Walchand College of Engineering, Sangli

(A Govt. Aided Autonomous Institute)

1947

Proposed
Credit System and Course Content for the 10th AC meeting

M. Tech in Control System Engineering

First Year M. Tech. Control System Engineering

Semester I and II

Academic Year 2020-2021

BoS Minutes

MINUTES OF BOARD OF STUDIES
DEPARTMENT OF ELECTRICAL ENGINEERING
WALCHAND COLLEGE OF ENGINRRING, SANGLI

Meeting No.	: 24
Day/ Date/ Time	: Tuesday, 28th May 2019, 11.00 a.m.
	: H.O.D Cabin, Department of Electrical Engineering, WCE, Sangli.

MEMBERS PRESENT:

1. Dr.D.S.More, Chairman (H.O.D.)
2. Prof.Dr.P.M.Joshi (Member)
3. Dr.D.B.Kulkarni (Member)
4. Dr. S. S. Dambhare (Member)
5. Dr. V. N. Kalkhambkar (Member)
6. Prof.Dr.A.P.Vaidya (Member)
7. Mr.A.B.Patil (Member)
8. Mr.N.V.Patel (Member)
9. Mrs.S.L.Shaikh (Member)
10. Dr.R.P.Hasabe (Members)
11. Mrs.S.P.Diwan (Member)
12. Mr.S.S.Karvekar (Member)
13. Mr.V.P.Mohale (Member)
14. Dr.S.B.Joshi (Member)

Agenda Item No BOS – 24 -01:

Approval of Minutes of Last BOS Meeting.

Structure of B.Tech Electrical, M.Tech Power System Engineering and M.Tech Control System Engineering were approved. Also content of the course Basic Electrical Engineering was approved.

Agenda Item No BOS – 24 -02:

Approval of the resolution made in adhoc BOS and DAB.

Redefining of POs for M.Tech Power System Engineering and Control System Engineering were approved.

Agenda Item No BOS – 24 -03:

Approval of Revised POs for UG Electrical Engineering Programme.

It was suggested from external BOS members to reframe POs with simple words keeping the meaning same. In PSO's how WCE Electrical Engg programme is different from other institutes should get reflected was also suggested. With the modification as suggested by BOS members is carried out and POs of UG program are approved

<u>Agenda Item No BOS – 24 -04:</u>

Approval of New Syllabus of Second Year B.Tech Electrical Engineering Implemented from 2019-20 (First Year B.Tech Electrical from 2018-19).

It was asked by BOS members to include pre-requisite for all the courses and also to verify CO's of each course and if possible revisit it. BOS members advised to change the title of the experiments of all the courses so that the aim of the experiment becomes clear in the title itself. .

<u>Agenda Item No BOS – 24 -05:</u>

Approval for attainment of POs and PEOs for Academic Year 2017-18.

Attainment of POs and PEOs were explained to External BOS members in detail, with which they were satisfied. PO attainment of the 2017-18 is approved.

<u>Agenda Item No BOS – 24 -06:</u>

Any other point with the permission of the chairman.

Since there were no further issues, the meeting was concluded by giving vote of thanks to all committee members by the chairman.

Chairman

Dr. D. S. More
Department of Electrical Engineering
WCE, Sangli.

Dated: 28/05/2019

Copy To:

1. Director
2. Dean Academic
3. All Faculty Members, Department of Electrical Engineering

Table of Credits

Sr. No	Odd Sem Credits	Even Sem Credits	Total Credits
FY	**18**	**18**	**36**
SY	**13**	**16**	**29**
Total Credits	**31**	**34**	**65**

Credit System and Evaluation Scheme

Credit System for F.Y. M. Tech. (Control System Engineering) Sem- I AY 2020-21

Sr.No.	Category	Course Code	Course Name	L	T	P	Hrs	Credits	ISE-1	MSE*	ISE-2	ESE
Professional Core (Theory)												
1	HS	4IC501	Research Methodology	2	0	0	2	2	10	30	10	50
2	PC	4CS501	Applied Digital Control	3	0	0	3	3	10	30	10	50
3	PC	4CS502	Process Control	3	0	0	3	3	10	30	10	50
Professional Core (Lab)												
4	PC	4CS551	Applied Digital Control Lab	0	0	4	4	2	25	25	25	25
5	PC	4CS552	Process Control Lab	0	0	4	4	2	25	25	25	25
Professional Elective (Theory)												
6	PE	4CS5**	Professional Elective 1	3	0	0	3	3	10	30	10	50
7	PE	4CS5**	Professional Elective 2	3	0	0	3	3	10	30	10	50
Mandatory Life Skill Courses												
8	MC	Refer list	Mandatory Life Skill Course	2	0	0	2	0	10	30	10	50
Value Added Professional Courses $												
9	VAPC	Refer list	Value Added Professional Courses	0	0	0	2	2	0	0	0	0
Value Added Life-Skill Courses $												
10	VALS	Refer list	Value Added Life Skill Courses	0	0	0	2	2	0	0	0	0
			Total	**16**	**0**	**8**	**24**	**18**				

