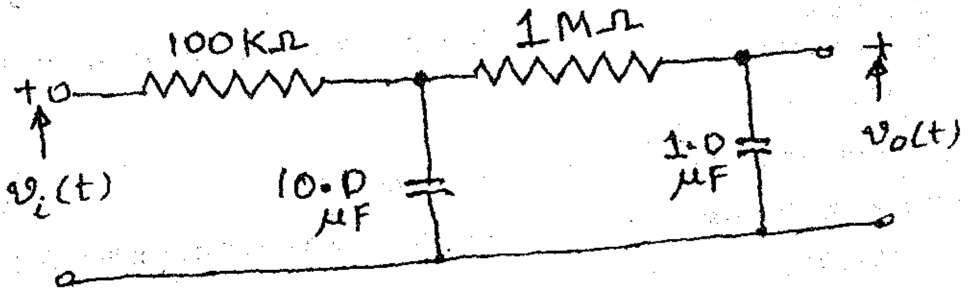
$c(t) = 1 - 3e^{-2t} + 2e^{-3t}$

Evaluate

i) Closed loop transfer function

ii) Open loop transfer function **(2+2+2 = 6 Marks)**

(b) For the electric circuit shown in Fig. 2 find $\frac{V_0(s)}{V_i(s)}$ using Mason's rule.



(6 Marks)

FIG. 2

(c) Obtain a block diagram representation and evaluate the transfer function of an armature controlled D-C motor. **(8 Marks)**

3. **(a)** With usual notations, derive an expression for the unit step-response of an under-damped second order system. Therefrom, derive expressions for peak time and percentage peak over shoot. **(6+4+2=12 Marks)**

   (b) Step response of a certain control system is shown in Fig. 3. Assuming single loop unity feed back, determine its open loop and closed loop transfer functions.

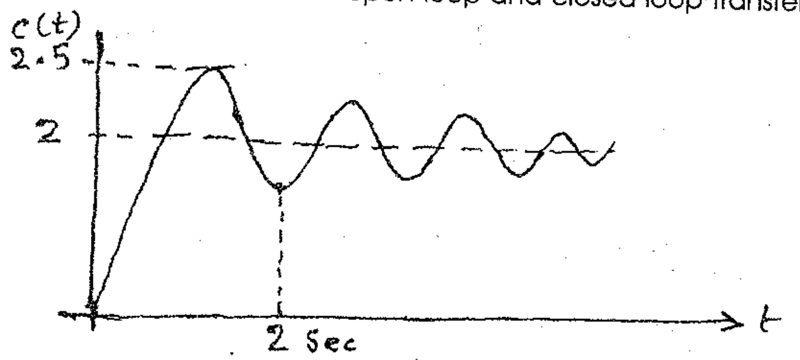


FIG. 3 **(8 Marks)**

4. **(a)** For the block diagram shown in fig. 4,

   i) What 'Type' of system does $\frac{C(s)}{E(s)}$ represent ?

   ii) Find $\frac{C(s)}{R(s)}$

   iii) Find the position, velocity and acceleration error constants

   iv) If $r(t) = 10u(t)$, evaluate C_{SS}

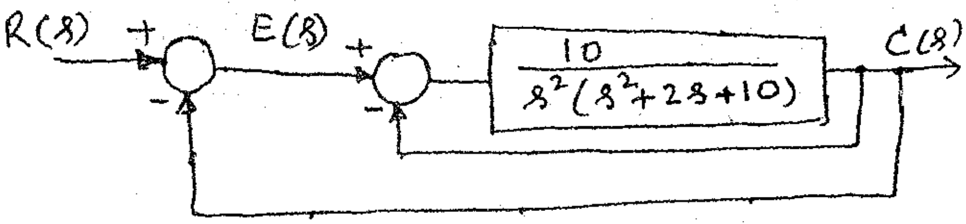


FIG. 4

(2+2+3+2=9 Marks)

   (b) The open loop transfer function of a unity feed back system is $G(s) = \frac{K(s+2)}{s(s+3)\ (s^2+5s+10)}$

   i) Find the value of K so that the steady state error for the input $r(t) = tu(t)$ is less than or equal to 0.01.

   ii) For the value of K found in part i), verify whether the closed loop system is stable or not, using R-H criterion. **(4+7 Marks)**

5. **(a)** Using angle criterion , prove that the complex part of the root loci for the loop transfer function

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

   is circular. What is the centre ? What is its radius ? **(6 Marks)**

   (b) Following all the 10 steps, draw the root locus diagram for the loop transfer function.

$$G(s)\ H(s) = \frac{K}{s(s^2+8s+17)}$$

   From the diagram evaluate the value of K for a system damping ratio of 0.5. **(14 Marks)**

6. **(a)** State and explain 'Nyquist stability criterion'. **(6 Marks)**

(b) Sketch the complete Nyquist diagram and find the range of K for closed loop stability for the loop transfer function **(8 Marks)**

$$G(s)\,H(s) = \frac{K}{s(s+1)\,(s+2)}$$

(c) Define the terms 'Gain Margin' and 'phase margin'. Explain how these can be determined from polar plots. **(6 Marks)**

7. **(a)** With usual notations, derive expressions for resonant peak and resonant frequency of a unity feed back second order system. **(3+4=7 Marks)**

(b) Find the open loop transfer function of a unity feed back second order control system for which resonant peak = 1.1 units and resonant frequency = $11.2 rad/sec$ **(6 Marks)**

(c) Compute analytically the gain margin and phase margin if **(3+4=7 Marks)**

$$GH(s) = \frac{200}{s(s^2+12s+100)}$$

8. **(a)** The open loop transfer function of a unity feed back system is

$$G(s) = \frac{K}{s(1+0.2s)\,(1+0.05s)}$$

Draw the bode asymptotic magnitude plot and phase plot. From the graph

i) Find gain limit

ii) Determine the value of K for a gain margin of 10dB. What is the corresponding phase margin.

iii) Determine the value of K for a phase margin of 40^0. What is the corresponding gain margin ? **(3+3+2+3+3=14 Marks)**

(b) Find the transfer function which has the asymptotic bode magnitude plot showing Fig. 5.

