**DHANALAKSHMI SRINIVASAN COLLEGE OF ENGINEERING AND TECHNOLOGY**

**DEPARTMENT OF**

**ELECTRICAL AND ELECTRONICS ENGINEERING**

QUESTION BANK

V SEMESTER

IC6501 – CONTROL SYSTEMS

Regulation– 2013

Academic Year 2018–19

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| **UNIT I SYSTEMS AND THEIR REPRESENTATION** | | | |
| 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. | | | |
| **PART A** | | | |
| **Q.No.** | **Questions** | **BTL**  **Level** | **Domain** |
| 1. | List the advantages of closed loop system over open loop system. | BTL 1 | Remembering |
| 2. | Define the terms (i) Physical Model (ii) Mathematical Model. | BTL 1 | Remembering |
| 3. | What are the basic elements in control systems? | BTL 1 | Remembering |
| 4. | Define transfer function. Give an example for it. | BTL 1 | Remembering |
| 5. | What are the basic elements used for modeling mechanical translational  system? | BTL 1 | Remembering |
| 6. | List the basic elements for modeling in mechanical rotational system. | BTL 1 | Remembering |
| 7. | Distinguish the terms sink and source. | BTL 2 | Understanding |
| 8. | Discuss any 2- applications of synchro. | BTL 2 | Understanding |
| 9. | Describe the characteristics of negative feedback in control systems. | BTL 2 | Understanding |
| 10. | Discuss the terms (i) Signal Flow Graph (ii) Non-touching loop. | BTL 2 | Understanding |
| 11. | Illustrate the terms (i) Block Diagram Reduction (ii) Mason;s Signal Flow  Graph Method. | BTL 3 | Applying |
| 12. | Draw the electrical analog of a thermometer with neat diagram. | BTL 3 | Applying |
| 13. | Illustrate the terms (i) Path (ii) Forward Path (iii) Loop (iv) Non-touching  Loop. | BTL 3 | Applying |
| 14. | Compare Signal Flow Graph approach with block diagram reduction  technique of determining transfer function. | BTL 4 | Analyzing |
| 15. | Define open loop and closed loop system. | BTL 4 | Analyzing |
| 16. | Analyze the need of electrical zero position of a synchro transmitter. | BTL 4 | Analyzing |
| 17. | Explain the aligned position of a Synchro transmitter and synchro receiver. | BTL 5 | Evaluating |
| 18. | Can we use servomotor for position control? Support the answer with  necessary details**.** | BTL 5 | Evaluating |
| 19. | Create the expression for Masons gain formula to find the system transfer | BTL 6 | Creating |

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|  | | function. | | |  | |  |
| 20. | | Formulate the force balance equation for ideal dash pot and ideal spring**.** | | | BTL | 6 | Creating |
| **PART – B** | | | | | | | |
| 1. | 1. Compare the open and closed loop control systems how it is distinguished with closed loop system. (6) 2. Write the differential equations governing the mechanical rotational system as shown in Fig. . (7) | | | | BTL4 | | Analyzing |
| 2. | 1. Compose the given block diagram shown in fig to signal flow graph and determine the closed loop transfer function C(s)/R(s). (8)      1. Differentiate DC and AC Servo Motor. (5) | | | | BTL 6 | | Creating |
| 3. | 1. Explain open loop and closed loop control systems with examples. 2. Derive the transfer function of an armature controlled DC Servo Motor. | | (7) | (6) | BTL | 4 | Analyzing |
| 4. | Find the transfer function y2(s) / f(s) as shown in Fig. . (13) | | | | BTL 3 | | Applying |
| 5. | 1. With neat diagrams, Discuss the working of AC Servo Motor. (6) 2. Estimate the Transfer function of field Controlled DC Servo Motor. (7) | | | | BTL2  BTL 2 | | Understanding  Understanding |

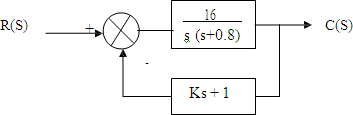
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| 6. | Calculate (13) | the | transfer | function | Y2(S)/F(S) | for | the | given | mathematical | model. | BTL 3 | Applying |
| 7. | Identify the overall gain C(S) / R(S) for the signal flow graph shown below.  (13) | | | | | | | | | | BTL 1 | Remembering |
| 8. | (i) Arrange the differential equation for the Mechanical system as shown in Fig.  .And also find the transfer function X2(S)/F(S). (13) | | | | | | | | | | BTL 4 | Analyzing |
| 9. | 1. Develop the transfer function X5(S)/X1(S) using Mason’s Gain formula for the system given.      1. Describe the construction and working principle of Synchro with neat sketch.(7+6) | | | | | | | | | | BTL 6  BTL 1 | Creating  Remembering |

