SIDDHARTHA INSTITUTE OF ENGINEERING AND TECHNOLOGY

Vision of the Institution [SIET]:

To be a pioneer institute and leader in engineering education whose primary concern would be the development of the human race and betterment of society through their knowledge, technological understanding and the spirit of progress.

Mission of the Institution [SIET]:

To create a conductive environment for student centric learning and industry institute interaction.
To integrate the state of the art infrastructure, facilities and cutting edge academic delivery.
To develop and nurture socially conscious technocrats through continuing education and research.

Department of Electrical and Electronics Engineering

Vision of the Department:

To produce the professionally competent graduates in the field of electrical and electronics engineering for addressing the challenges in industry and society

Mission of the Department:

1. To develop Institute Industry Interaction for collaborative research and entrepreneurial skills among the stake holders.
2. To offer high quality graduate program in Electrical and Electronics domain and to prepare students for professional career and higher studies.
3. To promote excellence in teaching, research and positive contributions to society.

PROGRAMME EDUCATIONAL OBJECTIVES (PEO's):-

1. To prepare students with excellent foundation in mathematics, basic sciences and engineering subjects to enable them to find employment or pursue higher studies.
2. To inculcate problem solving capabilities in students with analysis, design and practical skills which would facilitate them to innovate modern equipment for societal development
3. To have an understanding in the importance of lifelong and professional development with ethical values

PROGRAM SPECIFIC OUTCOMES (PSO's):-

1. To apply science, engineering, mathematics through differential and integral calculus, complex variables and to solve electrical engineering problems
2. To demonstrate proficiency in the use of software and hardware which are required to practice electrical engineering problems.

PROGRAM OUTCOMES (POS):

PO1: Engineering Knowledge: Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.

PO2: Problem Analysis: Identify, formulate, research literature and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences.

PO3: Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal and environmental considerations.

PO4: Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data and synthesis of information to provide valid conclusions.

PO5: Modern Tool Usage: Create, select and apply appropriate techniques, resources and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6: The Engineer and Society: Apply reasoning informed by contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice.

PO7: Environment and Sustainability: Understand the impact of professional engineering solutions in societal and environmental contexts and demonstrate knowledge of and need for sustainable development.

PO8: Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice.

PO9: Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams and in multi-disciplinary settings.

PO10: Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations and give and receive clear instructions.

PO11: Project Management and Finance: Demonstrate knowledge and understanding of engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12:Life-long Learning: Recognize the need for and have the preparation and ability to Engage in independent and life- long learning in the broadest context of technological Change.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

REVISED ACADEMIC CALENDAR (2018-19)

FOR NON-AUTONOMOUS CONSTITUENT& AFFILIATED COLLEGES

B. TECH. II, III & IV YEARS I & II SEMESTERS

I SEM

S. No	EVENT	DATE	Duration
12.	Commencement of Instruction	9th July 2018	--
13.	First Mid Term Examinations	4th to 6th Sept. 2018	--
14.	Submission of First Mid Term Exam Marks to University on or before	15th Sept. 2018	--
15.	Parent-Teacher Meeting	13th Oct. 2018	--
16.	Dussehra recess	15th to 20th Oct. 2018	1 week
17.	Last date of Instruction	10th Nov. 2018	16 weeks
18.	Second Mid Term Examinations	12th to 14th Nov. 2018	--
19.	Preparation Holidays and Practical Examinations	15th to 24th Nov. 2018	1 week
20.	Submission of Second Mid Term Exam Marks to University on or before	24th Nov. 2018	--
21.	End Semester / Supplementary Examinations	26th Nov. to 8th Dec. 2018	2 weeks
22.	Semester Break	10th to 15th Dec. 2018	1 week

II SEM

S. No	EVENT	DATE	Duration
11.	Commencement of Instruction	24th Dec. 2018	--
12.	First Mid Term Examinations	18th to 20th Feb. 2019	--
13.	Submission of First Mid Term Exam Marks to University on or before	27th Feb. 2019	--
14.	Parent-Teacher Meeting	9th March. 2019	--
15.	Last date of Instruction	20th April 2019	16 weeks
16.	Second Mid Term Examinations	22nd to 24th April 2019	--
17.	Preparation Holidays and Practical Examinations	25th April to 4th May 2019	1 week
18.	Submission of Second Mid Term Exam Marks to University on or before	2nd May 2019	--
19.	End Semester / Supplementary Examinations	6th to 18th May 2019	2 weeks
20.	Summer Vacation	20th May to 13th July 2019	8 weeks

17.12.18

DIRECTOR

ACADEMIC & PLANNING, JNTUH

COURSE INFORMATION SHEET

PROGRAMME: Electrical and Electronics Engineering	**DEGREE:** B.TECH
COURSE: CONTROL SYSTEMS	SEMESTER: **II B.Tech - II SEM** CREDITS: **4**
COURSE CODE: EE404ES **REGULATION:** R16	**COURSE TYPE:** CORE
CORRESPONDING LAB COURSE CODE (IF ANY):	**CONTACT HOURS: 4+1**(Tutorial) hours/Week.
LAB COURSE NAME: CONTROL SYSTEMS LAB	

SYLLABUS:

Unit	*Topic*	*Chapters*			*No of Classes*
I	**Introduction &Transfer Function Representation**	*Text book-1 &2, Reference Book 3*	*Chapter 1*		*34*
II	**Time Response Analysis**	*Text book-1 &2, Reference Book 3*	*Chapter 2*		*08*
III	**Stability Analysis,Root locus technique & Frequency response analysis**	*Text book-1 &2, Reference Book 3*	*Chapter 3*		*17*
IV	**Stability Analysis In Frequency Domain, Classical Control Design Techniques**	*Text book-1 &2, Reference Book 3*	*Chapter 4*		*09*
V	**State Space Analysis of Continuous Systems**	*Text book-1 &2, Reference Book 3*	*Chapter 5*		*06*
				Contact classes for syllabus coverage	**74**
				Tutorial classes	**5**
				Lectures beyond syllabus	**02**
				Special Descriptive Tests	**06**
				Remedial classes/NPTEL Classes	**03**
				Total No. of classes	**90**

Text Books (to be acquired by the Students)

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

B.TECH. ELECTRICAL AND ELECTRONICS ENGINEERING

COURSE STRUCTURE & SYLLABUS (2016 - 17)

II YEAR I SEMESTER

S. No.	Course Code	Course Title	L	T	P	C edits
1	MA301BS	Mathamatics – IV	4	1	0	4
2	EE302ES	Electromagnetic Fields	4	1	0	4
3	EE303ES	Electrical Machines-I	4	1	0	4
4	EE304ES	Network Theory	3	0	0	3
5	EE305ES	Electronic Circuits	3	0	0	3
6	EE306ES	Electrical Machines Lab - I	0	0	3	2
7	EC306ES	Electronic Devices & Circuits Lab	0	0	3	2
8	EE307ES	Networks Lab	0	0	3	2
9	*MC300ES	Environmental Science and Technology	3	0	0	0
		Total Credits	**21**	**3**	**9**	**24**

II YEAR II SEMESTER

S. No.	Course Code	Course Title	L	T	P	Credits
1	EC401ES	Switching heory & Logic Design	3	1	0	3
2	EE402ES	Power Systems - I	4	1	0	4
3	EE403ES	Electrical Machines – II	4	1	0	4
4	EE404ES	Control Systems	4	1	0	4
5	SM405MS	Business Economics and Financial Analysis	3	0	0	3
6	EE406ES	Control Systems Lab	0	0	3	2
7	EE407ES	Electrical Machines Lab - II	0	0	3	2
8	EE408ES	Electronic Circuits Lab	0	0	3	2
9	*MC400HS	Gender Sensitization Lab	0	0	3	0
		Total Credits	**18**	**4**	**12**	**24**

TIME TABLES

NAME:MR.S.RAJESH **WORK LOAD: 06**

SUB : II /II EEE -CONTROL SYSTEMS

Day/period	1	2	3	4		5	6	7
TIME	9.00am To 10.00am	10.00am To 10.50am	10.50am To 11.40am	11.40am To 12.30pm	12.20 PM TO 1.00 PM	1.10pm To 2.00pm	2.00pm To 2.50pm	2.50pm To 3.40pm
MON				CS				
TUE		CS			L			
WED	CS				U			
THU		CS			N			
FRI				CS	C			
SAT					H			

Signature of the Faculty

JNTU Syllabus Copy:

EE404ES: CONTROL SYSTEMS

B.Tech. II Year II Sem.

L	T	P	C
4	1	0	4

UNIT – I

Introduction: Concepts of Control Systems- Open Loop and closed loop control systems and their differences- Different examples of control systems- Classification of control systems, Feed-Back Characteristics, Effects of feedback. Mathematical models – Differential equations - Impulse Response and transfer functions - Translational and Rotational mechanical systems.

Transfer Function Representation: Transfer Function of DC Servo motor - AC Servo motor- Synchro transmitter and Receiver, Block diagram representation of systems considering electrical systems as examples - Block diagram algebra – Representation by Signal flow graph - Reduction using mason's gain formula.

UNIT-II

Time Response Analysis: Standard test signals - Time response of first order systems – Characteristic Equation of Feedback control systems, Transient response of second order systems - Time domain specifications – Steady state response - Steady state errors and error constants – Effects of proportional derivative, proportional integral systems

UNIT – III

Stability Analysis: The concept of stability - Routh stability criterion – qualitative stability and conditional stability.

Root Locus Technique: The root locus concept - construction of root loci-effects of adding poles and zeros to G(s) H(s) on the root loci.

Frequency Response Analysis: Introduction, Frequency domain specifications-Bode diagrams-Determination of Frequency domain specifications and transfer function from the Bode Diagram-Phase margin and Gain margin-Stability Analysis from Bode Plots.

UNIT - IV

Stability Analysis In Frequency Domain: Polar Plots, Nyquist Plots and applications of Nyquist criterion to find the stability - Effects of adding poles and zeros to G(s)H(s) on the shape of the Nyquist diagrams.

Classical Control Design Techniques: Compensation techniques – Lag, Lead, and Lead-Lag Controllers design in frequency Domain, PID Controllers.

UNIT – V

State Space Analysis of Continuous Systems: Concepts of state, state variables and state model, derivation of state models from block diagrams, Diagonalization- Solving the Time invariant state Equations- State Transition Matrix and its Properties.

TEXT BOOKS:

1. "I. J. Nagrath and M. Gopal", "Control Systems Engineering", New Age International (P) Limited, Publishers, 5th edition, 2009
2. "B. C. Kuo", "Automatic Control Systems", John wiley and sons, 8th edition, 2003.

REFERENCE BOOKS:

1. "N. K. Sinha", "Control Systems", New Age International (P) Limited Publishers, 3rd Edition, 1998.
2. "NISE", "Control Systems Engineering", John wiley, 6th Edition, 2011.
3. "Katsuhiko Ogata", "Modern Control Engineering", Prentice Hall of India Pvt. Ltd., 3rd edition, 1998.

CONTROL SYSTEMS– LESSION PLAN

S.No	Tentative Dates	Unit No.	Chapter	Topic to be covered	No. of Periods	Cumu lative	Teaching Aids	Actual Dates
1	27/12/18	I	INTRODUCT-ION AND BASIC CONCEPTS	Concepts of Control Systems Open Loop and closed loop control systems and their differences	2	2	Chalk & Talk	
2	28/12/18			Different examples of control systems	2	4	Chalk & Talk	
3	02/01/19			Mathematical model	1	5	Chalk & Talk	
4	03/01/19			Mechanical Translational systems & Problems related	2	7	Chalk & Talk	
5	04/01/19			Mechanical Rotational systems & Problems related	2	9	Chalk & Talk	
6	07/01/19			Feed-Back Characteristics, Effects of feedback.	2	11	Chalk & Talk	
7	09/01/19			F-V, F-I, T-V, T-I Analogies	1	12	Chalk & Talk	
8	10/01/19			Problem on mechanical rotational system	2	14	Chalk & Talk	
9	11/01/19			Problem on Translational system	1	15	Chalk & Talk	
10	21/01/19		TRANSFER FUNCTION REPRESENT-ATION	Transfer Function of Armature controlled & Field controlled DC Servo motor	2	17	Chalk & Talk	
11	23/01/19			AC Servo motor-Transfer Function	2	19	Chalk & Talk	
12	02/01/19			Synchro Transmitter and Receiver	2	21	Chalk & Talk	
13	24/01/19			Block diagram representation of systems considering electrical systems as examples	2	23	Chalk & Talk	
14	28/01/19			Block diagram algebra	2	25	Chalk & Talk	
15	29/01/19			Representation by Signal flow graph	2	27	Chalk & Talk	
16	30/01/19			Reduction using Mason's gain formula.	3	30	Chalk & Talk	
17	31/01/19			Problems Related	4	34	Chalk & Talk	
18	01/02/19	II	TIME RESPONSE ANALYSIS	Standard test signals - Time response of first order systems	2	36	Chalk & Talk	
19	04/02/19			Characteristic Equation of Feedback control systems	1	37	Chalk & Talk	
20	05/02/19			Transient response of second order systems	1	38	Chalk & Talk	
21	07/02/19			Time domain specifications – Steady state response	1	39	Chalk & Talk	
22	08/02/19			Steady state errors and error constants	2	41	Chalk & Talk	
23	09/02/19			Effects of proportional derivative, proportional integral systems.	1	42	Chalk & Talk	

24	11/02/19	III	STABILITY ANALYSIS IN S-DOMAIN	The concept of stability – Routh's stability criterion, limitations of Routh's stability	2	43	Chalk & Talk	
25	12/02/19			Qualitative stability and conditional stability	2	45	Chalk & Talk	
26	13/02/19		ROOT LOCUS TECHNIQUE	The root locus concept	1	46	Chalk & Talk	
27	14/02/19			Construction of root loci-effects of adding poles and zeros to G(s) H(s) on the root loci.	2	48	Chalk & Talk	
28	01/03/19			Problems Related root locus	3	51	Chalk & Talk	
29	05/03/19		FREQUENCY RESPONSE ANALYSIS	Introduction, Frequency domain specifications	2	53	Chalk & Talk	
30	07/03/19			Bode diagrams-Determination of Frequency domain specifications and transfer function from the Bode Diagram	3	56	Chalk & Talk	
31	13/03/19			Phase margin and Gain margin-Stability Analysis from Bode Plots. Problems Related.	3	59	Chalk & Talk	
32	18/03/19	IV	STABILITY ANALYSIS IN FREQUENCY DOMAIN	Polar Plots	2	61	Chalk & Talk	
33	22/03/19			Nyquist Plots and applications of Nyquist criterion to find the stability	2	63	Chalk & Talk	
34	25//03/19			Effects of adding poles and zeros to G(S) H(S) on the shape of the Nyquist diagrams	2	65	Chalk & Talk	
35	28/03/19		CLASSICAL CONTROL DESIGN TECHNIQUES	Compensation techniques-Lag, Lead and Lead-Lag Controllers design in frequency Domain	2	67	Chalk & Talk	
36	01/04/19			PID controllers	1	68	Chalk & Talk	
37	04/04/19	V	STATE SPACE ANALYSIS OF CONTINOUS SYSTEMS	Concepts of state, State variables and state model	1	69	Chalk & Talk	
38	08/04/19			Derivation of state models form block diagrams	2	71	Chalk & Talk	
39	10/04/19			Diagonalization-Solving the time invariant state equations	1	72	Chalk & Talk	
40	11/04/19			State Transition Matrix and its Properties	2	74	Chalk & Talk	
		TOTAL HOURS				74		
		Tutorial Classes				5		
		Descriptive Tests				5		
		Classes for beyond syllabus				2		
		Remedial Classes				4	Grand Total=90	

Signature of Faculty

Signature of HOD

COURSE OBJECTIVES:

Course Name: Control Systems (EE404ES) for academic year 2018-19 (II-II)

1. To understand the different ways of system representations such as Transfer function representation and state space representations and to assess the system dynamic response.
2. To assess the system performance using time domain analysis and methods for improving it
3. To assess the system performance using frequency domain analysis and techniques for improving the performance
4. To design various controllers and compensators to improve system performance

COURSE OUTCOMES

Course Name: Control Systems (EE404ES) for academic year 2018-19 (II-II)

ITEM	S.No.	DESCRIPTION	PO MAPPING
EE404ES4.1	1	Improve the system performance by selecting a suitable controller and/or a compensator for a specific application	
EE404ES4.2	2	Apply various time domain and frequency domain techniques to assess the system performance	
EE404ES4.3	3	Apply various control strategies to different applications (Example: Power systems, Electrical drives etc…)	
EE404ES4.4	4	Test system Controllability and Observability using state space representation and applications of state space representation to various systems	
EE404ES4.5	5	Develop an algorithm to build a transfer function using mathematical tools such as state space analysis	

Mapping of program educational objectives (PEO's) , program outcomes (PO) program specific objectives (PSO) for electrical and Electronics engineering

Course Name: Control Systems (EE404ES) for academic year 2018-19 (II-II)

Course Outocmes (CO's)	PROGRAM OUTCOMES (PO)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
EE404ES4.1	3	2	3	2	3	1	2	-	1	-	2	3
EE404ES4.2	3	3	3	3	2	-	2	-	-	1	2	3
EE404ES4.3	3	3	3	3	3	3	3	-	-	1	1	3
EE404ES4.4	3	2	3	2	3	1	1	-	1	-	2	3
EE404ES4.5	3	3	3	2	3	2	1	-	1	1	2	3
Average	3	2.6	3	2.4	2.8	1.4	1.8	-	0.6	0.6	1.8	3

Course Outocmes (CO's)	PEO1	PEO2	PEO3
EE404ES4.1	3	3	2
EE404ES4.2	3	3	2
EE404ES4.3	3	3	2
EE404ES4.4	3	3	2
EE404ES4.5	3	3	3
Average	3	3	2.2

Course Outocmes (CO's)	PROGRAM SPECIFIC OUTCOMES (PSO'S)	
	PSO1	PSO2
EE404ES4.1	3	3
EE404ES4.2	3	3
EE404ES4.3	3	3
EE404ES4.4	3	3
EE404ES4.5	3	3
Average	3	3

B.Tech II-II

Electrical and Electronics Engineering

Control Systems (R16-Regulation)

Unit – I

2 to 3 MARKS QUESTIONS

1. Explain the basic components of a control systems
2. Explain the classification of control systems with examples
3. What do you mean by open loop and closed control system ? Give its examples
4. State the advantages and drawbacks of open loop and closed loop control system
5. Explain the operation fo ordinary traffic signals which control the automobile traffic at road way intersections. Why are they open loop system
6. Explain the the different applications of closed loop and open loop system.
7. Explain the the temperature control system using open loop as well as closed loop system approach.Explain the difference between open loop and closed loop systems with examples
8. Write a note on servomechanism
9. Define transfer function and state its advantages and limitations
10. Derive the relation between impulse reponse and transfer function
11. Define and explain the following terms related to the transfer function of a system
    a) Poles b) Zeros c) Characteristic equation D) Pole-Zero plot V) order
12. What is mathematical modeling and state is importance
13. Expain translator and rotarty elements of mechanical systems
14. What are the types of forces which resist the mechanical motion explain
15. Explain the force-voltage and force-current analogies form basics

5 MARKS QUESTIONS

16. State the requirements of good servomotors? Explain the application of AC and DC servomotors
17. Write a note on DC and AC servo motor and mention its applications
18. Derive the armature controlled and field control transfer function of DC and AC servo motors and develop the block diagrams
19. How AC servomotor is different than normal induction motor? Sketch its torque-speed characteristics and explain its working
20. Explain the difference between AC servomotor and DC servomotor
21. With the help of neat sketches, explain the construction and working principle of synchro transmister and receiver
22. Explain the use of synchros as an error detector
23. Explain the importance of block diagram represantain and explain the rules of block diagram reduction
24. What is signal flow graph? Explain with an example
25. State the properties of signal flow graph
26. Define the following terms with respect to signal flow graph
    a) Forward path b)Dummy node c) Non-touching loop d) Loop gain e) sourec and sink node f) Chain node g)self loop h) transmittance i) node and Branch
27. Explain how to construc signal flow graph from give sutable example for each
    a) Set of equations b) Block diagram
28. State and explain Mason's gain formula for the signal flow graph and explain the need of it.
29. Compare block diagram representation with signal flow graph representation
30. Explain the advantages of signal flow graph over block diagram reduction technique
31. Explain the procedure to obtain blockdiagram from the signal flow graph
32. Discuss the effect of feedback on control system
33. Why feedback is introduced in control systems how it improves the performance of the system
34. Explain the effect of feed back on the sensitivity of a closed loop system
35. What is sensititity explain it with respect to open loop and closed loop systems
36. What are the characteristics of feedback systems

a

Unit- II

2 to 3 MARKS QUESTIONS

1. What is the difference between steady state response and transient response of a control system?
2. Define time response and explain stead state and transient response
3. What are the standard test signalsused in the analysis of control systems? Explain briefly
4. Define stady state error
5. Derive the expression of steady state error for a simple closed loop system
6. What is teady stae error? How steady state error can be determined?
7. What are static error coefficients / Derive the formula for each. How they are related to the steady state error?
8. Explain the static error coefficients. Derive their expressions
9. What is the difference between type and order of a system
10. Show that the steady state error becomes zero when type of the system increases

5 MARKS QUESTIONS

11. Define three error constants. Express steady state error in terms of error constants of type-0,type-1 and type-2 systems
12. State the limitations of static error coefficient method
13. Explain the significance of generalized error series
14. Define time contant. What is its importance?
15. Explain the effect of dampling ratio or constant on the system response
16. Draw the response of system for $\zeta=0$, $\zeta=1$, $\zeta>0$, $\zeta<0$,$0<\zeta<0$
17. With the help of graphical p[lot explain the significance of damping ratio for its various values
18. What is damping ratio. Show the locations of roots in s-plane for second order system for various values of damping ratio.
19. Derive and draw the transient response of underdamped ,undamped,critically damped,overdameped second order system when excited by unit step input
20. Define various time domain specifications
21. Explain and derive the formule of the rise time, peak time, settling time and peak overshoot with respect to unit step response of a prototype second order system for a unit step input
22. Explain the effect of PI and PD control on the performance of control system
23. What are the various types of controllers ? Explain them in brief
24. Why derivative controller alone is not used in the control system.