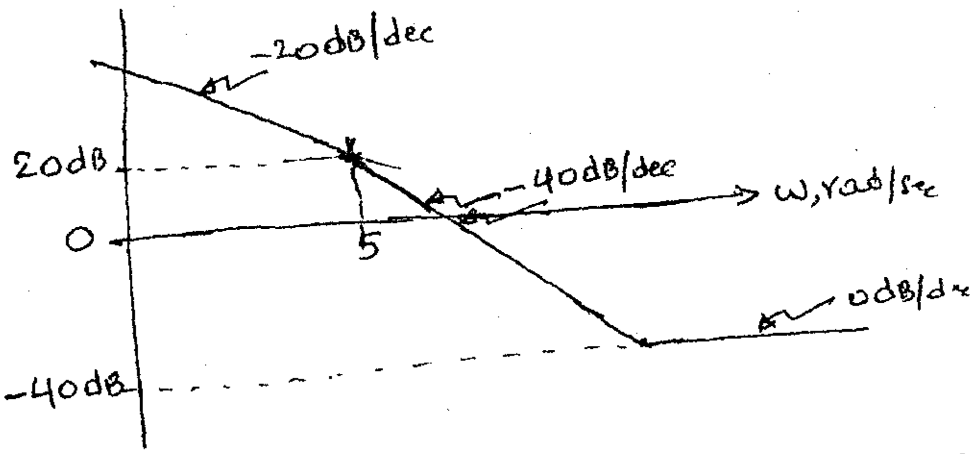


FIG. 5 **(6 Marks)**

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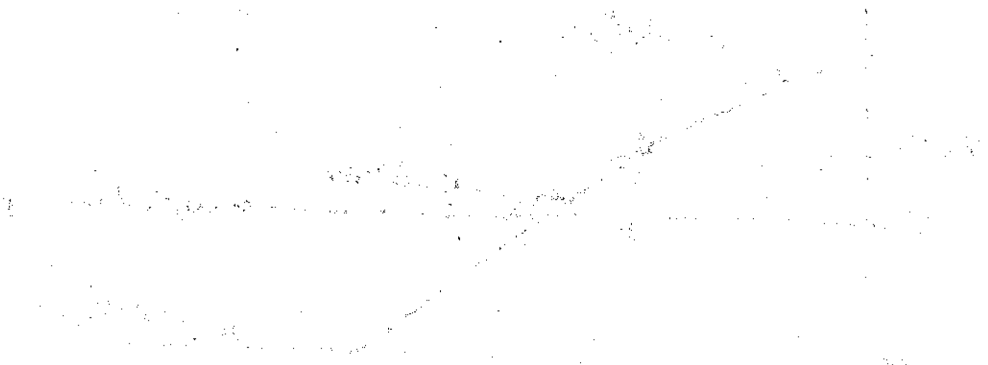

 EE43

USN | | | | | | | | | | |

NEW SCHEME

Fourth Semester B.E. Degree Examination, July 2006

EC / EE / IT / TC / BM / ML

Control Systems

Time: 3 hrs.] [Max. Marks:100

Note: 1. ***Answer any FIVE full questions.***

1 a. Explain the difference between open loop and closed loop control systems, with one example for each. **(06 Marks)**

b. For the mechanical system shown in figure Q1 (b),

i) Write the differential equations governing the dynamic behaviour of the system.

ii) Write an F-V analogous electric network. **(07 Marks)**

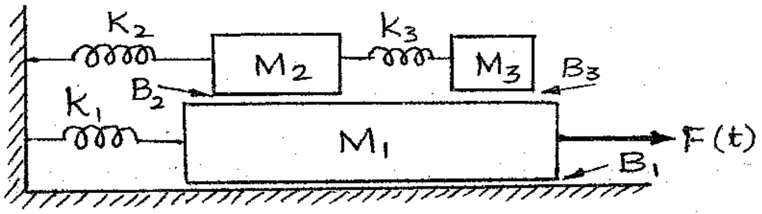

Fig. Q1 (b)

c. Draw a block diagram representation for the electric circuit shown in figure Q1 (c) and evaluate the transfer function $\frac{E_o(s)}{E_i(s)}$. **(07 Marks)**

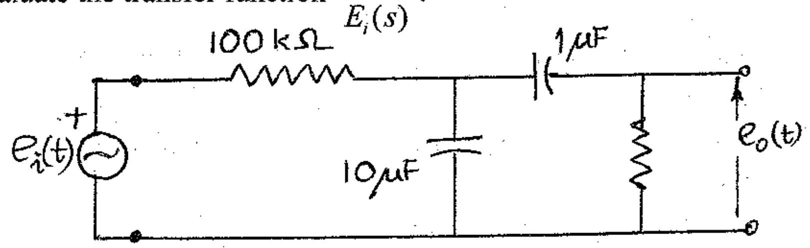

Fig. Q1 (c)

2 a. Define the term "transfer function". The unit step response of single loop, unity feed back control system is given by,

$$c(t) = 1 - 1.25e^{-2t} + 0.25e^{-10t}$$

Determine its closed loop and open loop transfer functions. **(08 Marks)**

b. Draw the signal flow graph for the block diagram shown in figure Q2 (b) and evaluate $\frac{C(s)}{R(s)}$, using Mason's formula. **(12 Marks)**

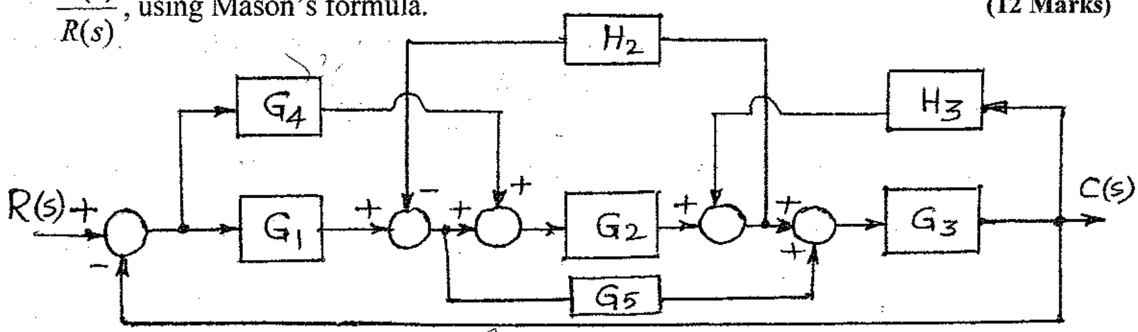

Fig Q2 (b)

Contd....2

3 a. For the system shown in figure Q3 (a),

i) Identify the 'Type' of $\frac{C(s)}{E(s)}$.

ii) Find the values of K_p, K_v and K_a

iii) If r(t) = 10 u(t), find the steady state value of the out put. **(07 Marks)**