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| 10. | Formulate the transfer function for the block diagram shown in Fig. ..   1. using the Block diagram Reduction Technique. 2. using Mason’s Gain Formula. (7+6) | BTL 6 | Creating |
| 11. | 1. Develop the transfer function of AC Servo Motor. (7) 2. With neat diagram, explain the working principle of Field Controlled DC Servo   Motor. (6) | BTL 6  BTL 5 | Creating Evaluating |
| 12. | 1. Illustrate the Transfer Function of Thermal system consists of a thermometer inserted in a liquid bath. (6) 2. Compare DC Motor and DC Servo Motor and list out the applications of DC Servo Motor**.** (7) | BTL 3  BTL 4 | Applying  Analyzing |
| 13. | 1. Describe the Mathematical Modelling of fundamental component of Mechanical Rotational System. (6) 2. Describe how a Synchro works as error detector with neat diagram. (7) | BTL 1  BTL 1 | Remembering  Remembering |
| 14. | What is meant by Servo mechanism? Explain the construction, working and also obtain the mathematical expression for (i) DC Servo Motor (ii) AC Servo Motor. (13) | BTL 5 | Evaluating |
| **PART – C** | | | |
| 1. | Identify and obtain the electrical current analogy for the Mechanical system as shown in Fig. and also draw the circuit diagram. (15) | BTL 1 | Remembering |
| 2. | (i) What is meant by Synchros ? Explain the following parts of Synchros (i) Syncro  Transmitter (ii) Synchro Receiver (iii) Error detector (iv) Position Control applications with suitable diagram for each. (15) | BTL 5 | Evaluating |

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| 3. | In block diagram reduction explain the following terms(i) Block diagram (ii) Error  Detector (iii) Take off Point (iv) Forward Path (v) Feedback path. And also express the rules for block diagram technique with suitable tabulation. (15) | BTL 2 | Understanding |
| 4. | (i)Create the Mathematical Model for (i) Mechanical Translational System (ii)  Mechanical Rotational System (iii) Series RLC Circuit (iv) Parallel RLC Circuit with suitable diagram and expression. (15) | BTL 6 | Creating |

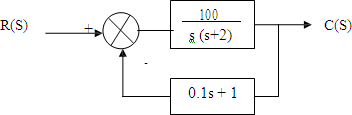
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| **UNIT II - TIME RESPONSE** | | | |
| Time response – Time domain specifications – Types of test input – I and II order system response – Error  coefficients – Generalized error series – Steady state error – Root locus construction- Effects of P, PI, PID modes of feedback control –Time response analysis. | | | |
| **PART - A** | | | |
| **Q.No.** | **Questions** | **BT** | **Competence** |
| 1. | For the system described by *C* ( *S* )  16 Show the nature of the time  *R* ( *S* ) (*S* 2  8*S*  16 )  response. | BTL 3 | Applying |
| 2. | Classify the time domain specifications. | BTL 3 | Applying |
| 3. | Define Delay time, Rise time, Peak time. | BTL 1 | Remembering |
| 4. | Define Step, Ramp & Parabolic signal | BTL 1 | Remembering |
| 5. | Calculate the acceleration error coefficient for  *C* (*S* )  *K* (1  *S* )(1  2*S* )  *R* (*S* ) *S* 2 (*S* 2  4*S*  20 ) | BTL3 | Applying |
| 6. | Evaluate the type and order of the system. *G*(*S* )  *K*  *S* (*TS* 1) | BTL 5 | Evaluating |
| 7. | How is a system classified depending on the value of damping? | BTL 2 | Understanding |
| 8. | Give the type and order of the following system. *G*(*S* )*H* (*S* ) 200  (*S* 2  20*S*  200) | BTL 2 | Understanding |
| 9. | What is steady state error? Mention the 3-different static error constants. | BTL 2 | Understanding |
| 10. | Distinguish between type and order of the system. | BTL 4 | Applying |
| 11. | List the drawback of static coefficients. | BTL 1 | Remembering |
| 12. | Give the relation between static and dynamic error coefficients. | BTL 1 | Remembering |
| 13. | Explain the need for a controller and different types of controller. | BTL 5 | Evaluating |
| 14. | State the basic properties of root locus. | BTL 1 | Remembering |
| 15. | Give the transfer function G(s) of a PID Controller. | BTL 2 | Understanding |

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| 16. | What is the effect on system performance when a Proportional Controller is used in a system?. | BTL 6 | Creating |
| 17. | Infer why derivative controller is not separately used in control systems. | BTL 4 | Analyzing |
| 18. | Explain about the PI Controller. | BTL 4 | Analyzing |
| 19. | Express the PID Controller Equation. | BTL 2 | Understanding |
| 20. | Generalize the effect of PI Controller on the system performance. | BTL 6 | Creating |
| **PART - B** | | | |
| 1. | 1. Outline the time response of first order system when it is subjected to a unit step input. (8) 2. Determine the response of the unity feed back system whose open loop   transfer function *G* ( *S* )  4 and when the input is unit step. (5)  *S* ( *S*  5) | BTL 2 | Understanding |
| 2. | Derive the expressions for second order system for underdamped case and when the unit is step input. (13) | BTL 1 | Remembering |
| 3. | 1. The open loop transfer function of a unity feedback system is given by   *G* ( *S* )  1 The input to the system is described by r(t)=4+6t.Find the  *S* ( *S*  1)  generalised error coefficient and steady state error. (6)   1. For a unity feedback control system the open loop transfer function is given by *G*(*S* )  10(*S*  2)   *S* 2 (*S*  5)  (a) Find the position ,velocity and acceleration error co-efficients. (b) Also  find steady state error when the input is *R* ( *S* )  3  2  1 (7)  *S S* 2 3*S* 3 | BTL 4 | Analyzing |
| 4. | 1. Measurements conducted on a Servomechanism show the system response to be c(t)=1+0.2 ê-60t -1.2 ê –10t when subjected to a unit step. Give the expression for closed loop transfer function. (6) 2. 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.   (7) | BTL 4 | Analyzing |