Unit-III

2 to 3 MARKS QUESTIONS

1. Define the term stability and hence define stable, unstable, marginally or criticall satable , relativel stable, asymptotic stable and conditionally stable systems
2. How the roots of characteristic equation are related to stability
3. Compare absolute stability and relative stability
4. State and explain Routh's stability criteriaon
5. What is the relation between the stability and coefficients of characteristic polynomial.

6. Explain the difficulties in Routh-Hurwitz's criterion. How to overcome themHow routh's criterion can be used to obtain the range of values of K required for the system stabiltity
7. State the advanatages and dis avantages of routh's array method
8. Difine root locus and explain the anle and magnitude condition of the root locus
9. Explain the various rules to sketch the root locus
10. State the rules for finding out the root locus on the ral axis
11. What is breakway and break in points ? How to dermine them
12. What is centroid How to calculate it
13. Define the asymptotes and why they are necessary in root louse and how can we find out
14. Explain the general procedure to construct the root locus of a system

5 MARKS QUESTIONS

15. What are the effects adding open loop poles and zero on the nature of the root locus and on the system
16. State the advantages of root locus
17. What is frequency reponse. What are the advantages of frequency domain analysis
18. Explain the frequency domain specifications and derive their formule
19. Derive the expression for resonant peak and resonant frequency and hence establish the correlation between time domine and frequency domain response.
20. Define bandwidth and derive the expression for bandwidth of a standared second order system
21. Discuss the nature of bode plots of

    a) Pole at the origin b) simple pole c) simple zero d) Quadratic pole
22. What are asymptotic bode plot? How correction can be applied to obtain accurate bode plot
23. Write a note on determination of range of K form the bode plot
24. Show that in the Bode magnitude plot the slope corresponding to a quadratic factor is -40 db/dec
25. Explain the significance of the bode plot in the stability anlaysis of control systems
26. Show that in case of a quadratic factor the phase angle is fuction of frequency as well as damping ratio
27. Show that bode plots of a system transfer function having many factors can be obtained by adding the bode plots of individual factors
28. Define gain crossoer frequency, Phase crossover frequency, gain margin and phase margin,cut-off rate ,band width
29. How to obtain gain margin and phase margin form bode plot How the stability of a system can be predicted form gain margin and phase margin.
30. Explain the steps for the constructin of bode plots
31. Disscuss the general procedure of determination of transfer function from bode plot

Unit – IV

2 TO 3 MARKS QUESTIONS

1. Define and explain polar plot
2. Explain how type of the system determines the shape of the polar plot
3. Discuss the effect of adding one pole and one zero simultaneously and separatel to a transfer function on the polr plot
4. How to obtain wgc and wpc from polar plot
5. Define analytic function and singularities

6. State and explain principle of argument
7. With respect to a function q(s): "Every s-plane countour which which does not pass through any singular points of q(s) has a corresponding contour in q(s) plane" Elaborate
8. What is Nyquist contour?
9. How do you select a Nyquist contour when there are poles on the imaginary axis in stability analysis of a given system
10. Explain the steps for the contruyction of Nysquist plot
11. Explain the method of determination of range of K for stability form Nyquist plot
12. Write a note on advantages of Nyquist plot
13. Explain what is conpenstion and why is it required in control system.Describe the different types of compensation schemes
14. Which are the important electrical networks used paractically for the compensation of the control systems

5 MARKS QUESTIONS

15. Explain the steps to design the lead compensator using the bode plot
16. What is lead compensator? Obtain its transfer function and sketch its pole-zero plot also sketch its bode plot
17. Locate the oples and zeros aof lead network and sketch their polar plots and bode plot
18. Derive athe relation between Φm and α for the lead compensatorWhat is lead-lag compensator obtain its transfer function
19. Explain the procedure to design tohe lead –lag compensator in frequency domain
20. Locate the ples and zeros aof lead –lag network and sketch its magnitude bode plot
21. Draw and explain the polar plot of lag lead network

UNIT-V

1. State the advantages and limitations of state variable approach
2. Discuss the significanace of state space analysis
3. Define and explain the following terms
   a) State variables b) state vector c) state trajectory d) state e) state space
4. Develop the state model of linear time invariant equation
5. Explain the state variable and state transition equation
6. Define what state transition matrix and modal matrix and mention its uses
7. Obtain the state model of armature controlled and field controlled DC servo motor
8. Show that the state model is not a unique property
9. Explain the state space representation using phase variables .
10. State advantages and limitations of state space representation
11. Explain the foster's form of state space representation state the features of matrix-A
12. Explain the state space representation using jordan's canonical form
13. Explain the state model using cascade programming . state the features of matrix AExplain the derivation of transfer function from the state model.
14. Obtain the solution of a state mode and hence define state transition matrix
15. State the properties of state transition matrix
16. Explain the laplace transorm method for finding the state transition matrix
17. Obtain the solution of non-homogeneous state equation using laplace ransform method
18. State and explain the controllability and observability tests
19. Define controllability and observabiltiy

OBJECTIVE TYPES QUESTIONS
CONTROL SYSTEMS

1. In an open loop control system
(a) Output is independent of control input
(b) Output is dependent on control input
(c) Only system parameters have effect on the control output
(d) None of the above

Ans: a

2. For open control system which of the following statements is incorrect ?
(a) Less expensive
(b) Recalibration is not required for maintaining the required quality of the output
(c) Construction is simple and maintenance easy
(d) Errors are caused by disturbances

Ans: b

3. A control system in which the control action is somehow dependent on the output is known as
(a) Closed loop system
(b) Semiclosed loop system
(c) Open system
(d) None of the above

Ans: a

4. In closed loop control system, with positive value of feedback gain the overall gain of the system will
(a) decrease
(b) increase
(c) be unaffected
(d) any of the above

Ans: a

5. Which of the following is an open loop control system ?
(a) Field controlled D.C. motor
(b) Ward leonard control
(c) Metadyne
(d) Stroboscope

Ans: a

6. Which of the following statements is not necessarily correct for open control system ?
(a) Input command is the sole factor responsible for providing the control action
(b) Presence of non -linearities causes malfunctioning
(c) Less expensive
(d) Generally free from problems of non-linearities

Ans: b

7. In open loop system
(a) the control action depends on the size of the system
(b) the control action depends on system variables (c)
the control action depends on the input signal
(d) the control action is independent of the output

Ans: d

8 has tendency to oscillate.
(a) Open loop system
(b) Closed loop system
(c) Both (a) and (b)

Ans:(d) bNeither (a) nor (b)

9. A good control system has all the following features except
(a) good stability
(b) slow response
(c) good accuracy

Ans:(d) bsufficient power handling capacity

10. A car is running at a constant speed of 50 km/h, which of the following is the feedback element for the driver ?
(a) Clutch
(b) Eyes
(c) Needle of the speedometer
(d) Steering wheel

Ans:(e) cNone of the above

11. The initial response when the output is not equal to input is called
(a) Transient response
(b) Error response
(c) Dynamic response

Ans:(d) aEither of the above

12. A control system working under unknown random actions is called
(a) computer control system
(b) digital data system
(c) stochastic control system

Ans:(d) cadaptive control system

13. An automatic toaster is a _____ loop control system.
(a) open
(b) closed
(c) partially closed

Ans:(d) aany of the above

14. Any externally introduced signal affecting the controlled output is called a
(a) feedback
(b) stimulus
(c) signal

Ans:(d) bgain control

15. A closed loop system is distinguished from open loop system by which of the following ?
(a) Servomechanism
(b) Feedback
(c) Output pattern

Ans:(d) bInput pattern

16 is a part of the human temperature control system.
(a) Digestive system
(b) Perspiration system
(c) Ear

Ans:(d) bLeg movement

17. By which of the following the control action is determined when a man walks along a path ?
(a) Brain
(b) Hands
(c) Legs

Ans:(d) dEyes

18 is a closed loop system.
(a) Auto-pilot for an aircraft
(6) Direct current generator
(c) Car starter

Ans:(d) aElectric switch

19. Which of the following devices are commonly used as error detectors in instruments ?

(a) Vernistats

(b) Microsyns
(c) Resolvers

Ans:(d) dAny of the above

20. Which of the following should be done to make an unstable system stable ?
(a) The gain of the system should be decreased
(b) The gain of the system should be increased
(c) The number of poles to the loop transfer function should be increased
(d) The number of zeros to the loop transfer function should be increased

Ans: b

21 increases the steady state accuracy.
(a) Integrator
(b) Differentiator
(c) Phase lead compensator

Ans:(d) aPhase lag compensator

22. A.C. servomotor resembles
(a) two phase induction motor
(b) Three phase induction motor
(c) direct current series motor

Ans:(d) auniversal motor

23. As a result of introduction of negative feedback which of the following will not decrease ?
(a) Band width
(b) Overall gain
(c) Distortion

Ans:(d) aInstability

24. Regenerative feedback implies feedback with
(a) oscillations
(b) step input
(c) negative sign

Ans:(d) dpositive sign

25. The output of a feedback control system must be a function of
(a) reference and output
(b) reference and input
(e) input and feedback signal
(d) output and feedback signal

Ans: a

26 is an open loop control system.
(a) Ward Leonard control
(b) Field controlled D.C. motor
(c) Stroboscope

Ans:(d) bMetadyne

27. A control system with excessive noise, is likely to suffer from
(a) saturation in amplifying stages
(b) loss of gain
(c) vibrations

Ans:(d) aoscillations

28. Zero initial condition for a system means
(a) input reference signal is zero
(b) zero stored energy
(c) ne initial movement of moving parts
(d) system is at rest and no energy is stored in any of its components

Ans: d

29. Transfer function of a system is used to calculate which of the following ?
(a) The order of the system
(b) The time constant
(c) The output for any given input

Ans:(d) cThe steady state gain

30. The band width, in a feedback amplifier.
(a) remains unaffected
(b) decreases by the same amount as the gain increase
(c) increases by the sane saaaajajt as the gain decrease
(d) decreases by the same amount as the gain decrease

Ans: c

31. On which of the following factors does the sensitivity of a closed loop system to gain changes and load disturbances depend ?
(a) Frequency
(b) Loop gain
(c) Forward gain

Ans:(d)Alld of the above

32. The transient response, with feedback system,

(a) rises slowly
(b) rises quickly
(c) decays slowly

Ans:(d)decaysd quickly

33. The second derivative input signals modify which of the following ?
(a) The time constant of the system
(b) Damping of the system
(c) The gain of the system
(d) The time constant and suppress the oscillations

Ans:(e)Noned of the above

34. Which of the following statements is correct for any closed loop system ?
(a) All the co-efficients can have zero value
(6) All the co-efficients are always non-zero
(c) Only one of the static error co-efficients has a finite non-zero value

Ans:(d)Nonec of the above

35. Which of the following statements is correct for a system with gain margin close to unity or a phase margin close to zero ?
(a) The system is relatively stable
(b) The system is highly stable
(c) The system is highly oscillatory

Ans:(d) cNone of the above

36. Due to which of the following reasons excessive bond width in control systems should be avoided ?
(a) It leads to slow speed of response
(b) It leads to low relative stability
(c) Noise is proportional to band width

Ans:(d) cNone of the above

37. In a stable control system backlash can cause which of the following ?
(a) Underdamping
(b) Overdamping
(c) Poor stability at reduced values of open loop gain

Ans:(d) dLow-level oscillations

38. In an automatic control system which of the following elements is not used ?

(a) Error detector

(b) Final control element
(c) Sensor

Ans:(d) dOscillator

39. In a control system the output of the controller is given to
(a) final control element
(b) amplifier
(c) comparator
(d) sensor

Ans:(e) anone of the above

40. A controller, essentially, is a
(a) sensor
(b) clipper
(c) comparator

Ans:(d) camplifier

41. Which of the following is the input to a controller ?
(a) Servo signal
(b) Desired variable value
(c) Error signal

Ans:(d) Sensed signal

42. The on-off controller is a ____ system.
(a) digital
(b) linear
(c) non-linear

Ans:(d) discontinuous

43. The capacitance, in force-current analogy, is analogous to
(a) momentum
(b) velocity
(c) displacement

Ans:(d) dmass

44. The temperature, under thermal and electrical system analogy, is considered analogous to
(a) voltage
(b) current
(c) capacitance

(d) charge

Ans:(e) anone of the above

45. In electrical-pneumatic system analogy the current is considered analogous to
(a) velocity
(b) pressure
(c) air flow

Ans:(d) dair flow rate

46. In liquid level and electrical system analogy, voltage is considered analogous to
(a) head
(b) liquid flow
(c) liquid flow rate

Ans:(d) anone of the above

47. The viscous friction co-efficient, in force-voltage analogy, is analogous to
(a) charge
(b) resistance
(c) reciprocal of inductance
(d) reciprocal of conductance

Ans:(e) bnone of the above

48. In force-voltage analogy, velocity is analogous to
(a) current
(b) charge
(c) inductance

Ans:(d) acapacitance

49. In thermal-electrical analogy charge is considered analogous to
(a) heat flow
(b) reciprocal of heat flow
(c) reciprocal of temperature
(d) temperature

Ans:(e) dnone of the above

50. Mass, in force-voltage analogy, is analogous to
(a) charge
(b) current
(c) inductance
(d) resistance

Ans: c

51. The transient response of a system is mainly due to
(a) inertia forces
(b) internal forces
(c) stored energy

Ans:(d)frictionc

52 signal will become zero when the feedback signal and reference signs are equal.
(a) Input
(b) Actuating
(c) Feedback

Ans:(d)Referenceb

53. A signal other than the reference input that tends to affect the value of controlled variable is known as
(a) disturbance
(b) command
(c) control element

Ans:(d)referencea input

54. The transfer function is applicable to which of the following ?
(a) Linear and time-in variant systems
(b) Linear and time-variant systems
(c) Linear systems
(d) Non-linear systems

Ans:(e) aNone of the above

55. From which of the following transfer function can be obtained ?
(a) Signal flow graph
(b) Analogous table
(c) Output-input ratio
(d) Standard block system

Ans:(e) aNone of the above

56 is the reference input minus the primary feedback.
(a) Manipulated variable
(b) Zero sequence
(c) Actuating signal

Ans:(d) cPrimary feedback

57. The term backlash is associated with
(a) servomotors
(b) induction relays
(c) gear trains

Ans:(d) any of the above

58. With feedback ____ increases.
(a) system stability
(b) sensitivity
(c) gain

Ans:(d) aeffects of disturbing signals

59. By which of the following the system response can be tested better ?
(a) Ramp input signal
(b) Sinusoidal input signal
(c) Unit impulse input signal

Ans:(d) cExponentially decaying signal

60. In a system zero initial condition means that
(a) The system is at rest and no energy is stored in any of its components
(b) The system is working with zero stored energy
(c) The system is working with zero reference signal

Ans: a

61. In a system low friction co-efficient facilitates

(a) reduced velocity lag error (b) increased

velocity lag error (c) increased speed of response

Ans:(d) areduced time constant of the system

62. Hydraulic torque transmission system is analog of
(a) amplidyne set
(b) resistance -capacitance parallel circuit
(c) motor-generator set

Ans:(d) any of the above

63. Spring constant in force-voltage analogy is analogous to
(a) capacitance
(b) reciprocal of capacitance
(c) current

Ans:(d)resistanceb

64. The frequency and time domain are related through which of the following?
(a) Laplace Transform and Fourier Integral
(b) Laplace Transform
(c) Fourier Integral

Ans:(d)Eithera (b) or (c)

65. An increase in gain, in most systems, leads to
(a) smaller damping ratio
(b) larger damping ratio
(c) constant damping ratio

Ans:(d)nonea of the above

66. Static error co-efficients are used as a measure of the effectiveness of closed loop systems for specified _______ input signal.
(a) acceleration
(b) velocity
(c) position

Ans:(d)alld of the above

67. A conditionally stable system exhibits poor stability at
(a) low frequencies
(b) reduced values of open loop gain
(c) increased values of open loop gain

Ans:(d) bnone of the above

68. The type 0 system has _____ at the origin.
(a) no pole
(b) net pole
(c) simple pole
(d) two poles

Ans:(e)nonea of the above

69. The type 1 system has _____ at the origin.
(a) no pole
(b) net pole
(c) simple pole

Ans:(d)twoc poles

70. The type 2 system has at the origin.

(a) no net pole
(c)(b) simplenetpolepole

Ans:(d)twod poles

(a)71. constant,Thepositionconstantandvelocity errors of a

type-2 system are (b) constant, infinity

(d)(c) zero,zero, constantzero

Ans: c

72. Velocity error constant of a system is measured when the input to the system is unit ______ function.
(a) parabolic
(b) ramp
(c) impulse

Ans:(d)stepb

73. In case of type-1 system steady state acceleration is
(a) unity
(b) infinity
(c) zero

Ans:(d)10b

74. If a step function is applied to the input of a system and the output remains below a certain level for all the time, the system is
(a) not necessarily stable
(b) stable
(c) unstable
(d) always unstable

Ans:(e)anya of the above

75. Which of the following is the best method for determining the stability and transient response ?
(a) Root locus
(b) Bode plot
(c) Nyquist plot

Ans:(d)Nonea of the above

76. Phase margin of a system is used to specify which of the following ?
(a) Frequency response
(b) Absolute stability
(c) Relative stability

