DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

EE 2253: CONTROL SYSTEMS

1. SYSTEMS AND THEIR REPRESENTATION 9

Basic elements in control systems – Open and closed loop systems – Electrical analogy of mechanical and thermal systems – Transfer function – Synchros – AC and DC servomotors – Block diagram reduction techniques – Signal flow graphs.

2. TIME RESPONSE 9

Time response – Time domain specifications – Types of test input – I and II order system response – Error coefficients – Generalized error series – Steady state error – P, PI, PID modes of feed back control.

3. FREQUENCY RESPONSE 9

Frequency response – Bode plot – Polar plot – Determination of closed loop response from open loop response – Correlation between frequency domain and time domain specifications.

4. STABILITY OF CONTROL SYSTE 9

Characteristics equation – Location of roots in S plane for stability – Routh Hurwitz criterion – Root locus construction – Effect of pole, zero addition – Gain margin and phase margin – Nyquist stability criterion.

5. COMPENSATOR DESIGN 9

Performance criteria – Lag, lead and lag-lead networks – Compensator design using bode plots.

L = 45 T = 15 Total = 60

TEXT BOOKS

1. I.J. Nagrath and M. Gopal, 'Control Systems Engineering', New Age International Publishers, 2003.

2. Benjamin C. Kuo, Automatic Control systems, Pearson Education, New Delhi, 2003.

REFERENCE BOOKS

1. K. Ogata, 'Modern Control Engineering', 4th edition, PHI, New Delhi, 2002.

2. Norman S. Nise, Control Systems Engineering, 4th Edition, John Wiley, New Delhi, 2007.

3. Samarajit Ghosh, Control systems, Pearson Education, New Delhi, 2004

4. M. Gopal, 'Control Systems, Principles and Design', Tata McGraw Hill, New Delhi, 2002.

EE 2253 CONTROL SYSTEMS

Two Marks Questions

1.What is frequency response?

A frequency response is the steady state response of a system when the input to the system is a sinusoidal signal.

2.List out the different frequency domain specifications?

The frequency domain specification are

i)Resonant peak. ii)Resonant frequency.

3.Define –resonant Peak (ir)?

The maximum value of the magnitude of closed loop transfer function is Called resonant peak.

4.Define –Resonant frequency(if)?

The frequency at which resonant peak occurs is called resonant frequency.

5.What is bandwidth?

The bandwidth is the range of frequencies for which the system gain Is more than 3 dbB.The bandwidth is a measure of the ability of a feedback system to reproduce the input signal ,noise rejection characteristics and rise time.

6.Define Cut-off rate?

The slope of the log-magnitude curve near the cut-off is called cut-off rate. The cut-off rate indicates the ability to distinguish the signal from noise.

7.Define –Gain Margin?

The gain margin,kg is defined as the reciprocal of the magnitude of the open loop transfer function at phase cross over frequency.

Gain margin kg = 1 / | G(jw pc) |.

8.Define Phase cross over?

The frequency at which, the phase of open loop transfer functions is called phase cross over frequency w pc.

9.What is phase margin?

The phase margin ,g is the amount of phase lag at the gain cross over Frequency required to bring system to the verge of instability.

11.Define Gain cross over?

The gain cross over frequency w gc is the frequency at which the magnitude of the open loop transfer function is unity..

12.What is Bode plot?

The Bode plot is the frequency response plot of the transfer function of a system. A Bode plot consists of two graphs. One is the plot of magnitude of sinusoidal transfer function versus log w.The other is a plot of the phase angle of a sinusoidal function versus log w.

13.What are the main advantages of Bode plot?

The main advantages are:

i) Multiplication of magnitude can be in to addition.

ii) A simple method for sketching an approximate log curve is available.

iii) It is based on asymptotic approximation. Such approximation is sufficient if rough information on the frequency response characteristic is needed.

iv) The phase angle curves can be easily drawn if a template for the phase angle curve of 1+ jw is available.

14.Define Corner frequency?

The frequency at which the two asymptotic meet in a magnitude plot is calledcorner frequency.

15.Define Phase lag and phase lead?

A negative phase angle is called phase lag.

A positive phase angle is called phase lead.

16.What are M circles?

The magnitude of closed loop transfer function with unit feed back can be shown to be in the for every value if M.These circles are called M circles.

17.What is Nichols chart?

The chart consisting if M & N loci in the log magnitude versus phase diagram is called Nichols chart.

18.What are two contours of Nichols chart?

Nichols chart of M and N contours, superimposed on ordinary graph. The M contours are the magnitude of closed loop system in decibels and the N contours are the phase angle locus of closed loop system.

19.How is the Resonant Peak(Mr), resonant frequency(Wr) , and band Width determined from Nichols chart?

i) The resonant peak is given by the value of ì.contour which is tangent to G(jw) locus.

ii) The resonant frequency is given by the frequency of G(jw) at the tangency point.

iii) The bandwidth is given by frequency corresponding to the intersection point of G(jw) and –3dB M-contour.

20What are the advantages of Nichols chart?

The advantages are:

i) It is used to find the closed loop frequency response from open loop frequency response.

ii) Frequency domain specifications can be determined from Nichols chart.

iii) The gain of the system can be adjusted to satisfy the given specification.

21.What are the two types of compensation?

i. Cascade or series compensation

ii. Feedback compensation or parallel compensation

22.What are the three types of compensators?

i. Lag compensator

ii. Lead compensator

iii. Lag-Lead compensator

23.What are the uses of lead compensator?

- **speeds up the transient response**
- **increases the margin of stability of a system**
- **increases the system error constant to a limited extent.**

24.What is the use of lag compensator?

***Improve the steady state behavior of a system, while nearly preserving its transient response.**

25.When is lag lead compensator is required?

The lag lead compensator is required when both the transient and steady state response of a system has to be improved

26.What is a compensator?

A device inserted into the system for the purpose of satisfying the specifications is called as a compensator.

26.What is nyquist contour

The contour that encloses entire right half of S plane is called nyquist contour.

27.State Nyquist stability criterion.