Course List for F.Y. M. Tech. (Control System Engineering) Sem-I AY 2020-21

Sr.No.	Course Code	Course Name
Professional Elective 1		
1	4CS511	Optimal Control
2	4CS512	Multivariable Control
3	4CS513	Control Techniques for Electrical Drives

Professional Elective 2		
1	4CS515	System Identification
2	4CS516	Advanced Digital Signal Processing

1. Notes:

* For Lab courses, there will be only internal continuous assessment.

$ For Value added (Professional and Life-Skill), the mode of teaching (LTP) is decided by the resource person.

Diss Ph-I and Phase II together: Guide Contact hours: 2, Self Study: 18
Diss Ph-III and Phase IV: Guide Contact hours: 2, Self Study: 30

Credit System for F.Y. M. Tech. (Control System Engineering) Sem- II AY 2020-21

Sr.No.	Category	Course Code	Course Name	L	T	P	Hrs	Credits	ISE-1	MSE*	ISE-2	ESE
Professional Core (Theory)												
1	PC	4CS521	Non-Linear Dynamical Systems	3	0	0	3	3	10	30	10	50
2	PC	4CS522	PLC and Embedded Control	3	0	0	3	3	10	30	10	50
Professional Core (Lab)												
3	PC	4CS571	Non-Linear Dynamical Systems Lab	0	0	4	4	2	25	25	25	25
4	PC	4CS572	PLC and Embedded Control Lab	0	0	4	4	2	25	25	25	25
5	PC	4CS573	Industrial Project	0	0	4	4	2	25	25	25	25
Professional Elective (Theory)												
6	PE	4CS5**	Professional Elective 3	3	0	0	3	3	10	30	10	50
7	PE	4CS5**	Professional Elective 4	3	0	0	3	3	10	30	10	50
Mandatory Life Skill Courses												
8	MC	Refer list	Mandatory Life Skill Course	2	0	0	2	0	10	30	10	50
Value Added Professional Courses #												
9	VAPC	Refer list	Value Added Professional Courses	0	0	0	2	2	0	0	0	0
Value Added Life-Skill Courses #												
10	VALS	Refer list	Value Added Life Skill Courses	0	0	0	2	2	0	0	0	0
			Total	**14**	**0**	**12**	**26**	**18**				

Course List for F.Y. M. Tech. (Control System Engineering) Sem-II AY 2020-21

Sr.No.	Course Code	Course Name
		Professional Elective 3
1	4CS531	Adaptive Control
2	4CS532	Real Time Control Applications

		Professional Elective 4
1	4CS535	Neural Network and Fuzzy Control
2	4CS536	Robust Control

Notes:

* For Lab courses, there will be only internal continuous assessment.

$ For Value added (Professional and Life-Skill), the mode of teaching (LTP) is decided by the resource person.

Diss Ph-I and Phase II together: Guide Contact hours: 2, Self Study: 18
Diss Ph-III and Phase IV: Guide Contact hours: 2, Self Study: 30

ODD Semester

Professional Core (Theory) Courses

Title of the Course: Research Methodology Course Code: 4IC501	L	T	P	Cr
	2	--	--	2

Pre-Requisite Courses: None

Textbooks:

1. C. R. Kothari, Research Methodology, New Age international
2. Deepak Chopra and Neena Sondhi, Research Methodology : Concepts and cases, Vikas Publishing House, New Delhi
3. Ranjit Kumar, Research Methodology: A Step by Step Guide for Beginners, 2nd Edition

References:

1. E. Philip and Derek Pugh, How to get a Ph. D. – a handbook for students and their supervisors, open university press
2. Stuart Melville and Wayne Goddard, Research Methodology: An Introduction for Science & Engineering Students
3. G. Ramamurthy, Research Methodology, Dream Tech Press, New Delhi

Course Objectives:

1. Understand some basic concepts of research and its methodologies
2. Identify and formulate the research problems, state the hypothesis,
3. Organize and conduct and present research in a more appropriate manner
4. Prepare research artifacts to the college and papers to Conferences and Journals

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive	
		level	Descriptor
CO1	**Classify** various methods to solve research problem.	3	Applying
CO2	**Construct** a research problem in respective engineering domain.	3	Applying
CO3	**Investigate** various data analysis techniques for a research problem.	4	Analyzing
CO4	**Author** the survey paper based on literature review for research problem.	6	Creating

CO-PO Mapping:

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

Assessments :

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% 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 issues, Copyrights and Patenting etc.	**4**
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, Research Design Process, Measurement and scaling techniques, Data Collection – concept, types and methods, Processing and analysis of data, Design of Experiment	**5**
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, techniques such as ANOVA, Chi square test etc., Nonparametric tests. Correlation and regression analysis	**5**
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 WORD, Latex etc.	**4**
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.
Module 5: Learn methods for presenting the research results
Module 6: Applying RM in respective disciplines of Engineering.

Title of the Course: Applied Digital Control **Course Code: 4CS501**	L	T	P	Cr
	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:

CO	**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.

Course Contents:

Module 1: Controller Structures	**Hrs.**

Feed forward controllers, One degree of freedom, Two degree of freedom, Lag-Lead controller, PID Controller, Well behaved signal, Solving Aryabhatta's Identity.	**6**
Module 2: Controller Realization	**Hrs.**
Direct structure, Canonical and non-canonical structure, Cascade and parallel realization, PID controller Implementation, Microcontroller implementation of 1st, 2nd and higher order modules, Choice of Sampling interval.	**6**
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, systems with delay.	**6**
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, PID Tuning Through Pole Placement Control.	**6**
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 plant, LQR through pole placement.	**6**
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, kalman filter design.	**6**

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.
5. Evaluate and design Internal Model Controller.
6. Evaluate and design the state feedback controller, Kalman filter and LQR

Title of the Course: Process Control Course Code: 4CS502	L	T	P	Cr
	3	--	--	3

Pre-Requisite Courses: Control System Engineering

Textbooks:

1. George Stephanopoulos, "Chemical Process Control - An introduction to Theory and Practice", Prentice-Hall of India, 1st Edition 1984.

References:

1. Thomas E. Marlin, "Process Control - Design Processes and Control System for Dynamic Performance, 2nd Edition", Mc Graw Hill publication.
2. F.G. Shinskey, "Process Control System – Application, Design and Tuning", McGraw-Hill Publication, 3rd Edition, 1988.
3. Curtis D. Johnson, "Process Control Instrumentation Technology", 7th Edition, Pearson Education, 7th 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 control.
3. It also provides the design of various types of controllers for single loop and multi loop control system.
4. It gives the overview of advanced controllers used in process control and multivariable predictive control.

Course Learning Outcomes:

CO	After the completion of the course the student will be able to	Bloom's Cognitive	
		level	Descriptor
CO1	**Calculate** the various models of industrial processes.	3	Applying
CO2	**Analyze** the problems associated with open loop and close loop process control system.	4	Analyzing
CO3	**Evaluate** the performance of processes with various conventional and advanced controllers.	5	Evaluating
CO4	**Design** various conventional and advanced controllers for the processes.	6	Creating

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
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: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 model, Modeling considerations for control purposes, the input-output model, degree of freedom.	**5**
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 systems.	**5**
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 proportional (p) control, Integral (I) control and derivative (D) control on the response of controlled process, effect of composite control actions.	**6**
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, problem in designing feed forward controllers, practical aspects on the design of feed forward controllers, F/F – F/B control.	**7**
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 selection of loops, design of non-interacting control loops. Overview of modern control methodologies: PLC, SCADA, DCS, Adaptive control, variable structure control.	**7**
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, model predictive control, process model based control, implementation guidelines. Process control design: sequence of design steps, statistical process control.	**6**

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	T	P	Cr
Course Code: 4CS551	--	--	4	2

Pre-Requisite Courses: Control System Engineering

Textbooks:

1. Kannan M. Moudgalya, Digital Control, Wiley 2007, (IITB).

References:

1. Belanger, Control Engineering – Modern Approach, International Edition 1995.
2. Z.Gajic, M. Lelic,Modern Control Systems Engineering, PHI Series in System & Control Engineering 1996
3. Torkel Glaw and Lennard Ljung Control Theory- Multivariable & Nonlinear Methods, Taylor & Francis Publication London & New York 2002
4. Bernard FriedLand, Advanced Control System Design, Prentice Hall International 2000
5. B.C.Kuo,Digital Control System, 2nd Edition, Oxford Press 2003

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:

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
LA1	Lab activities, attendance, journal	Lab Course Faculty	During Week 1 to Week 4 Submission at the end of Week 5	25
LA2	Lab activities, attendance, journal	Lab Course Faculty	During Week 5 to Week 8 Submission at the end of Week 9	25
LA3	Lab activities, attendance, journal	Lab Course Faculty	During Week 10 to Week 14 Submission at the end of Week 14	25
Lab ESE	Lab Performance and related documentation	Lab Course faculty	During Week 15 to Week 18 Submission at the end of Week 18	25

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 Course Code: 4CS552	L	T	P	Cr
	--	--	4	2

Pre-Requisite Courses: Control Systems Engineering Lab

Textbooks:

1. George Stephanopoulos, "Chemical Process Control - An introduction to Theory and Practice", Prentice-Hall of India, 1st Edition 1984.

References:

1. Thomas E. Marlin, "Process Control - Design Processes and Control System for Dynamic Performance, 2nd Edition", Mc Graw Hill publication.
2. F.G. Shinskey, "Process Control System – Application, Design and Tuning", McGraw-Hill Publication, 3rd Edition, 1988.
3. Curtis D. Johnson, "Process Control Instrumentation Technology", 7th Edition, Pearson Education, 7th Edition. 2003.

Course Objectives :

1. To provide the foundation level knowledge of Process Control.
2. To provide the basics for mathematical model of the process.
3. To provide the knowledge of various types of controller for single loop and multi-loop control system.
4. To provide the knowledge of advanced controllers used in process control.
5. Provide the knowledge of multivariable predictive control.

Course Learning Outcomes:

CO	After the completion of the course the student will be able to	Bloom's Cognitive	
		level	Descriptor
CO1	**Determine** the model of process by performing experiments on Process Control System.	2	Understanding
CO2	**Apply** the tuning techniques for various controllers.	3	Applying
CO3	**Evaluate** the performance of given Process Control system.	5	Evaluating
CO4	**Demonstrate** the use of advanced controllers.	3	Applying

CO-PO Mapping :

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

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
LA1	Lab activities, attendance, journal	Lab Course Faculty	During Week 1 to Week 4 Submission at the end of Week 5	25
LA2	Lab activities, attendance, journal	Lab Course Faculty	During Week 5 to Week 8 Submission at the end of Week 9	25
LA3	Lab activities, attendance, journal	Lab Course Faculty	During Week 10 to Week 14 Submission at the end of Week 14	25

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

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 **Course Code: 4CS511**	L	T	P	Cr
	3	--	--	3

Pre-Requisite Courses: Control System Engineering

Textbooks:

1. D.S.Naidu, 'Optimal Control Systems', CRC Press, 2002.

References:

1. Frank L Lewis, *"Optimal Control",* John Wiley, New York, 1986.
2. Kirk D.E*, "Optimal Control Theory*", Dover Publications, 2004.

Course Objectives :

1. This course provides the basic concepts of optimal control.
2. It provides the methodology of designing LQR and LQT optimal control.
3. It gives the overview of optimization in constrained and non-constrained controls.

Course Learning Outcomes:

CO	**After the completion of the course the student will be able to**	Bloom's Cognitive	
		level	Descriptor
CO1	**Apply** various concepts of optimal control.	3	Applying
CO2	**Analyze** the systems using LQR and LQT optimal control.	4	Analyzing
CO3	**Design** of optimal control in constrained and non-constrained systems.	6	Creating

CO-PO Mapping:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1			3			
CO2				2		
CO3						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
ISE 1	10
MSE	30
ISE 2	10
ESE	50

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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: Introduction to Optimal Control	Hrs.
Classical and Modern Control, Optimization, Optimal Control, Plant, Performance Index, Constraints, Calculus of Variations.	**6**
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 ,Lagrange Multiplier Method ,Extrema of Functionals with Conditions , Terminal Cost Problem.	**6**
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 Systems with State Constraints.	**6**
Module 6: Pontryagin Minimum Principle	**Hrs.**
Constrained System, Pontryagin Minimum Principle, The Hamilton-Jacobi-Bellman Equation, LQR System Using H-J-B Equation.	**6**

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 Control Course Code: 4CS512	L	T	P	Cr
	3	--	--	3

Pre-Requisite Courses: Control System

Textbooks:

1. P.Albertos, A.Sala, *"Multivariable Control",* springer Int. 2008.
2. Z. Bubnicki, *"Multivariable Control",* springer int. 2005.
3. B.wayne Beguetle, *"Modeling with Control",* PHI 2008.