Ans:(d)Timec response

77. Addition of zeros in transfer function causes which of the following ?
(a) Lead-compensation
(b) Lag-compensation
(c) Lead-lag compensation

Ans:(d) bNone of the above

78. technique is not applicable to nonlinear system ?
(a) Nyquist Criterion
(b) Quasi linearization
(c) Functional analysis

Ans:(d) aPhase-plane representation

79. In order to increase the damping of a badly underdamped system which of following compensators may be used ?
(a) Phase-lead
(b) Phase-lag
(c) Both (a) and (b)
(d) Either (a) and (b)

Ans:(e) aNone of the above

80. The phase lag produced by transportation relays
(a) is independent of frequency
(b) is inverseh'proportional to frequency
(c) increases linearly with frequency

Ans:(d) cdecreases linearly with frequency

81. In a stable control system saturation can cause which of the following ?
(a) Low-level oscillations
(b) High-level oscillations
(c) Conditional stability

Ans:(d) aOverdamping

82. Which of the following can be measured by the use of a tacho-generator ?

(a) Acceleration
(b) Speed
(c) Speed and acceleration
(d) Displacement

Ans:(e) bNone of the above

83 is not a final control element.
(a) Control valve
(b) Potentiometer
(c) Electro-pneumatic converter

Ans:(d) bServomotor

84. Which of the following is the definition of proportional band of a controller ?
(a) The range of air output as measured variable varies from maximum to minimum
(b) The range of measured variables from set value
(c) The range of measured variables through which the air output chan¬ges from maximum to minimum
(d) Any of the above

Ans:(e) cNone of the above

85. In pneumatic control systems the control valve used as final control element converts
(a) pressure signal to electric signal
(b) pressure signal to position change
(c) electric signal to pressure signal
(d) position change to pressure signal

Ans:(e) bnone of the above

86. Pressure error can be measured by which of the following ?
(a) Differential bellows and straingauge
(b) Selsyn
(c) Strain gauge

Ans:(d) aStrain gauge and potentiometer

87. Which of the following devices is used for conversion of co-ordinates ?
(a) Microsyn
(b) Selsyn
(c) Synchro-resolver

Ans:(d) cSynchro-transformer

88. The effect of error damping is to
(a) provide larger settling lime
(b) delay the response
(c) reduce steady state error
(d) any of the above

Ans:(e) cnone of the above

89 technique gives quick transient and stability response
(a) Root locus
(b) Bode
(c) Nyquist

Ans:(d) aNichols

90. A phase lag lead network introduces in the output
(a) lag at all frequencies
(b) lag at high frequencies and lead at low frequencies
(c) lag at low frequencies and lead at high frequencies

Ans:(d) cnone of the above

91. Which of the following is the non-linearity caused by servomotor ?
(a) Static friction
(b) Backlash
(c) Saturation

Ans:(d) cNone of the above

92 can be extended to systems which are time-varying ?
(a) Bode-Nyquist stability methods
(b) Transfer functions
(c) Root locus design

Ans:(d) dState model representatives

93. When the initial conditions of a system are specified to be zero it implies that the system is
(a) at rest without any energy stored in it
(b) working normally with reference input
(c) working normally with zero reference input

Ans:(d) dat rest but stores energy

94. Which of the following is an electromechanical device ?
(a) Induction relay

(b) Thermocouple
(d)(c) LVDTAnyof the above

Ans:(e) cNone of the above

(a)95. reducesAdifferentiatordampingis usually not a part of a control system because it (b) reduces the gain margin

(c) increases input noise
Ans:(d) cincreases error

96. If the gain of the critical damped system is increased it will behave as

(a) oscillatory
(c)(b) overdampedcriticallydamped

(d) underdamped
Ans:(e) dnone of the above

97. In a control system integral error compensation ______ steady state error

(a) increases
(c)(b) doesminimizesnothave any effect on

Ans:(d) bany of the above

98. With feed back ____ reduces.
(6)(a) systemsystem stabilitygain

(c) system stability and gain
Ans:(d) bnone of the above

99. An amplidyne can give which of the following characteristics ?

(a) Constant current
(c)(b) ConstantConstantcurrentvoltageas well as constant voltage

(e)(d) ConstantNoneofthecurrent,aboveconstant voltage

and constant power Ans: d

100. Which of the following can be measured byLVDT?

(b)(a) DisplacementVelocity

(c) Acceleration

Ans:(d) dAny of the above

101 directly converts temperature into voltage.
(a) Thermocouple
(b) Potentiometer
(c) Gear train
(d) LVDT

Ans:(e) aNone of the above

102. The transfer function technique is considered as inadequate under which of the following conditions ? (a) Systems having complexities and non-linearities
(b) Systems having stability problems
(c) Systems having multiple input dis¬turbances

Ans:(d) dAll of the above

103. Which of the following is the output of a thermocouple ?
(a) Alternating current
(b) Direct current
(c) A.C. voltage
(d) D.C. voltage

Ans:(e) dNone of the above

104. A.C. servomotor is basically a
(a) universal motor
(b) single phase induction motor
(c) two phase induction motor

Ans:(d) cthree phase induction motor

105. The first order control system, which is well designed, has a
(a) small bandwidth
(b) negative time constant
(c) large negative transfer function pole

Ans:(d) cnone of the above

106. Which of the following is exhibited by Root locus diagrams ?
(a) The poles of the transfer function for a set of parameter values
(b) The bandwidth of the system
(c) The response of a system to a step input
(d) The frequency response of a system

Ans: A

Code No: 134AM

R16

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
B.Tech II Year II Semester Examinations, April - 2018
CONTROL SYSTEMS
(Common to EEE, ECE, EIE)

Time: 3 Hours **Max. Marks: 75**

Note: This question paper contains two parts A and B.
Part A is compulsory which carries 25 marks. Answer all questions in Part A.
Part B consists of 5 Units. Answer any one full question from each unit.
Each question carries 10 marks and may have a, b, c as sub questions.

PART- A

(25 Marks)

1.a) Write the Manson's gain formula. [2]
b) What are the basic properties of SFG? [3]
c) What are the standard test signals used in control systems? [2]
d) Distinguish between type and order of a system. [3]
e) Define a stable system. [2]
f) Explain the basics of root locus plot. [3]
g) What is polar plot? [2]
h) Define gain and phase margins. [3]
i) What is state diagram? [2]
j) Mention any four advantages of state variable representation. [3]

PART-B

(50 Marks)

2.a) Compare the AC and DC servomotors.
b) For the system represented by the block diagram shown in figure 1. Find $\frac{C}{R}$. [4+6]

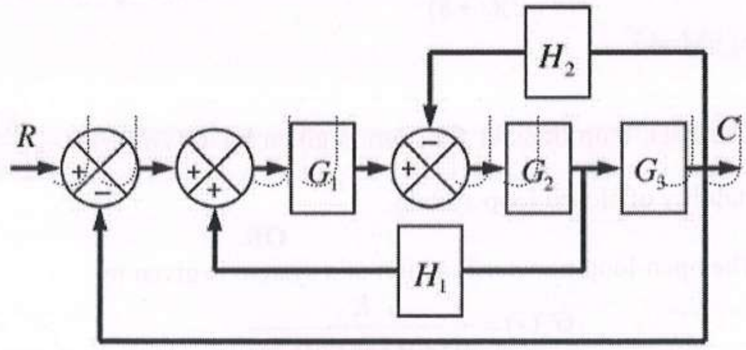


Figure: 1

OR

3.a) What are the characteristics of servomotors?

b) Find the overall gain $\frac{C(s)}{R(s)}$ for the signal flow graph shown in figure 2. [4+6]

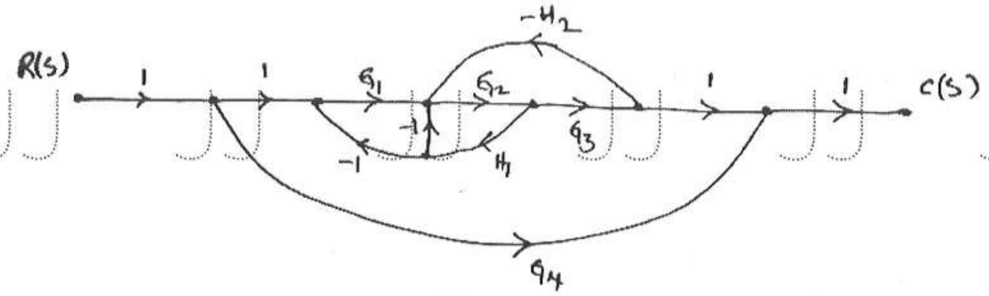


Figure: 2

4. The open-loop transfer function of a unity feedback control system is given by $G(s)=\frac{9}{s(s+3)}$. Find the natural frequency of response, damping ratio, damped frequency and time constant. [10]

OR

5. For unity feedback control system the open loop transfer function, $G(s)=\frac{10(s+2)}{s^2(s+4)}$.

Find the e_{ss} when the input is $r(t)=3-2t+3t^2$. And find K_p, K_v, and K_a. [10]

6.a) Determine the RH stability of given characteristic equation, $s^4+8s^3+18s^2+16s+5=0$.

b) Sketch the root locus of the system, whose open loop transfer function is,

$G(s)=\frac{K(s+15)}{s(s+1)(s+5)}$ [4+6]

OR

7. Given $G(s)=\frac{Ke^{-0.2s}}{s(s+2)(s+8)}$. Find K so that the system is stable with, a) GM=2db, b) PM=45^0 [10]

8. The open loop transfer function is given by $G(s)H(s)=\frac{K(1+4s)}{s^2(1+s)(1+2s)}$, Determine the stability of closed loop system. [10]

OR

9. The open-loop transfer function of a system is given by

$$G_p(s)=\frac{K}{s(1+0.1s)(1+0.2s)}$$

Design a lag-lead compensator to meet the K_v=100sec^{-1} and Phase margin ≥ 30^0. [10]

10.a) Define: i) State ii) State variables iii) State space representation.

b) Find the state transition matrix for the following matrix, $A = \begin{bmatrix} 1 & 0 \\ -1 & 1 \end{bmatrix}$.

c) Obtain the state space representation for the following differential equation.
$\ddot{y} + 5\dot{y} + 7y = 114$
Where 'y' is the output and 'u' is the input. [10]

OR

11. The state equation of a linear-time invariant system is given as,

$$\dot{X} = \begin{bmatrix} 0 & 5 \\ -1 & -2 \end{bmatrix} X + \begin{bmatrix} 1 \\ 1 \end{bmatrix} r \text{ and } y = \begin{bmatrix} 1 & 1 \end{bmatrix} X,$$

Find the transfer function and draw the state diagram. [10]

---ooOoo---

B. Tech II Year II sem Exams April - 2018.

Control systems Key.

PART - A

1 a) Mason's gain formula

$$T = \frac{\Sigma g_K \Delta_K}{\Delta}$$

T = Transfer function

Δ = 1 - [sum of all individual loop gain] + [sum of all possible gain products of two non touching loops] - [3 - non touching loops] + ---

g_K = gain of K^{th} forward path

Δ_K = the part of Δ not touching the K^{th} forward path

2 b) basic properties of (SFG)

(i) Represent all variables, summing points & take off points by nodes

(ii) If a summing point is placed before a take off point, represent the summing point & take off point by a single node

(iii) If summing point is placed after a take off point, represent the summing point and take off point by a seperate nodes

(c) standard Test signals

(1) Unit Ramp → $R(s) = 1/s^2$

(2) Unit step — $U(s) = 1/s$

(3) Unit Parabolic — $S(s) = 1/s^3$

(4) Unit impulse $\delta(s) = 1$

(5) Unit sin $a(s) = \frac{\omega}{s^2+\omega^2}$

(d) Type :- Type is defined as number of poles at origin in Transfer function

Ex 1) $\frac{1}{s+1}$ ⇒ Type - 0 ; 2) $\frac{1}{s(s+1)}$ - Type - 1

3) $\frac{1}{s^2(s+1)}$ - Type - 2

order : Highest degree of Polynomial of Transfer function

ex. $\frac{K}{s^3+2s^2+s+1}$ order - 3

→ e// A system is said to be stable if its response cannot be made to increase indefinitely by the application of a bounded input excitation.

→ (f) basics of root locus plot
(i) symmetrical about the real axis
(ii) locus starts from poles and terminates at zeros
(iii) Any point on the real axis is a part of the root locus if and only if the number of poles & zeros to its right is odd
(iv) calculate Asympotes, Breakaway points & angle of departure etc.

→ (g) It is a plot of the magnitude of $G(j\omega)$ verus the phase angle of $G(j\omega)$ on polar coordinates as "ω" is varied from zero to infinity.

→ (h) gain margin :- It is defined as the reciprocal of the magnitude of the $G(j\omega)H(j\omega)$ at phase cross over frequency

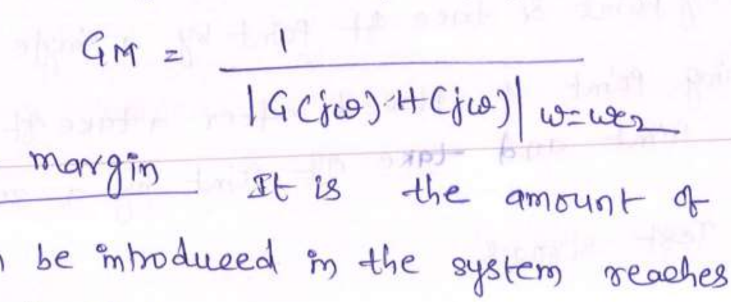
$$GM = \frac{1}{|G(j\omega)H(j\omega)|}\bigg|_{\omega=\omega_2}$$

Phase margin It is the amount of additional phase lag which can be introduced in the system reaches on the verge of instability is called phase margin

$$P.M = 180° + \angle G(j\omega)H(j\omega)\Big|_{\omega=\omega_{c1}}$$

→ (i) It is pictorial representation of state space analysis

$$\dot{x}(t) = Ax + by$$
$$y(t) = C^T x(t) + B(y)$$

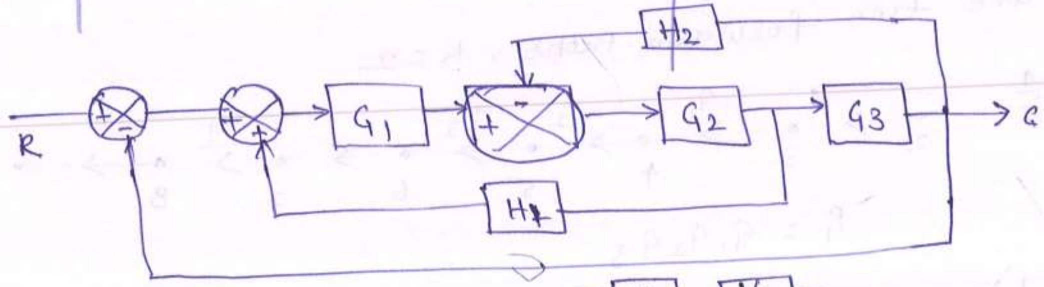


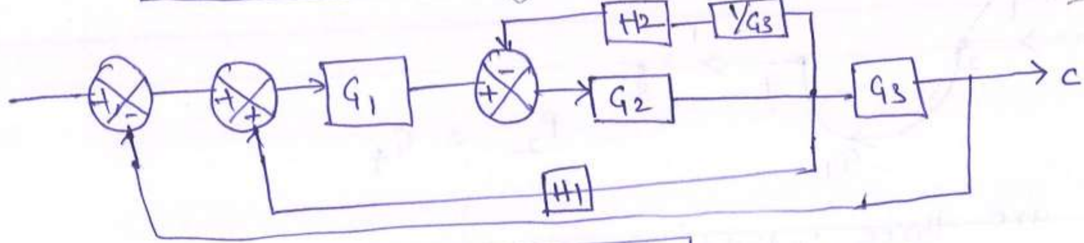
→ (j) Advantages of state space
(a) Applicable linear & non linear, time variant system
(b) Laplace Transform cannot be applied
(c) nth order equations can obtains solutions are easier
(4) It is a time domain approach.

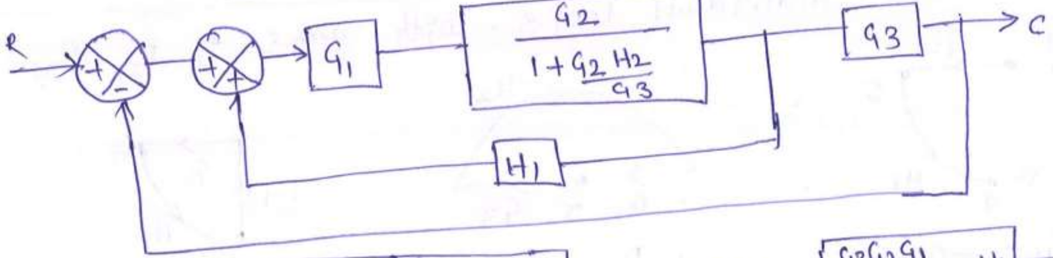
2a) comparision between AC & DC servomotors

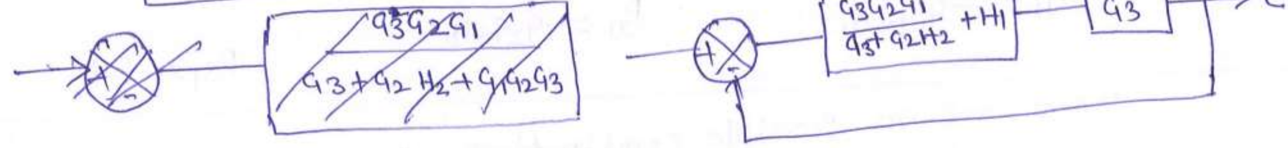
S.NO	AC servomotor	DC servomotor
(1)	Low power output about $\frac{1}{2}$ W	high power output
(2)	efficiency is less	High efficiency
(3)	Due to absence of commutator less maintance	due to commutator frequent maintance is required
(4)	stability problems are less	more stability problems
(5)	No radio frequency noise	produce radio frequency noise
(6)	smooth operation	Noisy operation
(7)	AC Amplifier used have no drift	Amplifiers used have a drift

2b









$$\frac{R}{S} = \frac{G_3^2 G_2 G_1 + H_1 G_3^2 + HG_2H_2}{G_3 + G_2H_2 + G_3^2 G_2 G_1 + HG_2^2 + H_2 G H_2}$$

15

3A Ans

Characteristics of servomotor.

a) linear relationship between electrical control signal and the rotor speed over a wide range

(b) It has low rotor Inertia. A servomotor must stop running without any time delay.

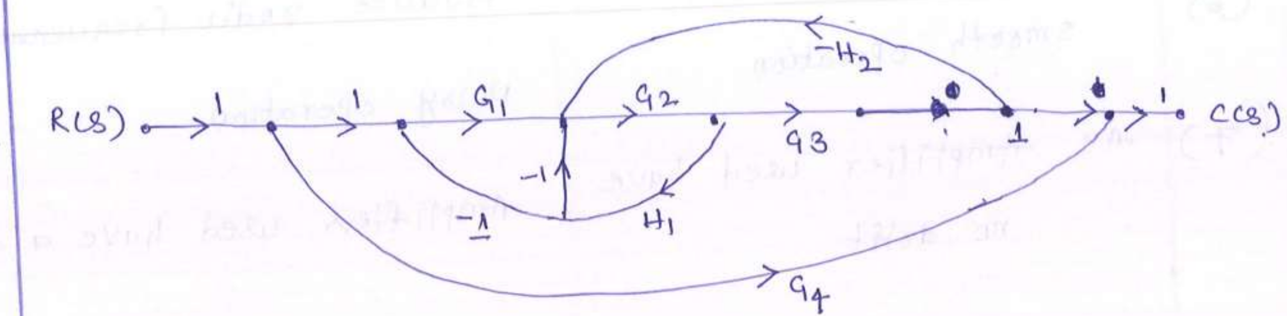
(c) Its response should be as fast as possible

(d) It should be easily reversible

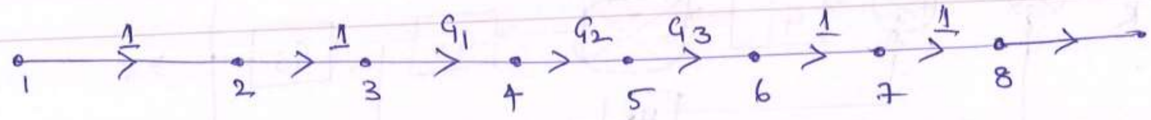
(e) It should have linear torque - speed characteristics

(f) Its operation should be stable without any oscillations or overshoots.