If the Nyquist plot of the open loop transfer function G(s) corresponding to the nyquist control in the S-plane encircles the critical point –1+j0 in the counter clockwise direction as many times as the number of right half S-plane poles of G(s),the closed loop system is stable.

28.Define Relative stability

Relative stability is the degree of closeness of the system,it an indication of strength or degree of stability.

29.What are the two segments of Nyquist contour?

i. An finite line segment C1 along the imaginary axis.

ii. An arc C2 of infinite radius.

30.What are root loci?

The path taken by the roots of the open loop transfer function when the loop gain is varied from 0 to _ are called root loci.

31.What is a dominant pole?

The dominant pole is a air of complex conjugate pair which decides the transient response of the system.

32.What are the main significances of root locus?

i. The main root locus technique is used for stability analysis.

ii. Using root locus technique the range of values of K, for as table system can be determined

33.What are the effect of adding a zero to a system?

Adding a zero to a system increases peak overshoot appreciably.

34.What are N circles?

If the phase of closed loop transfer function with unity feedback is _, then tan _ will be in the form of circles for every value of _. These circles are called N circles.

35.What is control system?

A system consists of a number of components connected together to perform a specific function . In a system when the output quantity is controlled by varying the input quantity then the system is called control system.

36.What are the two major types of control system?

the two major types of control system are open loop and closed loop

37.Define open loop control system.

The control system in which the output quantity has no effect upon the input quantity are called open loop control system. This means that the output is not feedback to the input for correction.

38.Define closed loop control system.

The control system in which the output has an effect upon the input quantity so as to maintain the desired output value are called closed loop control system.

39.What are the components of feedback control system?

the components of feedback control system are plant , feedback path elements, error detector and controller.

40.Define transfer function.

The T.F of a system is defined as the ratio of the laplace transform of output to laplace transform of input with zero initial conditions.

41.What are the basic elements used for modeling mechanical translational system.

Mass, spring and dashpot

42.What are the basic elements used for modeling mechanical rotational system?

Moment of inertia J,fdashpo with rotational frictional coefficient B and torsional spring with stiffness K

43.Name two types of electrical analogous for mechanical system.

The two types of analogies for the mechanical system are Force voltage and force current analogy

44.What is block diagram?

A block diagram of a system is a pictorial representation of the functions performed by each component of the system and shows the flow of signals. The basic elements of block diagram are blocks, branch point and summing point.

45.What is the basis for framing the rules of block diagram reduction technique?

The rules for block diagram reduction technique are framed such that any modification made on the diagram does not alter the input output relation.

46.What is a signal flow graph?

A signal flow graph is a diagram that represents a set of simultaneous algebraic equations .By taking L.T the time domain differential equations governing a control system can be transferred to a set of algebraic equations in s-domain.

47. What is transmittance?

The transmittance is the gain acquired by the signal when it travels from one node to another node in signal flow graph.

48.What is sink and source?

Source is the input node in the signal flow graph and it has only outgoing branches. Sink is a output node in the signal flow graph and it has only incoming branches.

49.Define non touching loop.

The loops are said to be non touching if they do not have common nodes.

50.Write Masons Gain formula.

Masons Gain formula states that the overall gain of the system is

T = 1/ __k Pk _k k-o.of forward paths in the signal flow graph.

Pk- Forward path gain of kth forward path _ = 1-[sum of individual loop gains] +[sum of gain products of all possible combinations of two non touching loops]-[sum of gain products of all possible combinations of three non touching loops]+…_k - _ for that part of the graph which is not touching kth forward path.

51.Write the analogous electrical elements in force voltage analogy for the elements of mechanical translational system.

Force-voltage e,

Velocity v-current I ,
Displacement x-charge q,
Frictional coeff B-Resistance R
Mass M- Inductance L
Stiffness K-Inverse of capacitance 1/C

52.Write the analogous electrical elements in force current analogy for the elements of mechanical translational system.

Force-current i
Velocity v-voltage v
Displacement x-flux_
Frictional coeff B-conductance 1/R
Mass M- capacitance C
Stiffness K-Inverse of inductance 1/L

53.Write the force balance equation of an ideal mass element .

F = M d2x /dt2

54. Write the force balance equation of ideal dashpot element .

F = B dx /dt

55. Write the force balance equation of ideal spring element .

F = Kx

56.Distinguish between open loop and closed loop system Open loop Closed loop

1.Innaccurate
2.Simple and economical
3.The changes in output due to external disturbance are not corrected
Accurate
Complex and costlier
The changes in output due to external disturbances are corrected automatically

4.They are generally stable

Great efforts are needed to design a stable system

57.What is servomechanism?

The servomechanism is a feedback control system in which th output is Mechanical position (or time derivatives of position velocity and acceleration,)

58.Why is negative feedback invariably preferred in closed loop system?

The negative feedback results in better stability in steady state and rejects Any disturbance signals.

59.What is transient response?

The transient response is the response of the system when the system changes from one state to another.

60.What is steady state response?

The steady state response is the response of the system when it approaches infinity.

61.What is an order of a system?

The order of asystem is the order of the differential equation governing the system.The order of the system can be obtained from the transfer function of the given system.

62.Define Damping ratio.

Damping ratio is defined as the ratio of actual damping to critical damping.

63.List the time domain specifications.

The time domain specifications are

i.Delay time

ii.Rise time

iii.Peak time

iv.Peak overshoot

64.Define Delay time.

The time taken for response to reach 50% of final value for the very first time is delay time.

65.Define Rise time.

The time taken for response to raise from 0% to 100% for the very first time is rise time.

66.Define peak time.

The time taken for the response to reach the peak value for the first time is peak time.

67.Define peak overshoot.

Peak overshoot is defined as the ratio of maximum peak value measured from the Maxmium value to final value

68.Define Settling time.

Settling time is defined as the time taken by the response to reach and stay within specified error

69.What is the need for a controller?

The controller is provided to modify the error signal for better control Action

70.What are the different types of controllers?

Proportional controller

PI controller

PD controller

PID controller

71.What is proportional controller?

It is device that produces a control signal which is proportional to the input error signal.

72.What is PI controller?

It is device that produces a control signal consisting of two terms –one proportional to error signal and the other proportional to the integral of error signal.

72. What is PD controller?

PD controller is a proportional plus derivative controller which produces an output signal consisting of two time -one proportional to error signal and other proportional to the derivative of the signal.

73 What is the significance of integral controller and derivative controller in aPID controller?

The proportional controller stabilizes the gain but produces a steady state error.

The integral control reduces or eliminates the steady state error.

74.Why derivative controller is not used in control systems?

The derivative controller produces a control action based on the rate of change of error signal and it does not produce corrective measures for any constant error.

75.Define Steady state error.

The steady state error is defined as the value of error as time tends to infinity.

76.What is the drawback of static coefficients?

The main draw back of static coefficient is that it does not show the variation of error with time and input should be standard input.

77. What is step signal?

The step signal is a signal whose value changes from zero to A at t= 0 and remains constant at A for t>0.

78. What is ramp signal?

The ramp signal is a signal whose value increases linearly with time from an initial value of zero at t=0.the ramp signal resembles a constant velocity.

79.What is a parabolic signal?

The parabolic signal is a signal whose value varies as a square of time from an initial value of zero at t=0.This parabolic signal represents constant acceleration input to the signal.

80.What are the three constants associated with a steady state error?

Positional error constant
Velocity error constant
Acceleration error constant

81.What are the main advantages of generalized error co-efficients?

i) Steady state is function of time.
ii) Steady state can be determined from any type of input

82. What are the effects of adding a zero to a system?

Adding a zero to a system results in pronounced early peak to system response thereby the peak overshoot increases appreciably.

83. State-Magnitude criterion.

The magnitude criterion states that s=sa will be a point on root locus if for that value of s , | D(s) | = |G(s)H(s) | =1

84.State – Angle criterion.

The Angle criterion states that s=sa will be a point on root locus for that value of s, , _D(s) = _G(s)H(s) =odd multiple of 180°

85. What is a dominant pole?

The dominant pole is a pair of complex conjugate pair which decides the transient response of the system.

86.What is stepper motor?

A stepper motor is a device which transforms electrical pulses into equal increments of rotary shaft motion called steps.

87.What is servomotor?

The motors used in automatic control systems or in servomechanism are called servomotors. They are used to convert electrical signal into angular motion.

88.Name the test signals used in control system

the commonly used test input signals in control system are impulse step ramp acceleration and sinusoidal signals.

89.Define BIBO stability.

A linear relaxed system is said to have BIBIO stability if every bounded input results in a bounded output.

90.What is the necessary condition for stability.

The necessary condition for stability is that all the coefficients of the characteristic polynomial be positive.

91.What is the necessary and sufficient condition for stability.

The necessary and sufficient condition for stability is that all of the elements in the first column of the routh array should be positive.

92.What is quadrantal symmetry?

The symmetry of roots with respect to both real and imaginary axis called quadrantal symmetry.

93.What is limitedly stable system?

For a bounded input signal if the output has constant amplitude oscilllations Then the system may be stable or unstable under some limited constraints such a system is called limitedly stable system.

94.What is synchros?

A synchros is a device used to convert an angular motion to an electrical signal or viceversa.

95.What is steady state error?

The steady state error is the value of error signal e(t) when t tends to infinity.

96.What are static error constants.

The Kp Kv and Ka are called static error constants.

97.What is the disadvantage in proportional controller?

The disadvantage in proportional controller is that it produces a constant steady state error.

98.What is the effect of PD controller on system performance?

The effect of PD controller is to increase the damping ratio of the system and so the peak overshoot is reduced.

99.Why derivative controller is not used in control system?

The derivative controller produces a control action based on rare of change of error signal and it does not produce corrective measures for any constant error. Hence derivative controller is not used in control system

100.What is the effect of PI controller on the system performance?

The PI controller increases the order of the system by one, which results in reducing the steady state error .But the system becomes less stable than the original system.

Sixteen Marks Questions

1. For a given mechanical or electrical or electromechanical system derive the transfer function.

- **. Free body diagram**
- **. Differential equation**
- **. Transfer function**

2.Determination of the overall transfer function using Block diagram reduction technique.

- **. Reduction of block diagram**
- **. Determination of Transfer function**

3. Determination of the overall transfer function from the given signal flow graph using Mason's gain formula.

- **. Reduction of signal flow graph**
- **. Apply masons gain formula**

4.Write the procedure for constructing the block diagram of a given mechanical or electrical or electromechanical system.

- **. Write the differential equation**
- **. Develop block diagram**

5.Find the electrical analogical variables of a mechanical rotational system.

- **. Write the differential equation**
- **. Draw the equivalent electrical network**

6.Derive the expressions of the time domain specifications for a second order system with unit step input.

- **. Time response of second order system**
- **. Rise time**
- **. Peak time**
- **. Peak overshoot**
- **. Settling time**

7.Find the time response of a first order system for various standard inputs.

- **. Apply the input**
- **. Solve using partial differential equation**
- **. Apply inverse Laplace transform**

3. Find the time response of a second order system for unit step input.

- **. Apply the input**
- **. Solve using partial differential equation**
- **. Apply inverse Laplace transform**

8.Problems using static error coefficients or generalized error coefficients.

- **. Find the error coefficient**
- **. Apply in formula**

9.Explain the working of Synchro transmitter and receiver.

- **. Diagram**
- **. Working principle**

10.Write the rules for constructing the root locus.

- **. Locate poles & Zeros**
- **. Find centroid & asymptotes**

. Find Break away or Break in points
. Find crossing point in imaginary axis

11.Problems using root locus technique.
. Locate poles & Zeros
. Find centroid & asymptotes
. Find Break away or Break in points
. Find crossing point in imaginary axis

12.Stability analysis using Routh's criterion.
. Construct routh arry
. Check the first column for stability

13.Derive the expression for the frequency domain specifications of a second order system.
. Gain Margin
. Phase margin
. Gain cross over frequency
. Phase crossover frequency

14.Given the open loop transfer function G(s)H(s)=1/s(s+1)(2s+1) of a unity feedback system. Find the gain margin and phase margin using polar plot.
. Ans: gain margin =1.42db
. phase margin =12o
. Find croner frequency
. Calculate gain & phase for various Values of w
. Sketch the plot

15.Write the step by step procedure for plotting the magnitude plot and phase plot of a open loop system represented by the transfer function G(s).
. Find croner frequency
. Calculate gain & phase for various Values of w
. Sketch the plot

16.Obtain the resonant peak, resonant frequency, band width,gain margin, phase margin of the system represented by the open loop transfer function G(j_)=10/ j_(1+0.1 j_)(1+0.05 j_).
. Solve by using Nicholas chart.
. resonant peak =5 db
. resonant frequency =8 rad/sec
. band width=12 rad/sec
. gain margin=8.5 db
. phase margin=30o

17.Given the open loop transfer function a system with unity feed back,G(s)H(s)=K/s(s+2)(s+10).Determine the range of K for which closed loop system is stable.
. Nyquist stability criterion.
. $0<K<240$.

18.Write the procedure for designing the lead compensator.
. Find the value of K
. Find the phase margin of uncompensated system
. Find the new phase margin

. Find new gain cross over frequency
. Calculate B & T
. Find Gc(S)
. Find Go(s)
. Verify Phase margin

19.Write the procedure for designing the lag compensator.

. Find the value of K
. Find the phase margin of uncompensated system
. Find the new phase margin & gain cross over frequency
. Calculate _ & T
. Find Gc(S)
. Find Go(s)
. Verify Phase margin

20.Write the procedure for designing the lag-lead compensator.

. Find the value of K
. Find the phase margin of uncompensated system
. Find the new phase margin
. Find new gain cross over frequency
. Calculate B, _ , T1 & T2
. Find Gc(S)
. Find Go(s)
. Verify Phase margin

21.Design Problems

22.Write how will you select a suitable compensator for the given system.

. Ref book ,"Advanced Control Theory" by Nagoor Kani, Unit I

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DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

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3. M.N. Bandyopadhyay, 'Control Engineering Theory and Practice', Prentice Hall of India, 2003.

UNIT - 1: SYSTEMS AND THEIR REPRESENTATION

PART-A

1. **State & explain the principle of superposition?**
2. **State the properties of linear system?**
3. **What is a time invariant system? (Nov/Dec 2004)**
4. **Explain the principle of homogeneity.**
5. **What are the power dissipating elements in a mechanical system?**
6. **What are the energy storing elements in electrical system?**
7. **Define servomechanism?**
8. **Define transfer function? (Nov/Dec 2004) (April/May 2005)**
9. **What is open loop T. F.?**
10. **Define node.**
11. **Define a branch.**
12. **Define input node or source.**
13. **Define output node or sink.**
14. **Define a path.**
15. **What is forward path and loop?**
16. **Define forward path gain.**
17. **What is a loop gain?**
18. **Define overall gain of the system.**
19. **Give the Mason's gain formula.**
20. **The open loop system gain increases by 20%. Calculate the value of the change in the closed loop gain assuming unity feedback. (April/May 2003)**

21. Name three functional components used in control system. Describe the role played each of them. (April/May 2003)
22. What is an error detector? (April/May 2005)

UNIT - 2: TIME RESPONSE

PART-A

1. Define delay time? (Nov/Dec 2004)
2. What is a step signal?
3. What is a ramp signal?
4. What is impulse signal?
5. What is rise time? (Nov/Dec 2004)
6. What is peak time?
7. What is peak overshoot? (April/May 2003)
8. What is setting time? (April/May 2003) (Nov/Dec 2004) (April/May 2005)
9. What is steady state error?
10. Write the two Evans conditions.
11. What are the various static error constants? How are they related to the steady state role error? (April/May 2003)
12. What are the units K_p, K_v & K_a? (Nov/Dec 2004)

UNIT - 3: FREQUENCY RESPONSE

PART-A

1. Define damping ratio? (April/May 2004)
2. What are the frequency domain specifications?

3. **Define resonance peak ?**
4. **Define resonance frequency.**
5. **Define the gain cross over ?**
6. **Define delay time?**
7. **What is frequency response?**
8. **What is resonant frequency?**
9. **What is Bandwidth?**
10. **What is polar plot?**
11. **What is corner frequency? (April/May 2005)**
12. **What is Bode plot?**
13. **What is decade?**
14. **What is octave?**
15. **What is minimum phase transfer function?**
16. **What is all pass systems?**
17. **What is non minimum phase transfer function? (Nov/Dec 2004)**
18. **Define gain and phase margin. (April/May 2003)**
19. **State the stability requirements in time domain & frequency domain. (April/May 2003)**
20. **What is the correlation that exists between frequency response and transient response methods? (April/May 2004)**
21. **For the following transfer function sketch the Bode magnitude plot. G(s) = 40 (s+1)/(5s+1)(s2+2s+4) (April/May 2004)**

22. In terms of bode plot, define stability. (April/May 2005)

UNIT - 4: STABILITY OF CONTROL SYSTEM

PART-A

1. What is cut off rate and what it indicates?
2. Explain the principles of Nyquist stability?
3. The higher the phase margin the better is the stability. True/False?
4. What is asymptotic stability?
5. What is stability?
6. What is the necessary and sufficient condition for a system to be stable?
7. What is Nyquist criterion?
8. What is Nyquist contour? (April/May 2005)
9. When is closed loop system stable?
10. What is BIBO?
11. What is a relaxed system?
12. What is characteristics equation?
13. The characteristic equation of a system is s2-5s+2=0 state whether the system stable or not?
14. What is a break away point?
15. Relative stability: Explain.
16. What is the phase angle criterion in the root locus technique? (April/May 2003)
17. What is the effect of adding a pole to a second order system? (April/May 2004)

18.What is root locus? (Nov/Dec 2004)

UNIT - 5: COMPENSATOR DESIGN

PART-A

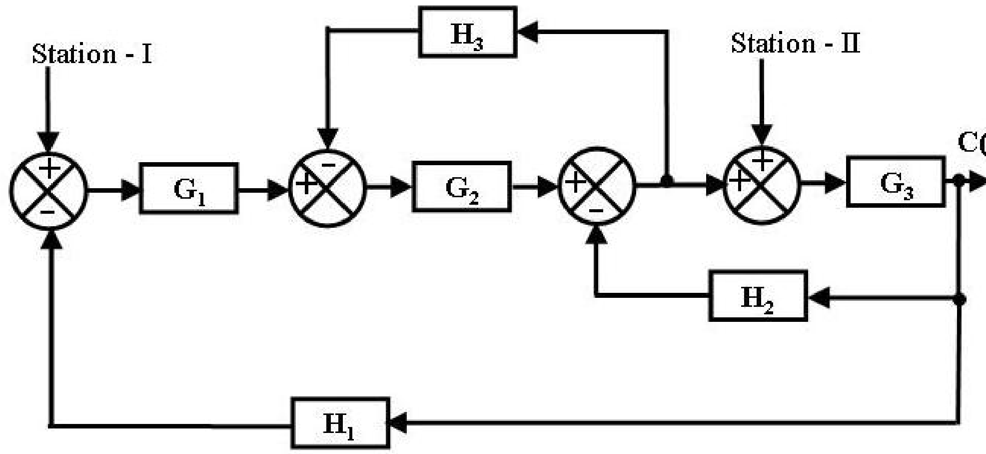
1. **What are compensators?**
2. **What is series compensation?**
3. **What is parallel compensation?**
4. **What is lead compensator? (April/May 2003) (April/May 2005)**
5. **What is lag compensator? (April/May 2003)**
6. **What is the use of lead compensators?**
7. **What is the use of lag compensator?**
8. **When is lag and lead compensators used?**
9. **What is a lag – lead compensator? (April/May 2005)**
10. **What is feedback compensation?**
11. **What is the need of a compensator to be introduced in a system? (April/May 2004)**

UNIT - 1: SYSTEMS AND THEIR REPRESENTATION

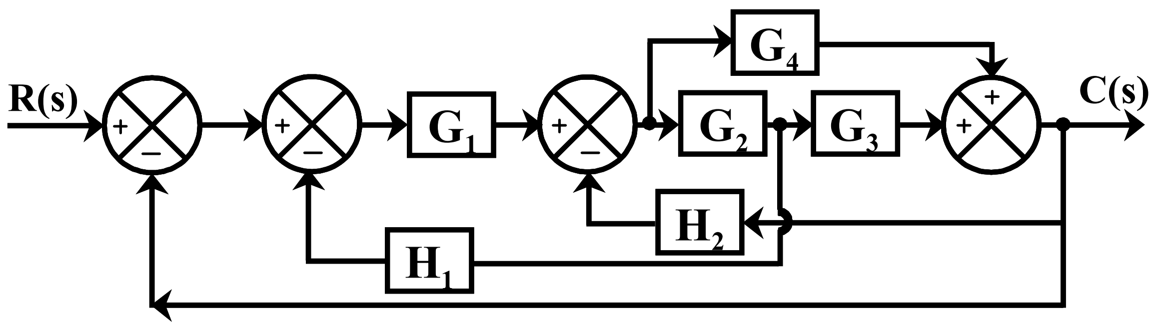
PART-B

1. **a)Reduce the block diagram given below to find the closed loop Transfer function by reduction method when the I/P R is at station-II**

b) Reduce the block diagram given above to find the closed loop Transfer function by signal flow graph when the I/P R is at station-I



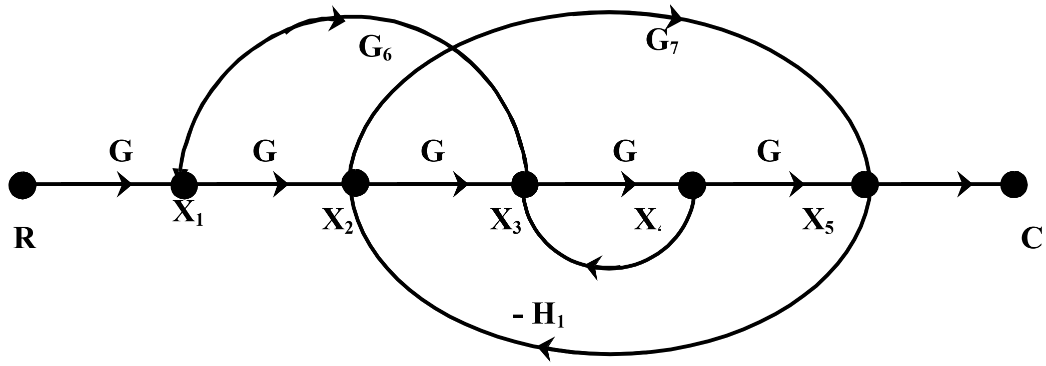
2. Explain thermal and hydraulic control systems.
3. Determine the transfer function of the given block diagram by block diagram reduction or signal flow graph.



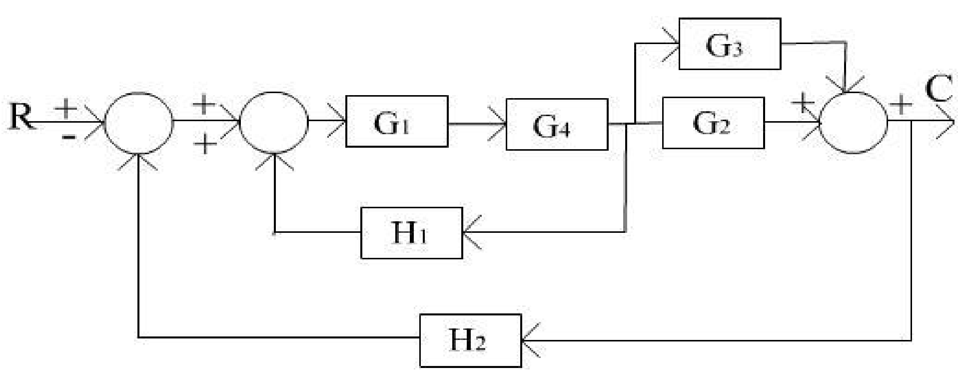
4. Construct a block diagram for armature controlled and field controlled DC Motor.
5. a) Find the order of a series RLC network using Transfer Function Model.

   b) Explain the state variable model using a simple mechanical network.
6. Describe the constructional features of synchro & discuss how it can be used as an error detector?

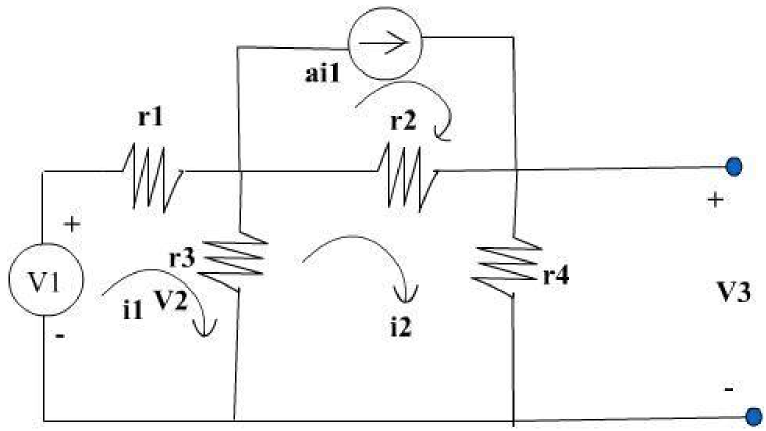
7. Explain the transfer function of an armature controlled DC motor.
8. Explain the transfer function of field controlled DC motor.
9. Explain the operation of AC servomotor.
10. Explain the operation of DC servomotor.
11. Find the transfer of the system whose SFG is drawn in the figure. (April/May 2003)



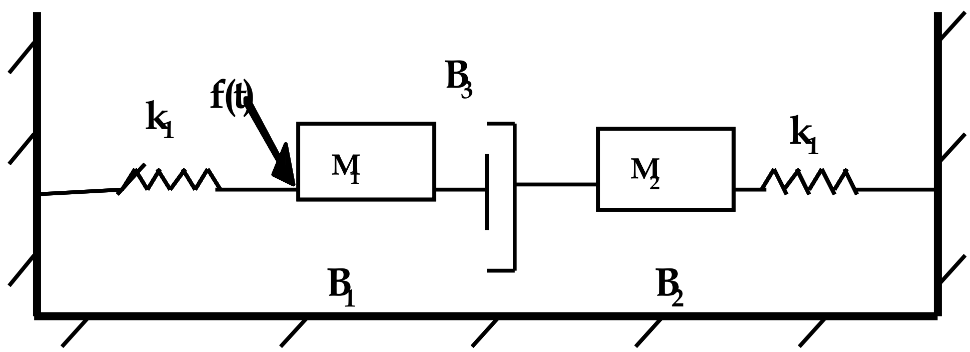
12. Determine the transfer function C(s) /R(s) of the system (April/May 2004)



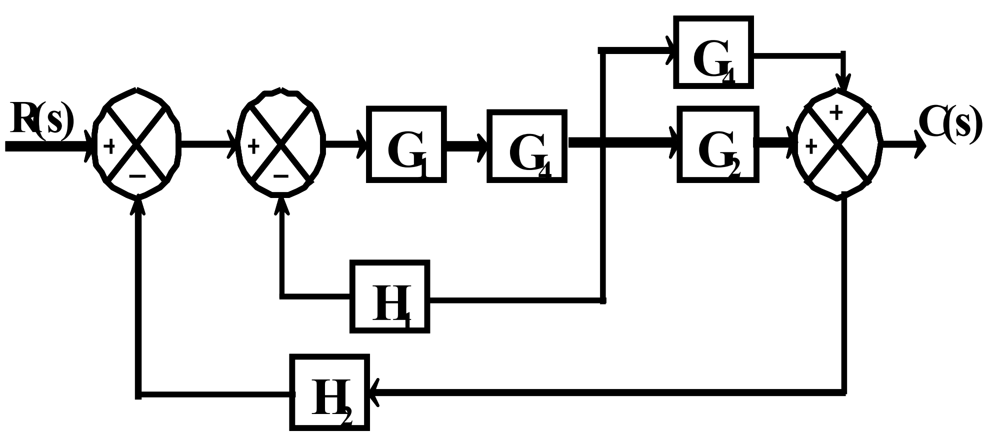
13. Draw the signal flow graph of the electrical network shown in fig 2.Also find V_3/V_1 . (April/May 2004)



14. State and explain Mason's gain formula. (April/May 2005)
15. Derive the transfer function of Dc servomotor under field control. (April/May 2005)
16. Write the equations for the mechanical system. (April/May 2005)



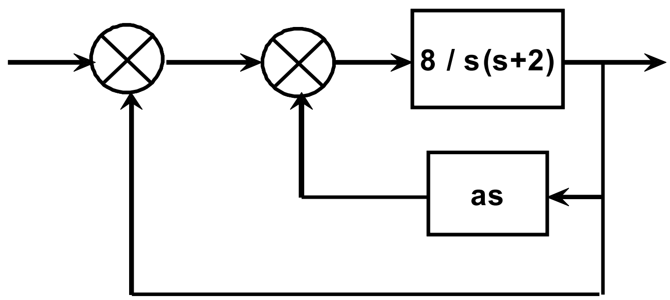
17. Simplify the block diagram and obtain the closed loop transfer function. (Nov/Dec 2004)



UNIT - 2: TIME RESPONSE

PART-B

1. **The system given below unity feedback control system In the absence of derivative feedback, determine the damping factor and natural frequency. Also determine the steady state error for a unit ramp input**



2. **A unity feedback control system has an amplifier signal with gain K_A = 10 and the gain ratio, G(s) = 1 /[s(s+2)] in the feed forward path. A derivative feedback H(s) = sK_o is introduced as a minor loop around G(s). Determine the derivative feedback constant K_o , damping ratio is 0.6**
3. **The open loop transfer function of a servo system with unity feedback is G(s) = 10/[s(0.1s+1)]. Evaluate the static error constants of the system. Obtain the steady state error of the system if the input r(t) = $a_0 + a_1t + a_2t^2/2$**
4. **For a unity feedback system control system the open loop transfer function G(s) = 10(s+2)/ [s^2(s+1)]. Find the steady state error using generalized error coefficients.**
5. **A unity feedback control system is characterized by the following open loop transfer function**

$G(s) = (0.4s+1)/ [s(s+0.6)]$. Determine the transient response for unit step input and draw the response. Evaluate the maximum overshoot, rise time, peak time and settling time for 5% and 2% tolerance.

6. Explain the PI – controller using OPAMP.
7. Explain the PID – controller using OPAMP.
8. Explain the PD – controller using OPAMP.
9. For a unity feedback system control system the open loop transfer function $G(s) = 10(s+2)/ [s^2(s+1)]$. Find the steady state error using generalized error coefficients when the input is $3/s - 2/s^2 + 1/3s^3$.
10. A unity feed back system has an open loop transfer function $G(s) = 25 / [s(s+8)]$. Determine the damping ratio, peak overshoot and time required to reach the peak output. Now a proportional component having a gain of 302 is introduced in the system. (April/May 2003)
11. The response of a system subject to a unit step input is $c(t) = 1+0.2e^{-60t}-1.2e^{-10t}$ (April/May 2003)
12. A Unity feedback system is characterized by the open loop transfer function $G(s) = 1/s(0.5s+1)(0.2s+1)$.Determine the steady state errors for unit- step ,unit ramp and unit acceleration input .Also determine the damping ratio and natural frequency of the dominant roots. (April/May 2004)
13. For a second order system whose open loop transfer function $G(s) = 4/s(s+2)$. Determine the maximum over

shoot ,the time to reach the maximum over-shoot when a step displacement of 18° is given to the system. Find the rise time and the setting time for an error of 7 % .What is the time constant of the system? (April/May 2004)

14. **Define the time domain specifications for a second order system. Derive an expression for time to peak and peak overshoot for a system order under damped system. (April/May 2004)**
15. **The loop transfer function of a system G(s)H(s) = 40/[s(02s+1)]. Obtain its generalized error constants. Also find its steady state error when the input is r(t) = (3+4t)t. (April/May 2004)**
16. **Determine the values of K and a of the closed loop system, so that the maximum overshoot in unit step response is 25% and peak time is 2 seconds. Assume that J = 1kg-m^3. (Nov/Dec 2004)**

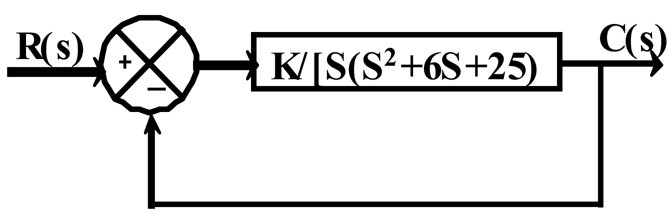
UNIT - 3: FREQUENCY RESPONSE

PART-B

1. **Explain Constant M and Constant N circles.**

2. Sketch the Bode Plot for the following transfer function and determine the system's gain K for the gain cross over frequency to be 5 rad/sec $G(s) = Ks^2 / [(1+0.2s)(1+0.02s)]$
3. Consider the unity feedback system having an open loop transfer function $G(s) = K/[s(1+0.2s)(1+0.05s)]$. Sketch the polar plot and determine the value of K so that (i) Gain margin is 18db (ii)Phase Margin is 60°.
4. The open loop transfer function of an unity feedback system is $G(s) = Ke^{-0.2s}/[s(1+0.25s)(1+0.1s)]$. Using Nicholas Chart, determine the phase margin and gain margin when K=1. Also find the value of K if the gain margin of the system is 4db.
5. Sketch the bode plot for the following transfer function & find the gain & phase margin. $G(s) = 20 / [s (1+3s) (1+4s)]$
6. The open loop transfer function of unity feedback system is $G(s) = K / [s (1+0.5s) (1+4s)]$. Using polar plot, determine the phase and gain margin. Also determine value of K so that the gain margin is 20 db.
7. Sketch the bode plot for the following transfer function & find the gain & phase cross over frequencies. $G(s) = 10 / [s (1+0.4s) (1+0.1s)]$
8. The open loop transfer function of unity feedback system is $G(s) = K e^{-0.2s}/ [s (1+0.25s) (1+0.1s)]$. Using Nichols Chart, determine the phase and gain margin. Also determine value of K so that the gain margin is 4 db.

9. Sketch the Nyquist plot for the following transfer function of a control system G(s) = K/[(s+2)(s+6)] for a system gain K=60. (April/May 2003)
10. Explain the use of M & N circles for the study of stability of the system. (April/May 2003)
11. What are constant M and N circles and where they are used? (April/May 2004)
12. Draw the polar plot for the transfer function G(s) = 10 (s+2)/ s(s+1)(s+3). (April/May 2004)
13. Explain how phase margin and gain margin are determined from polar and bode plots. (April/May 2004)
14. Derive the unit step and unit ramp response of first order system and plot their responses. (Nov/Dec 2004)
15. For the following open loop system transfer function sketch the Bode magnitude and phase plot for G(s)H(S) = 10(s+50) /[s(s+5) (Nov/Dec 2004)
16. Draw the bode plot for a system whose open loop transfer function is G(s)H(s) = 8(1+jw/2)/[jw(1+j2w)(1+jw/8)] (April/May 2004)
17. Sketch the root loci of the control system. (Nov/Dec 2004)