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| 5. | 1. The open loop transfer function of a unity feedback system is given by   *G* ( *S* )  *K* where K and T are positive constants. By what factor  *S* (*TS*  1)  should the amplifier gain reduced so that the peak overshoot of unit step response of the closed loop system is reduced from 75% to 25%. (7)   1. For a closed loop system with *G*(*S* )  1 and H(S) =5 calculate the   (1 *S* )  generalized error coefficients and find error. (6) | BTL 3 | Applying |
| 6. | Evaluate the expression for dynamic error coefficients of the following  system *G* ( *S* )  10 (13)  *S* ( *S*  1) | BTL 1 | Remembering |
| 7. | A unity feedback system is characterised by an open loop transfer  function *G*(*S* )  *K* . Analyse and determine the gain K so that the  *S* (*S* 10)  system will have a damping ratio of 0.5. For this value of K determine settling time, peak overshoot and time to peak over shoot for a unit step input. (13) | BTL 4 | Analyzing |
| 8. | Find the static error coefficients for a system whose transfer function is  *G* ( *S* ) *H* ( *S* )  10 .And also find the steady state error for r(t)=1+  *S* (1  *S* )(1  2 *S* )  t + t2/2. (13) | BTL 5 | Evaluating |
| 9. | Develop the time response of a typical under damped second order system for a unit step input. (13) | BTL 1 | Remembering |
| 10. | Draw the root locus of the following system.  *G*(*S* )*H* (*S* )  *K* (13)  *S* (*S* 1)(*S*  2)) | BTL 6 | Creating |
| 11. | 1. Sketch the root locus of the system whose open loop transfer function is   *G* ( *S* )  *K* . Find the value of K so that damping ratio is 0.5. (7)  *S* (*S*  2)( *S*  4)   1. A unity feedback system has an amplifier with gain KA=10 and gain ratio   *G* ( *S* )  1 in the feed forward path. A derivative feedback,H(S)=S KO  *S* (*S*  2)  is introduced as a minor loop around(s).Estimate the derivative feedback constant,KO ,so that the system damping factor is 0.6. (6) | BTL 2 | Understanding |
| 12. | 1. Explain the rules to construct root locus of a system. (6) 2. With a neat diagram explain the effect of PD Controller in detail. (7) | BTL 2 | Understanding |
| 13. | Explain the effect by adding P,PI, PD and PID Controllers in feedback control systems. (13) | BTL 1 | Remembering |

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| 14. | 1. For a servomechanisms with open loop transfer function   *G* ( *S* )  10 .What type of input signal gives constant steady state  *S* (*S*  2)( *S*  3)  error and calculate its value. (7)   1. Compute the static error coefficients for a system whose   *G*(*S*)  10 and also find the steady state error forr(t)=1+ t + t2/2.(6)  *S*(1 *S*)(1 2*S*) | | | | BTL 3 | Applying |
| **PART - C** | | | | | | |
| 1. | Evaluate the expression for dynamic error coefficients of the following  system *G* (*S* )  10 (15)  *S* (1  *S* ) | | | | BTL 5 | Evaluating |
| 2. | (i) The overall transfer function of a control system is given by  *C*(*S* )  16 .It is desired that the damping ratio is  *R*(*S* ) (*S* 2 1.6*S* 16)  0.8.Determine the derivative rate feedback constant Ki and compare rise time, peak time, maximum overshoot and steady state error for unit ramp input function without and with derivative feedback control. (9)  (ii) Compare P,I and D Controller. (6) | | | | BTL 4 | Analyzing |
| 3. | Draw the root locus for a system is given by *G*(*S* )  | *K* (*S*  1)  *S* (*S* 2  5*S*  20) | . | (15) | BTL 6 | Creating |
| 4. | A positional control system with velocity feedback as shown in fig. Give the response of the system for unit step input.  (15) | | | | BTL 6 | Creating |



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| **UNIT III FREQUENCY RESPONSE** | | | |
| Frequency response – Bode plot – Polar plot – Determination of closed loop response from open loop response -  Correlation between frequency domain and time domain specifications- Effect of Lag, Lead and Lag-Lead compensation on Frequency response- Analysis. | | | |
| **PART A** | | | |
| **Q.No.** | **Questions** | **BTL**  **Level** | **Domain** |
| 1. | Define the terms (i) Phase margin (ii) Gain margin (iii) Gain Cross-over frequency (iv) Phase Cross-over Frequency. | BTL 1 | Remembering |
| 2. | Give the advantages of Frequency response analysis. | BTL 1 | Remembering |

