ANNA UNIVERSITY, CHENNAI

UNIVERSITY DEPARTMENTS

REGULATIONS – 2015

CHOICE BASED CREDIT SYSTEM

M.E CONTROL AND INSTRUMENTATION ENGINEERING

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs) :

I. To prepare students, for having career in teaching Institutions/research organizations/industries that meet, the needs of, national and international interest

II. To develop among students, the ability to analyze systems, develop controllers and work with automation systems

III. To prepare students, to work in interdisciplinary groups

IV. To provide students, good foundation in mathematical, scientific and engineering fundamentals

V. To promote student awareness, for life-long learning and introduce them to professional ethics and code of practice

PROGRAMME OUTCOMES (POs):

On successful completion of the programme,

1. Ability to solve linear algebraic and differential equations, determine optimal solutions, apply statistical techniques
2. Ability to analyze and interpret linear and non-linear systems
3. Ability to design controllers to meet the given specification for linear single and multiple input-output systems
4. Ability to review, prepare and present technical developments
5. Ability to work on professional software packages for system analysis and design problems
6. Ability to develop software packages for design problems in well-known professional platforms
7. Ability to analyze and design control and instrumentation hardware
8. Ability to reproduce scientific principle of transducers and their principles
9. Ability to design and conduct experiments on control system design and automation
10. Ability to provide a comprehensive solution for, a research or an industrial problem or develop an innovative/ indigenous/ usable product of societal interest

Program Educational Objective	Program Outcome									
	a	b	C	d	e	f	g	h	i	j
1	✓	✓	✓	✓	✓		✓	✓	✓	✓
2		✓	✓	✓	✓		✓		✓	✓
3				✓	✓	✓			✓	✓
4	✓			✓				✓		✓
5				✓	✓	✓				✓

			PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
YEAR 1	**SEM 1**	Applied Mathematics for EE	✓									
		Control System Design	✓	✓	✓		✓		✓			
		Soft Computing Techniques	✓			✓		✓	✓	✓		
		Transducers and Measurements	✓		✓	✓	✓	✓	✓	✓	✓	✓
		Elective I										
		Elective II										
	SEM 2	Industrial Process Automation				✓	✓	✓	✓	✓	✓	✓
		Dynamics and Control of Industrial Process			✓	✓						
		Non- linear control	✓	✓	✓		✓			✓		
		Virtual Instrumentation Lab					✓	✓			✓	
		Elective III										
		Elective IV										
		Control System Design Lab		✓		✓	✓	✓			✓	
YEAR 2	**SEM 3**	Elective V										
		Elective VI										
		Project Work Phase I	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	SEM 4	Project Work Phase II	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

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REGULATIONS – 2015
CHOICE BASED CREDIT SYSTEM
M.E. CONTROL AND INSTRUMENTATION ENGINEERING

CURRICULA AND SYLLABI I TO IV SEMESTERS
SEMESTER - I

S.NO	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	MA7156	Applied Mathematics for Electrical Engineers	FC	4	4	0	0	4
2.	CO7101	Transducers and Measurements	PC	4	4	0	0	4
3.	CO7151	Control System Design	PC	4	4	0	0	4
4.	CO7152	Soft Computing Techniques	PC	3	3	0	0	3
5.		Elective I	PE	3	3	0	0	3
PRACTICALS								
6.	CO7111	Control System Design Lab	PC	4	0	0	4	2
7.	CO7112	Soft Computing Techniques Lab	PC	2	0	0	2	1
			TOTAL	**24**	**18**	**0**	**6**	**21**

SEMESTER - II

S.NO	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	CO7201	Dynamics and Control of Industrial Process	PC	4	4	0	0	4
2.	CO7202	Industrial Process Automation	PC	4	4	0	0	4
3.	CO7251	Non Linear Control	PC	3	3	0	0	3
4.		Elective II	PE	3	3	0	0	3
5.		Elective III	PE	3	3	0	0	3
PRACTICALS								
6.	CO7211	Non Linear Control Lab	PC	2	0	0	2	1
7.	CO7212	Virtual Instrumentation Lab	PC	4	0	0	4	2
			TOTAL	**23**	**17**	**0**	**6**	**20**

