QUESTIONBANK

SUBJECTCODE&NAME:EE3503/CONTROLSYSTEMS

YEAR/SEM:III/V

UNITI

MODELING OF LINEAR TIME INVARIANT SYSTEM

PART-A[2MARKS]

1. ***What is meant by a system?***

A system is a collection of elements or components that are organized for a common purpose. Everysystem is delineated by its spatial and temporal boundaries, surrounded and influenced by its environment, described by its structure and purpose and expressed in its functioning.

2. ***Write Mason's Gain formula. The Mason's gain Formula is given by,***

$$- \sum$$

T= transfer function or gain of the system
P_k = gain of one forward path
k = an integer representing the forward paths in the system
Δ_k = 1 – the loops remaining after removing path j. If none remain, then $\Delta k = 1$.
Δ = 1 – Sum of loop gains + Sum of non touching loop gains taken two at a time – Sum of non touching loop gains taken three at a time + Sum of non touching loop gains taken four at a time

3. ***What are the three basic elements in electrical and mechanical system?***

The three basic elements of Electrical systems are

i. Resistance (R)
ii. Capacitance (C)
iii. Inductance (L)

The three basic elements of Mechanical systems are

i. Mass (M)
ii. Dashpot (B)
iii. Spring (K)

4. ***How will you get closed loop frequency response from open loop response?***

The G(jω) locus or the Nichols plot is sketched on the standard Nichols chart. The meeting point of M-contour with G(jω) locus gives the magnitude of closed loop system and the meeting point with N circle gives the argument/phase of the closed loop system.

5. ***List out the advantages of closed loop and open loop control system.***

The advantages of open loop systems are

Such systems are simple in construction.
Very much convenient when output is difficult to measure.
Such systems are easy when maintenance point is view.
Such systems are economical.

The advantages of closed loop systems are

i. Closed loop control systems are more accurate even in the presence of non-linearities

ii. The sensitivity of the system may be made small to make the system more stable

iii. The closed loop systems are less affected by noise.

6.What are the basic elements of a control systems? The components of feedback control system are

iv. plant ,
v. feedback path
vi. elements,
vii. error detector and
viii. controller.

Write the force balance equation for ideal dashpot and ideal spring. The force balance equations for ideal dashpot is The force balance equations for ideal spring

2. ***What is Control Systems?***

To control means to regulate, to direct or to command. Hence a control system is an arrangement of different physical elements connected in such a manner so as to regulate, direct or command itself or some other system.

3. ***Differentiate between open loop and closed loop control systems.***

Open Loop Systems:

An open-loop control system takes input under the consideration and doesn't react on the feedback to obtain the output.

It is also called a non-feedback control system.

There are no disturbances or variations in this system and works on fix conditions.

Closed Loop Systems:

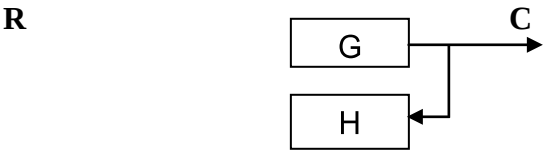
A closed loop system is also referred as a feedback control system. These systems record the output instead of input and modify it according to the need.

It generates preferred condition of the output as compared to the original one.

It doesn't encounter any external or internal disturbances.

4. ***Prove the rule for eliminating negative and positive feedback loop.***

Negative feedback loop:



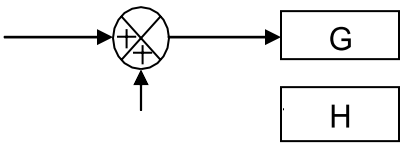
C = G(R-CH)

C= GR – GCH

C + CGH = GR

C(1+GH) = GR

Positive Feedback loop:



C = G(R+CH)

$C = GR + GCH$

$C - CGH = GR$

$C(1-GH) = GR$

14.Name any two dynamic models used to represent control systems.