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| 3. | | Identify for +20db/sec slope change in Bode Plot. | BTL 1 | Remembering |
| 4. | | Define the terms: Resonant peak and Resonant frequency. | BTL 1 | Remembering |
| 5. | | Why is frequency response analysis important in control  applications? | BTL 1 | Remembering |
| 6. | | Define the following methods of frequency response plot.  (i) Bode Plot (ii) Polar Plot (iii) Nyquist Plot (iv) Nichol’s Chart. | BTL 1 | Remembering |
| 7. | | What is starting and ending point of a polar plot identified for the  system. Explain with suitable diagram. | BTL 2 | Understanding |
| 8. | | Describe the different frequency domain specifications. | BTL 2 | Understanding |
| 9. | | Mention the uses of Nichol’s Chart. | BTL | Understanding |
| 10. | | Express the relationship between speed and frequency. | BTL 2 | Understanding |
| 11. | | Draw the polar plot of *G*(*S*)  1  (1 *TS*) | BTL 3 | Applying |
| 12. | | Find the corner frequency of *G*(*S*)  10  *S*(1 0.5*S*) | BTL 3 | Applying |
| 13. | | Draw the circuit of lead compensator and its pole zero diagram. | BTL 3 | Analyzing |
| 14. | | Draw the approximate polar plot for a Type 0 second order system. | BTL 3 | Applying |
| 15. | | Compare Lead. Lag and Lead-Lag Compensator with suitable  example. | BTL 4 | Analyzing |
| 16. | | Compare the need for Lag/Lag-Lead Compensation. | BTL 4 | Analyzing |
| 17. | | Evaluate the Frequency domain specification of a Second order system when closed loop transfer function is given by  *C*(*S*) 64  *R*(*S*) (*S* 2 10*S*  64) | BTL 5 | Evaluating |
| 18. | | Evaluate the term Corner frequency. | BTL 5 | Evaluating |
| 19. | | Create the suitable diagram for the (i) Starting Point (ii) Ending  point of Polar Plot for identify the system. | BTL 6 | Creating |
| 20. | | Formulate the expression for (i) Resonant Peak (ii) Resonant  Frequency. | BTL 6 | Creating |
| **PART – B** | | | | |
| 1. | (i) Describe the use of Nichol’s chart to obtain closed loop frequency response from open loop frequency response of a unity  feedback system. (7) | | BTL 1 | Remembering |

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|  | (ii) Describe the correlations between time and frequency domain  specifications. (6) |  |  |
| 2. | With Mathematical expression define the following Frequency Domain specifications (i) Gain Margin (ii) Phase Margin (iii) Gain Cross over Frequency (iv) Phase Cross over Frequency (v)  Resonant Peak (vi) Resonant Frequency (vii) Bandwidth. (13) | BTL 1 | Remembering |
| 3. | Draw and show the Bode plot for the open loop transfer function  of a unity feedback system *G*(*S* )  10(*S*  3) and  *S* (*S*  2)(*S* 2 3*S*  25)  Determine : (i) Gain Margin (ii) Phase Margin (iii) Gain Cross Over Frequency (iv) Phase Cross Over Frequency. (13) | BTL 3 | Applying |
| 4. | The Open Loop Transfer Function *G*(*S* )  *K*  *S* (1 0.5*S* )(1 4*S* )  Determine the values manually calculate (i) Gain Margin (ii)  Phase Margin (iii) Gain Cross Over Frequency (iv) Phase Cross Over Frequency(v) Stability range K. (13) | BTL 3 | Applying |
| 5. | What is meant by Compensator? Summarize the following effects  of compensator (i) Lead Compensator (ii) Lag Compensator (iii) Lead-Lag Compensator withy suitable transfer function. (13) | BTL 2 | Understanding |
| 6. | Sketch the Bode plot and hence find Gain cross over frequency, Phase cross over frequency, Gain margin and Phase margin for the  function *G*(*S* )  10(*S*  3) (13)  *S* (*S*  2)(*S* 2  4*S* 100) | BTL 3 | Applying |
| 7. | Develop the Bode plot for the open loop transfer function of a  unity feedback system *G*(*S* )  10 and Determine: (i)  *S* (*S*  2)(*S*  6)  Gain Margin (ii) Phase Margin (iii) Gain Cross Over Frequency  (iv) Phase Cross Over Frequency. (13) | BTL 6 | Creating |
| 8. | Draw and show the polar plot of the system open loop transfer function with unity feedback system given by  *G*(*S* )  10 Determine the phase and gain margin. (13)  *S* (*S* 1)(*S*  4) | BTL 3 | Applying |
| 9. | The given transfer function *C*(*S* )  10(*S*  2) . Evaluate (i)  *R*(*S* ) (*S* 2  4*S*  5)  Magnitude (ii) Phase Angle (iii) Band width. (13) | BTL 5 | Evaluating |

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| 10. | The Open Loop Transfer Function *G*(*S* )  *K* . Determine and  (*S* 1)3  Calculate the (i) Gain Margin (ii) Phase Margin (iii) Gain Cross  Over Frequency (iv) Phase Cross Over Frequency (v) Stability range K. (13) | BTL 3 | Applying |
| 11. | Draw the Polar plot for the open loop transfer function of a unity  feedback system *G*(*S*)  10(*S*  3) and Determine and  *S*(*S*  2)(*S* 23*S*  25)  Point out : (i) Gain Margin (ii) Phase Margin (iii) Stability. (13) | BTL 4 | Analyzing |
| 12. | Write the Estimation Procedure for Polar Plot and obtaining (i) Gain Margin (ii) Phase Margin. And also point out the stability of the system. (13) | BTL 4 | Analyzing |
| 13. | Sketch the polar plot for the following transfer function and find Gain cross over frequency, Phase cross over frequency, Gain margin  and Phase margin for *G*(*S* )  400 (13)  *S* (*S*  2)(*S* 10) | BTL 5 | Evaluating |
| 14. | The Second Order System has the closed loop transfer function  *C*(*S* )  8 . Calculate the following Frequency Domain  *R*(*S* ) (*S* 2 4*S*  8)  specifications (i) Resonant Peak (ii) Resonant Frequency (iii) Bandwidth. (13) | BTL 3 | Applying |
| **PART C** | | | |
| 1. | 1. Evaluate the expression for(i) Resonant Peak (ii) Resonant Frequency (iii) Bandwidth. (8) 2. Obtain the expression for the correlation between time domain   and frequency domain analysis. (7) | BTL 5 | Evaluating |
| 2. | Develop the Polar plot sketch approximation manually and also  write the expression for each (i)Type 0 and Order 1 (ii) Type 1 and Order 2 (iii)Type 2 and Order 4 (iv)Type 2 and Order 5. (15) | BTL 6 | Creating |
| 3. | Construct Polar plot for the system *G*(*S* )  5(*S* 10) whose  *S* (*S*  2)(*S*  6)  open loop transfer function is given below and Calculate (i)Gain margin (ii) Phase Margin (iii) Gain Cross-over Frequency (iv) | BTL 3 | Applying |