References:

1. Gopal,' *Modern Control System -State variable analyses*, TMH Publications, 2010.

Course Objectives :

1. This course provides the basic concepts of Multivariable Control.
2. It provides the methodology of designing Multivariable Control.
3. It gives the overview of centralized Multivariable controllers.

Course Learning Outcomes:

CO	After the completion of the course the student will be able to	Bloom's Cognitive	
		level	Descriptor
CO1	**Interpret** the basic concepts of Multivariable Control.	3	Applying
CO2	**Analyze** the centralized, decentralized and decoupled control in multivariable control system	4	Analyzing
CO3	**Evaluate** algorithms for centralized, decentralized and decoupled control in multivariable control system.	5	Evaluating

CO-PO Mapping :

	PO1	PO2	PO3	PO4	PO5	PO6
CO1			3			
CO2				2		
CO3						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
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: Multivariable Control	Hrs.
Introduction, Process and Instrumentation, process variable, Behavior, control aims, modes of operation , Feedback need, Model based control, Modeling errors, multivariable systems ,implementation issue.	**6**
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, disturbance model, case study-paper machine head box.	**6**
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 column.	**6**
Module 4: Solution to control problem	**Hrs.**
Control system design problem, control goal, variable selection, control structure, feedback control, feed forward control, two degree of freedom controller, Hierarchical control, control design issue, case study – ceramic kiln.	**6**
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 Boiler, Mixing process.	**6**
Module 6: Centralized closed loop control	**Hrs.**
State feedback, output feedback, rejection of deterministic, unmeasurable disturbance, Augmented plant, process and disturbance models, case study –magnetic suspension.	**6**

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 Course Code: 4CS513	L	T	P	Cr
	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, classification of mechanical load torques, steady state stability of the drive, constant torque and constant HP operation of the drive, closed loop speed control.	**6**
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 of operation, chopper control of DC shunt motor drives, four quadrant operation of chopper fed DC shunt motor drive.	**6**
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, 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.	**6**
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 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.	**6**
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. Torque equation of IM in terms of stator and rotor flux, direct torque and flux control method (DTC) and self-commissioning of the drive.	**6**
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. Switched reluctance motor drives, torque equation, converter circuits, operating modes and applications. Solar panel VI characteristics, solar powered pump, maximum power point	**6**

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 Course: System Identification Course Code: 4CS515	L	T	P	Cr
	3	--	--	3

Pre-Requisite Courses: Engineering Mathematics

Textbooks:

1. Arun K Tangirala, "*Principles of System Identification Theory and Practice", CRC Press, 2015.*
2. Sodderstrom & Stoica, "*System Identification",PHI,1989*

References:

3. Ljung L, Glad T, "*Modeling of Dynamic Systems*", *PHI, 1994*

Course Objectives :

1. To make students familiar with estimation of parametric, non-parametric models and notions of model quality.
2. To develop skills in students for choosing model structures.
3. To make students develop transfer function and state space models.

Course Learning Outcomes:

CO	**After the completion of the course the student will be able to**	Bloom's Cognitive	
		level	Descriptor
CO1	**Explain** fundamental aspects of system identification.	2	Understanding
CO2	**Apply** system identification for predicting dynamic models.	3	Applying
CO3	**Analyze** models obtained from system identification.	4	Analyzing

CO-PO Mapping :teach

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1				2		
CO2						1
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.

Course Contents:

Module 1: LTI System:-	**Hrs.**
Introduction, Step-wise Procedure for Identification, Models and classification, Non-parametric, parametric models, state space descriptions, Sampled data systems.	**4**

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 representations.	**7**
Module 3: Estimation Theory	**Hrs.**
Introduction to Estimation, Properties of estimator, Estimation methods, Estimation of Signal Properties.	**7**
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 ahead prediction, Infinite-step ahead prediction.	**7**
Module 5: Input-Output Identification	**Hrs.**
Estimation of Time-Series Models, Estimation of Impulse/Step (Response) Models, Estimation of Frequency Response Functions, Estimation of Parametric Input-Output Models.	**7**
Module 6: Sub-space Identification	**Hrs.**
State Space model for identification, Kalman filter, Innovations form, Sub-space identification algorithm, Estimating grey-box models.	**7**

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.

