Walchand College of Engineering, Sangli

(Government Aided Autonomous Institute)



Course Contents (Syllabus) for

First Year M. Tech. Electrical (Control Systems Engineering) Sem - I to II

AY 2020-21

ODD Semester Professional Core (Theory) Courses

Title o	Title of the Course: Research Methodology						L	Т	Р	Cr	
Cours	Course Code: 4IC501						2			2	
Pre-R	equisite (Courses: No	one								
Textb	ooks:										
1. C. R. Kothari, Research Methodology, New Age international											
2.	Deepak (Chopra and	Neena So	ndhi, Rese	earch Meth	odology : C	Concepts	and cas	ses, Vil	kas Publ	ishing
	House, New Delhi										
3.	Ranjit K	umar, Resea	arch Metho	odology: A	A Step by S	tep Guide f	or Begini	ners, 2n	d Edit	ion	
Refer	ences:										
1.	E. Philip a	and Derek F	Pugh, How	to get a F	Ph. D. – a h	andbook for	r students	and th	eir sup	ervisors	, open
-	university	press		~						~ .	
2.	Stuart M	elville and	Wayne C	Joddard,	Research	Methodolog	y: An I	ntroduc	ction f	or Scien	nce &
2	Engineeri G. Pomor	ng Students	oorob Mot	hodology	Droom To	oh Drogg No	w Dolhi				
<u> </u>				llouology,	Diealli ie	cii Fiess, înc					
	Underster	ves:	ia aanaant	a of record	rah and ita	mathadalaa	ion				
1. 2	Identify a	and formula	te the rese	arch probl	leme state	the hypothe					
2. 3	Organize	and conduct	t and prese	ent researc	ch in a mor	e appropriat	sis, e manner				
<i>3</i> . 4.	Prepare re	esearch artif	acts to the	college a	nd papers t	o Conferenc	es and Jo	ournals			
Cours	e Learnir	ng Outcome	es:		F-F						
CO	After th	ne completi	on of the	course th	e student s	should be a	ble to	Bloo	m's Co	gnitive	
		•						level	Des	criptor	
CO1	Classify	y various m	ethods to s	solve resea	arch proble	m.		3	App	olying	
CO2	Constr	uct a resear	ch problen	n in respec	ctive engin	eering doma	in.	3	App	olying	
CO3	Investig	gate various	data anal	ysis techn	iques for a	research pro	oblem.	4	Ana	lyzing	
CO4	Author	the surve	y paper t	based on	literature	review for	research	6	Crea	ating	
	problem	1.									
CO-P	О Марріі	ng:									
			PO1	PO2	PO3	PO4	PO5	PO	6		
		CO1	2								
	CO2 2 2										
	CO3 2										
		CO4		2							
Assessments :											
Teach	Teacher Assessment:										
Two c	Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End										
Semes	Semester Examination (ESE) having 20%, 30% and 50% weights respectively.										

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar etc.

MSE: Assessment is based on 50% of course content (Normally first three modules)

ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:	
Module 1: Introduction to Research	Hrs
What is research? Literature survey and review, types of research, the process of research.	4
Module 2: Research Procedures	Hrs.
Formulation of a research problem, Experimental design, Classification. Theoretical research,	
Formulating a problem, verification methods, modeling and simulations, ethical aspects, IPR	4
issues, Copyrights and Patenting etc.	
Module 3: Research Methods	Hrs
Steps in conducting research, Research Problem identification, Probable solutions, verification	
of the proposed methodology, conclusions. Meaning, Need and Types of research design,	5
Research Design Process, Measurement and scaling techniques, Data Collection - concept,	3
types and methods, Processing and analysis of data, Design of Experiment	
Module 4: Analysis Techniques	Hrs
Quantitative Techniques Sampling fundamentals, Testing of hypothesis using various tests like	
Multivariate analysis, Use of standard statistical software, Data processing, Preliminary data	
analysis and interpretation, Uni-variate and bi-variate analysis of data, testing of hypotheses,	5
techniques such as ANOVA, Chi square test etc., Nonparametric tests. Correlation and	
regression analysis	
Module 5: Research Communications	Hrs
Writing a conference paper, Journal Paper, Technical report, dissertation/thesis writing.	
Presentation techniques, Patents and other IPRs, software used for report writing such as	4
WORD, Latex etc.	
Module 6: Case Studies	Hrs
Case studies related to the respective disciplines of Engineering.	4
Module wise Measurable Students Learning Outcomes:	
After completion of the course students will be able to:	
Module 1: Understand the process of research.	
Module 2: Formulation of a research problem in respective study domains	
Module 3: Learn the important steps in conducting research	
Module 4: Applying data analytics for research validation.	
violule 5. Learn memous for presenting the research results	

Module 6: Applying RM in respective disciplines of Engineering.

Title of the Course: Applied Digital Control	L	Т	Р	Cr
Course Code: 4CS501	3			3

Pre-Requisite Courses: Control System Engineering

Textbooks:

- 1. "Digital Control", by Kannan M. Moudgalya, John Wiley and Sons Ltd., 2007.
- 2. "*Microcontroller Based Applied Digital Control*", by Dogan Ibrahim, John Wiley and sons Ltd., Edition 2006.

References:

- 1. "*Digital Control Engineering Analysis and Design*", by M. Sami Fadali and Antoni Visioli Else vier publication 2nd Edition 2013.
- 2. *"Discrete Time Control System"* By Katsuhiko Ogata, Pearson Education 2nd Edition 2005.

Course Objectives :

- 1. This course provides the basics of modeling of the physical system, analysis.
- 2. It provides the methodology of designing the controller with realization.
- 3. It gives the overview of advanced controllers like LQR.

Course Learning Outcomes:

СО	After the completion of the course the student will be able to	Bloom's Cognitive	
		level	Descriptor
CO1	Analyze various controller structures.	4	Analyzing
CO2	Evaluate controller performance using various control algorithms.	5	Evaluating
CO3	Design a controller to meet given performance specification.	6	Creating

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1				3		
CO2			2			
CO3				3		

Assessment:

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weightage respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment, oral, seminar, test (surprise/declared/quiz), and group discussion. [One assessment tool per ISE. The assessment tool used for ISE 1 shall not be used for ISE 2] MSE: Assessment is based on 50% of course content (Normally first three modules)

ESE: Assessment is based on 100% course content with70-80% weightage for course content (normally last three modules) covered after MSE.

Hrs.

Course Contents:

Module 1: Controller Structures

Feed forward controllers, One degree of freedom, Two degree of freedom, Lag-Lead controller,	6
PID Controller, Well behaved signal, Solving Aryabhatta's Identity.	
Module 2: Controller Realization	Hrs.
Direct structure, Canonical and non-canonical structure, Cascade and parallel realization, PID	
controller Implementation, Microcontroller implementation of 1 st , 2 nd and higher order	6
modules, Choice of Sampling interval.	
Module 3: PID Controller	Hrs.
Introduction, sampling, discretization techniques, PID controller, methods of tuning, 2-DOF	
controller with integral action, bumpless PID controller, PID with filtering, 2-DOF PID,	6
systems with delay.	
Module 4: Pole Placement Controllers	Hrs.
Dead-Beat and Dahlin Control, Pole Placement Controller with performance specifications,	
Implementation of Unstable Controllers, Internal Model Principle for Robustness, Redefining	
Good & Bad Polynomials, Comparing 1-DOF & 2-DOF Controllers, Anti Windup Controller,	6
PID Tuning Through Pole Placement Control.	
Module 5: Pole Placement Controllers Through IMC	Hrs.
Smith Predictor, Internal Model Control (IMC), IMC Design for Stable Plants, IMC in	
Conventional Form for Stable Plants, PID Tuning Through IMC, and IMC design fo unstable	6
plant, LQR through pole placement.	
Module 6: State Space Technique to Control Design	Hrs.
Pole placement, Ackerman formula, controllability, estimators, prediction estimators,	
observability, current estimators, regulator design, combined control law and estimator, LQR,	6
kalman filter design.	
Module wise Measurable Students Learning Outcomes :	
After completion of the course students will be able to:	
1. Analyze different controller structures and their specifications.	
2. Evaluate the PID controllers and implementation on microcontroller.	
3. Analyze and evaluate pole placement controllers with performance specifications and also	PID
tuning through pole placement controllers.	
4. Explain dead beat and Dahlin pole placement controllers through Internal Model Controller	r.

6. Evaluate and design the state feedback controller, Kalman filter and LQR

			<u> </u>		~
Title of	the Course: Process Control	L	Т	Р	Cr
Course	Code: 4CS502	3			3
Pre-Re	quisite Courses: Control System Engineering				
Textbo	oks:				
1.	George Stephanopoulos, "Chemical Process Control - An introduction t	o Theo	ory and	Practice	",
	Prentice-Hall of India, 1 st Edition 1984.				
Refere	nces:				
1.	Thomas E. Marlin, "Process Control - Design Processes and Control Sy	stem f	or Dyna	amic	
	Performance, 2 nd Edition", Mc Graw Hill publication.				
2.	F.G. Shinskey, "Process Control System – Application, Design and Tur	ning", N	McGrav	v-Hill	
	Publication, 3 rd Edition, 1988.				
3.	Curtis D. Johnson, "Process Control Instrumentation Technology", 7th H	Edition	, Pearso	on Educa	ation,
	7 th Edition. 2003.				
Course	Objectives:				
1.	This course provides the basics of process control.				
2.	It provides the methodology of modelling the process and close loop co	ntrol.			
3.	It also provides the design of various types of controllers for single loop	and m	nulti loo	op contro	ol
	system.				
4.	It gives the overview of advanced controllers used in process control an	d mult	ivariab	le predic	tive
	control.			_	
Course	Learning Outcomes:				
CO	After the completion of the course the student will be able to		Bloom	i's Cogni	itive
			level	Descrip	otor
C01	Calculate the various models of industrial processes.		3	Applyir	ng
CO2	Analyze the problems associated with open loop and close loop pro-	ocess	4	Analyzi	ing
	control system.				
CO3	Evaluate the performance of processes with various conventional	and	5	Evaluat	ing
	advanced controllers.				2
CO4	Design various conventional and advanced controllers for the process	es.	6	Creatin	g

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1			1			
CO2			1			
CO3				2		
CO4				2		1

Assessment: Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weightage respectively.