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|  | Phase Cross over Frequency (v) Stability. (15) |  |  |
| 4. | 1. Evaluate the correlations between time and frequency domain specifications. (7) 2. With Mathematical expression define the following Frequency   Domain specifications (i) Gain Margin (ii) Phase Margin (iii) Gain Cross over Frequency (iv) Phase Cross over Frequency. (8) | BTL 5  BTL 1 | Evaluating  Remembering |

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| **UNIT IV - STABILITY AND COMPENSATOR DESIGN** | | | |
| Characteristics equation – Routh Hurwitz criterion – Nyquist stability criterion- Performance criteria – Lag, lead and lag-lead networks – Lag/Lead compensator design using bode plots. | | | |
| **PART - A** | | | |
| **Q.No** | **Questions** | **BT Level** | **Competence** |
| 1. | Illustrate Nyquist stability criterion. And also write the  formula for stability analysis.. | BTL 3 | Applying |
| 2. | Define BIBO Stability. | BTL 1 | Remembering |
| 3. | Express Routh’s Hurwitz criterion. | BTL 2 | Understanding |
| 4. | How are the roots of the characteristic equation of a  system related to stability? | BTL 2 | Understanding |
| 5. | Solve and find the range of K for closed loop stable behaviour of the system with characteristic equation 4S4+24S3+44S2+24S+K using Routh Hurwitz stability criterion. | BTL 3 | Applying |
| 6. | Point out the techniques used for determination of closed  loop response from open loop response. | BTL 4 | Analyzing |
| 7. | What are two motions of system stability to be satisfied for a linear time-invariant system to be stable? | BTL 2 | Understanding |
| 8. | Judge what is dominant pole. | BTL 5 | Evaluating |
| 9. | State the necessary and sufficient condition for stability. | BTL 4 | Analyzing |
| 10. | What is characteristic equation? | BTL 1 | Remembering |
| 11. | List the advantages and disadvantages of phase lag  network. | BTL-1 | Remembering |
| 12. | Summarize the effect of adding open loop poles and zero  on the nature of the root locus and on system? | BTL 5 | Evaluating |
| 13. | Define compensator and list the types of compensators. | BTL 1 | Remembering |

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| 14. | Quote the need of compensator | BTL 1 | Remembering |
| 15. | Formulate the transfer function of lag compensator and  draw the electric lag network and its pole-zero plot. | BTL 6 | Creating |
| 16. | Point out the properties of Lag compensator | BTL 4 | Analyzing |
| 17. | What is meant by Lead compensator? Give example for  it. | BTL 2 | Understanding |
| 18. | Formulate the transfer function of lead compensator and  draw and show pole-zero plot. | BTL 6 | Creating |
| 19. | Differentiate between Gain margin and Phase margin. | BTL 3 | Applying |
| 20. | Define the terms (i) Asymptotic stable (ii) Marginally  stable. | BTL 1 | Remembering |
| **PART - B** | | | |
| 1. | Construct Routh’s array and estimate the stability analysis of the system represented by the characteristic equation and comment on the location of roots.  (i) (6)  (ii) (7) | BTL 2 | Understanding |
| 2. | 1. Use R-H criterion to determine the location of the roots and stability for the system represented by characteristic equationþ   . (6)   1. Write the procedure for the design of Lag compensator using Bode plot. (7) | BTL 2 | Understanding |
| 3. | 1. Obtain Routh’s array for the system whose characteristic polynomial equation is     Test the stability. (6)   1. Define Nyquist stability criterion and explain the different situations of it. (7) | BTL 1 | Remembering |
| 4. | Draw the Nyquist plot for the system whose open loop  transfer function *G*(*S* )*H* (*S* )  *K*  *S* (*S*  2)(*S* 10)  Determine the range of K for which closed loop system is stable. (13) | BTL 2 | Understanding |
| 5. | Determine the stability of closed loop system by Nyquist stability criterion, whose open loop transfer function is  given by, *G* ( *S* ) *H* ( *S* )  *S*  2 (13)  ( *S*  1)( *S*  1) | BTL-1 | Remembering |