Title of the Course: Advanced Digital Signal Processing **Course Code: 4CS516**	L	T	P	Cr
	3	--	--	3

Pre-Requisite Courses: Digital Signal Processing

Textbooks:

1. Sanjit Mitra, "Digital *Signal Processing* '' Tata McGraw Hill Publication, 3rd Edition, 2008.
2. Monson Hayes, *"Statiscal Signal Modeling''*, John Wiley 2002.
3. Rao & Gejji, "*Digital Signal processing''*, Pearson Education, 2ndEdition, 2008.

References:

1. Oppenheim Schafer, Ronald, "*Discrete Time Signal Processing*", Pearson Education, 2nd Edition, 1999.
2. Ifeachor, Jerris, Pearson Education, "*Discrete Signal Processing*", 2nd Edition, 2002.
3. Ashok Ambardar, "*Digital Signal Processing: A Modern Introduction*'', Thomson, 2007.

Course Objectives :

1. To develop skills for analyzing discrete time signals using transforms.
2. To make students familiar with methods of digital filters design.
3. To develop basic knowledge of random signal processing.

Course Learning Outcomes:

CO	**After the completion of the course the student will be able to**	Bloom's Cognitive	
		level	Descriptor
CO1	**Apply** transforms to discrete time signals for analysis.	3	Applying
CO2	**Analyze** the properties of discrete time systems and random signals processing.	4	Analyzing
CO3	**Evaluate** digital filters, structures and discrete time random signals.	5	Evaluating

CO-PO Mapping :

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1				2		
CO2				2		
CO3			1	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, 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: Discrete time signal and system	Hrs.
Classification of signals, operation on sequences, properties of systems, convolution sum, 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, block diagram representation, equivalent structures, fir and iir digital filter structures, all pass filters, lattice structures, all pass realization of iir transfer function.	8
Module 4: Digital Filter Design	**Hrs.**
Butter worth and chebyshev filters, IIR filter design, impulse invariant method, bilinear transformation, FIR filter design.	8
Module 5: Discrete Time Random Processes	**Hrs.**
Review of linear algebra, quadratic and hermitian form, random variables, random processes, 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 Course: Non-Linear Dynamical Systems Course Code: 4CS521	L	T	P	Cr
	3	--	--	3

Pre-Requisite Courses: Control System Engineering.

Textbooks:

1. H.K.Khalil. *Nonlinear systems* Prentice Hall, 3rd Edition 2002.
2. Jean-Jacques E.Slotine & Weiping Li. *Applied Nonlinear Control by* Prentice Hall, 1991.

References:

1. Shankar Sastry, *Nonlinear Systems: Analysis, Stability and Control*, Springer, New-York, 1999.
2. M. Vidyasagar, *Nonlinear Systems Analysis*, Prentice-Hall, 1993.

Course Objectives :

1. To make students familiar with features of nonlinear dynamical systems.
2. To develop skills in students for analyzing the behavior of nonlinear systems.
3. To develop skills in students for evaluating nonlinear system.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive	
		level	Descriptor
CO1	**Classify** features of nonlinear systems.	3	Applying
CO2	**Examine** behavior of nonlinear systems through various mathematical tools.	4	Analyzing
CO3	**Recommend** step by step approach for investigating the dynamics of nonlinear systems.	5	Evaluating

CO-PO Mapping :

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

Assessments :

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% 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 with 70-80% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Module 1: Nonlinear dynamical systems:-	**Hrs. 6**
Introduction, some features of nonlinear dynamical systems, first order systems, second order system, equilibrium points, classification of equilibrium points.	

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.
4. Analyze the theory of periodic obrits through various theorems.
5. Solve nonlinear system problem using interconnection between linear system and nonlinearities theory.
6. Apply Describing function method to nonlinear systems.

Title of the Course: PLC and Embedded Control Course Code: 4CS522	L	T	P	Cr
	3	--	--	3

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 course intends to exploit the PLC and Embedded Control for industrial automation
2. The course aims at developing programs using ladder logic for industrial automation
3. It intends to analyze the performance of automation systems employing PLC and Embedded Control

Course Learning Outcomes:

CO	**After the completion of the course the student should be able to**	Bloom's Cognitive	
		level	Descriptor
CO1	**Interpret** features of PLC and Embedded Control Systems used for Industrial Automation.	3	Applying
CO2	**Use** ladder logic programming technique for various PLC applications.	3	Applying
CO3	**Evaluate** the performance of PLC network configurations, PLC functions used for different application	5	Evaluating

CO-PO Mapping :

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

Assessments :

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% 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 with 70-80% weightage for course content (normally last three modules) covered 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, Power Supply for PLC	**6**
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 diagrams from process control description.	**6**
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 UP, DOWN counters, Case studies related to Industrial Automations	**6**
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, Programs related to Arithmetic, Comparison and Branch functions	**6**
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, typical PID functions	**6**
Module 6: PLC Networking	**Hrs.**
Networking of PLCs, Levels of Industrial Control, Types of Networking, Network Communications, Cell control by PLC Networks, Factors to consider in selecting a PLC	**6**

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 functions.
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 the Course: Non-linear Dynamical Systems Lab **Course Code: 4CS571**	L	T	P	Cr
	--	--	4	2

Pre-Requisite Courses: Control System Engineering

Textbooks:

1. Jean-Jacques E.Slotine & Weiping Li. *Applied Nonlinear Control by* Prentice Hall, 1991.

References:

1. H.K.Khalil Nonlinear *systems* 3rd Edition Prentice Hall, 2002.
2. Vukic, kuljaca, Donlagic, *Nonlinear control systems* by Marcel Dekker publisher, 2003

Course Objectives:

1. To make students simulate nonlinear system for analyzing its properties.
2. To develop skills in programming for determining stability of nonlinear system.
3. To make students understand the behavior of Periodic orbit through programming and simulation.

Course Learning Outcomes:

CO	**After the completion of the course the student will be able to**	Bloom's Cognitive	
		level	Descriptor
CO1	**Demonstrate** the properties of nonlinear systems using simulation.	3	Applying
CO2	**Analyze** the stability of nonlinear system using programming and simulation tools.	4	Analyzing
CO3	**Evaluate** the behavior of periodic orbit using programming and simulation tools.	5	Evaluating

CO-PO Mapping :

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

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
LA1	Lab activities, attendance, journal	Lab Course Faculty	During Week 1 to Week 4 Submission at the end of Week 5	25
LA2	Lab activities, attendance, journal	Lab Course Faculty	During Week 5 to Week 8 Submission at the end of Week 9	25
LA3	Lab activities, attendance, journal	Lab Course Faculty	During Week 10 to Week 14 Submission at the end of Week 14	25
Lab ESE	Lab Performance and related documentation	Lab Course faculty	During Week 15 to Week 18 Submission at the end of Week 18	25

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: (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	T	P	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 Learning Outcomes:

CO	**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-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
LA1	Lab activities, attendance, journal	Lab Course Faculty	During Week 1 to Week 4 Submission at the end of Week 5	25
LA2	Lab activities, attendance, journal	Lab Course Faculty	During Week 5 to Week 8 Submission at the end of Week 9	25
LA3	Lab activities, attendance, journal	Lab Course Faculty	During Week 10 to Week 14 Submission at the end of Week 14	25
Lab ESE	Lab Performance and related documentation	Lab Course faculty	During Week 15 to Week 18 Submission at the end of Week 18	25

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 the Course: Adaptive Control Course Code: 4CS531	L	T	P	Cr
	3	--	--	3

Pre-Requisite Courses: Applied Digital Control

Textbooks:

1. Kannan M. Moudgalya," Digital Control ", TMH publications, 2007.

References:

1. Astrom, Wittenmark," Adaptive Control ", Pearson Education, 1995.
2. Petros Ioannous, Jing Sun," Robust adaptive Control ", Prentice Hall Int. Ed., 1996.
3. B.N.Chatterji, K.K.Permar," System Identification ", Oxford and IBH publications, 1990.

Course Objectives :

1. This course provides the basic concepts of modern control techniques for controller design.
2. It provides the methodology of design control optimization in estimation for adaptive control.
3. It gives the overview of adaptive control design algorithms.