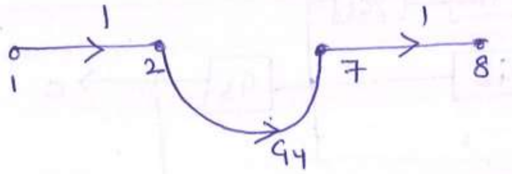
3b Ans,



There are two forward paths $K=2$

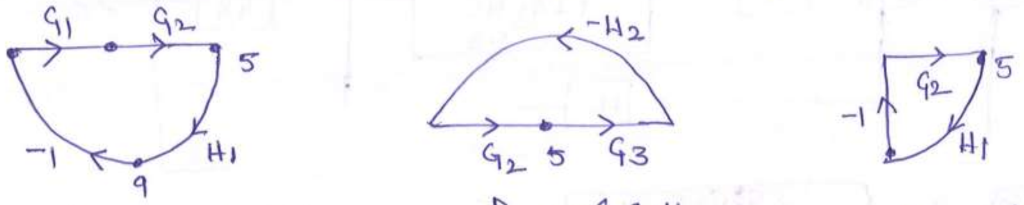


$P_1 = G_1 G_2 G_3$



$P_2 = G_4$

There are three individual loops with gains P_{11} P_{21} P_{31}



$P_{11} = -G_1 G_2 H_1$ $P_{21} = -G_2 G_3 H_2$ $P_{31} = -G_2 H_1$

There are no possible combinations of two non touching loops three non touching loops etc.

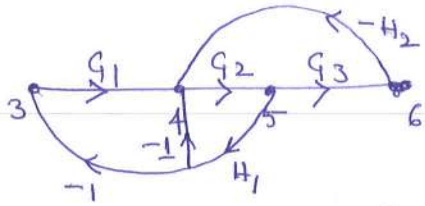
Calculation of Δ and Δ_K

$$\Delta = 1 - [P_{11} + P_{21} + P_{31}]$$

$$= 1 + G_1 G_2 H_1 + G_2 G_3 H_2 + G_2 H_1$$

since no part of graph touches forward path-1 $\Delta_1 = 1$

non-touching forwarded path -2



$$\therefore \Delta_2 = 1 - [-G_1 G_2 H_1 - G_2 G_3 H_2 - G_2 H_1]$$

$$= 1 + G_1 G_2 H_1 + G_2 G_3 H_2 + G_2 H_1$$

Transfer function T

$$T = \frac{1}{\Delta} \sum_K P_K \Delta_K = \frac{1}{\Delta}[P_1 \Delta_1 + P_2 \Delta_2$$

$$= \frac{1}{\Delta}\left[G_1 G_2 G_3 + G_4 (1 + G_1 G_2 H_1 + G_2 G_3 H_2 + G_3 H_1\right]$$

$$T = \frac{G_1 G_2 G_3 + G_4 + G_1 G_2 G_4 H_1 + G_2 G_3 G_4 H_2 + G_2 G_4 H_1]}{1 + G_1 G_2 H_1 + G_2 G_3 H_2 + G_2 H_1}$$

4A Sol- $G(s) = \frac{9}{s(s+3)}$

$$\frac{C(s)}{R(s)} = \frac{G(s)}{1+G(s)H(s)} = \frac{\frac{9}{s(s+3)}}{\frac{s(s+3)+9}{s(s+3)}} = \frac{9}{s^2+3s+9} \quad \text{—①}$$

compare eqⁿ ① with $s^2 + 2\delta\omega_n s + \omega_n^2$ we get.

$\omega_n^2 = 9 \Rightarrow \omega_n = 3$ — natural frequency 3 rad/sec

damping ratio

$$2\delta\omega_n s = 3s \Rightarrow \delta = \frac{3}{2\omega_n} = \frac{3}{2\times 3} = \frac{1}{2}$$

$\delta = 0.5$ under damped system

damped frequency $\omega_d = \omega_n\sqrt{1-\delta^2} = 3\sqrt{1-(0.5)^2}$

$$= 3\sqrt{0.75} = 3\times 0.866 = 2.59 \approx 2.6\ Hz$$

time constant $(\tau) = \frac{2\pi}{\omega_d} = \frac{2\times 3.14}{3\sqrt{0.75}} = \frac{6.28}{2.6} = 2.4$ sec

5 Ans:- $G(s) = \frac{10(s+2)}{s^2(s+4)}$

$H(s) = 1$

$K_p = \lim_{s\to 0} G(s)H(s) = \lim_{s\to 0} \frac{10(s+2)}{s^2(s+4)} = \infty$

$K_v = \lim_{s\to 0} sG(s)H(s) = \lim_{s\to 0} sG(s) = \lim_{s\to 0} \frac{s(10(s+2)}{s^2(s+4)} = \infty$

$K_a = \lim_{s\to 0} s^2 G(s)H(s) = \lim_{s\to 0} \frac{s^2\, 10(s+2)}{s^2(s+4)} = \frac{10\times 2}{4} = 5$ Ans

The error signal in s-domain $E(s) = \frac{R(s)}{1+G(s)H(s)}$

$R(s) = \frac{3}{s} - \frac{2}{s^2} + \frac{1}{3s^3}$

$G(s) = \frac{10(s+2)}{s^2(s+4)}$ and $H(s) = 1$

$\therefore E(s) = \frac{\frac{3}{s} - 2/s^2 - \frac{1}{3s^3}}{1 + \frac{10(s+2)}{s^2(s+4)}} = \frac{3/s - 2/s^2 + \frac{1}{3s^3}}{\frac{s^2(s+4)+10(s+2)}{s^2(s+4)}}$

$= 3/s\left[\frac{s^2(s+4)}{s^2(s+4)+10(s+2)}\right] - \frac{2}{s^2}\left[\frac{s^2(s+4)}{s^2(s+4)+10(s+2)}\right] + 1/3s^3\left[\frac{s^2(s+4)}{s^2(s+4)+10(s+2)}\right]$

The steady state error e_{ss} can be obtain from final value therem

steady state error $e_{ss} = \lim_{t\to 0} e(t) = \lim_{s\to 0} sE(s)$

$\therefore e_{ss} = \lim_{s\to 0} s\left\{3/s\left[\frac{s^2(s+4)}{s^2(s+4)+10(s+2)}\right] - 2/s^2\left[\frac{s^2(s+4)}{s^2(s+4)+10(s+2)}\right] + 1/3s^3\left[\frac{s^2(s+4)}{s^2(s+4)+10(s+2)}\right]\right\}$

$= \lim_{s\to 0}\left\{\frac{3s^2(s+4)}{s^2(s+4)+10(s+2)} - \frac{2s(s+4)}{s^2(s+4)+10(s+2)} + \frac{(s+4)}{3s^2(s+4)+30(s+2)}\right\}$

$= 0 - 0 + \frac{4}{60}$

$\therefore e_{ss} = 1/15$ Ans

6a Ans. RH stability criterion

$s^4 + 8s^3 + 18s^2 + 16s + 5 = 0$

s^4	1	18	5
s^3	8	16	

The elements of s^3 can be divided by 8 to simply fy the computations

s^4	1	18	5
s^3	1	2	
s^2	16	5	
s^1	1.7		
s^0	5		

$s^2 : \frac{(1\times18)-(2\times1)}{1} \quad \frac{(1\times5)-(0\times1)}{1}$

$s^2 : 16 \quad 5$

$s^1 : \frac{(16\times2)-(5\times1)}{16} = 1.68$

$s^0 : (1.7\times5)-(0\times16)$

$s^0 = 5$

Ist coloumn elements are no change in sign

so Result : (1) stable system

(2) All the ~~four~~ roots are lying on the left half s- plane

6b Ans- Root locus $G(s) = \frac{K(s+1.5)}{s(s+1)(s+5)}$

Step-1 : $s(s+1)(s+5) = 0 \Rightarrow s = 0, -1, -5$ Poles

zeros $s = 1.5$ and infinity

Step-2 Root locus exist between $s = -1.5$ & $s = -5$ and $s=0$ & -1

Step-3 angle of asymptotes & centroid.

$= \pm \frac{180(2q+1)}{n-m}$ Here $m=3$, $n=1$

If = $q = 0$ Angles $= \frac{\pm 180}{2} = \pm 90°$

centroid $= \frac{\text{sum of poles} - \text{sum of zeros}}{n-m}$

$= \frac{0-1-5-(-1.5)}{2} = -2.25$

Step 4 break away & break in Points

$$\frac{C(s)}{R(s)} = \frac{K(s+1.5)}{s(s+1)(s+5)+K(s+1.5)}$$

$$\therefore K = -\frac{(s^3+6s^2+5s)}{s+1.5} \Rightarrow \frac{dK}{ds} = \frac{-2(s^3+5.2s^2+9s+3.75)}{(s+1.5)^2}$$

$$\frac{dK}{ds} = 0$$

by trial & error method we get $-2.3 \pm j0.89$

So the cannot be break away points and no angle of departure and arrival

Step-5 find imaginary axis crossing point

$$s^3 + 6s^2 + 5s + Ks + 1.5K = 0$$

Put $s = j\omega \Rightarrow -j\omega^3 - 6\omega^2 + j5\omega + jK\omega + 1.5K = 0$

equating imaginary part to zero

$-j\omega^3 + j5\omega + jK\omega = 0 \quad \omega^2 = 5+K$

equating real part to zero

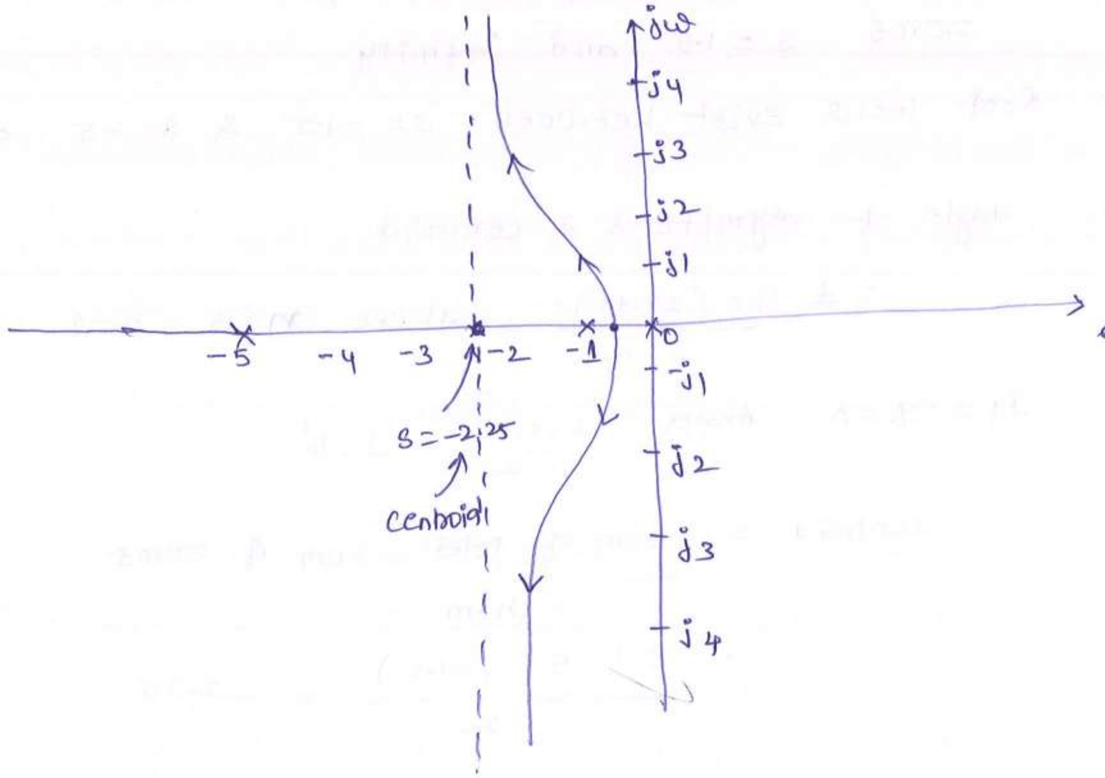
$$-6\omega^2 + 1.5K$$

$$\omega^2 = 5+K$$

$$-30 - 4.5K = 0$$

$$-4.5K = 30$$

$$K = -30/4.5 = -6.67$$



7 Ass- $G(s) = \frac{K e^{-0.2s}}{s(s+2)(s+8)}$ Bode plot find K so that the system is stable with a) GM = 2db (b) PM = 45°

Sol

$$G(s) = \frac{K e^{-0.2s} \times 0.0625}{s(1+0.5s)(1+0.125s)}$$

Let K=1

$$G(j\omega) = \frac{0.0625\, e^{-j0.2\omega}}{j\omega(1+j0.5\omega)(1+j0.125\omega)}$$

note: $\left|0.0625\, e^{-j0.2\omega}\right| = 0.0625$ and $\angle e^{-j0.2\omega} = -0.2\omega$ rad

Magnitude plot.

corner frequencies

$\omega_{c1} = \frac{1}{0.5} = 2$ rad/sec and $\omega_{c2} = \frac{1}{0.125} = 8$ rad/sec

changing in slop

Term	Corner freq rad/sec	slop dB/dec	Change in slope db/dec
$\frac{0.0625}{j\omega}$	—	-20	
$\frac{1}{1+j0.5\omega}$	$\omega_{c1} = \frac{1}{0.5} = 2$	-20	-20-20 = -40
$\frac{1}{1+j0.125\omega}$	$\omega_{c2} = \frac{1}{0.125} = 8$	-20	-40-20 = -60

Let $\omega_l = 0.5$ rad/sec & $\omega_h = 50$ rad/sec

Let A = |G(jω)| in db

At $\omega = \omega_l$, $A = 20\log\left|\frac{0.0625}{j\omega}\right| = 20\log\frac{0.0625}{0.5} = -18$db

At = ω_{cl} = $A = 20\log\left|\frac{0.0625}{j\omega}\right| = 20\log\frac{0.0625}{2} = -30$db

At $\omega = \omega_{c2}$; A = A = $\left[\text{slope from } \omega_{c1} \text{ to } \omega_{c2} \times \log\frac{\omega_{c2}}{\omega_{c1}}\right] + A(\text{at } \omega = \omega_{c1})$

$= -40 \times \log 8/2 + (-30) = -54$db

At $\omega = \omega_h$; $A = \left[\text{slope from } \omega_{c2} \text{ to } \omega_h \times \log\frac{\omega_h}{\omega_{c2}}\right] + A(\text{at } \omega = \omega_{c2})$

$= -60 \times \log\frac{50}{8} + (-54) = -102$ db

Phase plot

ω rad/se	$\phi = -0.2\omega \times \frac{180}{\pi} - 90 - \tan^{-1} 0.5\omega - \tan^{-1} 0.125\omega$
0.01	−90.4
0.5	−113.3
2	−171.9
4	−225.8

Draw the magnitude plote & phase plot on semi log paper.

Calculation of K.

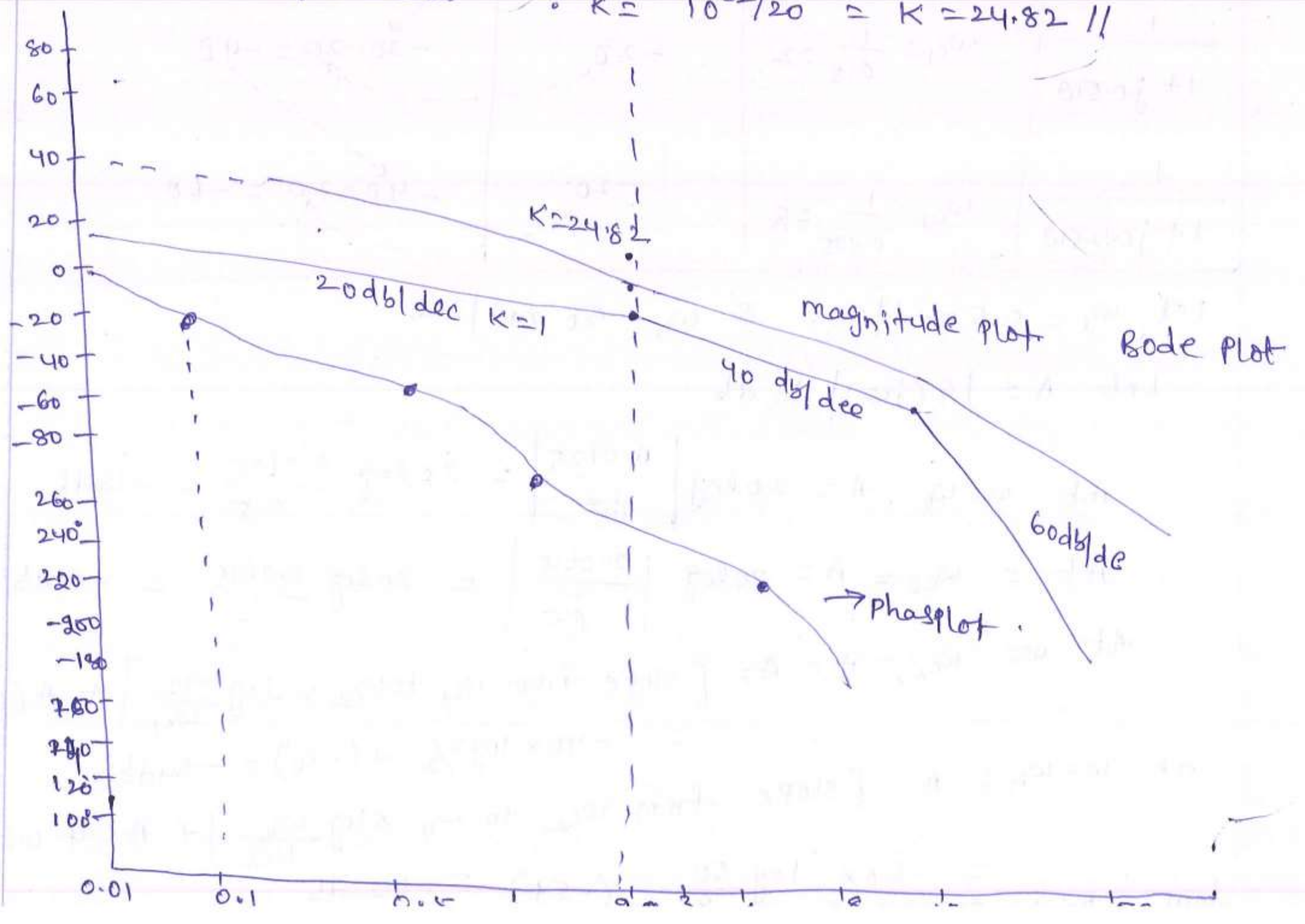
PM = 180 + ϕ_{gc} = where $\gamma = 45°$, $\phi_{gc} = \gamma - 180 = 45 - 180 = 135°$

with K=1, the db gain at $\phi = -135°$ is −24 db. This gain should be made to have to PM of 45°. Hence to every point of magnitude plot a db The corrected magnitude plot is obtained by shifting the plot with K=1 by 24 db upwards. The value of K is calculated by equating 20 log K to 24 db

$\therefore$ 20 log K = 24 ; $K = 10^{24/20}$; K = 15.84.