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| 6. | Use the routh stability criterion,determine the range of K for stability of unity feedback system whose open loop  transfer function is *G*(*S* )  *K* . (10)  *S* (*S* 1)(*S*  2)  (ii)State Routh stability criterion,.If the system is conditionally stable, solve and point out the range of K for which the system is stable. (3) | BTL-4 | Analyzing |
| 7. | 1. Test the stability for the system with characteristic equation  using Routh’s   Hurwitz. (6)   1. Construct Routh’s array and point out the stability of the system whose characteristic equation is . (7) | BTL-5 | Evaluating |
| 8. | The open loop transfer function of the uncompensated  system is *G* (*S* )  5 . Design a suitable compensator  *S* (*S*  2)  for the system so that the static velocity error constant Kv  is 20sec-1, the phase margin is atleast 550 and the gain margin is atleast 12dB. (13) | BTL-4 | Analyzing |
| 9. | 1. Describe the procedure for designing of a lag compensator. (6) 2. Describe the procedure for designing of a lag-lead compensator. (7) | BTL-1 | Remembeing |
| 10. | Design a Phase Lead compensator for the unity feedback  transfer function *G*(*S* )  *K* has specifications : a.  *S* (*S*  2)  Phase Margin> 550 b. The steady state error for ramp input is less than or equal to 0.33 and illustrate whether the design is acceptable or not. (Assume K=1). (13) | BTL-3 | Applying |
| 11. | Design a Lead compensator for the unity feedback transfer function with open loop transfer function  *G*(*S* )  *K* to satisfy the following  *S* (*S* 1)(*S*  5)  specifications: a. Kv> 50 . Phase Margin> 200. Illustrate whether the design is acceptable or not. (13) | BTL-3 | Appling |
| 12. | Design a Phase Lag compensator for the unity feedback  transfer function *G*(*S* )  5 has  *S* (*S* 1)(*S*  4)  specifications a. Phase Margin> 400 b. The steady state error for ramp input is less than or equal to 0.2 and check whether the design is acceptable or not. (13) | BTL-6 | Creating |

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| 13. | Explain the procedure of Lag Compensator using bode plot with an example. (13) | BTL-1 | Remembering |
| 14. | 1. Explain the different types of compensation techniques. (6) 2. A unity feedback system has the open loop transfer   function *G*(*S* )  *K* .Design and Point out a lead  *S* (*S*  2)  compensator for the system to achieve the following  specifications Velocity error constant Kv> 12 sec-1 , Phase Margin>450 . (7) | BTL-4 | Analyzing |
| **PART - C** | | | |
| 1. | The open loop transfer function of a unity feedback control system is given by  *G*(*S* )  *K* By applying Routh (*S*  2)(*S*  4)(*S* 26*S*  25)  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? (13) | BTL-4 | Analyzing |
| 2. | For a given system *G* ( *S* )  *K* Design a  *S* ( *S*  1)( *S*  2)  suitable lag-lead compensator to give Velocity error constant Kv=10 sec-1, Phase Margin> 500 ,Gain margin  > 10dB. (15) | BTL-6 | Creating |
| 3. | Realize the basic compensators using electrical network and obtain the transfer function, (15) | BTL-6 | Creating |
| 4. | Construct the Nyquist plot for the system whose open  loop transfer function is given by *K* (1  *S* ) 2 .Find  *G* ( *S* )   *S* 3  the range of K for stability. (15) | BTL-6 | Creating |

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| **UNIT V STATE VARIABLE ANALYSIS** | | | |
| Concept of state variables – State models for linear and time invariant Systems – Solution of state and output equation in controllable canonical form – Concepts of controllability and observability – Effect of  state feedback. | | | |
| **PART A** | | | |
| **Q.No.** | **Questions** | **BTL**  **Level** | **Domain** |
| 1. | Point out the drawbacks in transfer function model analysis. | BTL 4 | Analyzing |

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| 2. | The given state space model  ⎡ . ⎤  ⎢ *x*1 ⎥ ⎡  2 1 0 ⎤ ⎡ *x*1 ⎤ ⎡ 0 ⎤ ⎡ x1 ⎤  ⎢ *x* . ⎥  ⎢ 0  2 0 ⎥ ⎢ *x* ⎥  ⎢ 4 ⎥ *U* ; y=[1 0 0] ⎢x ⎥  ⎢ 2 ⎥ ⎢ ⎥ ⎢ 2 ⎥ ⎢ ⎥ ⎢ 2 ⎥  ⎢ *x*. ⎥ ⎢⎣ 0 0  3 ⎥⎦ ⎢ *x* ⎥ ⎢⎣ 5 ⎥⎦ ⎢ x 3 ⎥  ⎣ 3 ⎦ ⎣ 3 ⎦ ⎣ ⎦  Point out whether the given is controllable. | BTL 4 | Analyzing |
| 3. | Give the general form of the state space model for continuous  system and also draw the state diagram. | BTL 2 | Understanding |
| 4. | Define the following terms such as (i) State (ii) State Variable  (iii) State Vector (iv) State Space Model. | BTL 1 | Remembering |
| 5. | What is the state transition matrix? List any two methods for  finding state transition matrix. | BTL 1 | Remembering |
| 6. | Formulate the state space model with state diagram for  observable canonical form. | BTL 6 | Creating |
| 7. | Consider a system whose transfer function is given by Y(S)/U(S)  = 10(S+1)/S3+6s2+5s+10 . Solve and obtain a state model for this system. | BTL 3 | Applying |
| 8. | Obtain the state space model for the given differential equation  d 3 Y  6 d 2 Y  11 dY  6 Y  U(t)  dt 2 dt 2 dt Evaluate the transfer  function model. | BTL 5 | Evaluating |
| 9. | Consider a system whose transfer function is given by Y(S)/U(S)  = 10(S+1)/S3+6s2+5s+10 Evaluate the state model for the system. | BTL 5 | Evaluating |
| 10. | Express the homogeneous and non homogeneous state equation. | BTL 2 | Understanding |
| 11. | List the advantages of state space analysis. | BTL 1 | Remembering |
| 12. | Illustrate the condition for Controllability and Observability by  Kalman’s method. | BTL 3 | Applying |
| 13. | Express the necessary condition to be satisfied for the design of state observer? Also Write the Ackermann’s formula to find the  state observer gain matrix,G. | BTL 2 | Understanding |
| 14. | Write and explain the Formula in which the general form of state | BTL 4 | Analyzing |