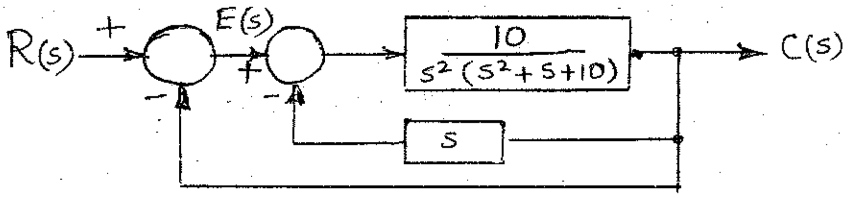

Fig Q3 (a)

b. Find the open loop transfer function of an equivalent prototype, single loop unity feed back system second order, whose step response is as shown in figure Q3 (b). **(06 Marks)**

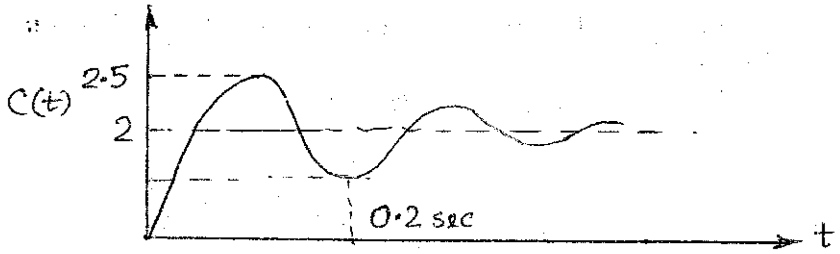

Fig Q3 (b)

c. The open loop transfer function of a unity feed back, single loop control system is given by,

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

i) Find the value of K so that the steady state error for a unit parabolic input is ≤ 0.1

ii) For the value of K found in part (i), verify whether the closed loop system is stable or otherwise. **(07 Marks)**

4 a. For the characteristic equations given below determine the number of roots with positive real part.

i) $s^6+s^5+3s^4+2s^3+5s^2+3s+1=0$

ii) $s^8+s^7+4s^6+3s^5+14s^4+11s^3+20s^2+9s+9=0$ **(10 Marks)**

b. The open loop transfer function of a single loop, unity feed back control system is given by,

$$G(s) = \frac{K(s+13)}{s(s+3)(s+7)}$$

i) Find the value of K for which the closed loop system is stable.

ii) Find the value of K for which the closed loop poles are more negative than – 1. **(10 Marks)**

5 a. For a single loop, unity feed back system, the open loop transfer function is given by,

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

Show that the complex part of the root locus is a circle. Identify its centre and radius. **(06 Marks)**

b. The characteristic equation of a single loop unity feed back control system is given by,

$$F(s) = s^3 + 8s^2 + 20s + k = 0$$

Sketch the complete root locus diagram and from that find,

i) Two values of K that make the system critically damped.

ii) Two values of K for which the damping ratio is 0.95.

iii) Write closed loop transfer functions for the values of K found in part (ii).

(14 Marks)

6 a. For the loop gain function given below, determine the value of K analytically, so that the gain margin is 12 dB.

$$GH(s) = \frac{K}{s(s^2 + 13s + 121)}$$

Further, for this value of K, find analytically (without plotting Bode plot), the phase margin. **(07 Marks)**

b. The open loop transfer function of a prototype single loop, unity feed back control system is given by,

$$G(s) = \frac{\omega_n^2}{s(s + 2\delta\omega_n)},$$

Show that the phase margin is given by,

$$P.M = \tan^{-1}\left\{2\delta\sqrt{2\delta^2 + \sqrt{1+(2\delta^2)^2}}\right\}$$ **(06 Marks)**

c. Suppose that $G(s)$ in part (b) is modified to read, $G(s) = \frac{K}{s(1+s\tau)}$

i) Determine the values of K and τ, so that Mr = 1.06 and $\omega_n = 12$ rad/sec.

ii) For the values of K and τ so found, evaluate the corresponding 3 dB bandwidth. **(07 Marks)**

7 a. Find the open loop transfer function of a single loop unity feed back system whose asymptotic Bode magnitude plot is as shown in figure Q7 (a). **(10 Marks)**

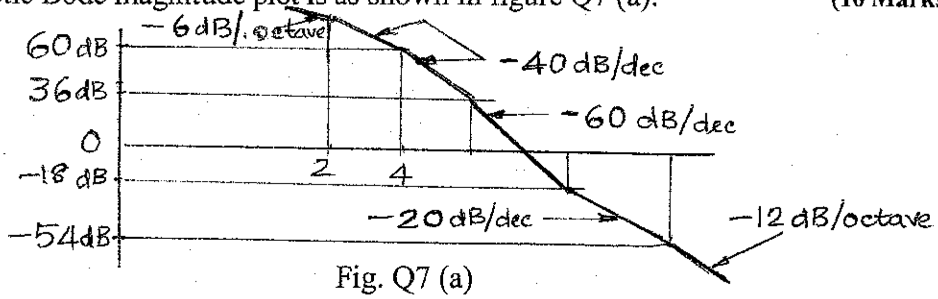

Fig. Q7 (a)

b. The open loop transfer function of a unity feed back single loop control system is given by,

$$G(s) = \frac{K}{s(1+0.02s)(1+0.05s)}$$

Draw the asymptotic Bode plots and hence find the value of K for which the gain margin is 10 dB. What is the corresponding phase margin? **(10 Marks)**

8 a. State and explain Nyquist stability criterion. **(06 Marks)**

b. The open loop transfer function of a single loop unity feed back system is given by,

$$G(s) = \frac{K(s+1)(s+3)}{s(s+2)(s-4)}$$

Draw the complete Nyquist diagram and there from find the range of K for which the system is absolutely stable. Verify your answer using R-H criterion. **(14 Marks)**

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USN

NEW SCHEME

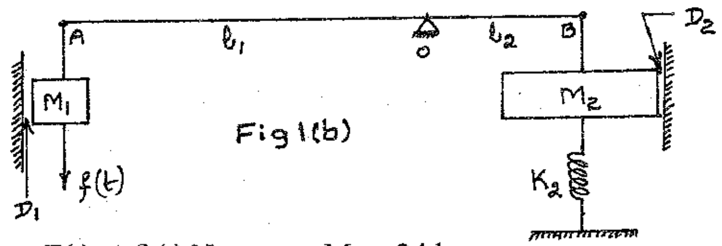
Fourth Semester B.E. Degree Examination, Dec. 06 / Jan. 07
Electrical and Electronics Engineering
Control Systems