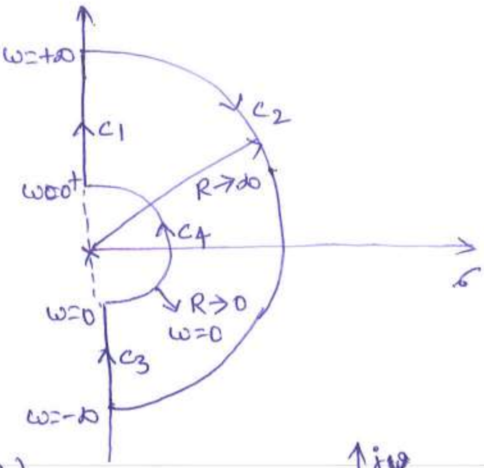
with K=1, the gain margin = −(−34) = 34 dB but the required gain margin is 2db. Hence the every point of magnitude plote a db gain of 32 db should be addtion this shifts plot upwards

20 log K = 32 $\therefore$ $K = 10^{32/20}$ = K = 24.82 //



8A84.

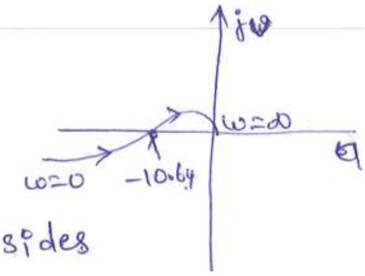
$$G(s)H(s) = \frac{K(1+4s)}{s^2(1+s)(1+2s)}$$



Mapping of section c_1

$$G(j\omega)H(j\omega) = \frac{(1+j4\omega)}{(j\omega)^2(1+j\omega)(1+j2\omega)}$$

$$= \frac{\sqrt{1+16\omega^2}}{\omega^2\sqrt{1+\omega^2}\sqrt{1+4\omega^2}} \angle(\tan^{-1}4\omega - 180^\circ - \tan^{-1}\omega - \tan^{-1}2\omega)$$



$\therefore \tan^{-1}4\omega - 180^\circ - \tan^{-1}\omega - \tan^{-1}2\omega = -180$

$\tan^{-1}4\omega = \tan^{-1}\omega + \tan^{-1}2\omega$ Apply tan both sides

$$4\omega = \frac{\omega+2\omega}{1-2\omega^2} \Rightarrow 1-2\omega^2 = \frac{3\omega}{4\omega} \Rightarrow -2\omega^2 = 3/4 - 1$$

$$\omega = \sqrt{\frac{-0.25}{-2}} = 0.354 \text{ rad/sec}$$

At $\omega_{pc} = 0.354$ rad/sec $|G(j\omega)H(j\omega)| = 10.64$

At $\omega \to 0$; $\infty \angle -180^\circ$; $\omega \to \infty$ $G(j\omega)H(j\omega) \to 0\angle -270^\circ$

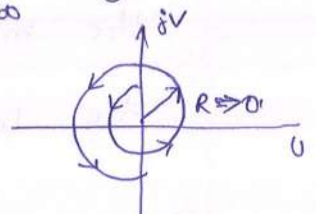
Mapping of section c_2

$$\frac{(1+4s)}{s^2(1+s)(1+2s)} \simeq \frac{4s}{s^2 \cdot s \cdot 2s} = 2/s^3 \qquad \text{Let } s = \lim_{R\to\infty} Re^{j\theta}$$

$$\therefore G(s)H(s)\Big|_{s=\lim_{R\to\infty} Re^{j\theta}} = 2/s^3\Big|_{s=\lim_{R\to\infty} Re^{j\theta}} = \frac{2}{\lim_{R\to\infty}(Re^{j\theta})^3} = 0\, e^{-j3\theta}$$

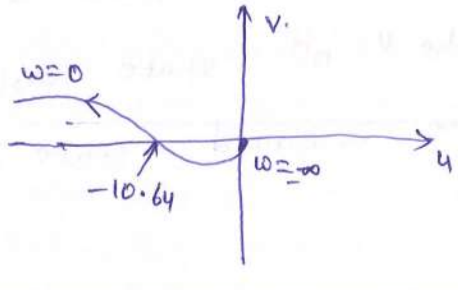
when $\theta = \pi/2$ $G(s)H(s) = 0e^{-j3\pi/2}$

$\theta = -\pi/2$ $G(s)H(s) = 0e^{+j3\pi/2}$.



Mapping of section c_3

In section c_3, ω varies from $-\infty$ to 0. The mapping of section c_3 is given by the locus of $G(j\omega)H(j\omega)$ as ω is varied from $-\infty$ to 0. This locus is the inverse polar plot of $G(j\omega)H(j\omega)$



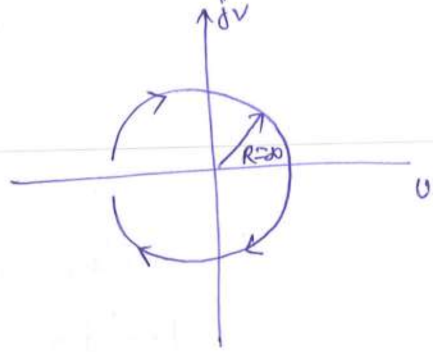
Mapping of section C_4

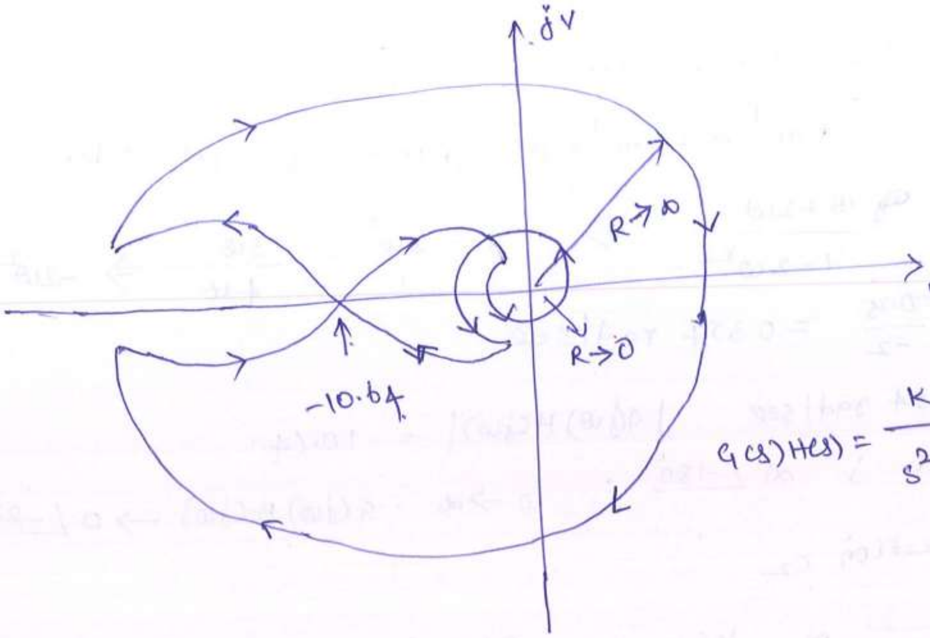
$$G(s)H(s) = \frac{(1+4s)}{s^2(1+s)(1+2s)} \approx \frac{1}{s^2 \times 1 \times 1} = 1/s^2$$

Let $s = \lim_{R \to 0} Re^{j\theta} = \frac{1}{\lim_{R\to 0} (Re^{j\theta})^2} = \infty e^{-j2\theta}$

when $\theta = -\pi/2 = G(s)H(s) = \infty\, e^{-j\pi}$

$\theta = \pi/2 \quad G(s)H(s) = \infty\, e^{-j\pi}$.





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

10 Ans

A) (i) state :- The state of a system at any time "t_0" is the minimum set of numbers $x_1, x_2, x_3 ---- x_n$, which along with the input to the system for time $t \geq t_0$ is sufficient to determine the behaviour of the system for all $t \geq t_0$

(ii) state variable The variables involved in determining the state of a dynamic system $x(t)$ are called state variable

(iii) state space :- The space whose co-ordinate axes are nothing but the "n" state variables with time as the implicit variable is called state space Representation.

10b Ans

STM $A = \begin{bmatrix} 1 & 0 \\ -1 & 1 \end{bmatrix}$

$$[sI-A] = \begin{bmatrix} s & 0 \\ 0 & s \end{bmatrix} - \begin{bmatrix} 1 & 0 \\ -1 & 1 \end{bmatrix} = \begin{bmatrix} s-1 & 0 \\ 1 & s-1 \end{bmatrix}$$

$$|sI-A|^{-1} = \frac{Adj\,[sI-A]}{|sI-A|} = \frac{1}{s^2-2s+1}\begin{bmatrix} s-1 & 0 \\ 1 & s-1 \end{bmatrix}$$

$$= \frac{1}{(s-1)^2}\begin{bmatrix} s-1 & 0 \\ 1 & s-1 \end{bmatrix} = \begin{bmatrix} \frac{s-1}{(s-1)^2} & 0 \\ \frac{1}{(s-1)^2} & \frac{s-1}{(s-1)^2} \end{bmatrix} = \begin{bmatrix} \frac{1}{s-1} & \frac{-1}{(s-1)^2} \\ 0 & \frac{1}{s-1} \end{bmatrix}$$

$$\phi = L^{-1}[sI-A]^{-1} = \begin{bmatrix} L^{-1}[1/s-1] & 0 \\ L^{-1}\left[\frac{1}{(s-1)^2}\right] & L^{-1}\left[\frac{1}{s-1}\right] \end{bmatrix} = L^{-1}\begin{bmatrix} \frac{1}{s-1} & \frac{-1}{(s-1)^2} \\ 0 & \frac{1}{s-1} \end{bmatrix}$$

$$\phi(t) = \begin{bmatrix} e^t & te^t \\ 0 & e^t \end{bmatrix} \quad \begin{bmatrix} e^t & -te^t \\ 0 & e^t \end{bmatrix} \text{ Ans}$$

10c Ans

State space Representation

$$\ddot{y} + 5\dot{y} + 7y = 114$$

$$y = x_1, \quad \dot{y} = \dot{x}_1 = x_2, \quad \ddot{y} = \ddot{x}_1 = \dot{x}_2$$

$$\ddot{y} = 114 - 5\dot{y} - 7y$$

$$\dot{x}_2 = 114 - 5x_2 - 7x_1$$

$$\dot{x}_1 = x_2$$

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -7 & -5 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 114 \end{bmatrix} u(t)$$

Ans

U4A8)

$$\dot{x}(t) = \begin{bmatrix} 0 & 5 \\ -1 & -2 \end{bmatrix} x + \begin{bmatrix} 1 \\ 1 \end{bmatrix} r \quad \text{and} \quad y = \begin{bmatrix} 1 & 1 \end{bmatrix} x$$

$$A = \begin{bmatrix} 0 & 5 \\ -1 & -2 \end{bmatrix}, \quad B = \begin{bmatrix} 1 \\ 1 \end{bmatrix}; \quad C = \begin{bmatrix} 1 & 1 \end{bmatrix}, \quad I = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$$

$$|sI - A| = \begin{bmatrix} s & 0 \\ 0 & s \end{bmatrix} - \begin{bmatrix} 0 & 5 \\ -1 & -2 \end{bmatrix} = \begin{bmatrix} s & -5 \\ 1 & s+2 \end{bmatrix}$$

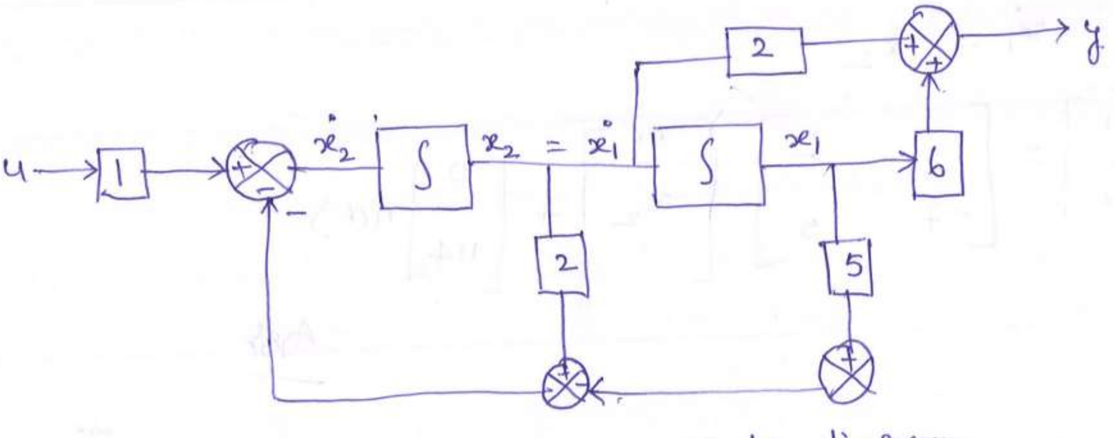
$$[sI - A]^{-1} = \frac{1}{s(s+2)+5} \begin{bmatrix} s+2 & 5 \\ -1 & s \end{bmatrix}$$

$$[sI - A]^{-1} = \begin{bmatrix} \frac{s+2}{s^2+2s+5} & \frac{5}{s^2+2s+5} \\ \frac{-1}{s^2+2s+5} & \frac{s}{s^2+2s+5} \end{bmatrix}$$

$$C[sI - A]^{-1}B = \begin{bmatrix} 1 & 1 \end{bmatrix} \begin{bmatrix} \frac{s+2}{s^2+2s+5} & \frac{5}{s^2+2s+5} \\ \frac{-1}{s^2+2s+5} & \frac{s}{s^2+2s+5} \end{bmatrix} \begin{bmatrix} 1 \\ 1 \end{bmatrix}$$

$$= \begin{bmatrix} \frac{s+1}{s^2+2s+5} & \frac{5+s}{s^2+2s+5} \end{bmatrix} \begin{bmatrix} 1 \\ 1 \end{bmatrix}$$

$$= \frac{s+1+5+s}{s^2+2s+5} = \frac{2s+6}{s^2+2s+5} = T(s)$$



state diagram.

Code No: 115AD **R13**

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

B. Tech III Year I Semester Examinations, November - 2015

CONTROL SYSTEMS

(Electrical and Electronics Engineering)

Time: 3 hours **Max. Marks: 75**

Note: This question paper contains two parts A and B.
Part A is compulsory which carries 25 marks. Answer all questions in Part A. Part B consists of 5 Units. Answer any one full question from each unit. Each question carries 10 marks and may have a, b, c as sub questions.

PART - A (25 Marks)

1.a) Explain the effect of negative feedback in control systems [2]
b) Find the TF of following system (figure 1). [3]

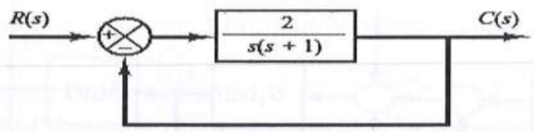


Figure 1

c) Syncro acts as error detector? Justify? [2]
d) Write the importance of SFG in control systems [3]
e) Define the standard test signals in control systems [2]
f) The damping ratio for the characteristic equation $s^2+2s+1=0$ is [3]
g) Define angle of departure and angle of arrival in root locus [2]
h) Write the drawbacks of RH criteria [3]
i) Explain the minimum phase system? [2]
j) Magnitude in decibels of give transfer function $G(s)=\dfrac{1}{(s+2)}$ is [3]

PART - B (50 Marks)

2.a) Explain any two examples of closed loop control systems.
b) Discuss electrical analogous of mechanical rotational systems. [5+5]

OR

3.a) Discus the characteristics of feedback in control systems.
b) Write the differential equations to represent the following system in figure 2 below and draw its electrical equivalent circuit [5+5]

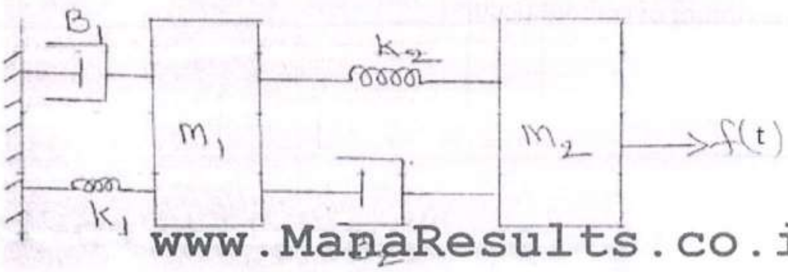


Figure 2

6. The open loop transfer functions of three systems are given as

a) $\frac{4}{(s+1)(s+2)}$ b) $\frac{2}{s(s+4)(s+6)}$ c) $\frac{5}{s^2(s+3)(s+10)}$

Determine respectively the positional, velocity and acceleration error constants for these systems. Also for the system given in determine the steady state errors with step input u(t)=1; ramp input r(t) = t and acceleration input r(t) = $\frac{1}{2}t^2$. [10]

OR

7. Obtain the unit – step response of a unity feedback control system whose open –loop transfer function is $G(s) = \frac{1}{s(s+1)}$. Obtain also the rise time, peak time, maximum overshoot and settling time. [10]

8. For unity feedback system given by $G(s) = \frac{K}{s(s+0.5)(s^2+0.6s+10)}$

a) Find the stability using RH criterion

b) for stable system find the range of K value. [8+2]

OR

9. Sketch the root loci for the system shown in Figure 2. [10]

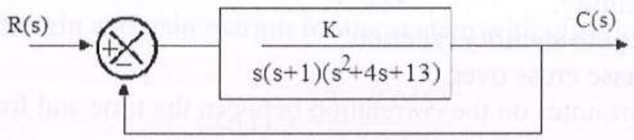


Figure 2

10. The forward path transfer function of a Unity-feedback control system is given as

$G(s) = \frac{K}{s(1+0.1s)(1+0.5s)}$

Draw the Bode plot of G(s) and find the value of K so that the gain margin of the system is 20 db. [10]

OR

11. Consider the system shown in Figure 3. Draw the Bode-diagram of the open-loop transfer function G(s) with K = 1. Determine the phase margin and gain margin. Find the value of K to reduce the phase margin by 10^0. [10]

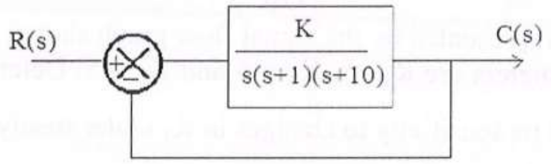


Figure 3

---ooOoo---

Code No: 115AD

R13

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
B. Tech III Year I Semester Examinations, November/December - 2017
CONTROL SYSTEMS
(Electrical and Electronics Engineering)

Time: 3 hours **Max. Marks: 75**

Note: This question paper contains two parts A and B.
Part A is compulsory which carries 25 marks. Answer all questions in Part A. Part B consists of 5 Units. Answer any one full question from each unit. Each question carries 10 marks and may have a, b, c as sub questions.

PART - A

(25 Marks)

1.a) Why is negative feedback invariably preferred in a closed loop system? [2]
b) Distinguish between open loop and closed loop system. [3]
c) What are the applications of synchro? [2]
d) Write the importance of SFG in control systems. [3]
e) Define peak overshoot. [2]
f) What is the effect of P, PI controller on the system performance? [3]
g) How will you find root locus on real axis? [2]
h) Write the drawbacks of RH criteria. [3]
i) What are frequency domain specifications? [2]
j) Define Gain margin and Phase margin. [3]

PART - B

(50 Marks)

2.a) Find the transfer function of the network given figure 1.