Assessment	Marks
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MSE	30
ISE 2	10
ESE	50
ISE 1 and ISE 2 are based on assignment, oral, sem	ninar, test (surprise/declared/quiz), and group

MSE: Assessment is based on 50% of course content (Normally first three modules)	
ESE: Assessment is based on 100% course content with70-80% weightage for course content (no	ormally
last three modules) covered after MSE.	
Course Contents:	
Module 1:Introduction to Process Control	Hrs.
Introduction, Design aspects of a process control system, Hardware for a process control	
system. Mathematical modeling and analysis of processes, development of a mathematical	5
model, Modeling considerations for control purposes, the input-output model, degree of	5
freedom.	
Module 2: Modelling of Process	Hrs.
Computer Simulation and linearization of nonlinear systems, Transfer functions and the Input-	
output models. Dynamic behavior of first-order systems, second-order system and higher order	5
systems.	
Module 3: Feedback Control of Process	Hrs.
Elements of feedback control system, types of feedback controllers, sensors, Transmission	
lines, final control elements. Dynamic behavior of feedback-controlled process, Effect of	6
proportional (p) control, Integral (I) control and derivative (D) control on the response of	U
controlled process, effect of composite control actions.	
Module 4: Multi Loop Control	Hrs.
Feedback control of system with large dead time or inverse response, processes with large Dead	
time, Dead time compensation, and control of systems with inverse response. Control systems	
with multiple loops, cascade control, split-range control, feed forward control, Ratio-control,	7
problem in designing feed forward controllers, practical aspects on the design of feed forward	
controllers, $F/F - F/B$ control.	
Module 5: MIMO Process	Hrs.
Multi-input, multi-output processes, degree of freedom and number of controlled and	
Manipulated variables, interaction and decoupling of control loops, relative gain array and	7
selection of loops, design of non-interacting control loops. Overview of modern control	'
methodologies: PLC, SCADA, DCS, Adaptive control, variable structure control.	
Module 6: Centralized Multivariable Control	Hrs.
Multivariable model predictive control, single-variable dynamic matrix control (DMC)	
algorithm, multivariable dynamic matrix control, internal model control, smith predictive,	6
model predictive control, process model based control, implementation guidelines. Process	U
control design: sequence of design steps, statistical process control.	
Module wise Measurable Students Learning Outcomes :	
After the completion of the course the student will be able to:	
1. Describe model the Process Control system.	
2. Evaluate performance of process by conventional control techniques.	

- 3. Analyze the process with conventional controllers for process control.
- 4. Analyze the process the advance controllers for process control.
- 5. Analyze the controllers for multi-input multi-output processes and able to evaluate the performance of multi-input multi-output process.
- 6. Design advance digital controller based on model of the process.

Professional Core (Lab) Courses

Title	of the Course: Applied Digital Control Lab	L	Т	Р	Cr
Cour	se Code: 4CS551			4	2
Pre-I	Requisite Courses: Control System Engineering				
Textl	books:				
1.	Kannan M. Moudgalya, Digital Control, Wiley 2007, (IITB).				
Refe	rences:				
1.	Belanger, Control Engineering – Modern Approach, International Editio	n 1995.			
2.	Z.Gajic, M. Lelic, Modern Control Systems Engineering, PHI Ser	ries in	Syster	n & C	ontrol
	Engineering 1996				
3.	Torkel Glaw and Lennard Ljung Control Theory- Multivariable & No	onlinea	r Metho	ods, Tay	/lor &
	Francis Publication London & New York 2002				
4.	Bernard FriedLand, Advanced Control System Design, Prentice Hall International Control System Design, Prenti	ernatio	nal 200	0	
5.	B.C.Kuo,Digital Control System, 2 nd Edition, Oxford Press 2003				
Cour	se Objectives :				
1.	This course provides the basics of modeling of the physical system, anal	ysis.			
2.	It provides the methodology of designing the controller with realization.				

3. It gives the overview of advanced controllers like LQR.

Course Learning Outcomes:

CO	After the completion of the course the student will be able to	Bloom	's Cognitive
		level	Descriptor
CO1	Analyze various types of digital controllers.	4	Analyzing
CO2	Experiment on closed loop systems using controllers.	3	Applying
CO3	Design pole placement controllers for various electrical systems.	6	Creating

CO-PO Mapping :

	PO1	PO2	PO3	PO4	PO5	PO6
CO1			3			
CO2				2		
CO3				2		1

Assessment:

There are four components of lab assessment, LA1, LA2, LA3 and Lab ESE.

IMP: Lab ESE is a separate head of passing.

Assessment	Based on	Conducted by	Conduction and Marks Submission	Marks
I A 1	Lab activities,	Lab Course Faculty	During Week 1 to Week 4	25
LAI	attendance, journal	Lab Course Faculty	Submission at the end of Week 5	23
1.42	Lab activities,	Lab Course Faculty	During Week 5 to Week 8	25
LAZ	attendance, journal	Lab Course Faculty	Submission at the end of Week 9	23
I A 3	Lab activities,	Lah Course Faculty	During Week 10 to Week 14	25
LAS	attendance, journal	Lab Course Faculty	Submission at the end of Week 14	23
Lab ESE	Lab Performance and	Lab Course faculty	During Week 15 to Week 18	25
	related documentation		Submission at the end of Week 18	23

Week 1 indicates starting week of Semester. Lab activities/Lab performance shall include performing experiments, mini-project, presentations, drawings, programming and other suitable activities, as per the

nature and requirement of the lab course. The experimental lab shall have typically 8-10 experiments.

Course Contents:

Any 8-10 experiments based on the syllabus

Computer Usage / Lab Tool: MATLAB/SCILAB

Title of the Course: Process Control Lab									Р	Cr
Course Code: 4CS552									4	2
Pre-Requisite C	Pre-Requisite Courses: Control Systems Engineering Lab									
Textbooks:										
1. George Stephanopoulos, "Chemical Process Control - An introduction to Theory and Practice", Prentice-Hall of India, 1 st Edition 1984.										
References:	References:									
 Thomas Performar F.G. Shin Publicatio Curtis D. 7th Edition 	 Thomas E. Marlin, "Process Control - Design Processes and Control System for Dynamic Performance, 2nd Edition", Mc Graw Hill publication. F.G. Shinskey, "Process Control System – Application, Design and Tuning", McGraw-Hill Publication, 3rd Edition, 1988. Curtis D. Johnson, "Process Control Instrumentation Technology", 7th Edition, Pearson Education, 7th Edition, 2003 									
Course Objectiv	ves :									
 To provid To provid To provid To provid system. To provid Provide the 	e the found e the basics le the know e the know he knowled	ation level s for mathe wledge of ledge of ad ge of multi	knowledg matical m various t lvanced co variable p	ge of Proces nodel of the p types of com ontrollers us predictive co	s Control. process. troller fo ed in proc ntrol.	r single le	oop and	d mult	i-loop	control
Course Learnin	ng Outcom	es:								
CO After th	ne completi	ion of the	course th	e student w	ill be able	e to	B	oom's	Cogni	tive
							leve	el l	Descrip	otor
CO1 Determ Process	ine the m Control Sy	nodel of j rstem.	process b	oy performi	ng exper	iments of	n 2	Un	derstan	ding
CO2 Apply t	he tuning te	echniques f	for variou	s controllers	•		3	Ap	plying	
CO3 Evaluat	te the perfo	rmance of	given Pro	cess Control	system.		5	Eva	aluating	g
CO4 Demons	strate the u	se of adva	nced cont	rollers.			3	Ap	plying	
CO-PO Mappir	ng:							-		
] [PO1	PO2	PO3	PO4	PO5	PO	6		
	CO1			1						
	CO2				1					
-	CO3				2					
-	CO4						2			
Assessment: There are four co	Assessment: There are four components of lab assessment, LA1, LA2, LA3 and Lab ESE.									
IMP: Lab ESE 18	IMP: Lab ESE is a separate head of passing.									
Assessment Based on Conducted by Conduction and Marks Submission Marks									larks	
LA1	LA1Lab activities, attendance, journalLab Course FacultyDuring Submission at the end of Week 4 Submission at the end of Week 525								25	
LA2	Lab act	ivities, e, journal	Lab Co	ourse Faculty	During Submissi	Week 5 on at the e	to <u>nd of</u> W	Week eek 9	8	25
LA3	Lab act attendance	ivities, e, journal	Lab Co	ourse Faculty	During Submissi	Week 10 on at the e) to nd of W	Week leek 14	14	25

Lob ESE	Lab Performance and	Lab Course feculty	During Week 15 to Week 18	25	ſ
	related documentation	Lab Course faculty	Submission at the end of Week 18	23	

Week 1 indicates starting week of Semester. Lab activities/Lab performance shall include performing experiments, mini-project, presentations, drawings, programming and other suitable activities, as per the nature and requirement of the lab course.

The experimental lab shall have typically 8-10 experiments.

Course Contents:

List of Experiment

- 1. Step response of first order system (single capacity system).
- 2. Step response of multi capacity process (coupled tank system).
- 3. Closed loop computer controlled pressure control system.
- 4. Tuning of P PI and PID controllers based on process reaction curve and Ziegler Nichols method.
- 5. Closed loop computer controlled level control system.
- 6. Closed loop computer controlled flow control system.
- 7. Tuning of controllers for level control system.
- 8. Tuning of controllers for flow control system.
- 9. Study of cascade controller for a flow control system.
- 10. Study of PLC and its process controlled applications.

Computer Usage / Lab Tool:

Matlab simulation experiments.