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|  | | space model into transfer functional approach. |  |  |
| 15. | | Illustrate Cayley-Hamilton theorem. | BTL 3 | Applying |
| 16. | | Define state trajectory. | BTL 1 | Remembering |
| 17. | | Define (i) Controllability of a system. (ii) Observability of the system. | BTL 1 | Remembering |
| 18. | | Express any 2-methods for the conversion of transfer functional model into state space model. | BTL 2 | Understanding |
| 19. | | Formulate the state space model with state diagram for controllable canonical form. | BTL 6 | Creating |
| 20. | | List the applications of state space model for the different system. | BTL 1 | Remembering |
| **PART – B** | | | | |
| 1. | Obtain and examine the state model of the following electrical system. (13) | | BTL 1 | Remembering |
| 2. | Obtain and examine the state space model for the mechanical system as shown in Fig.. Where u(t) is input and y(t) is output. Also derive the transfer function from the state space equations.  (13) | | BTL 1 | Remembering |
| 3. | The given state space model of the system  ⎡ . ⎤  ⎢ *x*1 ⎥ ⎡ 0 1 1 ⎤⎡ *x*1 ⎤ ⎡ 0 ⎤ ⎡ ⎤  ⎢ . ⎥ ⎢ ⎥⎢ ⎥ ⎢ ⎥ ⎢ x1 ⎥  ⎢ *x*2 ⎥  ⎢ 0 0 1 ⎥⎢ *x*2 ⎥  ⎢ 0 ⎥*U* ;y=[1 0 0] ⎢x 2 ⎥ Check  ⎢ . ⎥ ⎢⎣ 1  5  6⎥⎦ ⎢ *x*3 ⎥ ⎢⎣10⎥⎦ ⎢ x ⎥  *x* ⎣ ⎦ ⎣ 3 ⎦  ⎣ 3 ⎦  whether the given is controllable and observable or not. And also Point out duality by Kalman’s approach and Gilbert’s method. (13) | | BTL 4 | Analyzing |

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| 4. | Consider a system with state space model is given below.  ⎡ . ⎤ ⎡ x ⎤  ⎢ *x*1 ⎥ ⎡ 0 1 2 ⎤ ⎡ *x*1 ⎤ ⎡ 0 ⎤ ; y=[2 -4 0] ⎢ 1 ⎥  ⎢ *x*. ⎥  ⎢ 0 0 1 ⎥ ⎢ *x* ⎥  ⎢ 0 ⎥ *U* ⎢x 2 ⎥  ⎢ 2 ⎥ ⎢ ⎥ ⎢ 2 ⎥ ⎢ ⎥ ⎢ ⎥  ⎢ *x*. ⎥ ⎢⎣  1  2  3 ⎥⎦ ⎢ *x* 3 ⎥ ⎢⎣ 4 ⎥⎦ ⎣ x 3 ⎦  ⎣ 3 ⎦ ⎣ ⎦  Point out that the system is observable and controllable. (13) | | | | BTL 4 | Analyzing |
| 5. | .  Consider the state space model described by X ( t )  AX ( t )  Y ( t )  CX ( t )  A  ⎡  1 1 ⎤ ; C=[1 0]. Design and express a full-order state  ⎢  1  2 ⎥  ⎣ ⎦  observer. The desired Eigen values for the observer matrix  1  5; 2  5 . (13) | | | | BTL 2 | Understanding |
| 6. | Examine and convert the following transfer function for the state  space model ⎡ . ⎤ ; y=[1 0 ] ⎡ *x*1 ⎤  ⎢ *x*1 ⎥ ⎡ 0 1 ⎤ ⎡ *x*1 ⎤ ⎡ 0 ⎤ ⎢ *x* ⎥  ⎢ *x* . ⎥  ⎢  3  2 ⎥ ⎢ *x* ⎥  ⎢ 2 ⎥ *U* ⎢ 2 ⎥  ⎢ 2 ⎥ ⎢ ⎥ ⎢ 2 ⎥ ⎢ ⎥ ⎢⎣ ⎥⎦  ⎢ ⎥ ⎢⎣ ⎥⎦ ⎢⎣ ⎥⎦ ⎢⎣ ⎥⎦  ⎣ ⎦  ⎡ . ⎤ ⎡ *x*1 ⎤  ⎢ *x* 1 ⎥ ⎡  5  1 ⎤ ⎡ *x* 1 ⎤ ⎡ 2 ⎤ ; y=[1 2 ] ⎢ *x* ⎥ (13)  ⎢ *x* . ⎥  ⎢ 3  1 ⎥ ⎢ *x* ⎥  ⎢ 5 ⎥ *U* ⎢ 2 ⎥  ⎢ 2 ⎥ ⎢ ⎥ ⎢ 2 ⎥ ⎢ ⎥ ⎢⎣ ⎥⎦  ⎢ ⎥ ⎢⎣ ⎥⎦ ⎢⎣ ⎥⎦ ⎢⎣ ⎥⎦  ⎣ ⎦ | | | | BTL 1 | Remembering |
| 7. | Explain the concept of controllability  Kalman’s and Gilbert’s method . | and | observability  (13) | by | BTL 2 | Understanding |
| 8. | Solve and Calculate the value of state transition matrix or eAt by using (a) Laplace Transform Method (b) Cayley Hamilton’s  Theorem(c)A10 in which *A*  ⎡ 0 1 ⎤ (13)  ⎢  12 7 ⎥  ⎣ ⎦ | | | | BTL 3 | Applying |
| 9. | Determine the canonical state model of the system whose transfer  function *T* (*S* )  2(*S*  50) (13) (*S*  2)(*S*  3)(*S*  4) | | | | BTL 4 | Analyzing |
| 10. | Consider a system whose transfer function is given by  *Y* ( *S* )  10 ( *S*  1) Evaluate the state model for the  *U* ( *S* ) ( *S* 3  6 *S* 2  5 *S*  10 )  system (i) by Block diagram reduction (ii) Signal flow graph Method. (13) | | | | BTL 5 | Evaluating |
| 11. | Formulate the expression for the state space model for the | | | | BTL 6 | Creating |