The two dynamic models used to represent control systems are,

i. Mechanical Translational System
ii. Mechanical Rotational System

15.What are the characteristics of negative feedback?

i)Negative feedback occurs when some function of the output of a system, process, or mechanism is fed back in a manner that tends to reduce the fluctuations in the output, whether caused by changes in the input or by other disturbances.ii)Negative feedback tends to promote a settling to equilibrium, and reduces theeffects of perturbations.
iii)Negative feedback loops in which just the right amount of correction is applied with optimum timing can be very stable, accurate, and responsive.

16.What is translational system?

Consider a mechanical system in which motion is taking place along a straight line. Such systems are of translational type. These systems are characterized by displacement, linear velocity and linear acceleration.

17.Give the types of friction.

Friction can be divided into three types. They are

Viscous friction.
Static friction.
Coulomb friction.

18.What is block diagram?

A block diagram of a system is a pictorial representation of the functions performed byeach component of the system and shows the flow of signals.

19.What is signal flow graph?

The graphical representation of the variables of a set of linear algebraic equations representing the system is called signal flow graph.

20.What is the need for signal flow graph?

Block diagrams are very successful for representing control systems, but for complicated systems, the block diagram reduction process is tedious and time consuming. So signal flow graphs are needed which does not require any reduction process because of availability of a flow graph formula, which relates the input and output system variables.

UNIT–II

TIME DOMAIN ANALYSIS

PART-A[2MARKS]

1. ***Specify the time domain Specification?***

The time domain specifications are:

- Delay time.
- Rise time.
- Settling time.
- Maximum over shoot.
- Peak time.

2. ***What is meant by steady state error?***

The difference between the desired output and the actual output of the system is called steady state error, which is indicates the accuracy and plays an important role in designing the system.

3. ***What is dominant pole?***

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

4. ***List the Standard test signal used in time domain analysis.***

The standard test signals employed for time domain studies are

i. Step signal,
ii. Ramp signal,
iii. Parabolic signal and
iv. Impulse signal.

5. ***State the effect of PI Compensation in system performance.***

The PI controller is 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.

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

To find the root locus on real axis, choose a test point on the 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 number means, then the test point does not lie on the root locus.

7. ***How do you find the type of the system?***

The type number is given by number of poles of loop transfer function at the origin. The type number of the system decides the steady state error.

8. ***Find the unit impulse response of the system H(s) = 5s/(s+2) with zero initial conditions.***

The impulse response of the H(s) = 5s/(s+2) is , because for impulse function

Since system is in zero initial condition the response .

9. ***State the basic properties of root locus.***

- Root locus analysis helps in deciding the stability of the control systems with time delay.
- Information about settling time of the system also can be determined from the root locus.
- The absolute stability of the system can be predicted from the location of the roots in the S-plane.

10. ***What is type and order of the system?***

Type number of a system indicates the number of poles at the origin whereas the order of the system indicates the **order** of the differential equation governing the dynamics of a system. (or highest degree of denominator polynomial of the transfer function).

11. **What do you mean by peak over shoot?**

It is defined as the difference between the peak value of step response and the steady output.

12. ***Define settling time.***

Settling time is defined as the time taken by the response to reach and stay within a specified tolerance band of its final value.

13. ***What is the effect of system performance when a proportional controller is introduced in a system?***

The proportional controller improves the steady state tracking accuracy, disturbance signal rejection and relative stability of the system.

It also increases the loop gain of the system which results in reducing the sensitivity of the system to parameter variations.

14. ***What is type and order of the given system?***

Type of the given system is type- 1 and Order of the system is second order.

15. ***Define Rise time.***

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

16. ***Define peak time.***

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

17. ***Differentiate between steady state and transient response of the system?***

The output variation during the time, it takes to achieve its final value is known as transient response. The time required to achieve the final value is called transient response.It is that part of the time response which remains after complete transient response vanishes from the system output.

18. ***Why is the derivative control not used in control system?***

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. Hence derivative

controller is not used alone in the control system.

19. What is type and order of the system?

Type number of a system indicates the number of poles at the origin whereas the order of the system indicates the **order** of the differential equation governing the dynamics of a system. (or highest degree of denominator polynomial of the transfer function).