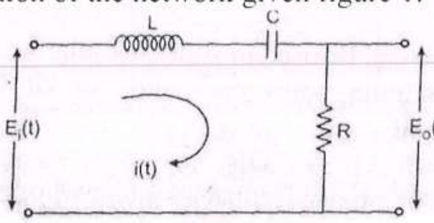


Figure 1

b) Explain translatory and rotary elements of mechanical systems. [5+5]

OR

3.a) What is feed back? Explain the effects of feedback.
b) Obtain the transfer function $X_1(s)/F(s)$ for the mechanical system shown figure 2. [5+5]

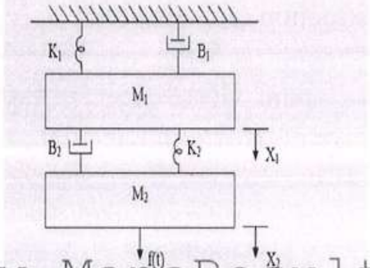


Figure 2

4.a) Explain the rules for block diagram reduction technique.
b) Derive the transfer function for armature controlled DC Servomotor. [5+5]

OR

5.a) Reduce the given block diagram and hence obtain the transfer function (figure 3).

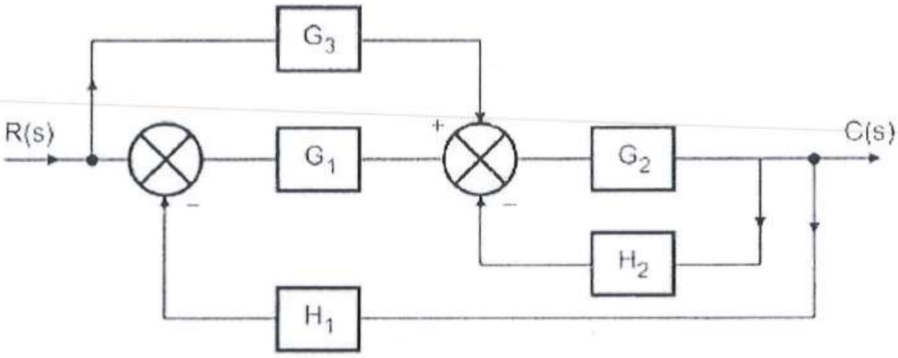


Figure 3

b) Write the applications AC servomotor. [5+5]

6.a) Determine the error coefficients and static error for $G(s)=\frac{1}{s(s+1)(s+10)}$, $H(s) = s + 2$
b) Find out the output of the undamped second order system when the input applied to the system is unit step input. [5+5]

OR

7.a) The open-loop transfer function of a unity feedback system is given by $G(s)=\frac{500}{s(1+0.1s)}$ Find the peak overshoot and time peak overshoot. If peak overshoot is to be reduced by 20%, what is the change in the gain?
b) Explain effects of proportional derivative and proportional integral controllers in system performance. [5+5]

8.a) How RH Stability criterion can be used to study the relative stability?
b) Explain the effects of adding poles and zeros to G(s)H(s) on the root loci by considering one the example. [5+5]

OR

9. Sketch the root locus plot of a unity feedback system whose open loop T.F is $G(s) = \frac{K(s^2-2s+2)}{(s+2)(s+3)(s+4)}$. [10]

10.a) Define
i) Minimum phase transfer function
ii) Non minimum phase transfer function.
b) Enlist the steps for the construction of Bode plots. [5+5]

OR

11. Sketch the Bode plots for a system $G(s) = \frac{15(s+5)}{s(s^2+16s+100)}$ Hence determine the stability of the system. [10]

---ooOoo---

SIDDHARTHA INSTITUTE OF ENGINEERING & TECHNOLOGY

Vinobha Nagar Ibrahimpatnam R R Dist-501506

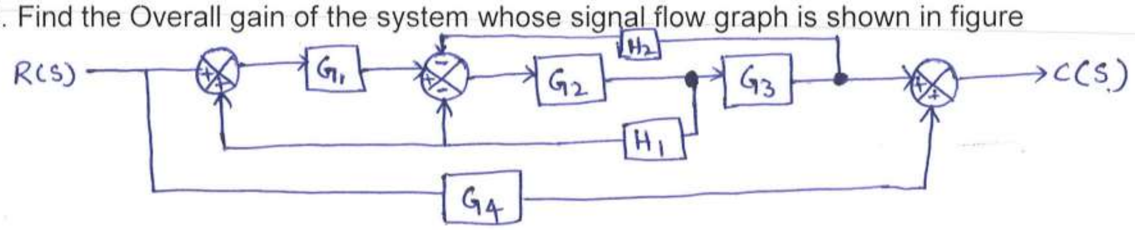
II B Tech II Sem I Mid Examinations February 2019

Branch: EEE **Date: 19-02-2019 FN**

Subject: Control Systems **Time: 60min**

Note: Answer Any Two of the Following

1. (A). What is Control System? What are the types of Control Systems? Explain with example?
   (B). Write the Analogous Electrical Elements in F-V, F-I , T-V , T-I for the Mechanical Translational and Rotational system.
2. (A). Explain the principal of synchro and write its applications.
   (B). Derive the transfer function of Armature controlled DC Servo Motor? And How AC Servo Motor different from Induction Motor
3. Find the Overall gain of the system whose signal flow graph is shown in figure



Figure

4. (A) the open loop transfer function of a unity feedback control system is give by $G(S) = \frac{K}{s(1+sT)}$
   By what factor the amplifier gain K should be multiplied so that the damping ratio is increased From 0.3 to 0.9
   (B)Consider a unity feedback control system with the closed loop transfer function $\frac{C(S)}{R(S)} = \frac{KS+b}{S^2+aS+b}$
   Determine the open loop transfer function. Show that the steady state error in the unit ramp input Response is given by $e_{ss} = \frac{a-K}{b}$

SIDDHARTHA INSTITUTE OF ENGINEERING & TECHNOLOGY

Vinobha Nagar Ibrahimpatnam R R Dist-501506

II B Tech II Sem I Mid Examinations February 2019

Branch: EEE **Date: 19-02-2019 FN**

Subject: Control Systems **Time: 60min**

Note: Answer Any Two of the Following

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   (B). Write the Analogous Electrical Elements in F-V, F-I , T-V , T-I for the Mechanical Translational and Rotational system.
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   (B). Derive the transfer function of Armature controlled DC Servo Motor? And How AC Servo Motor different from Induction Motor
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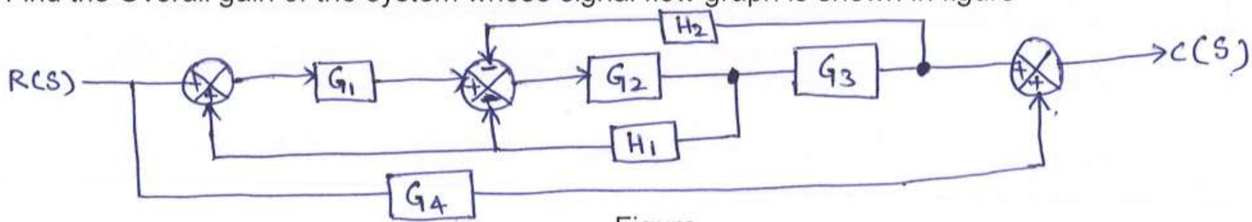

Figure

4. (A) the open loop transfer function of a unity feedback control system is give by $G(S) = \frac{K}{s(1+sT)}$
   By what factor the amplifier gain K should be multiplied so that the damping ratio is increased From 0.3 to 0.9
   (B)Consider a unity feedback control system with the closed loop transfer function $\frac{C(S)}{R(S)} = \frac{KS+b}{S^2+aS+b}$
   Determine the open loop transfer function. Show that the steady state error in the unit ramp input Response is given by $e_{ss} = \frac{a-K}{b}$

(25

SIDDHARTHA INSTITUTE OF ENGINEERING &TECHNOLOGY

Vinobha nager ibrahimpatnam..R.R.DistrictHyderabad-501506

II B.Tech. II Sem., Ist Mid-Term Examinations, February – 2019

Branch: EEE **Subject: CS**

Date: 19-02-19-FN **Objective Exam** **Time: 20min**

Name: ______________________ **Hall Ticket No.**______________________

Answer All Questions. All Questions Carry Equal Marks. Time: 20 Min. Marks: 10.

I. Choose the correct alternative:

1. In an open loop control system ( )
(a) Output is independent of control input (b) Output is dependent on control input
(c) Only system parameters have effect on the control output (d) None of the above

2. A control system in which the control action is somehow dependent on the output is known as ( )
(a) Closed loop system (b) Semi closed loop system
(c) Open system (d) none of the above

3. In negative feedback system the overall gain of the system will ( )
(a) Decrease (b) increase (c) be unaffected (d) any of the above

4. Which of the following is an open loop control system? ( )
(a) Field controlled D.C. motor (b) Armature controlled DC motor
(c) Air conditioner (d) Submarine system

5. A control system which obey both superposition and homogeneity principles are called ( )
(a) Computer control system (b) Linear systems
(c) Stochastic control system (d) adaptive control system

6. A closed loop system is distinguished from open loop system by which of the following ( )
(a) Servomechanism (b) Feedback (c)Output pattern (d) Input pattern

7. A.C. servomotor resembles ( )
(a) Two phase induction motor (b) Three phase induction motor
(c) Direct current series motor (d) Universal motor

8. The output of a feedback control system must be a function of ( )
(a) Reference and output (b) reference and input
(c) Input and feedback signal (d) output and feedback signal

9 Zero initial condition for a system means ( )
(a) Input reference signal is zero
(b) Zero stored energy
(c) No initial movement of moving parts
(d) System is at rest and no energy is stored in any of its components

10. The type 0 system has ______ at the origin. ( )
(a) No pole
(b) Net pole
(c) Simple pole (d) Two poles

Fill in the Blanks:

11. Velocity error constant of a system is measured constant steady state error when the input to the system is______________

12 In case of type-1 system steady state error for unit step input is______________

13. The PD and PI controllers shows their major effects on__________ and __________ States respectively

14. The Electrical equivalent of mechanical element mass (M) in force-voltage analogy is __________

15. Laplace transformation of impulse function is______________

16. Transfer function of the system is defined as______________

17. The type of the system depends based on the ______________

18. The value of the damping ratio and natural damped frequency of the given unity feedback Open loop system $G(S) = \frac{16}{S(S+1)}$ is respectively__________ and __________

19. Synchros uses for______________

20 Servo mechanism system is ______________ control system

-oOo-

26

SIDDHARTHA INSTITUTE OF ENGINEERING AND TECHNOLOGY

CONTROL SYSTEMS-2018-19

MID-1 KEY PAPER

1) B

2) A

3)B

4)A

5)B

6)B

7)A

8) D

9) D

10)A

11) RAMP

12) ZERO

13) TRANSIENT AND STEADY STATES RESPECTIVELY

14)L – INDUCTANCE

15)1-ONE

16) RATIO OF LAPLACE OUTPUT TO INPUT WITHOUT INITIAL CONDITIONS

17) NUMBER OF POLES AT ORIGIN

18) 0.125 & 4

19) ENCODERS AND ERROR DETECTORS

20) POSITION CONTROL SYSTEM

I-Mid Key

II. B. Tech II sem February -2019

Sub: Control systems   Name: S. Rajesh   Date: 19/02/19 FN

1 A) Control system: It is an arrangment of different Physical elements connected in such a manner so as to regulate, direct or command it self or some other system.

1) Linear & non linear system:

linear system Examples: 1) A resistance network show linear characteristis

$$f(x+y) = f(x) + f(y) \; ; \; f(\alpha x) = \alpha f(x)$$

non linear: $f(x_1+x_2) = (x_1+x_2)^2 \neq (x_1)^2 + (x_2)^2$

Ex: B-H curve, diode characteristics

(2) Time variant & time invariant.

Ex: space veehicle, rokket aerodynamic damping.

Ex: time invariant :- networks of RLC.

(3) continous & discrete time systems

continous :- a tachogenerator feed back to DC Motor

dis continous:- Microprocessor or computer.

1b Ans Analogy comparision Table

Translational	Rotational	Force voltage Analogy	Force-current Analogy
Force (F)	Torque (T)	voltage (V)	current (I)
Mass (M)	Inetria (J)	Inductance (L)	C
Friction constant (B)	Tortional friction (B)	Resistance (R)	$1/R$
Spring (K) N/m	K Nm/rad	$1/C$	$1/C$
Displacement "x"	θ	charge "q"	ϕ
velocity $\dot{x} = \frac{dx}{dx}$	$\dot{\theta} = \frac{d\theta}{dt} = \omega$	$i = \frac{dq}{dt}$	$e = \frac{d\phi}{dt}$

steady state error

$$e_{ss} = \lim_{s \to 0} s R(s) \frac{1}{1+G(s)H(s)}$$

$$e_{ss} = \lim_{s \to 0} s \cdot \frac{1}{s^2} \frac{1}{1 + \frac{Ks+b}{s^2+s(a-K)}}$$

$$\lim_{s \to 0} \frac{1}{s} \times \frac{s^2 + s(a-K)}{s^2 + s(a-K) + Ks + b}$$

$$\lim_{s \to 0} \frac{1}{s} \times \frac{s(s+a-K)}{s^2 + s(a-K) + Ks + b}$$

$$\boxed{e_{ss} = \frac{a-K}{b}}$$ proved.

SIDDHARTHA INSTITUTE OF ENGINEERING AND TECHNOLOGY

Vinobhanagar, Ibrahimpatnam, R.R.District-501506

Name of the Exam: B.TECH II-II MID-II TERM EXAMS APR-2019

Branch: EEE | Subject: CS

Date: 23-04-19-FN | Time: 1.30min

Answer any two questions from the following

(all questions carry equal 5 Marks) Max.Marks:10 M

1.A) Apply the Routh-Hurwitz Criterion to the following equation and investigate the stability

$$S^5+2S^4+24S^3+48S^2-25S-50=0$$

B) Consider a unity feedback control system with the following feed forward transfer function, plot the root locus for the system $G(S) = \frac{K}{S(S^2+4S+8)}$

2. A) Draw the Bode plot for the transfer function. From the graph determine ,$G(S) = \frac{16(S+2)}{S^2(S+8)(S+10)}$

i) Phase crossover frequency ii) Gain crossover frequency
iii) Phase margin
iv) Gain Margin v) Stability

B) Use Nyquist criterion, determine whether the closed loop system having the following open loop transfer function is stable or not. If not how may closed loop poles lie in the right half s-plane, $G(S)H(S)=\frac{1+4S}{S^2(1+S)(1+2S)}$

3. A) Sketch the polar plot for $G(S)=\frac{20}{S(S+1)(S+2)}$

B) Explain the design procedure and effect on Bode plot of Lead-Lag compensator and mention the Limitations and effects

4. A) Obtain the state model for the given transfer function and Draw the state diagram for given transfer function.$G(S) = \frac{16(S+2)}{S^2(S+8)(S+10)}$

B) Derive the Solution for State equation and Find the State Transition matrix (STM)

$$A=\begin{matrix} 2 & -2 & 3 \\ 1 & 1 & 1 \\ 1 & 3 & -1 \end{matrix}$$

C) A system is described by the matrices $A=\begin{matrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 0 & -2 & -3 \end{matrix}$, $B=\begin{matrix} 0 \\ 0 \\ 1 \end{matrix}$, $C=\begin{matrix} 1 & 2 & 0 \end{matrix}$

Determine the transfer Function

32

SIDDHARTHA INSTITUTE OF ENGINEERING AND TECHNOLOGY

Vinobhanagar, Ibrahimpatnam, R.R.District-501506

Name of the Exam: B.TECH II-II MID-II TERM EXAMS APR-2019

Branch: EEE | Subject: CS

Date: 23-04-19-FN | Time: 1.30min

Answer any two questions from the following

(all questions carry equal 5 Marks) Max.Marks:10 M

1.A) Apply the Routh-Hurwitz Criterion to the following equation and investigate the stability

$$S^5+2S^4+24S^3+48S^2-25S-50=0$$

B) Consider a unity feedback control system with the following feed forward transfer function, plot the root locus for the system $G(S) = \frac{K}{S(S^2+4S+8)}$

2. A) Draw the Bode plot for the transfer function. From the graph determine ,$G(S) = \frac{16(S+2)}{S^2(S+8)(S+10)}$

i) Phase crossover frequency ii) Gain crossover frequency
iii) Phase margin
iv) Gain Margin v) Stability

B) Use Nyquist criterion, determine whether the closed loop system having the following open loop transfer function is stable or not. If not how may closed loop poles lie in the right half s-plane, $G(S)H(S)=\frac{1+4S}{S^2(1+S)(1+2S)}$

3. A) Sketch the polar plot for $G(S)=\frac{20}{S(S+1)(S+2)}$

B) Explain the design procedure and effect on Bode plot of Lead-Lag compensator and mention the Limitations and effects

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B) Derive the Solution for State equation and Find the State Transition matrix (STM)

$$A=\begin{matrix} 2 & -2 & 3 \\ 1 & 1 & 1 \\ 1 & 3 & -1 \end{matrix}$$

C) A system is described by the matrices $A=\begin{matrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 0 & -2 & -3 \end{matrix}$, $B=\begin{matrix} 0 \\ 0 \\ 1 \end{matrix}$, $C=\begin{matrix} 1 & 2 & 0 \end{matrix}$

Determine the transfer Function

SIDDHARTHA INSTITUTE OF ENGINEERING &TECHNOLOGY

Vinobha nager ibrahimpatnam..R.R.DistrictHyderabad-501506

II B.Tech. II Sem., IInd Mid-Term Examinations, April – 2019

Branch: EEE **Subject: CS**

Date: 23-04-19-FN **Objective Exam** **Time: 30min**

Name: ______________________ Hall Ticket No.______________________

Answer All Questions. All Questions Carry Equal Marks. Time: 30 Min. Marks: 10.