Professional Elective (Theory) Courses

Title of the Course: Optimal Control										L	Т	Р	Cr
Cour	Course Code: 4CS511									3			3
Pre-l	Requis	site (Courses: Co	ontrol Sys	tem Engin	ieerin	g		1				
Text	books	:											
1.	1. D.S.Naidu, 'Optimal Control Systems', CRC Press, 2002.												
Refe	References:												
1.	1. Frank L Lewis, "Optimal Control", John Wiley, New York, 1986.												
2.	2. Kirk D.E, "Optimal Control Theory", Dover Publications, 2004.												
Cour	se Ob	jecti	ves :			_							
1.	This	cours	se provides	the basic of	concepts o	of opti	mal c	control.	1 / 1				
2. 3	It pro	ovide	s the metho	dology of	designing	LQR	and	LQI optim	al control	contro	10		
Cour	se Le	arnir	ng Outcome	or optimizes:		onsu	ameu		instramed	contro	15.		
CO	Af	iter t	he completi	ion of the	course th	e stu	dent	will be able	e to	В	loom's	Cogniti	ve
			· · · · ·							le	evel	Descri	ptor
CO	1 Ar	oply	various con	cepts of or	otimal con	trol.					3	Apply	ving
CO	2 Ar	nalyz	e the system	ns using L	OR and L	OT 0	ptima	l control.			4	Analy	zing
CO3 Design of optimal control in constrained and non-constrained systems.							6	Creat	ing				
CO-I	PO Ma	appii	ng:						2				U
			0										
				PO1	PO2	PO)3	PO4	PO5	PC)6		
			CO1				3						
			CO2					2					
			CO3							1			
Acco								·					
Topo	bor A		mont										
Two	comp	onent	s of In Sen	nester Eva	luation (I	SF)	One]	Mid Semes	ter Fxam	ination	(MSF)) and on	e End
Seme	ester E	xami	nation (ESF	E) having 2	20%, 30%	and f	50% y	weightage r	espective ¹	v.		, and on	
			Assess	ment	, 0070				M	arks			
			ISE	1						10			
			MS	E						30			
			ISE	2						10			
			ESI	Ξ						50			
ISE	1 and	d ISI	E 2 are ba	sed on a	ssignment	, ora	l, ser	ninar, test	(surprise	declar	ed/quiz), and g	group
disc	ussion	. [On	ne assessmen	nt tool per	ISE. The	asses	smen	t tool used t	for ISE 1	shall n	ot be us	sed for I	SE 2]
MSI	E: Ass	essm	ent is based	on 50% c	of course c	onter	t (No	ormally first	three mo	dules)			
ESE	e: Ass	essm	ent is based	l on 100%	course co	ontent	with	70-80% we	ightage fo	or cour	se cont	ent (nor	mally
last	three 1	modu	lles) covered	d after MS	E.								

Course Contents:	
Module 1: Introduction to Optimal Control	Hrs.
Classical and Modern Control, Optimization, Optimal Control, Plant, Performance Index,	6
Constraints, Calculus of Variations.	0
Module 2: Calculus of Variations and Optimal Control	Hrs.
Optimum of a Function and a Functional, Basic Variational Problem, Fixed-End Time and	
Fixed-End State System, Euler-Lagrange Equation, Different Cases for Euler-Lagrange	
Equation ,The Second Variation, Extrema of Functions with Conditions ,Direct Method	6
Lagrange Multiplier Method Extrema of Functionals with Conditions, Terminal Cost	
Problem.	
Module 3: Linear Quadratic Optimal Control Systems	Hrs.
Finite-Time Linear Quadratic Regulator, Riccati Coefficient, Finite-Time Linear Quadratic	
Regulator: Time-Varying Case, Infinite-Time LQR System.	6
Module 4: Linear Quadratic Tracking System	Hrs.
Linear Quadratic Tracking System: Finite-Time Case, LQT System: Infinite-Time Case, Fixed-	
End-Point Regulator System And Frequency-Domain Interpretation.	6
Module 5: Constrained Optimal Control Systems	Hrs.
Time-Optimal Control of LTI System, Solution of the TOC System, TOC of a Double Integral	
System, Fuel-Optimal Control Systems, Energy-Optimal Control Systems. Optimal Control	6
Systems with State Constraints.	
Module 6: Pontryagin Minimum Principle	Hrs.
Constrained System, Pontryagin Minimum Principle, The Hamilton-Jacobi-Bellman Equation,	(
LQR System Using H-J-B Equation.	0
Module wise Measurable Students Learning Outcomes :	
After the completion of the course the student will be able to:	
1. Explain Basic concepts of Optimal Control.	
2. Explain Basic concepts of calculus of variations	
3. Apply the LQR for control design.	
4. Apply the LQT for control design.	
5. Analyze and evaluate Algorithms and applications for constrained control.	
6. Analyze and evaluate Pontryagin Minimum Principle.	

Title of the Course: Multivariable ControlI							Т	Р	Cr
Course Code: 4CS512									3
Pre-Requisite Courses: Control System									
Textbooks:									
1. P.Albertos, A.Sala, "Multivariable Control", springer Int. 2008.									
2. Z. Bubnicki, "Multiv	ariable Co	ontrol", sp	oringer int.	2005.					
3. B.wayne Beguetle, "	Modeling ⁻	with Cont	rol", PHI 2	2008.					
References:									
1. Gopal,' Modern Cont	trol Systen	1 -State va	iriable ana	lyses, TMH	Publication	ons, 2	010.		
Course Objectives :									
1. This course provides	the basic of	concepts o	of Multivar	iable Contro	ol.				
2. It provides the metho	dology of	designing	Multivaria	able Control	l.				
3. It gives the overview	of central	ized Multi	ivariable co	ontrollers.					
Course Learning Outcome	es:							<u> </u>	
CO After the complet	ion of the	course th	e student	will be able	e to		Bloom	s Cognit	ive
		016.1.1				1	evel	Descrip	otor
CO1 Interpret the basic	c concepts	of Multiv	ariable Co	ntrol.			3	Apply	ing
CO2 Analyze the ce	ntralized,	decentral	ized and	decoupled	control	in	4	Analyz	ing
multivariable contr	ol system								
CO3 Evaluate algorith	ms for a	centralized	d, decentra	alized and	decouple	ed	5	Evalua	ting
control in multivar	iable conti	ol system	•						
CO-PO Mapping :			1						
	PO1	PO2	PO3	PO4	PO5	PO)6		
CO1			3						
CO2				2					
CO3						1			
Assessment:									
Teacher Assessment:									
Two components of In Sen	nester Eva	luation (I	SE), One I	Mid Semest	ter Examin	nation	(MSE) and on	e End
Semester Examination (ESE	E) having 2	20%, 30%	and 50% v	veightage re	espectively	/.			
Assess	ment				Ma	arks			
ISE	1				1	.0			
MS	E				3	80			
ISE 2 10									
ESE 50									
ISE 1 and ISE 2 are ba	ISE 1 and ISE 2 are based on assignment, oral, seminar, test (surprise/declared/quiz), and group								
discussion. [One assessme	discussion. [One assessment tool per ISE. The assessment tool used for ISE 1 shall not be used for ISE 2]								
MSE: Assessment is based	l on 50% o	of course c	content (No	rmally first	three mod	lules)			
ESE: Assessment is based	l on 100%	course co	ontent with	70-80% we	ightage for	r cour	se cont	ent (nori	nally
last three modules) covered	d after MS	E.							

Course Contents:	
Module 1: Multivariable Control	Hrs.
Introduction, Process and Instrumentation, process variable, Behavior, control aims, modes of	
operation, Feedback need, Model based control, Modeling errors, multivariable systems	6
,implementation issue.	
Module 2: Linear system models	Hrs.
Introduction, objective and modeling, first principle, state variable, linear model, I/O	
representation, system &subsystem, discretized model, equivalence of representation,	6
disturbance model, case study-paper machine head box.	
Module 3: Linear system Analysis:	Hrs.
Introduction ,linear system time response ,stability condition ,discretization ,gains and	
frequency response, system internal structure ,block system structure, Kalman form, I/O	
properties, model reduction, key issues in MIMO system analysis Case study -distillation	0
column.	
Module 4: Solution to control problem	Hrs.
Control system design problem, control goal, variable selection, control structure, feedback	- <u></u>
control, feed forward control, two degree of freedom controller, Hierarchical control, control	6
design issue, case study – ceramic kiln.	
Module 5: Decentralized and decoupled control	Hrs.
Introduction, multi-loop control, pairing selection, decoupling, SISO loops with MIMO cascade	
control, other possibilities, sequential -Hierarchical design and tuning, case study -steam	6
Boiler, Mixing process.	
Module 6: Centralized closed loop control	Hrs.
State feedback, output feedback, rejection of deterministic, unmeasurable disturbance,	6
Augmented plant, process and disturbance models, case study -magnetic suspension.	0
Module wise Measurable Students Learning Outcomes :	
After completion of the course students will be able to:	
1. Explain modelling and implementation of multi variable control.	
2. Evaluate the control problem	
3. Use linear system analysis for design	
4. Solve control problem and find solution.	
5. Analyze interaction in the system and methods for decoupling.	
6. Study different disturbance model.	

Title of the Course: Control Techniques for Electrical Drives	L	Т	Р	Cr
Course Code: 4CS513	3			3

Pre-Requisite Courses:

Textbooks:

1. G. K. Dubey, *Fundamentals of Electrical Drives*, Narosa publication, 2nd edition, 2002.

2. B. K. Bose, Modern Power Electronics and AC drives, Prentice Hall of India Pvt. India, 1986.

References:

- 1. Peter Vas, Vector Control of AC machines, Clarendon Press Oxford, 1999.
- 2. Ned Mohan, Advanced Electrical drives Analysis, control and modeling using simulink, John Wiley and sons, 2001.
- 3. P. S. Bhimra, "*Power Electronics*", 2nd edition, Khanna Publishers.

Course Objectives :

- 1. To provide the latest knowledge in the field of electrical drives.
- 2. To provide sufficient knowledge in the area of advanced control techniques for induction motor and synchronous machines.
- 3. To make the student aware of the research in the field of electrical drives.

Course Learning Outcomes:

CO	After the completion of the course the student will be able to	Bloom's Cognitive		
		level	Descriptor	
CO1	Explain various concept used in AC and DC drives.	2	Understanding	
CO2	Apply control techniques to AC and DC drives.	3	Applying	
CO3	Analyze control techniques for AC and DC drives.	4	Analyzing	
CO4	Evaluate various control schemes of AC and DC drives.	5	Evaluation	

CO-PO Mapping :

	PO1	PO2	PO3	PO4	PO5	PO6
CO1				1		
CO2				1		
CO3			1	2		
CO4			1	3		

Assessment:

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and One End Semester Examination (ESE) having 20%, 30% and 50% weightage respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment, oral, seminar, test (surprise/declared/quiz), and group discussion. [One assessment tool per ISE. The assessment tool used for ISE 1 shall not be used for ISE 2] MSE: Assessment is based on 50% of course content (Normally first three modules)

ESE: Assessment is based on 100% course content with70-80% weightage for course content (normally last three modules) covered after MSE.