SEMESTER - III

S.NO	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.		Elective IV	PE	3	3	0	0	3
2.		Elective V	PE	3	3	0	0	3
3.		Elective VI	PE	3	3	0	0	3
PRACTICALS								
4.	CO7311	Project Work Phase I	EEC	12	0	0	12	6
			TOTAL	**21**	**9**	**0**	**12**	**15**

SEMESTER - IV

SI. NO	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
PRACTICALS								
1.	CO7411	Project Work Phase II	EEC	24	0	0	24	12
			TOTAL	**24**	**0**	**0**	**24**	**12**

TOTAL NO. OF CREDITS: 68

FOUNDATION COURSES (FC)

S.No	Course Code	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.		Applied Mathematics for Electrical Engineers	FC	4	4	0	0	4

PROFESSIONAL CORE (PC)

S.No	Course Code	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.		Control System Design	PC	4	4	0	0	4
2.		Non Linear control	PC	3	3	0	0	3
3.		Dynamics and Control of Industrial Process	PC	4	4	0	0	4
4.		Industrial Process Automation	PC	4	4	0	0	4
5.		Transducers and Measurements	PC	4	4	0	0	4
6.		Soft Computing Techniques	PC	3	3	0	0	3
7.		Control System Design Lab	PC	4	0	0	4	2
8.		Virtual Instrumentation Lab	PC	4	0	0	4	2
9.		Soft Computing Techniques Lab	PC	2	0	0	2	1
10.		Non Linear Control Lab	PC	2	0	0	2	1

PROFESSIONAL ELECTIVES (PE)

S.No	Course Code	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	CO7001	Advanced Non linear Control	PE	3	3	0	0	3
2.	CO7002	Optimal Control and Filtering	PE	3	3	0	0	3
3.	CO7071	Control of Electrical Drives	PE	3	3	0	0	3
4.	CO7072	Multi Sensor Data Fusion	PE	3	3	0	0	3
5.	CO7073	Robotics and Control	PE	3	3	0	0	3
6.	CO7074	Robust Control	PE	3	3	0	0	3
7.	CO7075	System Identification and Adaptive Control	PE	3	3	0	0	3
8.	CO7076	System Theory	PE	3	3	0	0	3
9.	HV7071	Applications of High Electric Fields	PE	3	3	0	0	3
10.	HV7072	Design of Substations	PE	3	3	0	0	3
11.	HV7073	Electromagnetic Interference and Compatibility	PE	3	3	0	0	3
12.	PE7072	Power Electronics for Renewable Energy Systems	PE	3	3	0	0	3
13.	PE7151	Analysis and Design of Power Converters	PE	4	4	0	0	4
14.	PE7152	Analysis of Electrical Machines	PE	3	3	0	0	3
15.	PE7253	Solid State DC Drives	PE	3	3	0	0	3
16.	PE7351	Special Electrical Machines	PE	3	3	0	0	3

17.	PS7073	Optimisation Techniques	PE	3	3	0	0	3
18.	PS7074	Solar and Energy Storage System	PE	3	3	0	0	3
19.	PS7255	Smart Grids	PE	3	3	0	0	3
20.	ET7071	Advanced Digital Signal Processing	PE	3	3	0	0	3
21.	ET7073	Digital Instrumentation	PE	3	3	0	0	3
22.	ET7074	MEMS Technology	PE	3	3	0	0	3
23.	ET7075	VLSI Based Design Methodologies	PE	3	3	0	0	3
24.	ET7151	Advanced Digital Principles and Design	PE	4	4	0	0	4
25.	ET7152	Microcontroller Based System Design	PE	4	4	0	0	4
26.	ET7251	Real Time Operating System	PE	3	3	0	0	3
27.	ET7252	Software for Embedded Systems	PE	4	4	0	0	4
28.	PW7251	SCADA System and Applications Management	PE	3	3	0	0	3

EMPLOYABILITY ENHANCEMENT COURSES (EEC)

S.NO	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.		Project Phase I	EEC	12	0	0	12	6
2.		Project Phase II	EEC	24	0	0	24	12

MA7156 APPLIED MATHEMATICS FOR ELECTRICAL ENGINEERS **LT P C**
4 0 0 4

OBJECTIVES:

- To develop the ability to apply the concepts of Matrix theory and Linear programming in Electrical Engineering problems.
- To achieve an understanding of the basic concepts of one dimensional random variables and apply in electrical engineering problems.
- To familiarize the students in calculus of variations and solve problems using Fourier transforms associated with engineering applications..

