Academic Course Description

BHARATH UNIVERSITY Faculty of Engineering and Technology Department of Electronics and Communication Engineering

BEI601- Control Systems

Fifth Semester, 2015-16 (even Semester)

Course (catalog) description

System modeling, simulation, analysis and controller design. Differential equations, transfer function representation, block diagrams and signal flows. System dynamic properties in time and frequency domains, performance specifications. Stability analysis: Routh-Hurwitz criterion, Root Locus method, Bode gain and phase margins, Nyquist criterion. Bode plot and polar plot, Classical controller design in time and frequency domain: lead, lag, lead-lag compensation, rate feedback, PID controller.

Compulsory/Elective course: Compulsory for ECE students

Credit hours : 4 credits

Course Coordinator : Mr.R.Mohanraj, Asst. Professor, Department of ECE

Instructor(s) : Mr.Srinivasan, Asst. Professor, Department of ECE

Name of the instructor	Class handling	Office location	Office phone	Email (domain: @bharathuniv.ac.in)	Consultation
Mr.R.Mohanraj	Third year ECE	SA006		mohanraj.ece @bharathuniv.ac.in	9.00-9.50 AM
Mr.Srinivasan	Third year ECE	SA006		Srinivasan.etc @bharathuniv.ac.in	12.45-1.15 PM

Relationship to other courses

Pre-requisites : BPH101 Engineering Physics –I, BMA101 Mathematics –I

Assumed knowledge : The students will have a physics and mathematics background obtained at a high

School (or equivalent) level. In particular, working knowledge of basic mathematics

Including differentiation, integration and probability theories are assumed.

Following courses : Nil

Syllabus Contents

UNIT 1 CONTROL SYSTEM MODELLING

12 HOURS

System concept. Differential equations. Transfer functions. Introduction to model based design-Modelling of electric systems, Translational and rotational mechanical systems, simple Electro - mechanical systems. Block diagram representation of systems. Block Diagram reduction methods. Closed loop transfer function, determination of Signal flow graphs. Mason's gain formula. Examples. Need for modulation, Amplitude Modulation System, Single Tone & Multiple Tone Amplitude Modulation, Power Relation, Generation of Amplitude Modulation – Linear Modulation – Collector Modulation method Non-linear Modulation – Square law Modulator, Product Modulator, Switching Modulator - Demodulation of Amplitude Modulation – Envelope Detector, Coherent Detector, VSB, Performance comparison of various Amplitude Modulation System.

UNIT 2 TIME RESPONSE ANALYSIS

12 HOURS

First Order Systems. Impulse and Step Response analysis. Second Order system Analysis. Steady state error. Error Coefficients and Generalized error series. Principle of PI, PD and PID Compensation. Servo Motor, Synchros & Stepper Motor-analysis using Matlab.

UNIT 3 STABILITY IN TIME DOMAIN

12 HOURS

Stability Analysis. Routh - Hurwitz Criterion. Root locus Method. Construction of root, locus diagrams. Stability Study. Application of root locus diagram-analysis using Matlab.

UNIT 4 STABILITY IN FREQUENCY DOMAIN

12 HOURS

Frequency response analysis. Frequency domain specifications . Polar plot, Bode's Plot, Magnitude - Phase plot, Constant M and N Circles. Nichol's Chart Nyquist Stability Criterion. Relative Stability - gain Margin and Phase margin, determination from Polar plot, Bode's Plot and Magnitude – Phase Plot. Use of Nichol's Chart in system analysis to determine relative stability, Bandwidth, Resonance peak and resonance frequency- Analysis using Matlab.

UNIT 5 COMPENSATION TECHNIQUES

12 HOURS

Cascade and feedback compensation. Lag, Lead and Lag- lead Compensation. Design of Cascade Compensators - Using Bode's Plot.

TOTAL 60 HOURS

Text book(s) and/or required materials

TEXT BOOKS

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T1. J.Nagrath and M.Gopal, "Control System Engineering", New Age International Publishers, 5 Edition, 2007.

REFERENCES

- R1. Benjamin.C.Kuo, "Automatic control systems", Prentice Hall of India, 7thEdition, 1995.
- R2.M.Gopal, "Control System Principles and Design", TataMcGrawHill, 2ndEdition, 2002.
- R3. Schaum"sOutlineSeries, "FeedbackandControlSystems" Tata McGraw-Hill,2007.
- R4. John J.D"Azzo & Constantine H. Houpis, "Linear Control System Analysis and Design", Tata McGraw-Hill, Inc., 1995.
- R5. www.electrical4u.com

Computer usage: Nil

Professional component

General - 0%
Basic Sciences - 0%
Engineering sciences & Technical arts - 0%
Professional subject - 100%

Broad area: | Signal Processing | Electronics | Embedded

Test Schedule

S. No.	Test	Tentative Date	Portions	Duration	
1	Cycle Test-1	February 2 nd week	Session 1 to 20	2 Periods	
2	Cycle Test-2	March 2 nd week	Session 21 to40	2 Periods	
3	Model Test	April 2 nd week	Session 1 to 60	3 Hrs	
4	University Examination	ТВА	All sessions / Units	3 Hrs.	