Time: 3 hrs.] [Max. Marks:100

Note : *Answer any FIVE full questions.*

1 a. Explain the difference between open loop and closed loop control systems, with suitable examples. **(08 Marks)**

b. For the mechanical system shown in the fig1(b), draw the force-voltage analogous electrical system and determine the displacements as function of time at A & B; also draw approximately these displacements. The applied force is a unit impulse. **(12 Marks)**



$F(t) = \delta(t)$ N. $M_2 = 24$ kgms $l_1 = 100$ cms
$M_1 = 4$ kgms $D_2 = 60$ N / m / sec $l_2 = 25$ cms
$D_1 = 5$ N / m / sec $K_2 = 1.25$ cms / N (spring compliance)

2 a. For a negative feedback control system, starting from fundamentals, show that the closed loop transfer function M(s) is given by **(08 Marks)**

$$M(s) = {N_g D_h}/{(D_g D_h + N_g N_h)}, \text{ where } G(s) = {N_g}/{D_g} \; ; \; H(s) = {N_h}/{D_h}$$

b. The performance equations of a controlled system are given by the following set of linear algebraic equations. Draw the block diagram and determine $\frac{C(s)}{R(s)}$ by reducing the block diagram in steps.

$E_1(s) = R(s) - H_3(s)\,C(s)$
$E_2(s) = E_1(s) - H_1(s)\,E_4(s)$
$E_3(s) = G_1(s)\,E_2(s) - H_2(s)\,C(s)$
$E_4(s) = G_2(s)\;E_3(s)$
$C(s) = G_3(s)\;E_4(s)$ **(12 Marks)**

3 a. For the circuit shown in the Fig.3(a), write the performance equations considering the voltage and current variables as indicated, draw the corresponding signal flow graph and determine ${I_3(s)}/{V_1(s)}$ using Mason's Gain formula. **(14 Marks)**

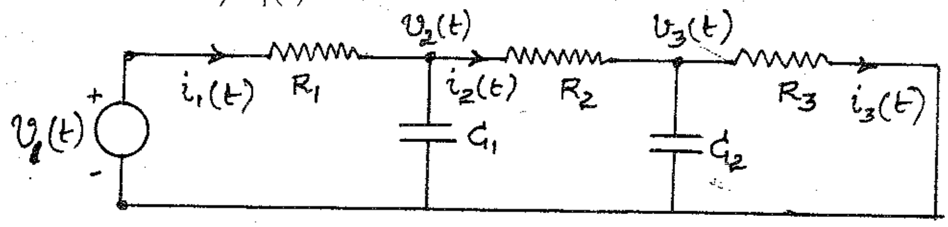


Fig.3(a)

Contd...2

$R_1 = 100k\Omega$; $R_2 = 50k\Omega$; $R_3 = 40k\Omega$; $C_1 = 10\mu F$; $C_2 = 5\mu F$

b. Briefly explain the following with examples :
   i) Part of signal flow graph not touching a forward path.
   ii) Mixed Node. **(06 Marks)**

4 a. What are impulse and step signals? How are they defined mathematically? What are their Lap lace Transformations? **(06 Marks)**
b. Starting from fundamentals, derive an expression for the step response of a typical under damped second order closed loop control system. Show the typical variation of the response and mark the settling time on a 5% tolerance basis. **(14 Marks)**

5 a. What are static error co-efficients? Derive expressions for the same. **(08 Marks)**
b. A negative feedback control system has

$$G(s) = \frac{K}{s(s^2+s+1)} \quad \text{and} \quad H(s) = \frac{1}{s+4}$$

Determine the range of k for the absolute stability of the system ; also determine the frequency of sustained self oscillations for the limiting value of k. **(12 Marks)**

6 a. State the rules for the construction of Root Loci of the characteristic equation of a feedback control system. **(06 Marks)**
b. For a negative feedback control system,

$$G(s) = {k}\Big/{s(s^2+4s+13)} \quad \text{and} \quad H(s) = \frac{1}{(s+4)}$$

Obtain the root locus for the root of the characteristic equation and plot the same using a scale of 1 unit of Real s = 2 cm and 1 unit of Imaginary s = 2 cm. **(14 Marks)**

7 a. For a closed loop control system, $G(s) = \frac{100}{s(s+8)}$, H (s) = 1. Determine the Resonant Peak and Resonant Frequency. **(06 Marks)**
b. A negative feedback control system has $G(s) = \frac{K}{(s+1)(s+4)}$ and $H(s) = \frac{1}{s}$

Obtain the complete Nyquist plot (G H Locus) and discuss the stability of the system (with respect to the variable parameter k). **(14 Marks)**

8 a. Show that for a unity feedback control system with $G(s) = {K}\Big/{s(s+a)(s+b)}$,

$G(jw_c) = \frac{-K}{ab(a+b)}$, where '$W_c$' is the phase cross over frequency. **(06 Marks)**

b. Given $G(s) = {80000}\Big/{s(s+2)(s+50)(s+200)}$ for a unity feedback control system, draw the Bode Plots and hence determine the Phase Margin and Gain Margin. **(14 Marks)**

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USN

NEW SCHEME

Fourth Semester B.E. Degree Examination, July 2007
EC / TE / EE / IT / ML / BM
Control Systems

Time: 3 hrs.] [Max. Marks:100

Note : ***Answer any FIVE full questions.***

1 a. Define a control system. Explain the difference between open loop and closed loop control systems with one example for each. **(08 Marks)**

b. For the mechanical system shown in fig.1(b), i) Draw the mechanical network ii) Write the differential equation of the system. **(12 Marks)**

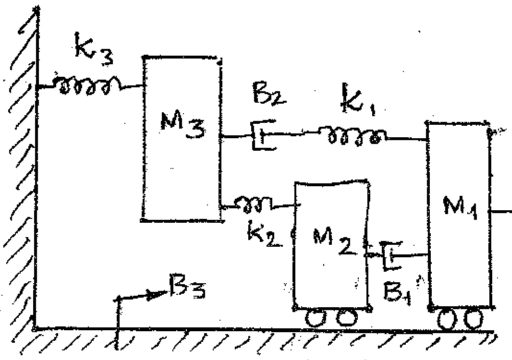

Fig.1(b)

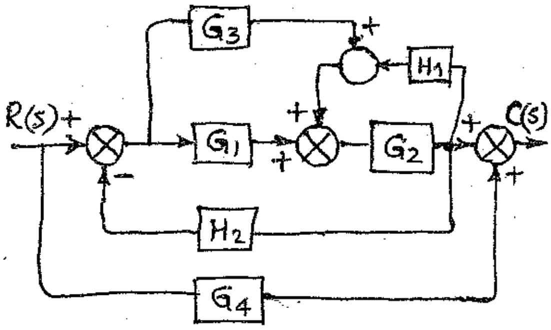

Fig.2(a)