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|  | continuous system and also draw the state diagram for it. (13) |  |  |
| 12. | Obtain the complete solution of non homogeneous state equation  using time domain method. (13) | BTL 6 | Creating |
| 13. | Obtain the following state space Model  ⎡ . ⎤ ⎡ x ⎤  ⎢ *x*1 ⎥ ⎡ 2 1 0 ⎤ ⎡ *x*1 ⎤ ⎡ 0 ⎤ ;y=[1 0 0] ⎢ 1 ⎥  ⎢ *x*. ⎥  ⎢ 0  2 0 ⎥ ⎢ *x* ⎥  ⎢ 4 ⎥*U* ⎢x 2 ⎥  ⎢ 2 ⎥ ⎢ ⎥ ⎢ 2 ⎥ ⎢ ⎥ ⎢ ⎥  ⎢ . ⎥ ⎢⎣ 0 0  3 ⎥⎦ ⎢ *x* 3 ⎥ ⎢⎣ 5 ⎥⎦ ⎣ x 3 ⎦  *x* ⎣ ⎦ Convert the state  ⎣ 3 ⎦  space model into canonical form state space model. And also calculate the value of state transition matrix. (13) | BTL 3 | Applying |
| 14. | With the case study Summarize (i) Armature control of DC Motor  (ii) Field Control of DC Motor. And also draw the (i) Block diagram(ii) State diagram and state space model for the system.(13) | BTL 2 | Understanding |
| **PART – C** | | | |
| 1. | The state space model ⎡ . ⎤ ; ⎡ x1 ⎤  ⎢ *x*1 ⎥ ⎡ 0 1 0 ⎤ ⎡ *x*1 ⎤ ⎡ 0 ⎤ ⎢x ⎥  ⎢ *x*. ⎥  ⎢ 0 0 1 ⎥ ⎢ *x* ⎥  ⎢ 0 ⎥ *U* ⎢ 2 ⎥  ⎢ 2 ⎥ ⎢ ⎥ ⎢ 2 ⎥ ⎢ ⎥ ⎢ x ⎥  ⎢ . ⎥ ⎢⎣  1  5  6 ⎥⎦ ⎢ *x* 3 ⎥ ⎢⎣ 1 ⎥⎦ ⎣ 3 ⎦ The  *x* ⎣ ⎦  ⎣ 3 ⎦  desired poles are S=-2+4j,-2-j4,-1.0 with state feedback control law U=KX. Estimate the state feedback gain matrix K. (15) | BTL 5 | Evaluating |
| 2. | Develop the expression of (i) Controllability (ii) Observability concept by the following methods (i) Gilbert’s Method (ii) Kalman’s  Method. (15) | BTL 6 | Creating |
| 3. | The state space model for the system is given  ⎡ . ⎤  ⎢ *x*1 ⎥ ⎡ 0 1 0 ⎤⎡ *x*1 ⎤ ⎡0⎤ ⎡ x1 ⎤ ⎡ x1 ⎤  ⎢ . ⎥ ⎢ ⎥⎢ ⎥ ⎢ ⎥ ; ⎢x ⎥ y=[1 0 0] ⎢x ⎥  ⎢*x*2⎥  ⎢ 0 0 1 ⎥⎢*x*2⎥  ⎢0⎥*U* ⎢ 2 ⎥ ⎢ 2 ⎥  ⎢ . ⎥ ⎢⎣1  5  6⎥⎦⎢ *x* ⎥ ⎢⎣1⎥⎦ ⎢ x 3 ⎥ ⎢ x 3 ⎥  ⎢⎣ *x*3⎥⎦ ⎣ 3⎦ ⎣ ⎦ ⎣ ⎦ Check and  illustrate whether the given system is controllable and observable by any one of the method and check the duality of the system. (15) | BTL 3 | Applying |
| 4. | Consider a linear system described by the following transfer  function, *Y* (*S* )  10 .Design a feedback controller with  *U* (*S* ) *S* (*S* 1)(*S*  2)  a state feedback so that the closed loop poles are placed at  -2,-1+ j1. (15) | BTL 5 | Evaluating |