Course Learning Outcomes:

CO	After the completion of the course the student will be able to	Bloom's Cognitive	
		level	Descriptor
CO1	**Analyze** modern and adaptive control techniques for controller design.	4	Analyzing
CO2	**Evaluate** various adaptive control algorithms.	5	Evaluating
CO3	**Design** various adaptive controllers like MRAC, STR and LQG.	6	Creating

CO-PO Mapping :

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1				3		
CO2			2			
CO3				3		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
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: Identification	**Hrs.**
Introduction, least square estimation, time series, ARMA process, prediction and error models, statistical properties of parameter estimation, frequency domain interpretation, noise model,	**6**

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 low, generalized minimum variance controller, ARMAX and ARIMAX model, PID tuning through GMVC control.	**6**
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, dynamic matrix control.	**5**
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 adaptive control scheme.	**6**
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 control problem, relation between STR and MRAC system, stochastic, adaptive control system.	**6**
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 design, linear quadratic regulator, kalman filter design.	**7**

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.
3. Analyze control optimization in estimation for adaptive control.
4. Design adaptive control algorithms.
5. Design different model structures in adaptive controllers.
6. Design LQG controller.

Title of the Course: Real Time Control Applications Course Code: 4CS532	L	T	P	Cr
	3	--	--	3

Pre-Requisite Courses: Microcontroller and Applications, Digital Signal Processing

Textbooks:

1. Dingyu Xue, YangQuan Chen, *System Simulation Techniques with Matlab and Simulink*, Wiley Publications, Edition I, 2014
2. TI User Manuals TMS320C2x, TMS 28335

References:

1. Website www.ti.com and www.DSPguide.com.
2. Harold Klee, Randal Allen, *Simulation of Dynamic Systems with MATLAB® and Simulink®*, CRC Press, Third Edition, 2011.
3. Katalin Popovici, Pieter J. Mosterman, *Real-time Simulation Technologies: Principles, Methodologies, and Applications*,CRC Press, 2012.

Course Objectives :

1. The course intends to introduce Embedded Control for Control Applications
2. The course aims at developing programs using target Microcontrollers using Matlab and Simulink
3. It intends to analyze the performance of Electrical Systems using advanced techniques like Hardware in loop simulation, Processor-in-loop simulation, etc.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive	
		level	Descriptor
CO1	**Implement** programs to solve real time control problems in Electrical Engineering.	3	Applying
CO2	**Examine** the performance of real time control system for various applications.	5	Evaluating
CO3	**Perform** real time simulations and/or hardware-in-loop simulations using target hardware like Arduino, dSpace, TI boards etc.	6	Creating

CO-PO Mapping :

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

Assessments :

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% 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 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 Matlab functions, Execution time and profiles	**6**
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 Equations, Non-linear equation solution and optimization	**6**
Module 3: Modeling and Simulation of Engineering systems	**Hrs.**
Physical system modeling with Simscape, Description of SimPowerSystems, Modeling and simulation of Electronics circuits, simulation of motors and electric drive systems	**6**
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 Microcontrollers	**6**
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, Applications in Power Electronics and Control Systems	**6**
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, dSpace Control, Case studies	**6**

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 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 Course Code: 4CS535	L	T	P	Cr
	3	--	--	3

Pre-Requisite Courses: Engineering Mathematics

Textbooks:

1. M.T.Hagan, H.B.Demuth, M.H.Beale, "Neural Network Design", PWS Publications, 1996.
2. Timothy J. ross, *'Fuzzy Logic with Engineering Applications'*, Pearson Publications, 2010

References:

1. Driankov, *'Fuzzy Control,* Narosa Publications, 2000.
2. B.Yegnanarayana, "*Artificial Neural Networks"*, PHI Publications, 2008.
3. Simon Haykin," *Neural Networks and Learning Machines*", Pearson-PHI publications, 2009.

Course Objectives :

1. This course provides the basic concepts of Neural Networks and Fuzzy Control
2. It provides the methodology of design Neural Networks and Fuzzy control.
3. It gives the overview of genetic algorithms and applications development.

Course Learning Outcomes:

CO	After the completion of the course the student will be able to	Bloom's Cognitive	
		level	Descriptor
CO1	**Explain** Neural Networks and Fuzzy Control.	2	Understanding
CO2	**Apply** genetic algorithms and optimization in NN, fuzzy applications development.	3	Applying
CO3	**Analyze** Neural Networks and Fuzzy Controller algorithms.	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, 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: 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 Course Code: 4CS536	L	T	P	Cr
	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:

CO	**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∞-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, 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 transformations.	**6**
Module 2: Stabilizing Controllers	**Hrs.**
Internal stability, stabilizing controllers, Stabilizing Controllers - State-Space Descriptions, stability analysis in frequency domain, system norms	**6**
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.	**6**
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 iteration.	**6**
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 unstable models.	**6**

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*∞-Control.
6. Analyze robust performance.

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