Mapping of Instructional Objectives with Program Outcome

To study control problem, control system dynamics and feedback principles. To study time response	nse Co	Correlates to		
of first and second order systems and basic state variable analysis and to do simple problems. To study	the [program		
concept of stability and criteria for stability and to do simple problems. To study the frequency response	nse (outcome		
through polar plots and Bode plots and Nyquist stability criteria and to do simple problems.	Н	М	L	
1. Outline the development of mathematical models to represent systems and their representation	n a	f,I,j	g	
by transfer functions				
2. Discuss the transient and steady state response of control systems	С	a,e,d	i	
3. Practice frequency domain plots (Bode and Polar)	d	а	h	
4. Analyze performance of control systems	e,j	a,e,g	i	
5. Design compensation networks.	a	i	b	
6. Design the different types of compensators	f			

H: high correlation, M: medium correlation, L: low correlation

Draft Lecture Schedule

Session	Topics	Problem Solving (Yes/No)	Text/Chapter
UNIT I	CONTROL SYSTEM MODELLING		
1.	System Concept	No	
2.	Differential equations	Yes	
3.	Transfer functions.	Yes]
4.	Modelling of electric systems,	Yes	T1] Chapter -1,
5.	Translational mechanical systems	Yes	[R1]Chapter-2,3
6.	Rotational mechanical systems	Yes]
7.	simple Electro - mechanical systems.	Yes]
8.	Block diagram representation of systems	Yes]
9.	Block Diagram reduction methods	Yes]
10.	Closed loop transfer function	Yes]
11.	Determination of Signal flow graphs	Yes	
12.	Mason's gain formula with Examples	Yes	
UNIT II	TIME RESPONSE ANALYSIS	·	
13.	First Order Systems	Yes	
14.	Impulse and Step Response analysis	Yes	
15.	Second Order system Analysis	Yes	
16.	Steady state error	Yes	
17.	Steady state error with input signal	Yes	[T1] Chapter -2,
18.	Error Coefficients	Yes	[R1]Chapter-4,5
19.	Generalized error series	Yes	
20.	Principle of PI, PD Compensation	Yes]
21.	PID Compensation	Yes	
22.	Servo Motor,	Yes]
23.	Synchros & Stepper Motor	Yes	7
24.	analysis using Matlab	Yes]
JNIT III	STABILITY IN TIME DOMAIN		
25.	Stability Analysis	Yes	