20. What are generalized error series?

They are the coefficients of generalized series. The generalized error series is given by The coefficients C_0, C_1, C_2,…,C_n are called generalized error coefficients or dynamic error coefficients.

UNITIII

FREQUENCY DOMAIN ANALYSIS

PART-A[2MARKS]

1. **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 ω. The other is a plot of the phase angle of a sinusoidal function versus log ω.

2. ***Define gain margin and phase margin.***

Gain Margin:

Greater will the gain margin greater will be the stability of the system. It refers to the amount of gain, which can be increased or decreased without making the system unstable. It is usually expressed in dB.

Phase Margin:

Greater will the phase margin greater will be the stability of the system. It refers to the phase which can be increased or decreased without making the system unstable. It is usually expressed in phase.

3. **Define Resonant Peak and Resonant Frequency.**

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

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

4. ***Mention any four frequency response specifications.***

The frequency response specifications are

1. Resonant peak 2. Resonant frequency 3. Band width 4. Cut-off rate 5. Gain margin
6. Phase Margin

5. ***What are m & n circles?***

The magnitude of closed loop transfer function with unit feedback can be shown for every value of M. These circles are called M circles.

N Circles:

The Angle of closed loop transfer function with unit feedback can be shown for every value of N. These circles are called N circles.

6. ***Define Corner Frequency.***

The magnitude plot can be approximated by asymptotic straight lines. The frequencies corresponding to the meeting point of asymptotes are called corner frequency. The slope of the magnitude plot changes at every corner frequencies.

7. ***What is Nichol's chart?***

The Nichols plot is a frequency response plot of the open loop transfer function of a system. It is a graph between magnitude of G(j) in db and the phase of g(j) in degree, plotted on a ordinary graph sheet.

The Nicholas chart consists of m and n contours superimposed on ordinary graph. Along each M contour the magnitude of closed loop system, M will be constant. Along each N contour, the phase of closed loop system will be constant. The ordinary graph consists of magnitude in db,

marked on the y-axis and the phase in degrees marked on x axis. The Nicholas chart is used to find the closed loop frequency response from the open loop frequency response.

8. What is Gain and Phase Crossover Frequency?

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

The phase cross over frequency is the frequency at which the phase of the open loop transfer function is 180.

9. List the advantages of Nichol's 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.

10. What are the Frequency Domain Specifications.

The frequency domain specifications are

i. Resonant peak.
ii. Resonant frequency.
iii. Bandwidth
iv. Cut-off rate
v. Gain margin
vi. Phase margin

11. Define –Resonant Peak

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

12. What is bandwidth?

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

13. 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.

14. 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 is available, angle curve of $1+ j\omega$.

15. Define Phase cross over?

The frequency at which, the phase of open loop transfer functions is 180° is called phase cross over frequency ωpc.

16. Define Gain cross over?

The gain cross over frequency ωgc is the frequency at which the magnitude of the openloop transfer function is unity.

17. What are the two types of compensation?

The two types of compensation are

i. Cascade or series compensation.

ii. Feedback compensation or parallel compensation.

18. When lag/lead/lag-lead compensation is employed?

Lag compensation is employed for a stable system for improvement in steady state performance.

Lead compensation is employed for stable/unstable system for improvement in transient state performance.

Lag-Lead compensation is employed for stable/unstable system for improvement in both steady state and transient state performance

19. What is a polar plot?

The sinusoidal transfer function

$$G(j\square) = Re[G(j\square)] + jIm[G(j\square)]$$

$$G(j\square) = \square G(j\square)\square\square \; G(j\square) = M\square$$

$$\square$$

From the above equations it is seen that G(j□)may be represented as a phasor of magnitude M and phase angle □. As the input frequency □ is varied from 0 to □, the magnitude M and phase angle □ change and hence the tip of the phasor G(j□) trace a locus in the complex plane. The locus thus obtained is known as polar plot.