I. Choose the correct alternative:

1. Which of the following is the best method for determining the stability and transient response? ( )
   (a)Root locus (b) Bode plot (c)Nyquist plot (d) None of the above
2. Phase margin of a system is used to specify which of the following? ( )
   (a)Frequency response (b) Absolute stability (c) Relative stability (d) Time response
3. Addition of zeros in transfer function causes which of the following? ( )
   (a) Lead-compensation (b) Lag-compensation
   (c) Lead-lag compensation (d) None of the above
4. Routh Hurwitz criterion cannot be applied when the characteristic equation of the system containing Coefficient's which is/are ( )
   a) Exponential function of s b) Sinusoidal function of s
   c) Complex d) Exponential and sinusoidal function of s and complex
5. The characteristic equation of a system is given as $S^3+25S^2+10S+50=0$. What is the number of the roots in the right half s-plane and the imaginary axis respectively? ( )
   a) 1, 1 b) 0, 0 c)2, 1 d)1, 2
6. The necessary condition in Routh's stability criterion of the linear system is that all the coefficients of Characteristic equation 1+G(s) H(s) =0, be real and have the: ( )
   a) Positive sign b) Negative sign c) Same sign d) Both positive and negative
7. The main objective of drawing root locus plot is ( )
   a) To obtain a clear picture about the open loop poles and zeroes of the system
   b) To obtain a clear picture about the transient response of feedback system for various values of open loop gain K
   c) To determine sufficient condition for the value of 'K' that will make the feedback system unstable
   d) Both b and c
8. In a bode magnitude plot, which one of the following slopes would be exhibited at high frequencies by a 4th order all-pole system? ( )
   a) -80dB/decade b) -40 dB/decade c) 40 dB/decade d) 80 dB/decade
9. For a stable closed loop system, the gain at phase crossover frequency should always be: ( )
   a) < 20 dB b) < 6 dB c) > 6 dB d) > 0 dB
10. The transfer function of a phase-lead controller is given by ( )
    a) (1+aTs)/(1+Ts) , a>1 T>0 b) (1+aTs)/(1+Ts) , a<1 T>0
    c) (1-aTs)/(1+Ts) , a>1 T>0 d) (1±Ts)/(1+Ts) , a<1 T>0

Fill in the Blanks:

11. The characteristic equation of a system is given as $3S^4+10S^3+5S^2+2=0$. This system is ______________
12. Root locus of s(s+2) +K(s+4) =0 is a circle. What are the coordinates of the center of this circle?__________
13. Root locus is used to calculate______________________
14. Number of roots of characteristic equation is equal to the number of ______________
15. The equation $2s^4+s^3+3s^2+5s+10=0$ has roots in the left half of s–plane__________________
16. The polar plot of a transfer function passes through the critical point (-1, 0). Gain margin is__________
17. For the transfer function G(s) H(s) = 1 / s(s+1) (s+0.5), the phase cross-over frequency is____________
18. If a Nyquist plot of G (jω) H (jω) for a closed loop system passes through (-2, j0) point in GH plane, what Would be the value of gain margin of the system in dB?________________
19. For Nyquist contour, the size of radius is ____________________
20. According to the property of state transition method, e^0 is equal to ______________

-oOo-

Assignment-2
Control Systems-2019

1.A) Apply the Routh-Hurwitz Criterion to the following equation and investigate the stability

$$S^5+2S^4+24S^3+48S^2-25S-50=0$$

B) Consider a unity feedback control system with the following feed forward transfer function, plot the root locus for the system **G(S)** = $\frac{K}{S(S^2+4S+8)}$

2. A) Draw the Bode plot for the transfer function. From the graph determine ,**G(S)** = $\frac{16(S+2)}{S^2(S+8)(S+10)}$

i) Phase crossover frequency ii) Gain crossover frequency iii) Phase margin
iv) Gain Margin v) Stability

B) Use Nyquist criterion, determine whether the closed loop system having the following open loop transfer function is stable or not. If not how may closed loop poles lie in the right half s-plane, **G(S)H(S)**=$\frac{1+4S}{S^2(1+S)(1+2S)}$

3. A) Sketch the polar plot for **G(S)**= $\frac{20}{S(S+1)(S+2)}$

B) Explain the design procedure and effect on Bode plot of Lead-Lag compensator and mention the Limitations and effects

4. A) Obtain the state model for the given transfer function and Draw the state diagram for given transfer function.**G(S)** = $\frac{16(S+2)}{S^2(S+8)(S+10)}$

B) Derive the Solution for State equation and Find the State Transition matrix (STM)

$$A=\begin{matrix} 2 & -2 & 3 \\ 1 & 1 & 1 \\ 1 & 3 & -1 \end{matrix}$$

C) A system is described by the matrices $A=\begin{matrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 0 & -2 & -3 \end{matrix}$, $B=\begin{matrix} 0 \\ 0 \\ 1 \end{matrix}$, $C=\begin{matrix} 1 & 2 & 0 \end{matrix}$

Determine the transfer Function

Assignment-2
Control Systems-2019

1.A) Apply the Routh-Hurwitz Criterion to the following equation and investigate the stability

$$S^5+2S^4+24S^3+48S^2-25S-50=0$$

B) Consider a unity feedback control system with the following feed forward transfer function, plot the root locus for the system **G(S)** = $\frac{K}{S(S^2+4S+8)}$

2. A) Draw the Bode plot for the transfer function. From the graph determine ,**G(S)** = $\frac{16(S+2)}{S^2(S+8)(S+10)}$

i) Phase crossover frequency ii) Gain crossover frequency iii) Phase margin
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3. A) Sketch the polar plot for **G(S)**= $\frac{20}{S(S+1)(S+2)}$

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C) A system is described by the matrices $A=\begin{matrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 0 & -2 & -3 \end{matrix}$, $B=\begin{matrix} 0 \\ 0 \\ 1 \end{matrix}$, $C=\begin{matrix} 1 & 2 & 0 \end{matrix}$

Determine the transfer Function

Mid-2 Key

1. Sub: Control system   Name: S. Rajesh   Date: 23/04/19 FN

B. Tech II-II MIB April-2019

1 A
Ans
$s^5 + 2s^4 + 24s^3 + 48s^2 - 25s - 50 = 0$

s^5	1	24	-25
s^4	2	48	-50
s^3	0	0	
s^2			
s^1			
s^0			

$\frac{(24\times2) - 48}{2} = 0$

$\frac{(-25\times2) - (1\times-50)}{2} = 0$

Third row is zero. Hence the auxiliary Polynomial A(s)

$A(s) = 2s^4 + 48s^2 - 50$

$\frac{dA(s)}{d(s)} = 8s^3 + 96s$

Now the Routh can be written as

s^5	1	24	-25
s^4	2	48	-50
s^3	8	96	
s^2	24	-50	
s^1	112.6		
s^0	-50		

No. of sign change in first column = 1

∴ No. of roots in right half s-plane = 1

$2s^4 + 48s^2 - 50 = 0$

$(s+1)(s-1)(s+j5)(s-j5)(s+2) = 0$

The roots of auxilary equations are dominant roots

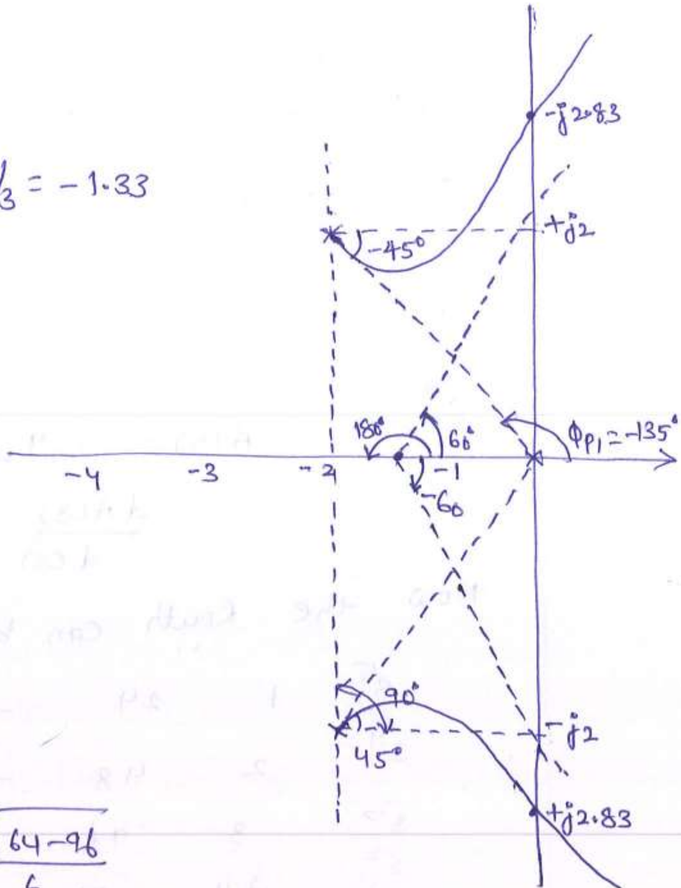
so the system is unstable

1 B

Root locus

$$G(s) = \frac{K}{s(s^2+4s+8)}$$

$S_1 = 0, \; S_2 = -2+j2, \; S_3 = -2-j2$



Step-1 No. of root locij

$P = 3, \; Z = 0 \qquad N = P = 3$

Step-2 :- centroid

$$\sigma_A = \frac{(0-2+j2-2-j2)-(0)}{3} = -4/3 = -1.33$$

Step-3 Angle of asymptotes

$$\phi = \frac{2K+1}{P-Z} \times 180$$

$K=0 \Rightarrow \phi_1 = 60°, \; K=1 \; \phi_2 = 180°$

$K=2 \qquad \phi_3 = 300°$

Step-4 Breakaway point

$1 + G(s)H(s) = 0$

$s^3 + 4s^2 + 8s + K = 0$

$K = -(s^3+4s^2+8s)$

$$\frac{dK}{ds} = -3s^2 + 8s + 8 = s = \frac{-8 \pm \sqrt{64-96}}{6}$$

$= -1.33 \pm j\,0.943$ No Breakaway point on real axis

Step-5 Point of intersection with $j\omega$ axis

$s^3 + 4s^2 + 8s + K = 0$

s^3	1	8
s^2	4	K
s^1	$\frac{32-K}{4}$	
s^0	K	

$32 - K = 0 \quad K = 32$

$4s^2 + K \Rightarrow 4s^2 + 32 = 0$

$s = \pm j\,2.83$

Step-6 Angle of departure

$$\phi_d = 180° - (135° + 90°) = -45°$$

2B. G(s) H(s) Nyquist criterion

$G(s) H(s) = \dfrac{1+4S}{s^2 (1+S)(1+2S)}$

Put $s = j\omega$ $= G(j\omega) H(j\omega) = \dfrac{1+j4\omega}{(j\omega)^2 (1+j\omega)(1+j2\omega)}$

ω	0	∞	0.1	2.0	4.0	20.
	$\angle -180^\circ$	$\angle -270$	$\angle -175$	$\angle -236.5^\circ$	$\angle -252.4$	$\angle -266.4$
	∞	0	105	0.21	0.03	0.00024

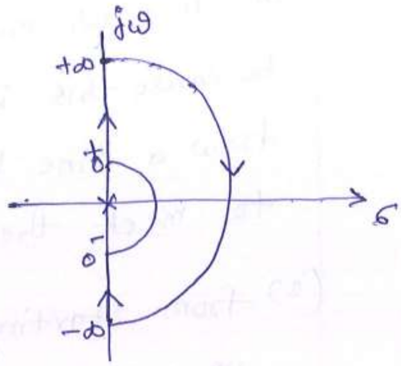
$M = |G(j\omega) H(j\omega)| = \sqrt{1+16\omega^2} \Big/ \left(\omega^2 \sqrt{1-\omega^2} \quad \sqrt{1+4\omega^2}\right)$

$\angle G(j\omega) H(j\omega) = \tan^{-1} 4\omega - 180^\circ - \tan^{-1}\omega - \tan^{-1} 2\omega = -180^\circ$

$\tan^{-1} 4\omega = \tan^{-1}\omega + \tan^{-1} 2\omega.$

$4\omega = \dfrac{\omega + 2\omega}{1+2\omega^2}$ $\quad \omega = 0.35$ rad/se

$|G(j\omega) H(j\omega)|_{\omega = 0.35^-} = -10.64$



2 Mapping of infinite semi circle

$\lim_{R \to \infty} \dfrac{1+Re^{j\theta} \cdot 4}{(R^2 e^{j2\theta})(1+Re^{j\theta})(1+2Re^{j\theta})} = 0\angle -270^\circ$

$\lim_{P \to 0} \left[\infty \angle 180^\circ \to \angle 0^\circ \to \angle -180^\circ \right.$

Since $OA = -10.64$ hence $(-1+j0)$

encircles two times in clock wise direction

$N = 2$

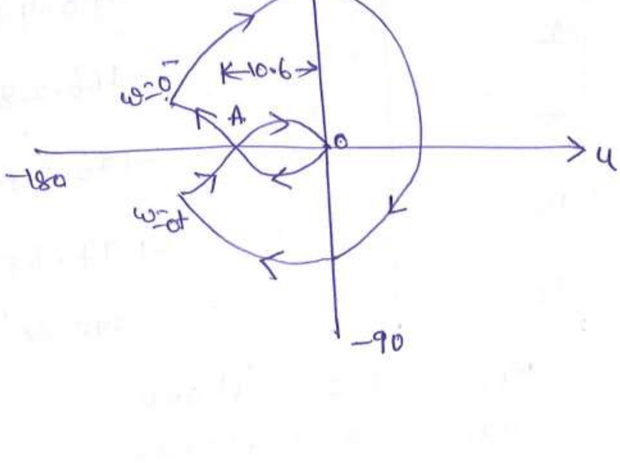
$P = 0$

$N = Z - P$

$2 = Z - 0$

$Z = 2$

system is unstable



2A87

A

$G(s) = \frac{16(s+2)}{s^2(s+8)(s+10)} = \frac{16(1+0.5s)}{s^2(1+0.125s)(1+0.1s)}$

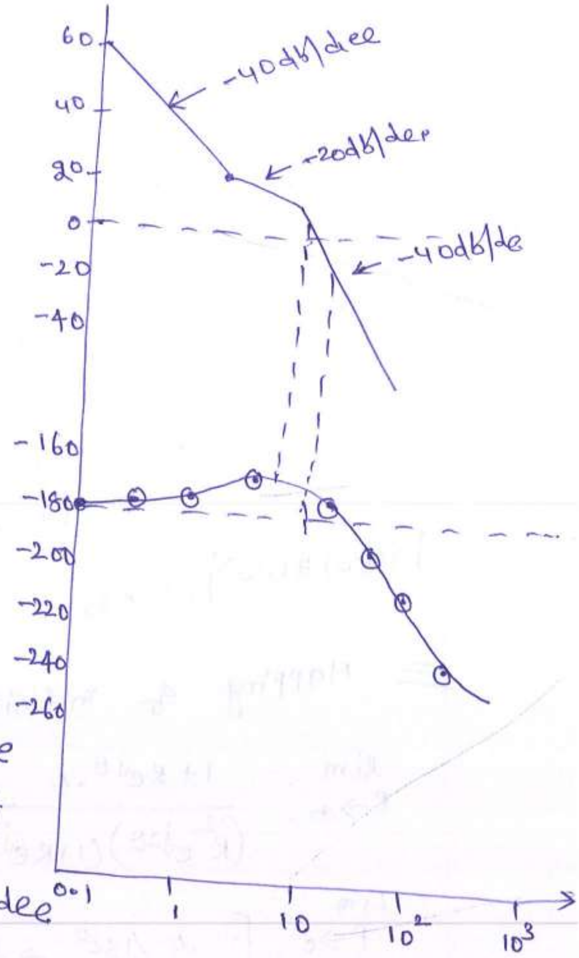
Put = $s = j\omega$

$G(j\omega) = \frac{16(1+j0.5\omega)}{(j\omega)^2(1+j0.125\omega)(1+j0.1\omega)}$

$\omega_1 = 1/0.5 = 2$ rad/sec

$\omega_2 = 1/0.125 = 8$ rad/see

$\omega_3 = 1/0.1 = 10$ rad/see



1) A ω-axis mark $\omega = \sqrt{K} = \sqrt{16} = 4$ rad/se be cause this is a type two system draw a line having the slop of −40dB/dee to meet the y. axis It is starting point

(2) from starting point a slope of −40db/dee up to 1st corner freqency

(3) −20 db/dee slop from Ist to IInd corner freq

(4) from IInd to 3rd. −40 db slope can draw

ω	$(-j\omega)^2 - \tan^{-1}0.125\omega - \tan^{-1}0.1\omega + \tan^{-1}0.5\omega$
0.1	−178.42
1	−166.28
5	−170.37
10	−197.65
30	−240.38°

$\omega_{pc} = 6.5$ rad/see

$\omega_{gc} = 8$ rad/see

PM = −8°

GM = −2 dB

$\omega_{gc} > \omega_{pc}$ so system is unstable.

3.A Ans

$G(s) = \frac{20}{s(s+1)(s+2)}$ Polar Plot

$|G(j\omega)| \angle G(j\omega) = \frac{20}{\omega\sqrt{1+\omega^2}\sqrt{4+\omega^2}} \angle -90^\circ - \tan^{-1}\omega - \tan^{-1}\omega/2$

$\lim_{\omega \to 0} |G(j\omega)| \angle G(j\omega) = \infty \angle -90^\circ$

$\lim_{\omega \to \infty} |G(j\omega)| \angle G(j\omega) = 0 \angle -270^\circ$

separating real & imaginary part of $G(j\omega)$

$G(j\omega) = \frac{-60\omega^2}{(\omega^4+\omega^2)(4+\omega^2)} + j\frac{20(\omega^3-2\omega)}{(\omega^4+\omega^2)(4+\omega^2)}$

equating $j\omega$ axis to zero

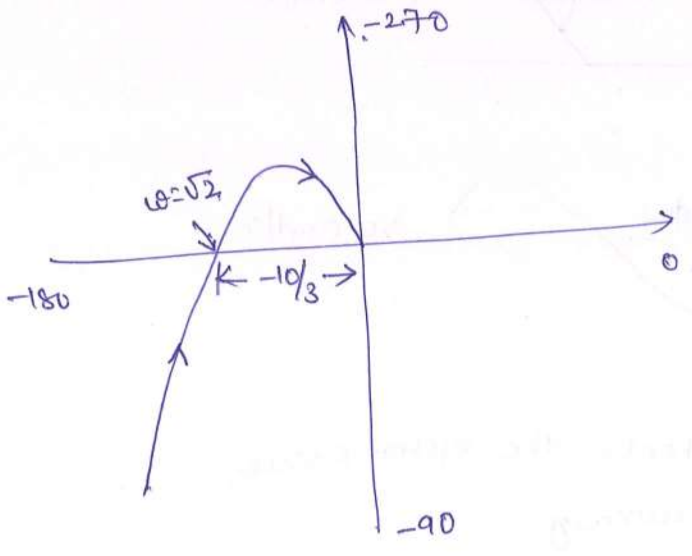
$\frac{20(\omega^3-2\omega)}{(\omega^4+\omega^2)(4+\omega^2)} = 0 \quad \therefore \omega = \pm\sqrt{2} \ \& \ \omega = \pm\infty$

$G(j\omega) = \frac{-10}{3} \angle 0$ and $0 \angle 0^\circ$

equating real part to zero

$\frac{-60\omega^2}{(\omega^4+\omega^2)(4+\omega^2)} = 0 \quad \omega = \infty$

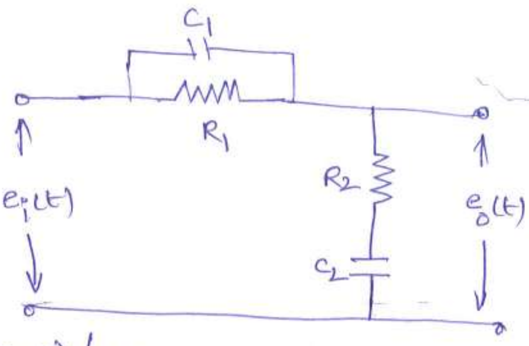
$0 \angle -270^\circ$



Polar Plot

3 Ans (15)

Lead-lag compensator



$$Z_1 = \frac{R_1}{1+R_1C_1S}, \quad Z_2 = \frac{1+R_2C_2S}{C_2S}$$

$$\frac{E_0(s)}{E_i(s)} = \frac{Z_2(s)}{Z_1(s)+Z_2(s)} = \frac{(1+R_2C_2S)/C_2S}{\frac{1+R_2C_2S}{C_2S} + \frac{R_1}{1+R_1C_1S}}$$

$$\frac{E_0(s)}{E_i(s)} = \frac{(1+R_1C_1S)(1+R_2C_2S)}{1+(R_1C_1+R_2C_2+R_1C_2)s + R_1R_2C_1C_2s^2}$$