UNIT I MATRIX THEORY **12**
The Cholesky decomposition - Generalized Eigen vectors, Canonical basis - QR factorization - Least squares method - Singular value decomposition

UNIT II CALCULUS OF VARIATIONS **12**
Concept of variation and its properties – Euler's equation – Functional dependant on first and higher order derivatives – Functionals dependant on functions of several independent variables – Variational problems with moving boundaries – problems with constraints - Direct methods: Ritz and Kantorovich methods

UNIT III ONE DIMENSIONAL RANDOM VARIABLES **12**
Random variables - Probability function – moments – moment generating functions and their properties – Binomial, Poisson, Geometric, Uniform, Exponential, Gamma and Normal distributions – Function of a Random Variable

UNIT IV LINEAR PROGRAMMING **12**
Formulation – Graphical solution – Simplex method – Two phase method - Transportation and Assignment Models

UNIT V FOURIER SERIES **12**
Fourier Trigonometric series: Periodic function as power signals – Convergence of series – Even and odd function: cosine and sine series – Non-periodic function: Extension to other intervals - Power signals: Exponential Fourier series – Parseval's theorem and power spectrum – Eigen value problems and orthogonal functions – Regular Sturm-Liouville systems – Generalized Fourier series

TOTAL: 60 PERIODS

BOOKS FOR STUDY:

1. Richard Bronson, "Matrix Operation", Schaum's outline series, 2nd Edition, McGraw Hill, 2011.
2. Gupta, A.S., Calculus of Variations with Applications, Prentice Hall of India Pvt. Ltd., New Delhi, 1997.
3. Oliver C. Ibe, "Fundamentals of Applied Probability and Random Processes, Academic Press, (An imprint of Elsevier), 2010.
4. Taha, H.A., "Operations Research, An introduction", 10th edition, Pearson education, New Delhi, 2010.

5. Andrews L.C. and Phillips R.L., Mathematical Techniques for Engineers and Scientists, Prentice Hall of India Pvt.Ltd., New Delhi, 2005.

REFERENCES

1. Elsgolts, L., Differential Equations and the Calculus of Variations, MIR Publishers, Moscow, 1973.
2. Grewal, B.S., Higher Engineering Mathematics, 42nd edition, Khanna Publishers, 2012.
3. O'Neil, P.V., Advanced Engineering Mathematics, Thomson Asia Pvt. Ltd., Singapore, 2003.
4. Johnson R. A. and Gupta C. B., "Miller & Freund's Probability and Statistics for Engineers", Pearson Education, Asia, 7th Edition, 2007.

CO7101 TRANSDUCERS AND MEASUREMENTS **L T P C**
4 0 0 4

COURSE OBJECTIVES

- To introduce the resistive and capacitive transducers and their transduction principles.
- To educate on Inductive and Resonant elements.
- Study of level and flow metering elements , their working principle.
- To introduce various optical sensors, their transduction principles and their applications.
- To introduce various advanced and miniature sensors and their applications.

UNIT I RESISTIVE AND CAPACITIVE ELEMENTS 12

Potentiometric, strain-gage and electrode elements – Resistive and Capacitive elements: structures, equivalent circuits and characteristics, single, differential and angle displacement elements, displacement to phase converters, and proximity elements, magnetostrictive elements, temperature instabilities and features.

UNIT II INDUCTIVE AND RESONANT ELEMENTS 12

Transformer elements: Single core, differential, rotating coil and synchro transformers, weak-field sensors - Electrodynamic elements: Moving-coil, variable-reluctance- single, differential and angle displacement elements - Resonant elements: vibrating strings, vibrating beams, vibrating cylinders, piezoelectric resonators, acoustical resonators, microwave cavity resonators.

UNIT III INDUSTRIAL METERING ELEMENTS 12

Dynamic characteristics of diaphragm, temperature drifts, Sensitivity drifts– Inertial mass elements: sensing and transduction elements of flowmeters electromagnetic flow meters, electromagnetic flow meters, sensing and transduction elements of levelmeter, Float type levelmeters, Electrical levelmeter -ultrasonic elements – Acoustical elements: acoustical filters.

UNIT IV OPTICAL SENSORS AND MICROSTRUCTURE DETECTORS 12

Photo detectors: Thermal detectors, pneumatic detectors, pyroelectric detectors, photoemissive devices, photo conductive detectors, photo diodes, avalanche photo diodes, schottky photo diodes, photo transistors – Fiber optic sensors: Fibers as light guides, reflection sensors, Intrinsic multimode sensor, temperature sensor, phase modulated sensor, fiber optic gyroscopes and other fiber sensors.

UNIT V MINIATURE SENSORS 12

Magnetic sensors: Hall Effect sensors, magnetoresistors – Piezoelectric sensors- Solid state chemical sensors: Silicon based sensors, metal oxide sensors, solid electrolyte sensors, membranes – Electromechanical micro sensors and basic factors of design.

TOTAL : 60 PERIODS

COURSE OUTCOME

- Ability to understand the basic principle of resistive and capacitive transducer.
- Ability to acquire a comprehensive knowledge on Inductive and Resonant Elements.
- Ability to understand the basic principle of level and flow metering elements.
- Students will be able to characterize the optical sensor and their transduction principle.
- Ability to acquire knowledge on latest sensor technology and advanced measurement Methodologies.

REFERENCES:

1. Alexander D Khazan, “Transducers and their elements – Design and application”, PTR Prentice Hall, 1994.
2. Ernest Doeblin,’ Measurement Systems: Application and Design,” Mc Graw-Hill, 2003.
3. Pavel Ripka and Alois Tipek,“Modern sensors hand book”, Instrumentation and measurement series, ISTE Ltd., 2007.
4. David Fraden. , PHI, 2004 “ Hand book of Modern Sensors, Physics, Design and Applications”, Third Edition, Springer India Pvt.Ltd, 2006.

CO7151 CONTROL SYSTEM DESIGN LT P C
4 0 0 4

COURSE OBJECTIVES

- To impart knowledge on continuous system and discrete system and effect of sampling.
- To impart knowledge on design of controllers using root-locus and frequency domain techniques.
- To educate on concept of state space and design of controllers and observers.
- To introduce the techniques of extending the theory on continuous systems to discrete time systems.
- To introduce the linear quadratic regulator and estimation in the presence of Noise.

UNIT I CONTINUOUS AND DISCRETE SYSTEMS 12

Review of continuous systems- Need for discretization-comparison between discrete and analog system. Sample and Hold devices - Effect of sampling on transfer function and state models-Analysis.

UNIT II ROOT LOCUS DESIGN 12

Design specifications-In Continuous domain - Limitations- Controller structure- Multiple degrees of freedom- PID controllers and Lag-lead compensators- Root locus design-Discretization & Direct discrete design.

UNIT III DESIGN IN FREQUENCY RESPONSE BASED DESIGN 12

Lag-lead compensators – Design using Bode plots- use of Nichole's chart and Routh-hurwitz Criterion-Jury's stability test- Digital design.

UNIT IV STATE VARIABLE DESIGN 12

Pole Assignment Design- state and output feedback-observers - Estimated state feedback - Design examples (continuous & Discrete).

UNIT V LQR AND LQG DESIGN 12

Formulation of LQR problem- Pontryagin's minimum principle and Hamiltonian solutions-Ricatti's equation – Optimal estimation- Kalman filter –solution to continuous and discrete systems - Design examples.

TOTAL: 60 PERIODS

COURSE OUTCOME

- Ability to understand the specification, limitation and structure of controllers.
- Ability to design a controller using Root-locus and Frequency Domain technique.
- Acquire knowledge on state space and ability to design a controller and observer.
- Ability to design LQR and LQG for a system.

REFERENCES

1. G. F. Franklin, J. D. Powell and M Workman, "Digital Control of Dynamic Systems", PHI (Pearson), 2002.
2. Graham C. Goodwin, Stefan F. Graebe and Mario E. Salgado "Control system Design", PHI (Pearson), 2003.
3. M.Gopal "Digital Control and State variable methods" Mc graw hill 4^{th} edition, 2012.
4. Benjamin C. Kuo "Digital control systems", Oxford University Press, 2004
5. M. Gopal "Modern control system Theory" New Age International, 2005.
6. J.J. D'Azzo, C.H. Houpis and s.N Sheldon,'Linear Control system analysis and design with MATLAB,' Taylor and Francis,2009.

CO7152 SOFT COMPUTING TECHNIQUES LT P C

3 0 0 3

COURSE OBJECTIVES

- To review the fundamentals of ANN and fuzzy set theory.
- To make the students understand the use of ANN for modeling and control of non-linear system and to get familiarized with the ANN tool box.
- To impart knowledge of using Fuzzy logic for modeling and control of non-linear systems and get familiarized with the FLC tool box.
- To make the students to understand the use of optimization techniques.
- To familiarize the students on various hybrid control schemes, P.S.O and get familiarized with the ANFIS tool box.

UNIT I OVERVIEW OF ARTIFICIAL NEURAL NETWORK (ANN) & FUZZY LOGIC 9

Review of fundamentals - Biological neuron, Artificial neuron, Activation function, Single Layer Perceptron – Limitations – Multi Layer Perceptron – Back propagation algorithm (BPA); Fuzzy set theory – Fuzzy sets – Operation on Fuzzy sets - Scalar cardinality, fuzzy cardinality, union and intersection, complement (yager and sugeno), equilibrium points, aggregation, projection, composition, fuzzy relation – Fuzzy membership functions.

UNIT II NEURAL NETWORKS FOR MODELLING AND CONTROL 9

Generation of training data - optimal architecture – Model validation- Control of non linear system using ANN- Direct and Indirect neuro control schemes- Adaptive neuro controller – Case study - Familiarization of Neural Network Control Tool Box.

UNIT III FUZZY LOGIC FOR MODELLING AND CONTROL 9

Modeling of non linear systems using fuzzy models(Mamdani and Sugeno) –TSK model - Fuzzy Logic controller – Fuzzification – Knowledge base – Decision making logic – Defuzzification-Adaptive fuzzy systems- Case study - Familiarization of Fuzzy Logic Tool Box.

UNIT IV GENETIC ALGORITHM 9

Basic concept of Genetic algorithm and detail algorithmic steps, adjustment of free parameters. Solution of typical control problems using genetic algorithm. Concept on some other search techniques like Tabu search, Ant-colony search and Particle Swarm Optimization.

UNIT V HYBRID CONTROL SCHEMES 9

Fuzzification and rule base using ANN–Neuro fuzzy systems-ANFIS –Optimization of membership function and rule base using Genetic Algorithm and Particle Swarm Optimization - Case study– Familiarization of ANFIS Tool Box.

TOTAL : 45 PERIODS

COURSE OUTCOME

Students,

- Will be able to know the basic ANN architectures, algorithms and their limitations.
- Also will be able to know the different operations on the fuzzy sets.
- Will be capable of developing ANN based models and control schemes for non-linear system.
- Will get expertise in the use of different ANN structures and online training algorithm.
- Will be knowledgeable to use Fuzzy logic for modeling and control of non-linear systems.

- Will be competent to use hybrid control schemes and P.S.O.

REFERENCES

1. Laurene V.Fausett, “Fundamentals of Neural Networks, Architecture, Algorithms, and Applications”, Pearson Education, 2008.
2. Timothy J.Ross, “Fuzzy Logic with Engineering Applications”, Wiley, Third Edition, 2010.
3. David E.Goldberg, “Genetic Algorithms in Search, Optimization, and Machine Learning”, Pearson Education, 2009.
4. W.T.Miller, R.S.Sutton and P.J.Webrose, “Neural Networks for Control”, MIT Press, 1996.
5. George J.Klir and Bo Yuan, “Fuzzy Sets and Fuzzy Logic: Theory and Applications”, Prentice Hall, First Edition, 1995.
6. N.P Padhy, S.P. Simon “Soft Computing With MATLAB Programming”,OXFORD print Feburary 2015.

CO7111 CONTROL SYSTEM DESIGN LAB

L T P C
0 0 4 2

COURSE OBJECTIVE

- To train the students to develop algorithm and learn complete analysis and design of control system.

PRACTICALS

1. Simulation and analysis of transfer function models and obtain time and frequency response.
2. Simulation and analysis of state space models for linear continuous and discrete time systems and obtain the time response.
3. Mathematical modeling and simulation of a physical system like Electrical, mechanical or chemical process.
4. Design and performance analysis of PID controlled physical systems using Root-locus technique.
5. Design and performance analysis of PID controlled physical systems using Bode plots.
6. Design and performance analysis of PID controlled physical systems using Zeigler Nichols approach.
7. Design and performance analysis of Lag-lead compensator controlled physical systems using Bode plots.
8. Solution of Ricatti’s equation in continuous and discrete domain.
9. Design and performance analysis of state and output feedback control of physical systems.
10. Design and performance analysis of estimator and estimated feedback control of physical systems.
11. Design and performance analysis of optimal control of physical systems.
12. Design and performance analysis of optimal estimation and control of physical systems.

TOTAL : 60 PERIODS

COURSE OUTCOME

- Ability to understand and use special software package used for control system.
- Good application knowledge of control theory.

CO7112 SOFT COMPUTING TECHNIQUES LAB LT P C
0 0 2 1

COURSE OBJECTIVES
- To familiarize the students with optimization techniques and Intelligent Controllers.
- To Implement different algorithms and Intelligent Controllers for various Process.
- To analyse the system performances for different controllers.

PRACTICALS
1. To implement adaline and madaline with bipolar inputs and outputs using NN toolbox.
2. To implement back propagation for a given input pattern using NN toolbox.
3. To implement discrete hopfield network and test for given input pattern using NN toolbox.
4. To implement fuzzy set operation and properties using FUZZY toolbox.
5. To perform max-min composition of two matrices obtained from Cartesian product using ‘m file’ in MATLAB.
6. Write a program to verify the various laws associated with fuzzy set using FUZZY toolbox.
7. Write a matlab program for maximizing f(x) =x^2 using GA, where x is ranges from 0 to 31 (Perform only 5 iterations). Find the function and ‘x’ value.
8. Design FLC for a FOPDT process using FUZZY toolbox.
9. Design a Neuro model for an inverted pendulum using NN toolbox.
10. Design Fuzzy model for an inverted pendulum using FUZZY toolbox.

TOTAL: 30 PERIODS

COURSE OUTCOME
- Ability to understand and use NN & FUZZY tool box using Software Packages.
- Ability to acquire knowledge on Identification of system & to work on simple application using MATLAB software.

CO7201 DYNAMICS AND CONTROL OF INDUSTRIAL PROCESS LT P C
4 0 0 4

COURSE OBJECTIVES
- To give an overview of the features associated with Industrial Type PID Controller such as reset windup, bumpless auto-manual transfer, proportional kick and derivative kick.
- To make the students understand the various PID tuning methods.

- To elaborate different types of control schemes such as cascade control, feed-forward control etc.
- To educate on multivariable systems and multi loop control To educate on various industrial processes.

UNIT I PROCESS DYNAMICS & CONTROL 12

Need for process control – Hierarchical decomposition of Control Functions - Continuous and batch processes – P&ID diagram - Self regulation - Interacting and non-interacting systems - Mathematical model of Level, Flow and Thermal processes – Lumped and Distributed parameter models – Linearization of nonlinear systems - Characteristic of ON-OFF, P, P+I, P+D and P+I+D control modes – Digital PID algorithm – Auto/manual transfer - Reset windup – Practical forms of PID Controller.

UNIT II PID CONTROLLER TUNING – SINGLE LOOP REGULATORY CONTROL 12

Evaluation criteria – IAE, ISE, ITAE and ¼ decay ratio – Tuning - Process reaction curve method- Z-N and Cohen-Coon methods, Continuous cycling method and Damped oscillation method – optimization methods – Auto tuning.

UNIT III ENHANCEMENT TO SINGLE LOOP REGULATORY CONTROL & MODEL BASED CONTROL SCHEMES 12

Cascade control – Split-range - Feed-forward control – Ratio control – Inferential control – override control - Smith predictor control scheme - Internal Model Controller - IMC PID controller– Single Loop Dynamic Matrix Control – Generalized Predictive Control.

UNIT IV MULTIVARIABLE SYSTEMS & MULTI-LOOP REGULATORY CONTROL 12

Multivariable Systems – Transfer Matrix Representation – Poles and Zeros of MIMO System - - Multi-loop Control - Introduction – Process Interaction – Pairing of Inputs and Outputs -The Relative Gain Array (RGA) – Properties and Application of RGA - Multi-loop PID Controller - Decoupling Control.

UNIT V CASE STUDIES 12

Introduction to Multivariable control – Multivariable PID Controller –Predictive PID Control - Control Schemes for Distillation Column, CSTR, