DEPARTMENT OF
AERONAUTICAL ENGINEERING
QUESTION BANK

SUBJECT CODE: EE 2365
SEM / YEAR: V/III
SUBJECT NAME: CONTROL ENGINEERING

UNIT I- INTRODUCTION

PART – A (2 Marks)

1) What is control system?

In a system, when output quantity is controlled by varying the input quantity, then it is called as control system.

2) What are the two major types of control systems?

Open loop systems and closed loop system.

3) Define open loop system.

It is a control system where the output quantity has no effect over the input quantity.

4) Define closed loop system.

It is a control system where the output quantity has effect over the input quantity in order to maintain the desired output.

5) What are the components of control system?
   1) Error detector 2) controller 3) open loop system 4) feedback

6) Name the two types of electrical analogous of mechanical translational systems.
   1) Force –voltage analogous systems. 2) force-Current analogous systems.

7) What are the basic elements used for modeling mechanical translational systems?
   1) Mass 2) Dash pot 3) Spring

8) What are the basic elements used for modeling mechanical rotational systems?
   1) Moment of inertia 2) Dash pot with rotational frictional coefficient 3)Torsional spring

9) Define transfer function.

It is the ratio of Laplace transform of output to the Laplace transform of input, with the initial conditions being zero.

10) Define linear system.

A system is said to be linear if it obeys the principle of super position and principle of homogeneity.

11) Define time invariant system.

It is a system whose input-output characteristics do not change with time.

12) What is mathematical model of a system?

It is a model of the system which shows the relation between the input and output of a system in the form of a mathematical equation/differential equation.

13) Write force balance equation of ideal spring, ideal mass and ideal dashpot.

For Ideal mass $f_m = M. (d^2x/dt^2)$, for ideal spring $f_k = k.X$ and for ideal dashpot $f_b = B. (dX/dt)$

PART – B (16 Marks)

1) With examples explain the concept of open loop and closed loop systems. Compare.(16)
2) Compare hydraulic systems with thermal systems. (16)
3) Compare electrical systems with mechanical systems (analogous). (16)
4) Compare open loop and closed loop systems. (16)
5) With a block diagram explain the concept of flight control systems. (16)
6) Write the differential equations governing the Mechanical system shown in fig .and determine the transfer function. (16)

7) Determine the transfer function Y2(S)/F(S) of the system shown in fig. (16)
8) Write the differential equations governing the Mechanical rotational system shown in fig. Draw the Torque-voltage and Torque-current electrical analogous circuits. (16)

Note: Diagrams in these above referred problems are given separately. Only the type of the questions expected/asked in the previous year university end semester examinations are referred here

UNIT II

OPEN AND CLOSED LOOP SYSTEMS

PART A (2 MARKS)

1) What is feedback? What type of feedback is employed in control system?

The Feedback is a control action in which the output is sampled and a proportional signal is given back to the input for automatic correction of any changes in desired output.

2) Why negative feedback is preferred in control systems? It improves the stability of the system.

3) State principle of superposition theorem (Or) the principle of homogeneity.

The principle of superposition and homogeneity states that if the system has responses $c_1(t)$ and $c_2(t)$ for the inputs $r_1(t)$ and $r_2(t)$ respectively, then, the system response to the linear combination of the individual outputs $a_1r_1(t)+ a_2r_2(t)$ is given by linear combination of the individual outputs $a_1c_1(t)+ a_2c_2(t)$, where a_1 and a_2 are constants.

4) What is signal flow graph?

It is a diagram that represents a set of simultaneous linear algebraic equations. By taking Laplace transform, the time domain differential equations governing a control system can be transferred to a set of algebraic equations in s-domain. The signal flow graph which is in the form of a graphical representation can be constructed using these equations.

5) Define non-touching loop.

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

6) What is transmittance?

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

7) 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 the signals.

8) What are the basic components of a block diagram?

The basic elements of a block diagram are block, branch points and summing point.

PART – B (16 Marks)

1. Determine the overall transfer function C(S)/R(S) for the system shown in fig. (16)
2. Obtain the closed loop transfer function C(S)/R(S) of the system whose block diagram is shown in fig. (16)
3. For the system represented by the block diagram shown in fig. Determine C1/R1and C2/R1. (16)
4. Obtain the closed loop transfer function C(S)/R(S) of the system whose block diagram is shown in fig. (16)
5. Find the overall gain of the system whose signal flow graph is shown in fig. (16)
6. Draw a signal flow graph and evaluate the closed loop transfer function of a system whose block is shown in fig. (16)

Note: Diagrams in these above referred problems are given separately. Only the type of the questions expected/asked in the previous year university end semester examinations are referred here.

UNIT III

CHARACTERISTIC EQUATIONS AND FUNCTIONS

PART – A (2 Marks)

1. What is time response?

It is the output of the closed loop system as a function of time. It is denoted by c(t).It is given by inverse of Laplace of product of input and transfer function of the system.

$C(t) = L^{-1}\{(C(s)\} = L^{-1}\{(R(s)\ G(s))/\ (1+G(s)\ H(s))\}$

2. What is transient and steady state response?

The transient response is the response of the system when the input changes from one state to another. The response of the system at t=∞ is called steady state response

3. Name the test signals used in time response analysis.

Step signal, ramp signal, parabolic signal sinusoidal signal and impulse signal

4. Define step signal.

The step signal is a signal whose value changes from 0 to A and remains constant at A for t>0 The mathematical representation of step signal is r(t) = A u(t), where u(t) = 1 fort≥0 and u(t) =0 for t<0.

5. Define Ramp signal and parabolic signal.

A ramp signal is a signal whose value increases linearly with time from an initial value of zero at t=0. It is mathematically represented as r (t) = A t, where fort≥0 and r (t) =0 for t<0.

A parabolic signal is a signal in which the instantaneous value varies as square of the time from an initial value of zero at t=0.It is mathematically represented as r (t) = $A.t^2/2$ for fort≥0 and r (t) =0 for t<0.

6. What is an impulse signal?

A signal which is available for very short duration is called impulse signal. Ideal impulse signal is a unit impulse signal which is defined as a signal having zero values at all-time except at t=0. At t=0, the magnitude becomes infinite.

7. How is system classified depending on the value of damping(ε)?

Undamped system (ε=0), under damped system (ε<1), critically damped system (ε=1) and over damped system (ε>1)

8. What is damped frequency of oscillation?

In under damped system, the response is damped oscillatory. The frequency of damed oscillation is given by $w_d=w_n$ Sqrt of $(1-\varepsilon^2)$.

9. The closed-loop transfer function of second order system is C(S)/R(S) =10/ S2 +6S +10. What is the type of damping? Since ε<1, the system is under damped.

10. List the time domain specifications.

Delay time, rise time, peak time, and maximum over shoot and settling time.

11. Define rise time.

Rise time is the time taken for response tom raise from 0% to 100% for the very first time.

12. Define delay time..

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

13. Define peak time.

It is the time taken for the response to reach the peak value for the very first time. It is the time taken for the response to reach the peak overshoot, M_p

14. What is steady state error?

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

15. What are static error constants?

The K_p, K_v and K_a are called static error constants. The se constants are associated with steady state error in a particular type of a system and for a particular input.

16. What are generalized error constants?

They are the coefficients of generalized error series. They are also called as dynamic error coefficients.

17. List the advantages of generalized error constants.

Generalized error series gives error signal as a function of time. Using generalized error constants, the steady state error can be determined for any type of input. But static error constants are used to determine steady state error when the input is any one of the standard input.

PART B (16 Marks)

1. (a) Derive the expressions and draw the response of first order system for unit step input. (8)

(b) Draw the response of second order system for critically damped case and when input is unit step. (8)

2. Derive the expressions for Rise time, Peak time, and Peak overshoot. (16)

3. A potential control system with velocity feedback is shown in fig. What is the Response of the system for unit step input? (16)

4. Measurements conducted on a Servomechanism show the system response to be c(t)=1+0.2 ê 60t-1.2 ê –10 t. when subjected to a unit step. Obtain an expression for closed loop transfer function. (16)

5. A positional control system with velocity feedback is shown in fig. What is the response c(t) to the unit step input. Given that ς =0.5.and also calculate rise time, peak time, Maximum overshoot and settling time. (16)

6. A unity feedback control system has an open loop transfer function G(S) = 10/S(S+2). Find the rise time, percentage over shoot, peak time and settling time. (16)

7. A closed loop servo is represented by the differential equation, where c is the Displacement of the output shaft, r is the displacement of the input shaft and (e= r-c) Determine undammed natural frequency, damping ratio and percentage maximum overshoot for unit step input. (16)

8. For a unity feedback control system the open loop transfer function G(S) = 10(S+2)/ {S^2 (S+1)}. Find (a) position, velocity and acceleration error constants.

(b) The steady state error when the input is R(S) where R(S) =3/S –2/S^2 +1/3S^3 (16)

9. The open loop transfer function of a servo system with unity feedback system is G(S) = 10/ S (0.1S+1).Evaluate the static error constants of the system. Obtain the steady state error of the system when subjected to an input given by the polynomial r(t) = a_0 +a_1t +a_2 /2 t^2 . (16)

UNIT IV

Concept of stability

PART – A (2 Marks)

1. What are the two methods of designing a control system?

Base on time domain specification and based on frequency domain specifications.

2. What is the time domain specification needed to design a control system?

Time domain specifications are needed to understand how the system performance is changing with respect to time. They are useful in understanding the transient and steady state performance of the systems What is frequency response?

The frequency response is a steady state output of the system, when the input is a sinusoidal signal.

3. What is the frequency domain specification needed to design a control system?

Frequency domain specifications are needed to understand how the system performance is changing with respect to the change in the frequency of the input signal applied.

4. Define gain cross over frequency.

It is the frequency at which the magnitude of open lop transfer function is unity.

5. Define Phase cross over frequency.

It is the frequency at which the phase of the Open loop transfer function is 180 degrees.

6. Define Phase Margin.

The phase margin (Y) is the amount of additional phase lag at the gain cross over frequency w_{gc}

7. Define Gain Margin.

The gain margin is defined as the reciprocal of the magnitude of open loop transfer function at phase cross over frequency w_{pc}.

8. What is Bode plot?

The bode plot is a frequency response plot of the transfer function of a system. It consists of two plots- magnitude plot and phase angle plot.

The magnitude plot is a graph between magnitude of a system transfer function in db and the frequency w. The phase plot is a graph between the phase or argument of a system transfer function in degrees and the frequency w. usually both the plots are plotted on a common x-axis in which the frequencies are expressed in logarithmic scale.

9. List the Frequency domain specifications.

Resonant peak, cut-off rate, resonant frequency, gain margin, band width and phase margin.

10. What is minimum phase system?

The minimum phase systems are systems with minimum phase transfer functions. In them, all poles and zeros will lie on the left half of s-plane.

11. What is non-minimum transfer function?

It is a transfer function with one or more zeros in the right half of s-plane.

12. What is Bandwidth?

The bandwidth is the range of frequencies for which the system gain is more than -3 db.

13. What is root locus?

The path taken by a root of characteristic equation when open loop gain K is varied from zero (0) to infinity (∞) is called root locus.

14. What is the necessary condition for stability?

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

15. What is characteristic equation?

The denominator polynomial of C(s)/R(s) is the characteristic equation of the system.

16. How the roots of characteristic are related to stability?

If the roots of characteristic equation has positive real part, then the impulse response of the system is not bounded (the impulse response will be infinite as (t) tends to Zero (0)).Hence the system will be unstable. If the roots has negative real parts, then, the impulse response is bounded (the impulse response becomes Zero (0) as (t) tends to Infinity (∞)). Hence the system will be stable.

17. Define stability.

The term stability refers to stable working conditions of a control system. In a stable system , the response or output is predictable, finite and stable for a given input(or changes in the system parameters)

18. What do you mean by dominant pole?

The dominant pole is a pair of complex conjugate pole which decides transient response of the system. In higher order systems, the dominant poles are very close to the origin and all other poles are widely separated and so they have less effect on transient response of the system.

19. What are break away points?

At breakaway points the root locus breaks from the real axis to enter into the complex plane.

20.What are break in points?

At break in points the root locus enters in to the real axis from the complex plane.

21. How will you find the root locus on real axis?

To find root locus on real axis, one test point is to be chosen on real axis. If the total number of poles and zeros on the real axis to the right of this test point is odd number, then, the test point lies on the root locus. If it is even, then, the test point does not lie on the root locus.

22. What are asymptotes? How will you find the angle of asymptotes?

Asymptotes are straight lines which are parallel to root locus going to infinity and meet the root locus at infinity.

Angle of asymptotes = {±180 ((2.q) +1)/ (n-m)}

N= number of poles= number of zeros and q= 0, 1, 2, 3, ……. (n-m)

PART – B (16 Marks)

1. Plot the Bode diagram for the following transfer function and obtain the gain and phase cross over frequencies. G(S) = 10/ S(1+0.4S) (1+0.1S) (16)

2. The open loop transfer function of a unity feedback system is G(S) = 1/ S(1+S)(1+2S) Sketch the Bode plot and determine the Gain margin and Phase margin. (16)

3. Sketch the Bode plot and hence find Gain cross over frequency, Phase cross over frequency, Gain margin and Phase margin(S) = 0.75(1+0.2S)/ S (1+0.5S) (1+0.1S) (16)

4. Sketch the Bode plot and hence find Gain cross over frequency, Phase cross over frequency, Gain margin and Phase margin. G(S) = 10(S+3)/ S(S+2) (S2+4S+100) (16)

5. Sketch the Bode plot for the following transfer function .and find Gain cross over frequency, Phase cross over frequency, Gain margin and Phase margin.
G(S) = 10(S+2)(S+4)/ S (S2 -3S+10) (16)

6. Construct the Bode plot for the function GH(S) =2(S+1)/ S2. Find Gain cross over frequency, Phase cross over frequency, Gain margin and Phase margin. (16)

7. Plot the Bode diagram for the following transfer function and obtain the gain and phase cross over frequencies. G(S) =KS2 / (1+0.2S) (1+0.02S). Determine the value of K for a gain cross over frequency of 20 rad/sec. (16)

8. Sketch the Bode plot and hence find Gain cross over frequency, Phase cross over frequency, Gain margin and Phase margin. G(S) = 10(1+0.1S)/ S(1+0.01S) (1+S). (16)

9. Write the short notes on correlation between the time and frequency response? (16)

10. Using Routh criterion, determine the stability of the system whose Characteristics equation is $S^4+8S^3+18S^2+16^1+5 =0$. (16)

11. $F(S)=S^6 +S^5-2S^4-3S^3-7S^2-4S^1-4 =0$.Find the number of roots falling in the RHS plane and LHS plane. (16)

UNIT V

SAMPLED DATA SYSTEMS

PART – A (2 Marks)

1. What is sampled data control system?

When the input or information at any or some points in a system is in the form of discrete pulses, then the system is called discrete data system or sampled data control system.

2. Write the advantages and disadvantages of sampled data control system.

1) Systems are highly accurate, fast and flexible.
2) Use of time sharing concept in digital computers results in economic cost and space.
3) Digital transducers used in the system have better resolution.
4) The digital controllers are less affected by noise, non-linearity and transmission error of noisy channel.

3. State (Shanon's) sampling theorem.

It states that a band limited continuous- time signal with highest frequency f_m hertz, can be uniquely recovered from its samples provided that the sampling rate F_S is greater than or equal to ($2f_m$) samples per second.

4. What is periodic sampling?

It is a sampling process in which the discrete- time signal or sequence is obtained by taking samples of continuous time signal periodically or uniformly at intervals of T seconds. Here T is called sampling period and (1/T) is called sampling frequency.

5. What are hold circuits?

Hold circuits are devices used to convert discrete time signals to continuous time signals.

6. What are the problems encountered in a practical hold circuits?

1) Errors in periodicity of sampling process.
2) Nonlinear variations in the duration of sampling aperture.
3) Droop (Changes) in the voltage held during conversions.

7. What are the methods available for the stability analysis of sampled data control system?

1) Jury's stability test.
2) Bilinear transformation
3) Root locus technique.

8. What are the advantages of state space analysis?

1) It is applicable to any type of systems (linear/nonlinear/time variant/time invariant and multiple input & multiple output systems)
2) It can be performed with initial conditions.
3) The variables used to represent the system can be any variable in the system.
4) Using this analysis, the internal states of the system at any time instant can be predicted.

9. What is state and what are state variables?

The state is the condition of a system at any time instant (t). A set of variable which describes the state of the system at any time instant are called as state variables.

10. What is state diagram?

The pictorial representation of the state model of the system is called state diagram. The state diagram of the system can be either in block diagram or signal flow graph form.

PART B (16 Marks)

1. Compare analog control system with digital control systems. (16)
2. Explain sampling theorem briefly and sample & hold operation. (16)
3. Explain stability analysis of sampled control system and Jury's stability. (16)
4. Explain Digital controllers with a neat block diagram . (16
5. Explain with a neat diagram digital PUID controllers. (16)

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