20. What are compensators?

In control systems design, under certain circumstances it is necessary to introduce some kind of corrective subsystems to force the chosen plant to meet the given specifications. These subsystems are known as compensators and their job is to compensate for the deficiency in the performance of the plant.

21. What are the two types of compensation techniques write short notes on them?

i. Cascade or series compensation.

ii. ii.Feedback compensation.

In cascade or series, the compensator transfer function is placed in cascade with the plant transfer function.

In feedback compensation, the compensator is placed in the feedback path.

22. Define Lead compensator.

Gc(s) = (s+Zc) / (s + Pc) = (s+1/γ)/ (s+ 1/at), where a = Zc/Pc < 1, t > 0, a< 1 ensures that the pole is located to the left of the zero. The compensator having a transfer of the form given above is known as a lead compensator. A lead compensator speeds up the transient response and increases the margin of stability of the system. It also helps to increase the system error constant though to a limited extent.

23. What is a lag compensator?

Gc(s) = (s+Zc) / (s + Pc) where b = Zc/Pc > 1. b>1 ensures that pole is to the right of zero, i.e. Nearer to the origin than zero. The compensator having a transfer function of the form given above is called a lag compensator. A lag compensator improves the steady state behavior of the

system while nearly preserving its transient response.

24. What is a lag lead compensator?

When both the transient and steady state response require improvement lag lead compensator is required. This is basically a lag lead compensator connected in series.

UNIT-IV

STATE VARIABLE ANALYSIS

PART-A[2MARKS]

1. Define stability.

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

2. What is nyquist contour

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

3. Define Relative stability.

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

4. What will be the nature of impulse response when the roots of characteristic equation are lying on imaginary axis?

If the root of characteristic equation lies on imaginary axis the nature of impulse response is oscillatory.

5. What is the relationship between Stability and coefficient of characteristic polynomial?

If the coefficient of characteristic polynomial are negative or zero, then some of the roots lie on the negative half of the S-plane. Hence the system is unstable. If the coefficients of the characteristic polynomial are positive and if no coefficient is zero then there is a possibility of the system to be stable provided all the roots are lying on the left half of the S-plane.

6. What is Routh stability criterion?

Routh criterion states that the necessary and sufficient condition for stability is that all of the elements in the first column of the routh array is positive. If this condition is not met, the system is unstable and the number of sign changes in the elements of the first column of routh array corresponds to the number of roots of characteristic equation in the right half of the S-plane.

7. What is limitedly stable system?

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

8. In routh array what conclusion you can make when there is a row of all zeros?

All zero rows in the routh array indicate the existence of an even polynomial as a factor of the given characteristic equation. The even polynomial may have roots on imaginary axis.

9. ***What are the two segments of Nyquist contour?***

i. An finite line segment C_1 along the imaginary axis.

ii. An arc C_2 of infinite radius.

10. ***State any two limitations of routh stability criterion.***

Simply determining the stability is not usually sufficient for the design of process control systems. It is important to develop the extent of stability as well as how close the system is to instability.

Stability analysis not accounted for in the Routh analysis technique include finding the degree of stability, the steady state performance of the control system, and the transient response of the system to disturbances.

Routh method occurs when the polynomial in question becomes so large that Routh stability is too computationally time consuming.

11. ***State the advantages of nyquist stability criterion over routh criterion.***

Most of the real systems experience delay such systems will have loop transfer functions involving exponentials. Such systems cannot be treated with Routh Hurwitz criterion and are difficult to treat with Root-Locus method. The stability of such systems can be estimated using Nyquist plot.

Nyquist plot in addition to providing absolute stability, also gives information on relative stability of stable systems and degree of instability of unstable system.

12. ***What is BIBO stability criterion?***

Bounded-input bounded-output (BIBO) stability is a form of stability for linear signals and systems that take inputs. If a system is BIBO stable, then the output will be bounded for every input to the system that is bounded.

13. ***What is the need for compensator?***

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

1. In order to obtain the desired performance of the system, we use compensating networks. Compensating networks are applied to the system in the form of feed forward path gain adjustment.
2. Compensate a unstable system to make it stable.