27. Location of poles on s-Plane for Stability 28. Routh - Hurwitz Criterion 29. Construction of Routh array 30. Routh array Cases 31. Root locus Method 32. Construction of root locus diagrams. 33. Root locus problems 34. Stability Study 35. Application of root locus diagram. 36. Analysis using Matlab 37. Frequency domain specifications 38. Frequency domain specifications 39. Polar plot, 40. Bode's Plot Magnitude & Phase plot 41. Constant M and N Circles, Nichol's Chart 42. Nyquist Stability Criterion 43. Relative Stability 44. Gain Margin and Phase margin 45. Determination from Polar plot 46. Use of Nichol's Chart relative stability 47. Bandwidth, Resonance peak resonance frequency. 48. Analysis using Matlab 49. [T1] Chapter -4, [R2] Chapter -6,7 Yes [T1] Chapter -4, [R2] Chapter -6,7 Yes 46. Use of Nichol's Chart relative stability 47. Bandwidth, Resonance peak resonance frequency. 48. Analysis using Matlab	2/	Definition of Stability analysis	Yes	-
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51. Design of Lag Compensation Using Bode plots 52. Design of Lag Compensation Using root locus 53. Lead Compensation 54. Design of Lead Compensation Using Bode plots 55. Design of Lead Compensation Using root locus 56. Lag- lead Compensation 57. Design of Lag-Lead Compensation Using Bode plots 58. Design of Lag-Lead Compensation Using root locus 59. Design of Cascade Compensators 59. Design of Cascade Compensators 51. The sign of Lag-Lead Compensation Using Bode plots 52. The sign of Lag-Lead Compensation Using Bode plots 53. Lead Compensation 54. The sign of Lag-Lead Compensation Using Bode plots 55. Design of Lag-Lead Compensation Using Bode plots 56. Lag-lead Compensation Using Bode plots 57. Design of Cascade Compensation Using root locus 58. Design of Cascade Compensation Using root locus 59. Design of Cascade Compensators	49.	Cascade and feedback compensation	Yes	
52. Design of Lag Compensation Using root locus 53. Lead Compensation 54. Design of Lead Compensation Using Bode plots 55. Design of Lead Compensation Using root locus 56. Lag- lead Compensation 57. Design of Lag-Lead Compensation Using Bode plots 58. Design of Lag-Lead Compensation Using root locus 59. Design of Cascade Compensators Yes [T1] Chapter -5, [R3]Chapter-8,7 Yes	50.	Lag Compensation	Yes	
53. Lead Compensation Yes [R3]Chapter-8,7 54. Design of Lead Compensation Using Bode plots 55. Design of Lead Compensation Using root locus Yes 56. Lag- lead Compensation Yes 57. Design of Lag-Lead Compensation Using Bode plots Yes 58. Design of Lag-Lead Compensation Using root locus Yes 59. Design of Cascade Compensators Yes	51.	Design of Lag Compensation Using Bode plots	Yes]
53. Lead Compensation 54. Design of Lead Compensation Using Bode plots 55. Design of Lead Compensation Using root locus 56. Lag- lead Compensation 57. Design of Lag-Lead Compensation Using Bode plots 58. Design of Lag-Lead Compensation Using root locus 59. Design of Cascade Compensators Yes Fig. 183] Chapter-8,7 Fig. 183] Chapter-8,7 Fig. 284 Fig. 183] Chapter-8,7 Fig. 285 Fig. 285 Fig. 183] Chapter-8,7 Fig. 285 Fig.	52.	Design of Lag Compensation Using root locus	Yes	[T1] Chapter -5,
55. Design of Lead Compensation Using root locus 56. Lag- lead Compensation 57. Design of Lag-Lead Compensation Using Bode plots 58. Design of Lag-Lead Compensation Using root locus 59. Design of Cascade Compensators Yes Yes	53.	Lead Compensation	Yes	
56. Lag- lead Compensation Yes 57. Design of Lag-Lead Compensation Using Bode plots Yes 58. Design of Lag-Lead Compensation Using root locus Yes 59. Design of Cascade Compensators Yes	54.	Design of Lead Compensation Using Bode plots	Yes	
57. Design of Lag-Lead Compensation Using Bode plots 58. Design of Lag-Lead Compensation Using root locus 59. Design of Cascade Compensators Yes Yes	55.	Design of Lead Compensation Using root locus	Yes	
58. Design of Lag-Lead Compensation Using root locus 59. Design of Cascade Compensators Yes	56.	Lag- lead Compensation	Yes	
59. Design of Cascade Compensators Yes	57.	Design of Lag-Lead Compensation Using Bode plots	Yes	
	58.	Design of Lag-Lead Compensation Using root locus	Yes	
60. Using Bode's Plot Yes	59.	Design of Cascade Compensators	Yes	
	60.	Using Bode's Plot	Yes	

Teaching Strategies

The teaching in this course aims at establishing a good fundamental understanding of the areas covered using:

- Formal face-to-face lectures
- Tutorials, which allow for exercises in problem solving and allow time for students to resolve problems in understanding of lecture material.
- Small periodic quizzes, to enable you to assess your understanding of the concepts.

Evaluation Strategies

 Cycle Test – I
 10%

 Cycle Test – II
 10%

 Model Test
 25%

 Attendance
 5%

 Final exam
 50%

Prepared by: Mr.Mohanraj, Assistant Professor, Department of ECE

Dated:

Addendum

ABET Outcomes expected of graduates of B.Tech / ECE / program by the time that they graduate:

- (a) an ability to apply knowledge of mathematics, science, and engineering
- (b) an ability to design and conduct experiments, as well as to analyze and interpret data
- (c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
- (d) an ability to function on multidisciplinary teams
- (e) an ability to identify, formulate, and solve engineering problems
- (f) an understanding of professional and ethical responsibility
- (g) an ability to communicate effectively
- (h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
- (i) a recognition of the need for, and an ability to engage in life-long learning
- (j) a knowledge of contemporary issues
- (k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Program Educational Objectives

- **PEO1:** Graduates will perform as a successful professional engineer in related fields of Electronics and Communication Engineering.
- **PEO2:** Graduates will pursue higher education and/or engage themselves in continuous professional development to meet global standards.
- **PEO3:** Graduates will work as a team in diverse fields and gradually move into leadership positions.
- **PEO4:** Graduates will understand current professional issues, apply latest technologies and come out with innovative solutions for the betterment of the nation and society.

Course Teacher	Signature
Mr.MOHANRAJ	
Mr.SRINIVASAN	

Course Coordinator	Acader	nic Coordinator	Professo	r In-Charge	HOD/ECE
(Mr.R.Mohanraj)	()	(Dr.)	(Dr.M.Sundararajan)