2 a. Obtain $\frac{C(s)}{R(s)}$ of the system shown in fig.2(a) by using block diagram reduction method. **(08 Marks)**

b. Draw the signal flow graph for the system of equation given below and obtain the over all transfer function $\frac{X_6}{X_1}$ using MGF

$$X_2 = G_1X_1 - H_1X_2 - H_2X_3 - H_6X_6$$
$$X_3 = G_1X_1 + G_2X_2 - H_3X_3$$
$$X_4 = G_2X_2 + G_3X_3 - H_4X_5$$
$$X_5 = G_4X_4 - H_5X_6$$
$$X_6 = G_5X_5$$

(12 Marks)

3 a. For a spring mass damper system shown in fig.3(a), an experiment was conducted by applying a force of 2 Newtons to the mass. The response x(t) was recorded using an xy plotter and the experimental result is as shown in fig.3(a) below. Find the values of M, K and B. **(08 Marks)**

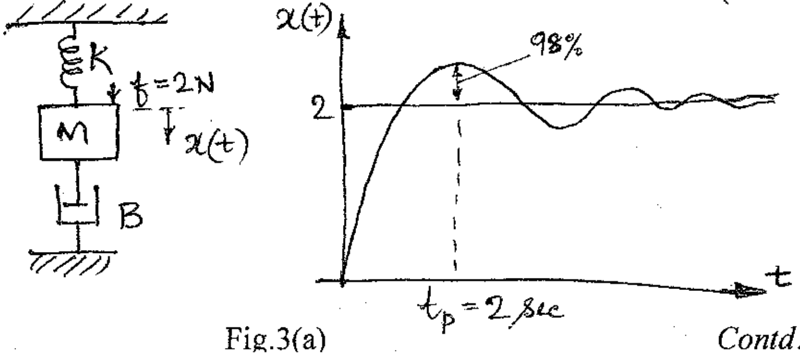

Fig.3(a)

b. Consider unity FBCS, whose OLTF is given by $G(s)=\frac{0.4s+1}{s(s+0.6)}$. Obtain the response to step input. For the same, calculate rise time, maximum peak overshoot, peak time and settling time. **(06 Marks)**

c. A unity FB system has $G(s)=\frac{K}{s(s+2)(s^2+2s+5)}$

i) For a unit ramp input, it is desired $e_{ss} \leq 0.2$, find K

ii) Determine e_{ss} if input $r(t)=2+4t+\frac{t^2}{2}$. **(06 Marks)**

4 a. Derive the condition on the impulse response so that the system is bounded input bound output (BIBO) stable. **(06 Marks)**

b. A unity FB system has $G(s)=\frac{K}{s(s+2)(s+4)(s+6)}$ using RH criteria; find the range of K for stability. Also find K_{max} and W_{max}. **(07 Marks)**

c. Determine the range of value of K (K>0) such that the characteristic equation is: $s^3+3(K+1)s^2+(7K+5)s+(4K+7)=0$ has roots more negative than S = -1. **(07 Marks)**

5 a. State the different rules for the construction of root locus. **(08 Marks)**

b. Sketch the root locus diagram of a control system having,

$$G(s)=\frac{K(s+1)}{s(s-1)(s^2+4s+16)}$$ **(12 Marks)**

6 a. State and explain Nyquist stability criterion. **(07 Marks)**

b. Sketch the Nyquist plot of a unity feedback control system having the open loop transfer function $G(s)=\frac{5}{s(1-s)}$. Determine the stability of the system using Nyquist stability criterion. **(13 Marks)**

7 a. The open loop transfer function of a unity FBCS is given by,

$$G(s)=\frac{K}{s(1+0.001s)(1+0.25s)(1+0.1s)}$$

Determine the value of K so that the system will have a phase margin of 40^0. What will be the gain margin then? Use Bode plot. **(14 Marks)**

b. With figure define the frequency domain specifications. **(06 Marks)**

8 a. Given $G(s)H(s)=\frac{12}{s(s+1)(s+2)}$. Draw the polar plot and hence determine if system is stable and its gain margin and phase margin. **(12 Marks)**

b. The OLTF of an unity FBCS is, $G(s)=\frac{K}{s(s+a)}$

i) Find the values of K and a so that m_r = resonant peak = 1.04 and w_r = resonant frequency = 11.55 rad/sec.

ii) For the values of K and a found in part (i), calculate the settling time and bandwidth of the system. **(08 Marks)**

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USN

EE43

Fourth Semester B.E. Degree Examination, Dec. 07 / Jan. 08

Control Systems

Time: 3 hrs. Max. Marks:100

Note : *1. Answer any FIVE full questions.*
2. Missing data, if any, may be suitably assumed.

1 a. Explain with examples open loop and closed loop control systems. List the merits and demerits of open loop and closed loop control systems. **(10 Marks)**

b. For the mechanical system shown in fig.1(b)
i) Draw the mechanical network ii) Write the differential equations describing the system
iii) Draw the F-V analogous electrical circuit after writing the corresponding electrical equations. **(10 Marks)**

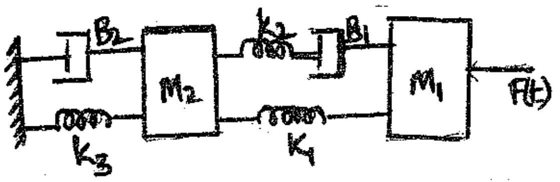

Fig.1(b)

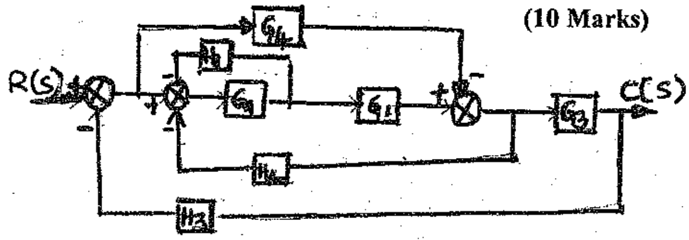

Fig.2(a)

2 a. For the system shown in fig.2(a), determine $C(s)/R(s)$ by block diagram reduction technique. **(10 Marks)**

b. For the signal flow graph shown in the fig.2(b), obtain transfer function Y_7/Y_1 and Y_7/Y_2. **(10 Marks)**