Course Contents:	
Module 1: Basics of drives	Hrs.
Types & parts of the Electrical drives, fundamental torque equation, speed torques	
characteristics DC motor & Induction motor, multi quadrant operation of the drive,	6
classification of mechanical load torques, steady state stability of the drive, constant torque and	U
constant HP operation of the drive, closed loop speed control.	
Module 2: DC motor drives	Hrs.
Methods of speed control, starting and breaking operation, single phase and three phase full	
controlled and half controlled converter fed DC drives, Multi quadrant operation of separately	
excited DC shunt motor, dual converter fed DC drives, circulating and non – circulating mode	6
of operation, chopper control of DC shunt motor drives, four quadrant operation of chopper fed	
DC shunt motor drive.	
Module 3: Induction motor drives	Hrs.
Speed control methods for three phase induction motor, VSI fed induction motor drive, constant	
torque (constant E/F and constant V/F), constant HP operation, closed loop speed control block	
diagram., CSI fed induction motor drive, speed torque characteristics of CSI fed drive, closed	
loop speed control block diagram, comparison of CSI fed and VSI fed induction motor drive,	6
Stator voltage control.	
Chopper controlled resistance in rotor circuit, slip power recovery using converter cascade in	
rotor circuit, sub synchronous and super synchronous speed control, Kramer speed control.	
Module 4: Modeling of Induction Motor and PWM Techniques	Hrs.
abc – dq transformation, transformation from stationary reference frame to synchronously	
rotating reference frame and vice versa. Equivalent circuits of induction motor in dynamic dq	
stationary and synchronously rotating reference frame. Permanent magnet synchronous machine	6
dq equivalent circuits. The three phase six step bridge inverter, three phase PWM inverter,	
PWM techniques such as sinusoidal PWM, hysteresis band current control PWM.	
Module 5: Vector Control and Direct Torque Control of Induction Motor	Hrs.
Vector control of induction motor, DC drive analogy, equivalent circuit, phasor diagram. Direct	
rotor flux oriented vector control and indirect rotor flux oriented vector control, stator flux	
oriented vector control.	6
Torque equation of IM in terms of stator and rotor flux, direct torque and flux control method	
(DTC) and self-commissioning of the drive.	
Module 6: Synchronous motor and SRM Drives	Hrs.
VSI fed synchronous motor drives, true synchronous and self-control mode, open loop and	
closed loop speed control of Permanent magnet synchronous machine, brushless DC motor	
drives.	6
Switched reluctance motor drives, torque equation, converter circuits, operating modes and	
applications. Solar panel VI characteristics, solar powered pump, maximum power point	

tracking and battery operated vehicles.

Module wise Measurable Students Learning Outcomes :

After completion of the course students will be able to:

- 1. Explain the basics of DC drive, induction motor drive and synchronous motor drive.
- 2. Explain various speed control methods of DC drives.
- 3. Describe various speed control methods of AC drives.
- 4. Explain modelling and PWM techniques required for induction motor and synchronous motor drive.
- 5. Describe the advanced control techniques for induction motor.
- 6. Explain the basics of synchronous motor and SRM drives.

Title of the Cou	ırse: Syster	n Identifi	cation				L	Т	Р	Cr
Course Code: 4	irse Code: 4CS515									3
Pre-Requisite (Courses: Er	ngineering	g Mathem	atics						
Textbooks:										
1. Arun K T	`angirala, " <i>H</i>	Principles	of System	Identificat	ion Theory	and Prac	tice", C	CRC Pr	ess, 201	15.
2. Sodderstrom & Stoica, "System Identification", PHI, 1989										
References:										
3. Ljung L,	3. Ljung L, Glad T, "Modeling of Dynamic Systems", PHI, 1994									
1 To make	ves:	milior wi	th actimat	tion of no	romotrio n	n norom	stria m	odala	and not	ions of
n. To make model qu	ality	annnar wi	ui estima	non or pa	rametric, no	on-parame	erric m	odels a	and not	IONS OI
2. To develo	op skills in s	students fo	r choosing	g model sti	uctures.					
3. To make	students dev	velop trans	sfer functi	on and stat	e space mo	dels.				
Course Learnin	ng Outcom	es:								
CO After t	he complet	ion of the	course th	e student	will be able	e to	E	Bloom'	s Cogni	tive
							lev	rel	Descrip	ptor
CO1 Explain	n fundamen	tal aspects	of system	n identifica	tion.		2	U	Jndersta	nding
CO2 Apply	system iden	tification	for predict	ing dynam	ic models.		3		Apply	ing
CO3 Analyz	e models of	otained fro	m system	identificat	ion.		4	-	Analyz	zing
CO-PO Mappi	ng :teach									
		PO1	PO2	PO3	PO4	PO5	PC)6		
	CO1				2					
	CO2						1			
	CO3				3					
Assessment:										
Teacher Assess	ment:									
Two componen	ts of In Ser	nester Eva	aluation (I	SE), One	Mid Semes	ter Exam	ination	(MSE) and o	ne End
Semester Exami	ination (ESI	E) having 2	20%, 30%	and 50%	weightage r	espective	ly.			
	Assess	ment				N	Iarks			
	ISE	1					10			
	MS	E					30			
	ISE	2					10			
	ES	E					50			
ISE 1 and IS	E 2 are ba	ased on a	ssignment	t, oral, se	minar, test	(surprise	/declar	ed/quiz	z), and	group
discussion. [Or	ne assessme	nt tool per	ISE. The	assessmer	nt tool used	for ISE 1	shall n	ot be u	sed for 1	ISE 2]
MSE: Assessm	nent is based	l on 50% o	of course c	content (No	ormally first	t three mo	odules)			
ESE: Assessm	nent is based	d on 100%	course co	ontent with	170-80% we	eightage f	or cour	se cont	ent (nor	rmally
last three modu	ules) covere	d after MS	E.							
Course Conten	ts:									
Module 1: LT	I System:-									Hrs.
Introduction,	Step-wise	Procedure	e for Ide	entification	n, Models	and cla	ssificat	tion, 1	Non-	4
parametric, par	ametric mo	dels, state	space des	criptions,	Sampled da	ta system	s			-

Module 2: Random Processes	Hrs.
Random variables, Covariance and Correlation, Auto-Correlation and Cross-Correlation functions, Moving Average models, Auto-Regressive models, ARMA models, Spectral	7
representations.	
Module 3: Estimation Theory	Hrs.
Introduction to Estimation, Properties of estimator, Estimation methods, Estimation of Signal	7
Properties.	
Module 4: Models and Predictions	Hrs.
General structure of LTI models in identification, Quasi stationarity, Non-parametric models	
(impulse, step and frequency response), Family of Parametric models, Predictions, One- step	7
ahead prediction, Infinite-step ahead prediction.	
Module 5: Input-Output Identification	Hrs.
Estimation of Time-Series Models, Estimation of Impulse/Step (Response) Models, Estimation	7
of Frequency Response Functions, Estimation of Parametric Input-Output Models.	/
Module 6: Sub-space Identification	Hrs.
State Space model for identification, Kalman filter, Innovations form, Sub-space identification	7
algorithm, Estimating grey-box models.	,
Module wise Measurable Students Learning Outcomes :	
After completion of the course students will be able to:	
1. Explain step wise procedure for system identification of dynamic models.	
2. Distinguish Random processes.	
3. Classify estimation problems.	
4. Identify and estimate dynamic models.	
5. Analyze systems using non-parametric and parametric input output models.	
6. Use State Space models for identification.	