UNIT - 4: STABILITY OF CONTROL SYSTEM

PART-B

1. A unity feedback control system has an open loop transfer function $G(s) = K / [s (s^2+4s+13)]$. Sketch the root locus.
2. Determine the range of values of K such that the chars equation $S^3 + 3 S^2 (K+1) + S (7K+5) + (4K+7) = 0$ has roots more negative than s = -1.
3. Find the stability for the system $s^6+2s^5+8s^4+12s^3+20s^2+16s+16 = 0$. Also determine the number roots lying on the right half, left half of s-plane and on the imaginary axis
4. Find the roots of the following polynomial by use of the root locus method → $3s^4 +10s^3+21s^2+24s+30=0$
5. The open loop transfer function of a unity feedback control system is given by $G(s) = K / (s+2)(s+4)(s^2+6s+25)$. By applying the Routh Criterion discuss the stability of the closed loop system as a function of K. Determine the values of K which will cause sustained oscillations in the closed loop system. What are the corresponding oscillation frequencies?
6. Find the roots of the characteristics equations for the systems whose open loop transfer functions are given below. Locate the roots in the s-plane and indicate the stability of each system.

   a) $G(s) H(s) = 1 / (s+2)(s+4)$

b) $G(s) H(s) = (s+3) / s(s+3)(s+8)$

7. Determine the range of values of K (K>0) such that the char eqn: $s^3+3(k+1)s^2+(7k+5)s+(4k+7) = 0$ has roots more negative than s=-1.
8. By Routh Stability Criterion, determine the stability of the system represented by the characteristics equation $9s^5-20s^4+10s^3-s^2-9s-10 = 0$. Comment on the location of roots of the characteristics equation.
9. Determine the stability of the given system $s^4+8s^3+18s^2+16s+5 = 0$. Also determine the number roots and where they lie on the s – plane.
10. Find the stability of the system $s^7+9s^6+24s^5+24s^4+24s^3+24s^2+23s+15 = 0$. Also determine the number of roots lying on the right half, left half of s-plane and on the imaginary axis.
11. Determine the stability of the given system $s^4+8s^3+18s^2+16s+5 = 0$. Also determine the number of roots and where they lie on the s - plane.
12. For the system given by the characteristics polynomial $s^6+4s^5+17s^4+56s^3+667s^2+2500s+1875$. Obtain the root distribution and comment on its stability. (April/May 2003)
13. By applying Nyquist stability criterion, find the value of K for which the system is just stable. $G(s) = K (s+2)/ (s+1)(s-1)$ & $H(s) =1$. (April/May 2004)

14. **Consider the characteristic polynomial T(s) = s5+s4+4s3+24s2+3s+63. Using the Routh- Hurwitz method, determine whether the system is stable. If not stable, how many poles are in the right half plane? (April/May 2004)**
15. **Explain the rules used to construct root locus.**
16. **Consider the characteristic polynomial. s2 +2s+2+K(s+1)=0. Draw the root locus for 0 <= K <= ∝ (April/May 2004)**
17. **Draw the Nyquist plot for the following and determine the stability G(s) = 10/[(s+1)(2s+1)(3s+1)] (Nov/Dec 2004)**
18. **Consider the characteristics equation $s^4+Ks^3+s^2+1 = 0$. Using Routh Method, Determine the range of K for stability. (Nov/Dec 2004)**
19. **Explain how a Nyquist plot may be used to determine the stability of a closed loop system. (April/May 2005)**
20. **Using Routh's stability criterion, discuss the stability of the system whose characteristics equation is $s^3+10s^2+50s+500 = 0$. (April/May 2005)**

UNIT - 5: COMPENSATOR DESIGN

PART-B

1. **Consider the unity feedback type-2 system with $G_f(s) = K/s^2(s+1.5)$. This system has zero steady state error for both the step and ramp inputs. It can be seen from its root locus plot that the closed loop poles always lie on the jw axis. It is desired to compensate the system as to meet**

the following transient response specifications: setting time $\leq$ 4sec, peak overshoot for step input $\leq$ 20 %. Explain the Lag Compensator with s – plane representation and equivalent circuit.

2. Consider a type-1 system with an open loop transfer function of $G_f(s)$ = K/ s(s+1)(s+4). The system is to be compensated to meet the following specifications: damping ratio = 0.5 and undamped natural freq = 2.
3. Consider a type-1 system with an open loop transfer function of $G_f(s)$ = K/ s(s+1)(s+4). The system is to be compensated to meet the following specifications: damping ratio = 0.5, setting time = 10sec and velocity error constant $\geq$ 5sec-1
4. The open loop transfer function of the uncompensated system is $G_f(s)$ = K/ [s(s+1)(s+4)]. This system is now required to be compensated to meet the following specifications: damping ratio = 0.5, underdamped natural frequency = 2 and error constant $\geq$ 0.5
5. Consider the system whose open loop transfer function is K/ s(s+1)(s+4). The system is to be compensated to meet the following specifications: damping ratio = 0.4, setting time = 10 sec and velocity error constant $\geq$ 5sec^{-1}.
6. Consider the system with open loop transfer function $G_f(jw)$ = K/ [jw(j0.1w+1)(j0.2w+1)] is to be compensated to

13. Discuss the design procedure of a lead network with one

30 sec-1, phase margin $\geq$ 50 and bandwidth = 12rad/sec.

7. A unity feedback system has an open loop transfer function G(s) = K/[s(1+2s)]. Design a suitable lag compensator so that the phase margin is 40° and the steady state error for ramp input is less than or equal to 0.2
8. Design a suitable compensator for a control system having transfer function as G(s) = 1/[s(s+1)(s+5)] to meet the specifications (i) over shoot of about 25 % and (ii) settling time of 5 seconds. (April/May 2003)
9. The forward path transfer function of a certain unity negative feedback control system is given as, G(s) = K / s(s+2)(s+30). The system has to satisfy the following specifications. Phase margin >=35°.Gain margin >= 20 dB Steady state error for unit ramp input <= 0.04 rad. Design a suitable series lead compensator. (April/May 2004)
10. Describe the different types of compensation schemes. (April/May 2004)
11. Discuss in detail about lead & lag networks. (Nov/Dec 2004)
12. A unity feedback system has an open loop transfer of G(s)= 4/[s(2s+1)]. It is desired to obtain a phase margin of 40° without sacrificing K_v of the system. Design a suitable lag network for the system. (April/May 2004)
13. Discuss the design procedure of a lead network with one example. (April/May 2004)