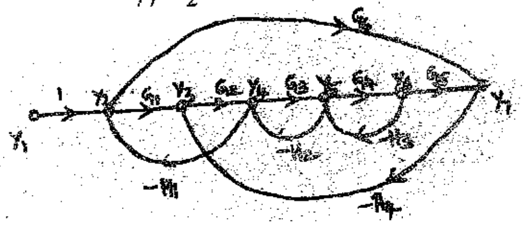

Fig.2(b)

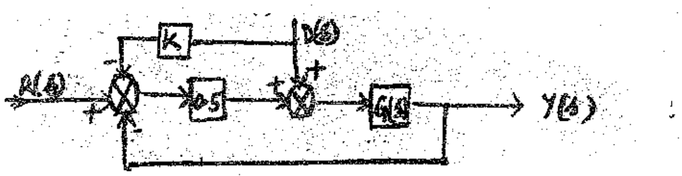

Fig.3(a)

3 a. The relation of the response Y(s) to the excitation R(s) in the presence of the undesired disturbance D(s) is represented by the fig.3(a). Determine K such that, with R(s) = 0, the output Y(s) = 0 for any disturbance D(s). **(06 Marks)**

b. It is desired that a control system with unity feed back, and forward path transfer function $G(s)=\frac{(s+\alpha)}{s^3+(1+\alpha)s^2+(\alpha-1)s+1-\alpha}$ be stable and the steady state error for a unit step input be less than or equal to 0.05. Determine the range of α that meets both requirements. **(06 Marks)**

c. Define the term transfer function. The unit step response of single loop, UFBCS is given by $C(t)=1-1.25e^{-2t}+0.25e^{-10t}$. Determine its closed loop and open loop transfer function. **(08 Marks)**

4 a. What are static error coefficients? Derive expressions for the same. **(06 Marks)**

b. Explain the following time domain specifications of a second order system:
i) Maximum overshoot ii) Peak time iii) Delay time iv) Rise time v) Settling time. **(06 Marks)**

c. For a servomechanism system with $G(s)=\frac{K_1}{s^2}$ and $H(s)=1+K_2 s$, determine the value of K_1 and K_2 so that the peak overshoot to a unit step response is 0.25 and peak time is 2 seconds. **(08 Marks)**

5 a. Show that the root loci for UFBCS, $G(s)=\frac{K(s+2)(s+3)}{s(s+1)}$ is a circle. **(06 Marks)**

b. Draw the root locus diagram for the loop transfer function $G(s)H(s)=\frac{K}{s(s^2+8s+17)}$. From the root locus evaluate the value of 'K' for a system damping ratio of 0.5. **(14 Marks)**

6 a. The polynomial $F(s)=s^4+2s^3+3s^2+s+1$ has all its roots in left hand side of a 's' plane. Use R-H criterion to determine the number of roots of F(s) lying between s = -0.5 and s = -1. **(10 Marks)**

b. State Routh-Hurwitz stability criterion. The system shown in fig.6(b) oscillates at a frequency of 2 radians/sec. Using R-H criterion determine the values of 'K' and 'a'. **(10 Marks)**

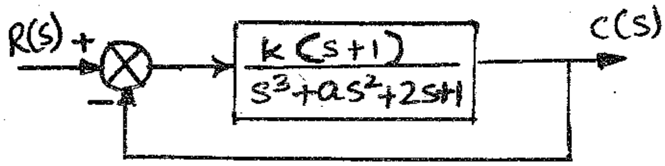

Fig.6(b)

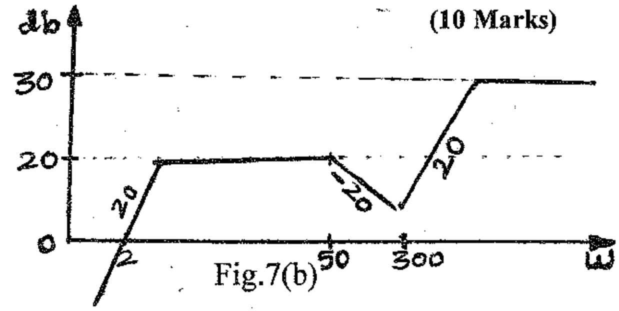

Fig.7(b)

7 a. The open loop transfer function of a unity feed back control system is given by $G(s)=\frac{K}{s(1+0.02s)(1+0.05s)}$. Draw the asymptotic Bode plots and hence find the value of 'K' for which the gain margin is 10 dB. What is the corresponding phase margin? **(12 Marks)**

b. Estimate the transfer function from the Bode plot shown in fig.7(b). Digits on line indicate slope in dB/dec. **(08 Marks)**

8 a. For a feedback system with $G(s)=\frac{120}{s(s+1)(s+5)}$, $H(s)=\frac{s}{6}$, determine peak resonance and resonance frequency. Derive the expressions used. **(10 Marks)**

b. Fig.8(b)(i) and Fig.8(b)(ii) represent Nyquist plots drawn for $\omega = 0$ to $\omega = \infty$ for two different G(s)H(s). Neither of these have poles on RH plane. For each case i) Complete the plot for 'ω' values on negative imaginary axis and $\omega = 0_+$ to $\omega = 0_-$. ii) Indicate the type of G(s)H(s) iii) Is the system stable? If not determine the number of zeros 1 + G(s)H(s) on RH of 's' plane. **(10 Marks)**

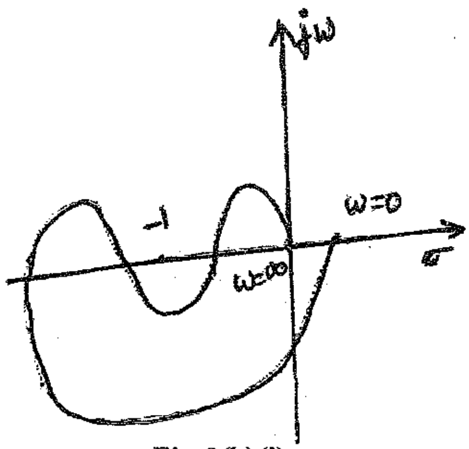

Fig.8(b)(i)

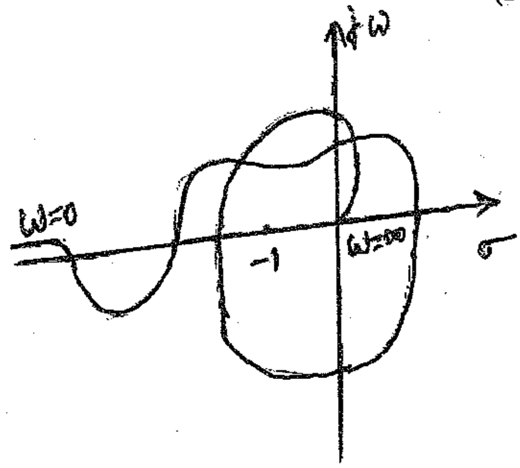

Fig.8(b)(ii)