Course Code: 40 Pre-Requisite Co Textbooks:	Course: Advanced Digital Signal Processing e: 4CS516 ie Courses: Digital Signal Processing '' Tata McGraw Hill on Hayes, "Statiscal Signal Modeling'', John Wiley 20 Gejji, "Digital Signal Processing '' Tata McGraw Hill on Hayes, "Statiscal Signal Modeling'', John Wiley 20 Gejji, "Digital Signal Processing'', Pearson Education heim Schafer, Ronald, "Discrete Time Signal Process or, Jerris, Pearson Education, "Discrete Signal Process Ambardar, "Digital Signal Processing: A Modern Intro- settives : velop skills for analyzing discrete time signals using tra- ke students familiar with methods of digital filters desi- velop basic knowledge of random signal processing. ning Outcomes: er the completion of the course the student will be a oly transforms to discrete time signals for analysis. lyze the properties of discrete time systems and rancessing. luate digital filters, structures and discrete time random oping : item soft in Semester Evaluation (ISE), One Mid Sementation (ESE) having 20%, 30% and 50% weightage Assessment unination (ESE) having 20%, 30% and 50% weightage				3			3		
Pre-Requisite Co Textbooks	f the Course: Advanced Digital Signal Processing e Code: 4CS516 equisite Courses: Digital Signal Processing ooks: Sanjit Mitra, "Digital Signal Processing '' Tata McGraw Hill Publicat Monson Hayes, "Statiscal Signal Modeling'', John Wiley 2002. Rao & Gejji, "Digital Signal processing '', Pearson Education, 2 nd Edit ences: Oppenheim Schafer, Ronald, "Discrete Time Signal Processing", Pe									1
Textbooks		gital Sign	al Processi	ing						
- CALOUUND.										
1. Sanjit Mitr	a, "Digital	Signal Pr	cocessing [;]	'' Tata Mc	Graw Hill P	ublication,	3rd Edi	ition,	2008.	
2. Monson Ha	ayes, "Stat	tiscal Sign	al Modeli	ng'', John	Wiley 2002	. nd				
<u>3. Rao & Gej</u>	ji, "Digital	l Signal pi	rocessing'	', Pearson I	Education,	2 nd Edition,	2008.			
References:	G 1 C	D 116	(D)	T ' C'	1.0.	22 D	г 1	<i>.</i> .	and r	1
1. Oppenneim 1999.	i Schafer,	Ronald,		Time Signo	il Processii	ig ^r , Pearso	n Eauc	ation	, 2 ⁻ Е	dition,
2. Ifeachor, Je	erris, Pears bordor "D	son Educa	tion, "Disc	crete Signa ssina: A Ma	l Processin dorn Intro	g ^r , 2 nd Edi duction'' T	ition, 20)02. 200	7	
Course Objectiv	$\frac{Datual}{PS}$	ignui Sigi	iui I Toces	sing. A me		<i>iuciion</i> , 1	110111501	1, 200)/.	
1 To develor	skills for	analyzing	discrete ti	ime signals	using trans	sforms				
2. To make st	udents fan	niliar with	methods	of digital fi	lters design	l.				
3. To develop	basic kno	wledge of	f random s	signal proce	essing.					
Course Learning	g Outcome	es:								
CO After the	e complet	ion of the	course th	ne student	will be abl	e to	Bloor	n's (Cognitiv	e
							level	De	scriptor	
CO1 Apply tr	ansforms t	to discrete	time sign	als for anal	ysis.		3	Ap	plying	
CO2 Analyze	the prope	erties of c	liscrete tii	me system	s and rand	om signals	4	An	alyzing	
processin	ng.									
CO3 Evaluate	e digital fil	lters, struc	tures and	discrete tin	ne random	signals.	5	Ev	aluating	;
CO-PO Mapping	g :									
		PO1	PO2	PO3	PO4	PO5	PO6			
	CO1				2					
	CO2				2					
	CO3			1	2					
Assessment:										
Teacher Assessm	nent:									
Two components	of In Sen	nester Eva	aluation (I	SE), One I	Mid Semes	ter Examin	ation (1	MSE)	and on	ie End
Semester Examin	ation (ESE	E) having 2	20%, 30%	and 50% v	veightage r	espectively	•			
	Assess	ment				Ma	rks			
	ISE	1				1	0			
	MS	E				30	0			
	ISE	2				10	0			
	ESI	E				50	0			
ISE 1 and ISE	2 are ba	used on a	ssignment	t, oral, ser	ninar, test	(surprise/d	eclared	/quiz), and	group
discussion. [One	assessme	nt tool per	ISE. The	assessmen	t tool used	for ISE 1 sł	nall not	be us	ed for I	SE 2]
MSE: Assessme	nt is based	l on 50% d	of course c	content (No	rmally first	three mod	ules)			
ESE: Assessme	nt is based	l on 100%	course co	ontent with	70-80% we	ightage for	course	cont	ent (nor	mally
1.0.04 41 1.1	es) covered	d after MS	SE							

Course Contents:	
Module 1: Discrete time signal and system	Hrs.
Classification of signals, operation on sequences, properties of systems, convolution sum,	4
sampling process.	4
Module 2: Discrete Time Fourier Transform	Hrs.
DFT, FFT, DIT FFT, DIF FFT algorithm, circular convolution.	6
Module 3: Digital filter structure	Hrs.
review of z transform, transfer function classification, iir and fir filter characteristics,	
complementary transfer function, inverse system, digital two-pairs, algebraic stability test,	0
block diagram representation, equivalent structures, fir and iir digital filter structures, all pass	8
filters, lattice structures, all pass realization of iir transfer function.	
Module 4: Digital Filter Design	Hrs.
Butter worth and chebyshev filters, IIR filter design, impulse invariant method, bilinear	0
transformation, FIR filter design.	δ
Module 5: Discrete Time Random Processes	Hrs.
Review of linear algebra, quadratic and hermitian form, random variables, random processes,	0
filtering random processes, special type of random processes.	8
Module 6: Signal Modeling	Hrs.
Least square method, pade approximation, prony's method, FIR least square inverse filters.	5
Module wise Measurable Students Learning Outcomes :	
After completion of the course students will be able to:	
1. Classify signal, systems and perform various operations on it.	
2. Calculate discrete time Fourier transform and F.F.T.	
3. Evaluate digital filter and various structures of it.	
4. Evaluate design of digital filters.	
5. Identify the properties of different random processes.	
6. Evaluate different signal modeling techniques	

Mandatory Life Skill Courses

EVEN Semester

Professional Core (Theory) Courses

Title of	f Course: Non-Line	ar Dynan	nical Syste	ems			L	Т	Р	Cr
Course	e Code: 4CS521		3			3				
Pre-Re	Pre-Requisite Courses: Control System Engineering. Fextbooks: Control System Engineering.									
Textbo	Textbooks:									
1.	H.K.Khalil. Nonline	ear system.	s Prentice	Hall, 3rd E	dition 2002	2.				
2.	Jean-Jacques E.Slot	ine & Wei	ping Li. A	pplied Nor	linear Con	trol by Prent	tice Ha	ll, 1991	l.	
Refere	nces:							• •	100	0
	Shankar Sastry, Nor	linear Sys linear Sys	stems: Ana	ilysis, Stabi	lity and Co	ontrol, Spring	ger, Ne	ew-Yor	k, 199	9.
Z. Course	Objectives •	unear sys	iems Anai	<i>ysts</i> , Flenti	ce-nall, 19	93.				
1	To make students fa	miliar wit	h features	of nonline	ar dynamic	al systems				
2.	To develop skills in	students f	or analyzi	ng the beha	vior of nor	nlinear system	ms.			
3.	To develop skills in	students	for evaluat	ting nonlin	ear system.	5				
Course	e Learning Outcom	es:								
CO	After the complet	ion of the	course th	e student s	should be a	able to	Bloon	n's Cog	gnitive	
						-	level	Des	scripto	r
C01	Classify features o	f nonlinea	r systems				3	An	nlving	
$\frac{cor}{CO2}$	Examine behavior	of nonlin	ear system	ns through	various ma	othematical	4	An	alvzino	σ
	tools		ear system	iis through	various inc	unematical	т	7 110	ar y 2111 ₂	5
C03	Recommend step	by step a	nnroach fe	or investio	ting the d	vnamics of	5	Eva	luatin	σ
	nonlinear systems	by step u		n mvestige	ung me u	ynamies or	5	Die	iiuutiii	5
CO-PC	Manning ·									
		PO1	PO2	PO3	PO4	PO5	PO6			
	COL	101	102	105	3	105	100			
					3					
							2			
	005									
Assessi	ments :									
Teache	er Assessment:									
Two co	omponents of In Ser	nester Eva	aluation (I	SE), One I	Mid Semes	ster Examina	tion (I	MSE) a	nd on	e End
Semest	er Examination (ESI	E) having 2	20%, 30%	and 50% v	veights resp	pectively.				
Assess	ment			Mar	KS					
ISE I				10						
MSE				30						
ISE 2				50						
ISE 1	and ISE 2 are based or	assignmer	nt/declared		ninar etc					
MSE ·	Assessment is based of	n 50% of c	ourse confe	ent (Normall	v first three	modules)				
ESE:	Assessment is based	on 100%	course con	tent with 70)-80% weig	htage for cou	irse cor	ntent (n	ormally	y last
three n	nodules) covered after	MSE.			U	0		,	-	
Course	e Contents:									L
Modu	le 1: Nonlinear dyr	namical sy	stems:-						H	rs. 6
Introd	uction, some feature	es of nonl	inear dyna	amical syst	ems, first o	order system	s, seco	ond ord	er	
system	n, equilibrium points	, classifica	ation of eq	uilibrium p	ooints.					

Module 2:Differential equation solution:-	Hrs. 8
Lipschitz functions, locally/globally Lipschitz, existence/uniqueness of solutions, Cauchy	
sequence, Banach spaces, Bellman Gronwall inequality, Stability of equilibrium point,	
Stability in sense of Lyapunov, Asymptotic stability, Lyapunov's theorem on stability, global	
asymptotic stability, linear systems.	
Module 3: Advanced Stability theory:-	Hrs. 5
Extension of Lyapunov's theorem in different context, converse Lyapunov theorem, instability	
theorem, equilibrium sets, LaSalle's Invariance principle, Barbashin and Krasovskii's theorems	
Module 4: Periodic Orbits:-	Hrs. 6
Bendixson criterion and Poincare-Bendixson criterion, Lotka predator prey model, van-der-Pol	
oscillator, Linearization.	
Module 5: Interconnection between linear system and nonlinearities:-	Hrs. 8
Signals, operators, norm of signals, finite gain L2 stable, passive filters, dissipation equality,	
positive real lemma, Kalman Yakubovich-Popov theorem, memoryless nonlinearities, loop	
transformation, circle criterion, limit cycle, Popov criterion.	
Module 6:- Describing function:-	Hrs. 6
Describing function method, jump hysteresis, sufficient condition for existence and	
nonexistence of periodic orbits, Describing function for nonlinearities, ideal relay with	
hysteresis and dead zone.	
Module wise Measurable Students Learning Outcomes :	
After the completion of the course the student should be able to:	
1. Classify the features of nonlinear dynamical systems.	
2. Determine the existence and uniqueness of solutions of differential equations.	
3. Study the stability problem using Lyapunov theory.	
 Analyze the theory of periodic obrits through various theorems. Solve perlineer system problem using interconnection between linear system and perlinear 	mitian
5. Solve nominear system problem using interconnection between intear system and nonlinear theory	nues
6. Apply Describing function method to nonlinear systems.	