14. **Sketch the electrical circuit of a Lag, Lead, lag-lead compensator.**

The circuit diagram for the **phase lead compensation** network.

15. ***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.

16. **Write the transfer function and pole zero plot of lag, lead and lag-lead compensator.**

The transfer function and pole zero plot for the **phase lead compensation** network.The transfer function for the **phase lag compensation** network.

The transfer function for the **phase lag- lead compensation** network.

17. ow are the location of roots of the characteristic equation related to stability? (OR) Define Routh Stability Criterion?

The necessary condition that all roots have negative real parts is that all the elements of the first column of the array have the same sign. The number of changes of sign equals the number of roots with positive real parts.

Two necessary but not sufficient conditions that all the roots have negative real parts are

a) All the polynomial coefficients must have the same sign.

b) All the polynomial coefficients must be nonzero.

18. What type of compensator suitable for high frequency noisy environment?

The suitable compensator used in high frequency noisy environment is lead compensator. Since the lead compensator is used to reduce the noise to a great extent compared to other compensators.

19. What is desired performance criteria specified in compensator design?

Effect of Phase Lead Compensation

1. The velocity constant Kv increases.
2. The slope of the magnitude plot reduces at the gain crossover frequency so that relative stability improves & error decrease due to error is directly proportional to the slope.
3. Phase margin increases.
4. Response becomes faster.

20. What is the Effect of Phase Lag Compensation

1. Gain crossover frequency increases.
2. Bandwidth decreases.
3. Phase margin will be increase.
4. Response will be slower before due to decreasing bandwidth, the rise time and the settling time become larger.

Effect of Phase Lag – Lead Compensation

1. Due to the presence of phase lag-lead network the speed of the system increases because it shifts gain crossover frequency to a higher value.

Due to the presence of phase lag-lead network accuracy is improved.

UNITV

DESIGN OF FEED BACK CONTROL SYSTEM

PART-A[2MARKS]

1. ***Define State and State Variable.***

It refers to smallest set of variables whose knowledge at t=t0 together with the knowledge of input for $t \geq t_0$ gives the complete knowledge of the behavior of the system at any time $t \geq t_0$.

State Variable:

It refers to the smallest set of variables which help us to determine the state of the dynamic system. State variables are defined by $x_1(t)$, $x_2(t)$..... $X_n(t)$.

2. ***What is controllability?***

A system is said to be completely state controllable if it is possible to transfer the system state from any initial state $X(t_0)$ at any other desired state X(t), in specified finite time by a control vector U(t).

3. ***What is observability?***

A system is said to be completely observable if every state X(t) can be completely identified by measurements of the output Y(t) over a finite time interval.

4. ***Write the properties of state transition matrix.***

The following are the properties of state transition matrix

$\Phi(0) = e^{Ax0} = I$ (unit matrix).

$\Phi(t) = e^{At} = (e^{-At})^{-1} = [\Phi(-t)]^{-1}$.

$\Phi(t_1+t_2) = e^{A(t1+t2)} = \Phi(t_1)\,\Phi(t_2) = \Phi(t_2)\,\Phi(t_1)$.

16. ***What is modal matrix?***

The modal matrix is a matrix used to diagonalize the system matrix. It is also called diagonalization matrix.

17. ***State the duality between controllability and observability.***

The concept of controllability and observability are dual concepts and it is proposed by kalman as principle of duality. The principle of duality states that a system is completely state controllable if and only if its dual system is completely state controllable if and only if its dual system is completely observable or vice versa.

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

The following three methods are available for the stability analysis of sampled data control system

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

19. **What is the necessary condition to be satisfied for design using state feedback?**

The state feedback design requires arbitrary pole placements to achieve the desire performance.

The necessary and sufficient condition to be satisfied for arbitrary pole placement is that the system is completely state controllable.

20. ***What is similarity transformation?***

The process of transforming a square matrix A to another similar matrix B by a transformation $P^{-1}AP = B$ is called similarity transformation. The matrix P is called transformation matrix.