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USN

06ES43

Fourth Semester B.E. Degree Examination, Dec 08 / Jan 09

Control Systems

Time: 3 hrs. Max. Marks:100

Note : ***Answer FIVE full questions, selecting atleast TWO questions from each part.***

PART - A

1 a. Distinguish between open loop and closed loop control system. Describe two examples for each. **(10 Marks)**

b. Write the differential equations for the mechanical system shown in fig. 1(b) and obtain f – v and f – I analogous electrical circuits. **(10 Marks)**

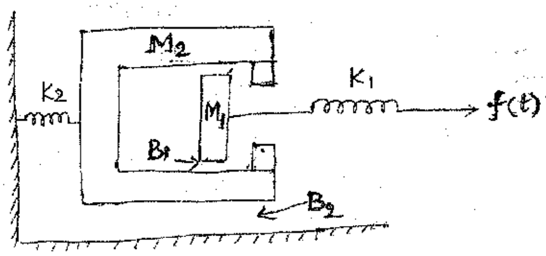


Fig. 1(b)

2 a. Draw a block diagram for the bridge circuit shown in fig.2(a), where vi and io are the input and output variables respectively. Also determine $\frac{I_o(s)}{V_i(s)}$ by block diagram reduction technique. **(12 Marks)**

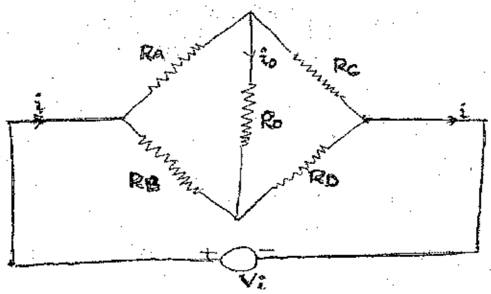


Fig. 2(a)

b. For the system represented by the following equation, find the transfer function $\frac{X(S)}{U(S)}$ by signal flow graph.

$x = x_1 + \alpha_3 U$; $\dot{x}_1 = -\beta_1 x_1 + x_2 + \alpha_2 U$; $\dot{x}_2 = -\beta_2 x_1 + \alpha_1 U$ **(08 Marks)**

3 a. Considering the response of a second order system to a unit step input, derive the following : i) Peak time (t_p) ii) Rise time (t_r) iii) Maximum overshoot (M_p). **(08 Marks)**

b. Assuming the time constant T of the controller to be 3 sec and the ratio of the torque to inertia K/J to be 3 rad^2/sec^2, find the damping ratio, rise time, peak time and maximum overshoot (M_p) of the system shown in fig 3(b). **(06 Marks)**

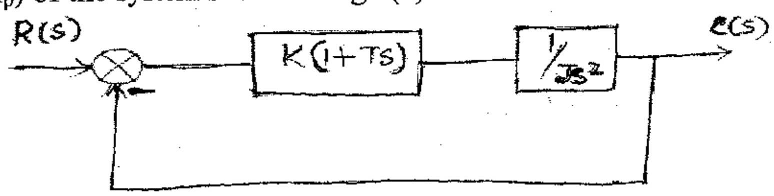


Fig.3(b)

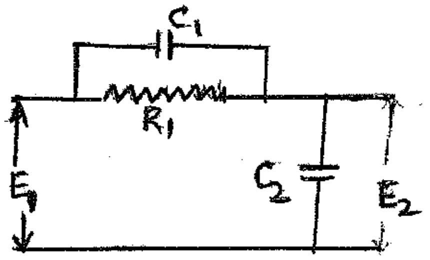
c. For a unity feedback system given by $G(s)=\dfrac{20(S+2)}{S(S+3)(S+4)}$

i) Find the static error constant

ii) Find the steady state error for r(t) = 3 u(t) + 5(t) u(t). **(06 Marks)**

4 a. What are the difficulties encountered while assessing the R-H criteria and how do you eliminate these difficulties, explain with examples. **(06 Marks)**

b. The open loop transfer function of a unity feedback control system is given by $G(S)=\dfrac{50}{S(1+0.05S)(1+0.2S)}$. Apply R-H criteria. Show that the system is unstable. Confirm that the introduction of the two terminal pair network connected in cascade with G(S) makes the system stable. **(08 Marks)**



$C_1 = 0.5\mu F$

$C_2 = 10\mu F$

$R_1 = 1M\Omega$.

c. Ascertain the stability of the system given by the characteristic equation $S^6 + 3S^5 + 5S^4 + 9S^3 + 8S^2 + 6S + 4 = 0$. **(06 Marks)**

PART - B

5 a. State the different rules for the construction of root locus. **(08 Marks)**

b. Sketch the root locus for the system $G(S)\ H(S)=\dfrac{K}{S(S+1)(S+2)(S+3)}$ **(12 Marks)**

6 a. State and explain Nyquist stability criterion. **(08 Marks)**

b. Draw the complete Nyquist plot of the system whose loop transfer function is given by $G(S)=\dfrac{50}{S(1+0.1S)(1+0.2S)}$ and hence determine whether system is stable or not. **(12 Marks)**

7 a. Explain the correlation between time and frequency response. **(08 Marks)**

b. The open loop transfer function of a unity feedback system is $G(S)=\dfrac{1}{S(1+0.5S)(1+0.1S)}$.

Find gain and phase margin. If a phase-lag element with transfer function of $\left(\dfrac{1+2S}{1+5S}\right)$ is added in the forward path find by how much the gain must be changed to keep the margin same. **(12 Marks)**

8 a. Define state transition matrix and list the properties of the state transition matrix. **(08 Marks)**

b. The state equation of a certain system is $\dot{x} = Ax$, where A is a 2×2 constant matrix.