Title of the Course: PLC and Embedded ControlLTPCr											
Course	e Code: 4	CS522						3			3
Pre-Re	quisite	Courses:	Instrume	ntation T	echniques	, Electrical	Measurer	nents,	Micro	ocontrolle	er and
Applica	ations										
Textbo	oks:										
1.	John W.	Webb, Ron	ald A. Re	is, <i>Progra</i>	ammable l	ogic control	llers, princ	iples &	& appli	ications,	PHI
	publicati	on, Eastern	Economic	Edition,	1994.						
Refere	nces:										
1. J	Iohn R. H 2004.	lackworth a	nd Peterso	on, <i>PLC cc</i>	ontrollers	programmii	ng methods	and a	pplica	<i>tions</i> , PE	II,
2. 0	Gary dun	ning, Introd	luction to I	PLC, Thor	mson learr	ning, Edition	n III, 2006.				
3. 1	William H	I. Bolton, P	Programme	able logic	controller	s, Newnes ,	Edition V	I, 2006	5.		
Course	e Objecti	ves :									
1. 7	The cours	e intends to	exploit th	e PLC and	d Embedd	ed Control	for industri	al auto	omatio	n	
2. 7	The cours	e aims at de	eveloping	programs	using lade	ler logic for	industrial	autom	ation		
3. 1	t intends	to analyze	the perform	nance of a	automation	n systems er	nploying F	LC an	d Emb	edded C	ontrol
Course	e Learnir	ng Outcom	es:								
CO	After th	e completio	n of the co	urse the st	udent sho	uld be able t	0	Blo	om's C	ognitive	
								leve	e l 1	Descriptor	r
CO1	Interpr	et features	of PLC a	and Embe	dded Con	trol System	ns used for		3 .	Applying	
	Industri	al Automat	ion.								
CO2	Use lad	der logic pr	ogrammin	g techniqı	ue for vari	ous PLC ap	plications.		3	Applying	
CO3	Evalua	te the per	formance	of PLC	network	configurat	ions, PLC		5	Evaluatin	ıg
	function	ns used for o	different a	pplication							
CO-PO) Mappin	ng:									
			PO1	PO2	PO3	PO4	PO5	PC)6		
		CO1			2						
					2						
		CO3				2					
Assess	ments •	000									
Teache	nents . er Assess	ment•									
	mponent	s of In Ser	nester Eva	luation (I	SE) One	Mid Semes	ster Exami	nation	(MSF	and on	e End
Semest	er Exami	nation (ESI	E) having 2	20%, 30%	and 50%	weights res	pectively.	nution	(INDL	<i>i)</i> and on	e Ena
Assess	ment				Ma	rks					
ISE 1					10						
MSE					30						
ISE 2					10						
ESE	ESE 50										
ISE 1	and ISE 2	are based on	assignmen	t/declared	test/quiz/se	eminar etc.					
MSE:	Assessme	nt is based o	n 50% of co	ourse conte	ent (Norma	lly first three	modules)			,	
ESE:	Assessme	ent is based	on 100% c	course cont	tent with 7	0-80% weig	htage for c	ourse o	content	(normall	y last
three n	nodules) c	overed after	MSE.								

Course Contents:	
Module 1: Introduction to PLC	Hrs.
Introduction, Advantages, Disadvantages, Parts of PLC, PLC Input module, PLC Output	
Module, PLC Architecture, PLC Operation, PLC as a computer, PLC memory and interfacing,	6
Power Supply for PLC	
Module 2: PLC programming	Hrs.
Ladder Logic Symbols, Latching and Unlatching of PLC, Programming on/ off inputs to	
produce on/off outputs, relation of digital gate logic to contact / coil logic, creating ladder	6
diagrams from process control description.	
Module 3: PLC Timer and Counter Functions	Hrs.
PLC timer functions, Types of PLC timers, Programming of Non-retentive timers for various	
applications, Programming of ON timers, OFF timers, PLC counter functions, Programming of	6
UP, DOWN counters, Case studies related to Industrial Automations	
Module 4: PLC Arithmetic, Comparison and Branch functions	Hrs.
PLC Arithmetic functions, PLC comparison functions, Conversion functions, Master control	
relay functions, PLC jump functions, Jump with return and Jump with No return functions,	6
Programs related to Arithmetic, Comparison and Branch functions	
Module 5: Advanced PLC functions	Hrs.
Data move system, data handling functions, Digital bit functions and applications, sequencer	
functions Analog PLC operations, PID control of continuous process, PID modules & tuning,	6
typical PID functions	
Module 6: PLC Networking	Hrs.
Networking of PLCs, Levels of Industrial Control, Types of Networking, Network	6
Communications, Cell control by PLC Networks, Factors to consider in selecting a PLC	U
Module wise Measurable Students Learning Outcomes :	
After the completion of the course the student should be able to:	
1. Interpret the basic features, advantages & disadvantages of PLC.	
2. Implement programs in PLC by using programming tools like ladder diagrams.	
3. Use PLC timer and counter functions to develop ladder logic programs.	
4. Implement various applications of PLC using PLC arithmetic, comparison and branch func	tions.

- 5. Employ and evaluate PLC for analog operations and design PID control using PLC
- 6. Interpret the PLC network configuration and select the PLC to meet given constraints.

Professional Core (Lab) Courses

Title of	Title of the Course: Non-linear Dynamical Systems Lab									P	Cr
Course Code: 4C8571										4	2
Pre-Re	Pre-Requisite Courses: Control System Engineering										
Textbo	ooks:										
1	Jean-Jac	ques E.Slotin	ne & Weipi	ing Li. Ap	oplied Nonlir	iear Conti	rol by Pre	ntice I	Hall, 199	91.	
Refere	ences:										
1. 1	1. H.K.Khalil Nonlinear systems 3rd Edition Prentice Hall, 2002.										
2.	Vukic, k	uljaca, Donl	agic, <i>Nonli</i>	near cont	trol systems	by Marce	el Dekker	publis	sher, 20	03	
Course	e Objec	tives:									
1. 7	To make	e students sin	nulate nonl	inear syst	tem for analy	zing its p	roperties.				
2.	To deve	lop skills in p	programmi	ng for det	termining sta	bility of n	onlinear	system	1.		
3.	To make	e students un	derstand th	e behavio	or of Periodic	e orbit thro	ough prog	ramm	ing and	simul	ation.
Course	e Learn	ing Outcom	es:								
CO	After	the completi	ion of the o	course th	e student w	ill be able	to		Bloom's	s Cog	nitive
									level	Des	criptor
CO1	Demo	nstrate the p	roperties o	f nonline	ar systems u	sing simul	ation.		3	Ap	olying
CO2	Analy	ze the stab	ility of n	onlinear	system usi	ng progra	amming	and	4	Ana	alyzing
	simula	tion tools.									
CO3	Evalu	ate the bel	havior of	periodic	e orbit usin	ng progra	amming	and	5	Eva	luating
	simula	tion tools.									
	Monn	ing .									
CO-PC	J Mapp	ing :									
			PO1	PO2	PO3	PO4	PO5	P	06		
		CO1		101		2	100				
		CO2				2					
		CO3							2		
Assess	ment:	0.00									
There a	are four	components	of lab asse	ssment. L	A1. LA2. L	A3 and La	b ESE.				
IMP: L	ab ESE	is a separate	head of pa	ssing.	,,						
Asse	essment	Base	d on	Con	ducted by	Conduc	tion and M	Iarks S	ubmissic	on 1	Marks
T	A 1	Lab act	ivities,	Lah Ca		During	Week	l to	Week	4	25
L	LAI	attendance	e, journal	Lad Co	burse Faculty	Submissi	on at the e	end of V	Week 5		25
I	Δ2	Lab act	ivities,	Lah Co	urse Faculty	During	Week 5	5 to	Week	8	25
L		attendance	e, journal	Lab CO	Juise Faculty	Submissi	on at the e	end of V	Week 9		23
I	A3	Lab act	ivities,	Lab Co	ourse Faculty	During	Week 1	0 to	Week	14	25
		attendance	e, journal		j	Submissi	on at the e	end of V	Week 14	10	
Lat	DESE	Lab Perform	mance and	Lab Co	ourse faculty	During	Week 1	5 to	Week	18	25
		related docu	imentation		•	Submissi	on at the e	end of V	week 18		
XX7. 1	1 1. 11	· · · · ·	1 6 6	N	T -1. (* **)	/T 1	C	1	11 . 1	1.	· · · ·
week	1 1nd1ca	ues starting	week of S	semester.		es/Lab pe		e sha		ie pei	10rming
experir	nents, n	nnn-project,	presentatio	ons, draw	ings, prograi	mming an	u otner s	uitable		ies, as	per the

nature and requirement of the lab course.

The experimental lab shall have typically 8-10 experiments.

Course Contents: (Experiments)

- 1. To simulate the effects of various non-linearities on system using MATLAB
- 2. To simulate linear and non-linear differential equations using MATLAB
- 3. Constructing phase portrait of linear system using MATLAB
- 4. Constructing phase portrait of non-linear system using MATLAB
- 5. Study of limit cycle using MATLAB Simulink
- 6. Simulation of predicting limit cycle using describing function analysis.
- 7. Study of Cart mounted Inverted Pendulum system.
- 8. Stability analysis using MATLAB.
- 9. Coding for constructing phase portrait of non-linear system.

Computer Usage / Lab Tool: MATLAB

Title of the Course: PLC and Embedded Control Lab	L	Т	Р	Cr
Course Code: 4CS572			4	2

Pre-Requisite Courses: Instrumentation Techniques, Electrical Measurements, Microcontroller and Applications

Textbooks:

1. John W. Webb, Ronald A. Reis, Programmable logic controllers, principles & applications, PHI publication, Eastern Economic Edition, 1994.

References:

- 1. John R. Hackworth and Peterson, PLC controllers programming methods and applications, PHI, 2004.
- 2. Gary dunning, Introduction to PLC, Thomson learning, Edition III, 2006.
- 3. William H. Bolton, Programmable logic controllers, Newnes, Edition VI, 2006.

Course Objectives :

- 1. The lab course is aimed to develop programming skills using PLC for Industrial Automation
- 2. The course intends to introduce the use of PLC for solving real world problems.
- 3. It will enable students to use PLC for control applications in electrical engineering

Course	e Learning Outcomes:			
СО	After the completion of the course the student should be able to	Bloom's Cognitive		
		level	Descriptor	
CO1	Execute experiments based on PLC and SCADA systems.	3	Applying	
CO2	Construct basic control systems using PLC and SCADA.	4	Analyzing	
CO3	Design ladder logic programs for various PLC applications.	6	Creating	
CO-PC	Manning ·			

CO-PO Mapping :

	PO1	PO2	PO3	PO4	PO5	PO6
CO1			2			
CO2				2		
CO3				2		

Assessments :

There are four components of lab assessment, LA1, LA2, LA3 and Lab ESE.

IMP: Lab ESE is a separate head of passing.