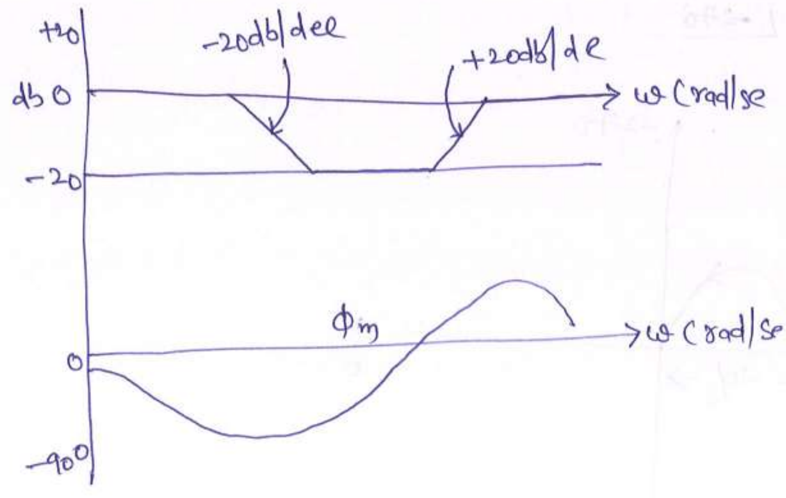
$$G(s) = \left(\frac{1+aT_1s}{1+T_1s}\right)\left(\frac{1+bT_2s}{1+T_2s}\right)$$

$aT_1 = R_1C_1$, $bT_2 = R_2C_2$, $T_1T_2 = R_1R_2C_1C_2$

$abT_1T_2 = R_1R_2C_2$

$$\boxed{ab = 1}$$

Bode plot for Lead Lag network



effects 1) fast Response the system Response

(2) more accuracy

(3) improves steady state response

4 Ans)

State model $G(s) = \dfrac{16(s+2)}{s^2(s+8)(s+10)}$

$$\frac{y(s)}{u(s)} = \frac{x_1(s)}{u(s)} \times \frac{y(s)}{x_1(s)}$$

$$x_1(s)\left[s^2(s+8)(s+10)\right] = y(s)\,16$$

$$x_1(s)\left[s^2(s^2+36s+80)\right] = y(s) = 16$$

$$x_1(s)\left[s^4+36s^3+80s^2\right] = y(s) = 16$$

$$\ddot{\ddot{x}}_1(t) + 36\dddot{x}_1(t) + 80\ddot{x}(t) = y(s)\,16$$

$$\dot{x}_1 = x_2$$

$$\ddot{x}_1 = \dot{x}_2 = x_3$$

$$\dddot{x}_1 = \ddot{x}_2 = \dot{x}_3 = x_4$$

$$\ddot{\ddot{x}}_1 = \dddot{x}_2 = \ddot{x}_3 = \dot{x}_4$$

$$\ddot{\ddot{x}}_1(t) = 16y(t) - 36\dddot{x}_1(t) - 80\ddot{x}(t)$$

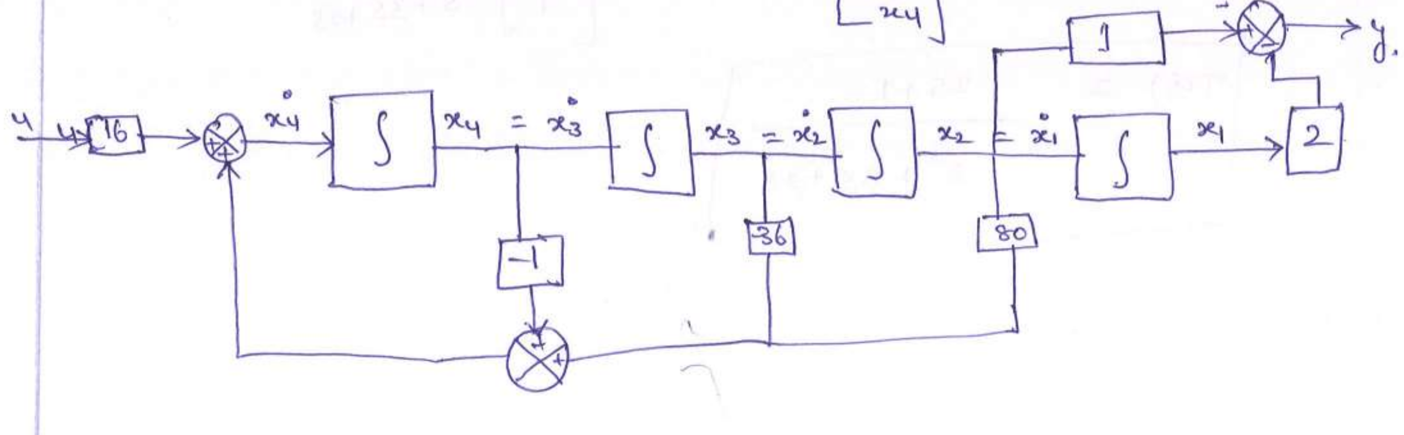
$$\dot{x}_4(t) = 16y(t) - 36x_4(t) - 80x_3(t)$$

$$\begin{bmatrix}\dot{x}_4(t)\\ \dot{x}_3(t)\\ \dot{x}_2(t)\\ \dot{x}_1(t)\end{bmatrix} = \begin{bmatrix}-36 & -80 & 0 & 0\\ 1 & 0 & 0 & 0\\ 0 & 1 & 0 & 0\\ 0 & 0 & 1 & 0\end{bmatrix}\begin{bmatrix}x_4\\ x_3\\ x_2\\ x_1\end{bmatrix} + \begin{bmatrix}16\\ 0\\ 0\\ 0\end{bmatrix} y(t)$$

$$y(s) = (s+2)\,x_1(s) = s x_1(s) + 2x_1(s)$$

$$\dot{x}_1(t) + 2x_1(t)$$

$$y(t) = \begin{bmatrix}1 & 2 & 0 & 0\end{bmatrix}\begin{bmatrix}x_1\\ x_2\\ x_3\\ x_4\end{bmatrix}$$



4b State Transition matrix

$$A = \begin{bmatrix} 2 & -2 & 3 \\ 1 & 1 & 1 \\ 1 & 3 & -1 \end{bmatrix} \quad A^2 = \begin{bmatrix} 5 & 3 & 1 \\ 4 & 2 & 3 \\ 4 & -2 & 7 \end{bmatrix} ; \quad A^3 = \begin{bmatrix} 14 & -4 & 17 \\ 13 & 3 & 11 \\ 13 & 11 & 3 \end{bmatrix} \text{ as so on}$$

$$e^{At} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} + \begin{bmatrix} 2t & -2t & 3t \\ t & t & t \\ t & 3t & -t \end{bmatrix} + \frac{t^2}{2} \begin{bmatrix} 5 & 3 & 1 \\ 4 & 2 & 3 \\ 4 & -2 & 7 \end{bmatrix} + \frac{t^3}{6} \begin{bmatrix} 14 & -4 & 17 \\ 13 & 3 & 11 \\ 13 & 11 & 3 \end{bmatrix} + \cdots$$

$$= \begin{bmatrix} 1+2t+5/2\,t^2+14/6\,t^3+\cdots & -2t+3t^2/2-\frac{2t^2}{3}+\cdots & 3t+t^2/2+\frac{17}{6}t^3+\cdots \\ t+2t^2+13/6\,t^3+\cdots & 1+t+t^2+\cdots & t+3t^2/2+11t^3/6+\cdots \\ t+2t^2+13/6\,t^3+\cdots & 3t-t^2+\frac{11t^3}{6}+\cdots & 1-t+\frac{7t^2}{2}+\frac{3t^3}{6}+\cdots \end{bmatrix} \text{Ans}$$

4C Transfer function

$$A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 0 & -2 & -3 \end{bmatrix} \quad B = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} \quad C = \begin{bmatrix} 1 & 2 & 0 \end{bmatrix}$$

$$[sI - A] = \begin{bmatrix} s & -1 & 0 \\ 0 & s & -1 \\ 0 & 2 & s+3 \end{bmatrix}$$

$$[sI-A]^{-1} = \frac{1}{s^3+3s^2+2s} \begin{bmatrix} s^3+3s+2 & s+3 & 1 \\ 0 & s^2+3s & s \\ 0 & -2s & s^2 \end{bmatrix}$$

$$C[sI-A]^{-1} = \begin{bmatrix} 1 & 2 & 0 \end{bmatrix} \begin{bmatrix} s^3+3s+2 & s+3 & 1 \\ 0 & s^2+3s & s \\ 0 & -2s & s^2 \end{bmatrix} \frac{1}{s^3+3s^2+2s}$$

$$C[sI-A]^{-1}B = \begin{bmatrix} s^2+3s+2 & 2s^2+7s+2s+1 \end{bmatrix} \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} \frac{1}{s^3+3s^2+2s}$$

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

→ In recent years, concept of automatic control has achieved a very important position in advancement of modern science. Automatic control systems have played an important role in the advancement and improvement of engineering skills. There are many advantages of automatic control system like.

i) cost of energy or power reduced.
ii) cost of processing materials in industries reduces.
iii) Quality of products improve
iv) Productivity increases.

→ The first significant control device was "James watt's flyball governer. This was invented in 1767 to keep the speed of the engine constant by regulating the supply of the steam to the engine.

→ In control system the ~~differential~~ behaviour of the system is described by the differential equations. Minorsky, in 1922 showed that to determine the stability from the differential equations describing the systems.

Definitions

Control system: It is an arrangement of different physical elements connected in such a manner so as to regulate, direct or command itself or some other system.

Plant: The portion of a system which is to be controlled or regulated is called the plant or the process.

Controller: The element of the system itself or External to the system which controlls the plant or the process is called controller.

Disturbances:- It is a signal which tends to adversely affect the value of the output of a system. If such a disturbance is generated within the system itself, it is called an "Internal Disturbance. The disturbance generated outside the system acting as an extra input to the system in addition to its normal input, affecting the output adversely is called an "External disturbance."

The input variable is generally referred as the reference input and output is generally Referred as the controlled output.

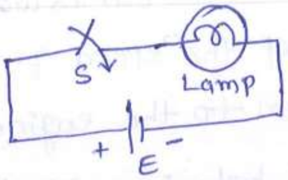
→ **Different Examples of control systems.**

Example - 1

If in a classroom, professor is delivering his lecture, the combination becomes a control system as; he tries to regulate, direct or command the students in order to achieve the objective which is to impart good knowledge to the students.

Example - 2

If a lamp is switched ON or OFF using a switch, the entire system can be called a controlled system.



Example - 3

When a child plays with the kite, he tries to control it with the help of string or rope and entire system can be considered as a control system.

→ Electric iron termostat, refrigeration control, toilet tank, water level control and sprinkler used to water a lawn, stepper motor motor positioning system, Automatic Toaster system, Traffic light controller, Automatic Door opening and Closing system, room heater, fan regulator, automatic coffee server, electric lift, theatre lamp dimmer, automatic dryer, Home Heating system, ship stabilization system, Motor speed control, Temperature control system are some of the Examples of both open loop & closed loop control systems.

Classification of control systems:-

Broadly control systems can be classified as

(1) Natural control system:- The biological systems, systems inside human being are of natural type

Example: The perspiration system inside the human body activates the secretion glands, secreating sweat. and regulates the temperature of human body.

2. **Manmade control systems:** The various systems, we are using in our day to day life are designed and manufactured by human beings. Such systems like vehicles, switches, Various Controllers etc. are called manmade control systems.

Example 2: An automobile system with gears, accelerator, braking system is a good example of manmade control system.

3. **Combinational control systems:** It is having combination of natural and manmade together i.e
Example: A Driver driving a vehicle. In such system, for successful operation of the system, it is necessary that natural systems (eye sight & brain activation simultaniously) along with systems in vehicles which are manmade must be active (brake, accelarator, steering ect)

→ But for the engineering analysis, control systems can be classified in many different ways. Some of the classifications are given below.

4. Time varying and Time - Invariant systems:

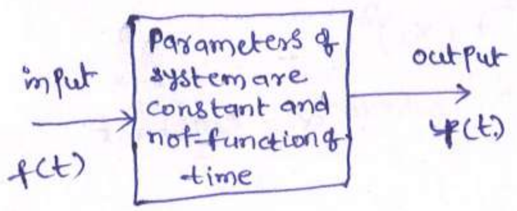
Time varying control systems are those in which Parameters of the systems are varying with time. It is not dependent on whether input and output are functions of time or not

Ex:-1: Space Vehicle whose mass decreases with time, as it leaves earth. The Mass is a parameter of space vehicle system.

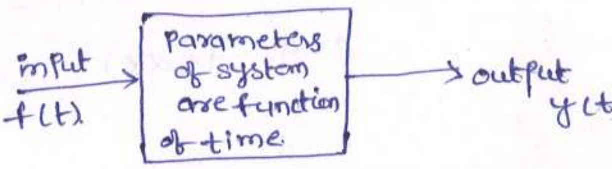
Ex:2: In case of a rocket, aerodynamic damping can change with time as the air density changes with the altitute.

The time invariant systems are those in which Parameter of the system are independent of time, which are not varying with time and are constants, if even though the inputs and outputs are functions of time.

Ex:- Different electrical networks which consist of Resistance, Capacitance and Inductance are time invarient system.



(a) Time invariant system



(b) Time varient system

5) Linear and Nonlinear systems :-

→ A control system is said to be linear if it satisfies following properties

a) The principle of superposition is applicable to the system. This means the response to several inputs can be obtained by considering one input at a time and then algebraically adding the individual results.

Mathematically Principle of superposition is expressed by two properties

(i) Additiv Property : which says that for "x" & "y" belonging to the domain of the function (f) then we have

$$f(x+y) = f(x) + f(y)$$

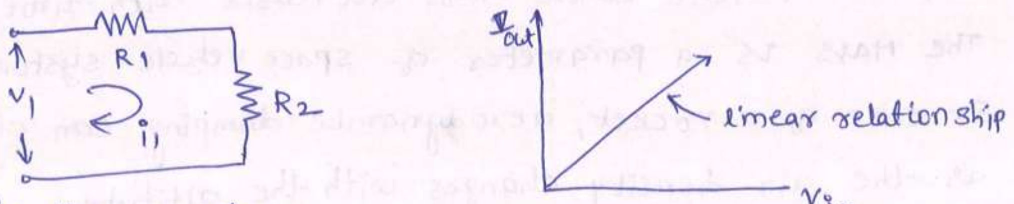
(ii) Homogeneous property : which says that for any "x" belonging the domain of the function (f) and for any scalar constant "α" we have

$$f(\alpha x) = \alpha f(x)$$

(b) The differential equation describing the system is linear having its coefficients as constante.

(c) Practically the output i.e response varies linearly with the input i.e forcing function for linear systems.

Real time Example :- A resistive network shown in the fig below is a linear system. and shows the linear relationship existing between input and output



(a) linear system

→ A control system is said to be nonlinear, if

(a) It does not satify the principle of superposition & Homogeneous properties

(b) The equations describing the system are non linear in nature.

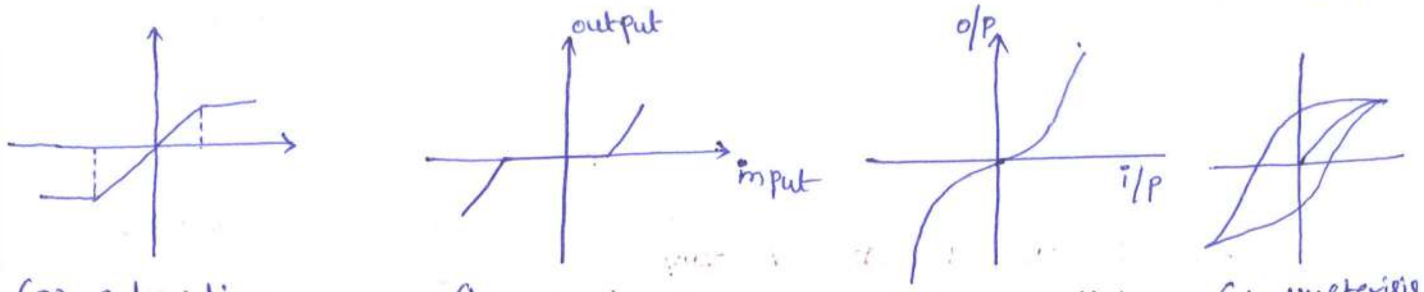
The function $f(x) = x^2$ is non-linear because

$$f(x_1+x_2) = (x_1+x_2)^2 \neq (x_1)^2 + (x_2)^2$$

and $f(\alpha x) = (\alpha x)^2 \neq \alpha x^2$ where α = constant.

c. The output does not vary linearly for nonlinear systems.

The equations of non linear system involves such non linear functions



(a) saturation (b) : Dead zone (c) Exponential or square law (d) Hysterisis or B-H curve

fig : Different types of non linearities.

Ex:- (1) B-H curve of magnetic field. (saturation)

(2) voltage- current characteristics of diode, those are Exponential

NOTE : Most of the physical systems are non-linear to certain Extent.

6) Continuous time and Discrete time Control systems :

In a continous time control system all system variable are the functions of a continous time variable "t"

Ex:- The speed control of a dc Motor using a tachogenerator feedback is an example of continous data system. At any time "t" they are dependent on time.

In discrete time systems one or more system variables are known only at certain discrete intervals of time. They are not continously dependent on the time.

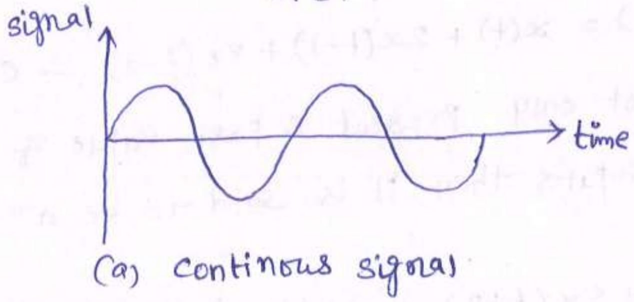
Ex:- Microprocessor or computer based systems use such discrete time signals.

The reasons for using such signals in digital controllers are

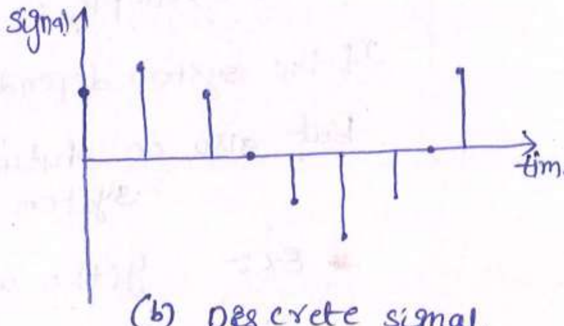
a) Such signals are less sensitive to noise

(b) Time sharing of one equipment with other channels is possible

(c) Advantageous from point of view of size, speed, memory, flexibility etc.



(a) continous signal



(b) Discrete signal.

Static and Dynamic systems :-

The system in which the output is dependent only on the input applied at the specific time and not on the initial conditions are called static systems. There are no energy storing elements in the static systems.

* Ex:- A pure resistive network.

The system in which output for each value of the independent variable at any instant "t" depends upon the present value of the input signal, but not on past and future value of the input signal. This system is also called "Memory less (or zero memory) system.

Mathematical Expression for static system, if "x" is a variable of function "f" it is

* $x(t) \longrightarrow y(t)$ (or) $x(n) \longrightarrow y(n)$

$\downarrow$ continous system — discrete system.

The systems in which the output is dependent on the input as well as on the initial conditions, that is past and future values of input signals i.e memory are called dynamic systems. It is also called "posses memory" system. A system which consist of Inductance and capacitance are examples.

Mathematical Expression for dynamic system, if "x" is a variable of function "f" it is

* $x(t) \rightarrow y(t-1)$ or $x(t) \rightarrow y(t+1)$ → continous system

$x(n) \rightarrow y(n-1)$ or $x(t) \rightarrow y(n+1)$ → discreate system.

Causal and Non causal systems :-

A system is said to be causal, if the present value of the output signal depents only on the present and past values of the input signal but does not depends on future inputs

* For Example : $y(t) = x(t) + 2x(t-1) + 3x(t-2)$ — Causal system

If the system depends not only present & past value of input signal but also on future inputs then it is said to be a "non causal" system

* Ex:- $y(t) = x(t) + 5x(t+3) + 2x(t-2)$ → non causal system.