If $x(0)=\begin{bmatrix}1\\-3\end{bmatrix}$ then $\overline{x}(t)=\begin{bmatrix}e^{-3t}\\-3e^{-3t}\end{bmatrix}$ and if $\overline{x}(0)=\begin{bmatrix}1\\1\end{bmatrix}$ then $\overline{x}(t)=\begin{bmatrix}e^{t}\\e^{t}\end{bmatrix}$

Determine the state transition matrix for the system and the system matrix A. **(12 Marks)**

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USN

06ES43

Fourth Semester B.E. Degree Examination, June-July 2009
Control Systems

Time: 3 hrs. Max. Marks:100

Note:1. ***Answer any FIVE full questions, choosing at least two questions from each.***
2. ***Missing data may be suitably assumed.***

Part–A

1 a. Mention the merits and demerits of open loop and closed loop control systems and give an example for each. **(06 Marks)**

b. For the mechanical system shown in figure Q1 (b), obtain the force-voltage analogous network. **(08 Marks)**

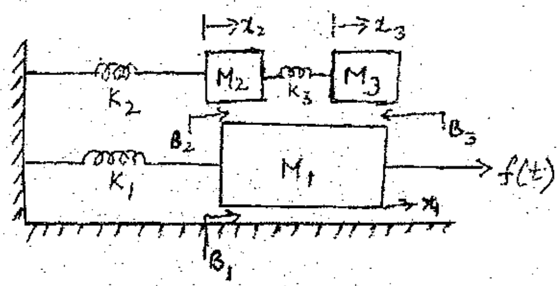

Fig. Q1 (b)

c. Obtain the transfer function of an armature controlled dc servomotor. **(06 Marks)**

2 a. Explain briefly the following terms:
i) Forward path. ii) Path gain. iii) Loop gain. iv) Canonical form. **(08 Marks)**

b. Obtain the C/R ratio for the block diagram shown using block-diagram reduction technique. **(06 Marks)**

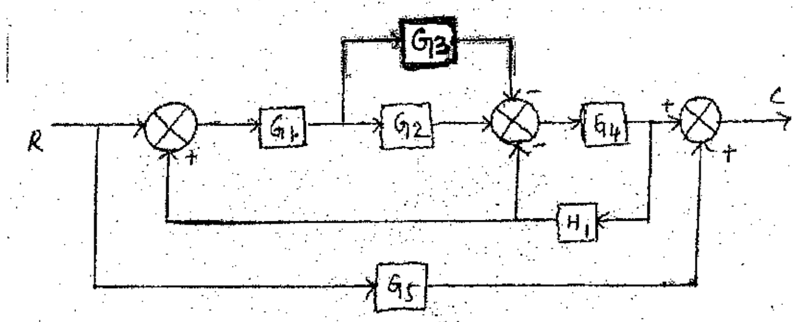

Fig. Q2 (b)

c. Find $\frac{C(s)}{R(s)}$ by Mason's gain formula (Fig. Q2 (c)). **(06 Marks)**

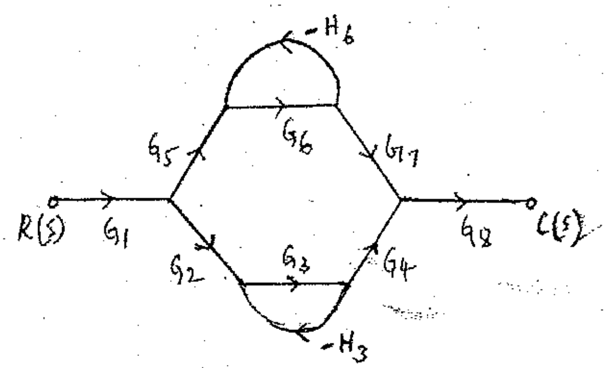

Fig. Q2 (c)

3 a. Derive an expression for the under damped response of a second order feed back control system for step input. **(06 Marks)**

b. Obtain expressions for rise-time and peak-time for a second-order feed back system response for a step input (under-damped case). **(06 Marks)**

c. A positional servomechanism is characterized by an open loop transfer function $G(s)=\frac{k}{s(s+\alpha)}$, where k and α are positive constants, for a unity feedback. Find the values of k and α for a damping coefficient value of 0.6 and damped frequency of 8 rad/sec. Also find the peak value of the response when the system is excited by a step of 2 volts. **(08 Marks)**

4 a. Find K_P, K_V and K_a for the system whose open loop transfer function is given by,

$$G(s)H(s)=\frac{10(s+2)(s+3)}{s(s+1)(s+5)(s+4)}.$$

Also find the steady-state error for an input $r(t)=3+t+t^2$. **(08 Marks)**

b. Explain Routh-Hurwitz 's' criterion for determining the stability of a system and mention by limitations. **(04 Marks)**

c. A unity feedback control system has:

$$G(s)=\frac{k(s+13)}{s(s+3)(s+7)}$$

Using the Routh's criterion, calculate the range of 'k' for which the system is

i) Stable

ii) Has its closed loop poles more negative than -1. **(08 Marks)**

Part–B

5 a. Explain briefly the following terms with respect to root-locus technique:

i) Centroid.

ii) Asymptote.

iii) Break away point. **(06 Marks)**

b. Sketch the root locus plot for a closed loop system having an open-loop transfer function: $G(s)H(s)=\frac{k(s+2)}{s(s+1)}$ for all values of k from 0 to ∞. Comment on the stability of the system. **(08 Marks)**

c. Show that a part of the root-locus for the open loop transfer function: $G(s)H(s)=\frac{k(s+2)}{s(s+1)}$ is a circle. **(06 Marks)**

6 a. The open loop transfer function of a negative feedback control system is:

$$GH(s)=\frac{1}{s(s+1)(s+\frac{1}{2})}$$

Sketch the polar plot and hence find the following:

i) Phase cross-over frequency.

ii) Gain cross-over frequency.

iii) Gain-margin.

iv) Phase-margin. **(10 Marks)**

b. Explain in detail the procedural steps of Nyquist stability criterion. **(04 Marks)**

c. A feed back control system has loop transfer function: $GH(s)=\frac{1}{s(s+1)}$.

Sketch the Nyquist plot and comment on the stability of a system. **(06 Marks)**

7 a. Derive expressions for resonant peak and resonant frequency for a second order system. **(06 Marks)**

b. Find the open-loop transfer function for a unity feed back second order control system for which resonant peak is 1.1 units and resonant frequency is 11.2 radians/sec. **(06 Marks)**

c. Sketch the Bode-plot for the transfer function: $G(s)=\frac{Ks^2}{(1+0.2s)(1+0.02s)}$

Determine the value of 'k' for the gain cross over frequency to be 5 rad/sec. **(08 Marks)**

8 a. Compare transfer function approach and state variable approach of analyzing control system. **(04 Marks)**

b. A feed back system is characterized by the closed loop transfer function:

$$GH(s)=\frac{s^2+3s+3}{s^3+2s^2+3s+1}.$$

Obtain its state model. **(08 Marks)**

c. State the properties of state transition matrix. Obtain the state transition matrix for:

$$A=\begin{bmatrix} 0 & -1 \\ 2 & -3 \end{bmatrix}$$ **(08 Marks)**

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