Assessment	Based on	Conducted by	Conduction and Marks Submission	Marks
Ι Δ 1	Lab activities,	Lah Course Fegulty	During Week 1 to Week 4	25
LAI	attendance, journal	Lab Course Faculty	Submission at the end of Week 5	23
1.4.2	Lab activities,	Lab Course Faculty	During Week 5 to Week 8	25
LAZ	attendance, journal	Lab Course Faculty	Submission at the end of Week 9	25
LA3	LA2 Lab activities,		During Week 10 to Week 14	25
LAS	attendance, journal	Lab Course Faculty	Submission at the end of Week 14	23
Lob ESE	Lab Performance and	Lab Course fegulty	During Week 15 to Week 18	25
LauESE	related documentation		Submission at the end of Week 18	23
L		1	1	

Week 1 indicates starting week of Semester. Lab activities/Lab performance shall include performing experiments, mini-project, presentations, drawings, programming and other suitable activities, as per the nature and requirement of the lab course.

The experimental lab shall have typically 8-10 experiments.

Course Contents:

- 1. Use different components of Relay and PLC logic.
- 2. Implement ladder diagram for ON/OFF and latching functions.
- 3. Design of PLC program for motor reversal control.
- 4. Illustrate stair case lighting using PLC programming.
- 5. Implement PLC program for building automation.
- 6. Design of PLC program for various arithmetical functions.
- 7. Devise the PLC program for traffic control system.
- 8. Design of ON/ OFF control mechanism using PLC timer functions.
- 9. Design of basic applications employing PLC counter functions.
- 10. Design of basic applications employing PLC analog inputs.

Computer Usage / Lab Tool: RSMicrologix, RSLinx, RSEmulator, PLC Trainerkit

Professional Elective (Theory) Courses

Title of	f the Course: Adap	ptive Cont	rol				L	Т	Р	Cr
Course Code: 4CS531 3										3
Pre-Re	Pre-Requisite Courses: Applied Digital Control									
Textbo	ooks:									
1. 1	Kannan M. Moudga	ılya," Digit	al Control	", TMH p	ublications,	2007.				
Refere	nces:									
	Astrom, Wittenmarl	k," Adaptiv	e Control	", Pearson	Education,	1995.	F 1 1	000		
2. 1	Petros Ioannous, Jin B N Chatterij K K J	lg Sun, " Ko Permar " Sy	obust adapi vstem Ider	tive Contro	", Prentic	e Hall Int. nd IBH pu	E0., I blicati	1996. ions 19	90	
Course	e Objectives :		ystem raei	inneation	, ОЛЮГИ И	na ibii pu	oncat	10115, 17	<i>J</i> 0.	
1.	This course provide	s the basic	concepts of	of modern	control tech	niques for	contr	oller de	sign.	
2. 1	It provides the meth	odology of	design co	ntrol optin	nization in e	estimation	for ad	laptive of	control.	
3. 1	It gives the overview	w of adaptiv	ve control	design alg	orithms.			-		
Course	e Learning Outcon	nes:								
CO	After the comple	tion of the	course th	e student	will be able	e to		Bloom	's Cogni	tive
								level	Descri	ptor
CO1	Analyze modern a	and adaptiv	e control t	techniques	for control	ler design.		4	Analyz	zing
CO2	Evaluate various	adaptive co	ontrol algo	orithms.				5	Evalua	ting
CO3	CO3 Design various adaptive controllers like MRAC, STR and LQG.							6	Creati	ing
CO-PO) Mapping :									
			1	1	1	1	1			
		PO1	PO2	PO3	PO4	PO5	P	06		
	CO1				3					
	CO2			2						
	CO3				3			1		
Assess	ment:									
Teache	er Assessment:									
Two co	omponents of In Se	emester Eva	aluation (I	(SE), One	Mid Semes	ter Exami	natior	n (MSE) and on	ie End
Semest	er Examination (ES	SE) having	20%, 30%	and 50%	weightage r	respectivel	у.			
	Asses	sment				Ma	arks			
	ISI	E 1]	10			
	M	SE					30			
	ISI	E 2]	10			
	ES	SE					50			
ISE 1	and ISE 2 are b	based on a	ssignment	t, oral, se	minar, test	(surprise/	declar	ed/quiz	a), and g	group
discus	ssion. [One assessm	ent tool per	ISE. The	assessmen	nt tool used	tor ISE 1 s	shall n	not be us	sed for I	SE 2]
MSE:	Assessment is base	ed on 50% (of course c	content (N	ormally firs	t three mod	dules)			11
ESE:	Assessment is base	ed on 100%	course co	ontent with	1/U-80% we	eightage fo	or cou	rse cont	ent (nor	mally
last th	ree modules) cover	ed after MS	DE.							
Course	e Contents:									

Nouue 1. Identification	1115.	
Introduction, least square estimation, time series, ARMA process, prediction and error models,	6	
statistical properties of parameter estimation, frequency domain interpretation, noise model,	U	

identification of heating tank, maximum likelihood estimation.	
Module 2: Minimum Variance Control	Hrs.
K-step ahead prediction error model, ARMAX, white noise model, ARIMAX model, minimum	
variance controller, control low for non-minimum phase system, minimum variance control	6
low, generalized minimum variance controller, ARMAX and ARIMAX model, PID tuning	0
through GMVC control.	
Module 3: Model Predictive Control	Hrs.
Model predictive control-introduction, generalized predictive control, noise model, ARIMAX	
model, gamma GPC, model derivation, optimization of objective function, predictive PID,	5
dynamic matrix control.	
Module 4: Adaptive Control Schemes	Hrs.
Adaptive control- introduction, adaptive schemes, adaptive control problem, deterministic self-	
tuning regulators, pole placement design, continuous and direct self-tuning, minimum variance	
and moving average controllers, stochastic self-tuning regulators, neural network and fuzzy	0
adaptive control scheme.	
Module 5: MRAC	Hrs.
Model reference adaptive control-introduction, MIT rule, determination of adaptive gain,	
lyapunov theory, model reference adaptive system using lyapunov, application to adaptive	6
control problem, relation between STR and MRAC system, stochastic, adaptive control system.	
Module 6: Linear Quadratic Gaussian Control	Hrs.
Linear quadratic Gaussian control- introduction, spectral factorization, controller design,	
simplified LQG control, performance analysis of controllers, state space approach to regulator	7
design, linear quadratic regulator, kalman filter design.	
Module wise Measurable Students Learning Outcomes :	
After completion of the course students will be able to:	
1. Analyze modern control techniques for controller design.	
2. Explain least square techniques.	
 Analyze control optimization in estimation for adaptive control. Design a denting control alogridhum 	
 Design adaptive control algorithms. Design different model structures in adaptive controllers. 	
6. Design LOG controller	

Title of the Course: Re	al Time Con	trol Appli	ications			L	Т	Р	Cr
Course Code: 4CS532						3			3
Pre-Requisite Courses:	essing	5							
Textbooks:									
1. Dingyu Xue, Yan	gQuan Chen,	System Si	mulation T	<i>Techniques</i>	with Matla	b and	Simuli	nk, Wile	у
Publications, Edit	ion I, 2014	-		-					-
2. TI User Manuals	FMS320C2x	, TMS 283	335						
References:									
1. Website www.ti.c	om and <u>www</u>	.DSPguid	e.com.						
2. Harold Klee, Ran Press Third Edition	dal Allen, <i>Sin</i>	nulation oj	f Dynamic	Systems wi	th MATLA	B® an	d Simu	link®, C	CRC
3 Katalin Ponovici	Dieter I Mos	terman R	Poal_time S	imulation T	echnologi	Pri	ncinlas		
Methodologies a	nd Annlicatio	ns CRC P	ress 2012	<i>mutation</i> 1	cennologie	5.171	ncipies	,	
Course Objectives :	ia ripplicalio	<i>ns</i> , erte r	1000, 2012.						
1 The course intend	s to introduce	e Embedde	ed Control	for Control	Applicatio	ons			
2. The course aims a	t developing	programs	using targe	et Microcor	trollers us	ing Ma	atlah ai	nd Simul	ink
3. It intends to analy	ze the perfor	mance of I	Electrical S	vstems usi	ng advance	ed tech	iniques	like	
Hardware in loop	simulation, F	Processor-i	in-loop sim	ulation, etc	<i>.</i>		1		
Course Learning Outco	omes:		-						
CO After the comple	etion of the co	ourse the st	tudent shou	ld be able t	0	Blo	om's Co	ognitive	
						leve	el I	Descriptor	
CO1 Implement pro	grams to solv	ve real tim	ne control j	problems ir	electrica	1	3 A	Applying	5
Engineering.									
CO2 Examine the p	erformance	of real ti	me contro	l system f	or various	5	5 E	Evaluatin	ıg
applications.									
CO3 Perform real t	ime simulat	ions and/o	or hardwar	e-in-loop s	simulations	s (6 (Creating	
using target har	dware like A	rduino, dS	pace, TI bo	oards etc.					
CO-PO Mapping :						•			
	PO1	PO2	PO3	PO4	PO5	PC)6		
CO1			2						
CO2				2					
CO3						2	2		
Assessments :									
Teacher Assessment:									
Two components of In	Semester Eva	aluation (l	ISE), One	Mid Semes	ter Exami	nation	(MSE) and on	e End
Semester Examination (ESE) having	20%, 30%	and 50%	weights resp	pectively.				
Assessment			Mar	ks					
ISE 1			10						
MSE			30						
ISE 2			10						
ESE			50						
ISE 1 and ISE 2 are based	t on assignment	nt/declared	test/quiz/se	minar etc.					
MSE: Assessment is base	a on 50% of c	ourse conte	ent (Normal	ly first three	modules)				

ESE: Assessment is based on 100% course content with 70-80% weightage for course content (normally last three modules) covered after MSE.

Course Contents:	
Module 1: Introduction	Hrs.
Overview of System Simulation Techniques, Target Hardware Selection, Data types, Matrix	
Computations in Matlab, Flow structures: Conditional structures, Loop Structures, Accelerating	6
Matlab functions, Execution time and profiles	
Module 2: MATLAB applications in Scientific Computations	Hrs.
Solutions to Linear Algebra Problems: Matrix Analysis and Computation, Matrix Equations,	
Non-linear Matrix functions, Solutions of Calculus Problems, Solutions of Ordinary Differential	6
Equations, Non-linear equation solution and optimization	
Module 3: Modeling and Simulation of Engineering systems	Hrs.
Physical system modeling with Simscape, Description of SimPowerSystems, Modeling and	6
simulation of Electronics circuits, simulation of motors and electric drive systems	0
Module 4: Microcontrollers for Real-time Control Applications	Hrs.
Selection of Microcontroller for Control Applications, Sampling frequency selection,	
Features, Architecture and Specifications of Arduino Microcontrollers, Piccolo and Delfino	6
Microcontrollers	
Module 5: Microcontroller Configuration for Real-time Applications	Hrs.
Arduino, Delfino and Piccolo configuration in Matlab/Simulink Environment, Timer	
applications, Analog to Digital Conversion examples, PWM configuration and examples,	6
Applications in Power Electronics and Control Systems	
Module 6: Introduction to Hardware-in-loop Simulations	Hrs.
External mode simulations, Simulink and real-time workshop, Hardware-in-loop simulation	
techniques, code generation, Introduction to dSpace and its blocks, Hardware-in-loop	(
simulations using Arduino, Processor-in-loop simulations, Applications of Arduino Control,	0
dSpace Control, Case studies	
Module wise Measurable Students Learning Outcomes :	
After the completion of the course the student should be able to:	
1. Interpret the basic features, advantages & disadvantages of simulation softwares for	real time
applications.	
2 Implement programs in programming tools like Matleb to solve problems in Linear algebra	

- 2. Implement programs in programming tools like Matlab to solve problems in Linear algebra.
- 3. Evaluate electric drive systems by modeling and simulation of Engineering Systems
- 4. Identify, configure and use target hardware for system development in Electrical Engineering
- 5. Use microcontrollers to develop real-time control applications using low cost target hardware
- 6. Develop the hardware-in-loop simulations and evaluate the performance of electric systems.

Title of the Course: Neural Network and Fuzzy Control L					L	Т	Р	Cr			
Course Code: 4C8535							3			3	
Pre-Requisite Courses: Engineering Mathematics											
Textbo 1. 2. 7	ooks: M.T.Hagan, H.I Fimothy J. ross	B.Den , <i>'Fuz</i>	nuth, M.H zy Logic v	Beale, "N with Engin	Neural Netw	vork Desig	n", PWS I Pearson P	Publica Publicat	tions, ions, 2	1996. 2010	
Refere	nces:										
1. 1 2. 1 3. 5	Driankov, <i>'Fuz</i> B.Yegnanaraya Simon Haykin,'	zy Cor na, "A " Neur	ntrol, Naro Artificial N ral Networ	osa Public Veural Net rks and Le	ations, 200 works", PH earning Ma	0. II Publicat chines", Pe	ions, 2008 earson-PH	I publio	cations	s, 2009.	
Course	e Objectives :										
1.	This course pro	vides	the basic	concepts c	of Neural N	etworks ar	d Fuzzy C	Control			
2.	It provides the i	metho	dology of	design Ne	eural Netwo	orks and Fi	izzy contr	ol. t			
Course	e Learning Ou	tcome	or generic		iis and appi		velopmen	ι.			
CO	After the con	npleti	on of the	course th	e student v	will be abl	e to	Blo	om's (Cognitive	
		I						leve	el De	escriptor	
CO1	Explain Neur	ral Ne	tworks an	d Fuzzy C	Control.			2	Uı	nderstand	ling
CO2	Apply geneti	c algo	orithms an	d optimiz	ation in N	N, fuzzy a	pplication	s 3	A	oplying	
	development.			-		-			-		
CO3	Analyze Neu	ral Ne	tworks an	d Fuzzy C	Controller a	lgorithms.		4	Aı	nalyzing	
CO-PO) Mapping :										
			PO1	PO2	PO3	PO4	PO5	PC	6		
	CO	D1			3						
	CO	02				2					
	CO)3				2					
Assess	ment:										
Teach	er Assessment:		·	1			· F	• ,•		. 1	F 1
	omponents of I	n Sen	nester Eva	aluation (I	SE), One I	VIId Semes	ster Exam	ination	(MSE	and on	e End
Semes			c) naving 2	20%, 30%		vergntage i	espective	ly.			
	A	ISE					IVI	10			
			F					30			
		ISE	2					10			
	ESE 50						50				
ISE 1	and ISE 2 a	re ha	<u>sed on a</u>	ssignment	oral ser	ninar test	(surprise)	/declare	ed/auiz	z) and o	orolin
discus	sion [One asse	essmei	nt tool per	· ISE. The	assessmen	t tool used	for ISE 1	shall no	ot be u	sed for I	SE 21
MSE:	Assessment is	based	on 50% o	of course c	content (No	rmally firs	t three mo	dules)		224 IOI II	
ESE:	Assessment is	based	l on 100%	course co	ontent with	70-80% we	eightage fo	or cours	se con	tent (nori	mally
last th	ree modules) c	overed	d after MS	SE.						•	-

Course Contents:	
Module 1: Neural Network	Hrs.
Neuron model & architectures, learning rule, Training multiple Neuron, convergence, Performance surfaces & optimum points, Taylor's series & directives & minimum values, Quadratic functions, performance optimization, steepest descent, Newton method, conjugate gradients.	6
Module 2: Supervised Learning Networks	Hrs.
Adaline network, mean square error, LMS algorithm, analysis of convergence, MLPs, back propagation, choice of network architecture, convergence, drawbacks & modification of BPN, application to control.	6
Module 3: Unsupervised Learning Networks	Hrs.
Associative learning- simple associative learning, unsupervised Hebb, modifications in Hebb, Instar and out star rule, application to control.	4
Module 4: Fuzzy Logic	Hrs.
Fuzzy mathematics, fuzzy mapping, fuzzy relations, Implication rules, Mamdani & Sugeno models, fuzzy rule Base structure, FKBS systems FKBC PID.	6
Module 5: Fuzzy Controller Design	Hrs.
Mamdani techniques, Takagi Sugeno Model, PDC techniques, Stability Analysis using matrix inequality, Application and implementation.	8
Module 6: Genetic-Neuro-Fuzzy System	Hrs.
Optimization, Genetic Algorithm, theory of GA, processes involve in genetic optimizations, applications of genetic algorithm, Neural-fuzzy combinations, fuzzy GA combinations.	6
Module wise Measurable Students Learning Outcomes :	
 After completion of the course students will be able to: 1. Explain concepts of neural networks. 2. Apply neural networks for controller design. 3. Analyze and evaluate neural networks for control development. 4. Explain concepts of fuzzy control. 	
5. Apply fuzzy logic for controller design.	

6. Analyze and evaluate genetic algorithms and applications for control development.

Title of the Course: Robust Control	L	Т	Р	Cr
Course Code: 4CS536	3			3

Pre-Requisite Courses: Engineering Mathematics

Textbooks:

1. Kemin Zhou, "Essentials of Robust Control", Prentice Hall Publications, 1997.

2. Kemin Zhou, John Doyle, "*Robust and Optimal Control*", Feher-Prentice Hall Publications, 1995.

References:

- 1. P. H. Petkov, M.M. Konstantinov, "Robust Control Systems", Springer Publications, 2005.
- 2. Sigurd Skogestad, Ian Postlethwaite, "Multivariable Feedback Control", Wiley Publications, 2005.

Course Objectives :

- 1. This course provides the basic concepts of robust control.
- 2. It provides the methodology of design of robust control.
- 3. It gives the overview of h-infinity design.

Course Learning Outcomes:

СО	After the completion of the course the student will be able to	Bloom's Cognitive	
		level	Descriptor
CO1	Explain basic concepts of robust control.	2	Understanding
CO2	Apply robust control design and stability analysis.	3	Applying
CO3	Analyze the $H\infty$ -Control.	4	Analyzing

CO-PO Mapping :

	PO1	PO2	PO3	PO4	PO5	PO6
CO1			3			
CO2				2		
CO3				2		

Assessment:

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weightage respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50
ISE 1 and ISE 2 are based on assignment are	cominer test (surprise/declared/quiz) and group

ISE 1 and ISE 2 are based on assignment, oral, seminar, test (surprise/declared/quiz), and group discussion. [One assessment tool per ISE. The assessment tool used for ISE 1 shall not be used for ISE 2] MSE: Assessment is based on 50% of course content (Normally first three modules)

ESE: Assessment is based on 100% course content with70-80% weightage for course content (normally last three modules) covered after MSE.

Course Contents:	
Module 1: Robust Control	Hrs.
Introduction to Basic Concepts, Systems and Signals, Stability of LTI Systems, Controller	
design, Loop shaping, Closed loop Transfer function loop shaping, Linear Fractional	6
transformations.	
Module 2: Stabilizing Controllers	Hrs.
Internal stability, stabilizing controllers, Stabilizing Controllers - State-Space Descriptions,	(
stability analysis in frequency domain, system norms	0
Module 3: Limitations on Performance	Hrs.
Limitations on performance SISO and MIMO systems, sensitivity, time lags, uncertainties,	(
phase lag, performance requirements imposed by disturbances and commands.	0
Module 4: Uncertainty and Robustness	Hrs.
Introduction to robustness, Uncertainties and representation, Configuration, Types of	
Uncertainties of System Components, SISO Robust performance and Stability.	6
Module 5: Robust Stability and Performance	Hrs.
General control configuration, representing uncertainty, Introduction to Stability and Robust	
Performance Test, structured and unstructured uncertainty, SSV ,mu-synthesis and DK	6
iteration.	
Module 6: Controller Design	Hrs.
LQG control, H2 and H∞-Control, H∞ loop shaping,, H∞ loop shaping design, introduction to	
model reduction techniques, balanced realizations, hankel norm approximation, reduction of	6
unstable models.	
Module wise Measurable Students Learning Outcomes :	
After completion of the course students will be able to:	
1. Explain Basic concepts of robust control.	
2. Explain Stabilizing Controllers for System Interconnections.	
3. Analyze the robust stability.	
4. Analyze and evaluating robust control design.	
5. Analyze and evaluating $H\infty$ -Control.	
6. Analyze robust performance.	

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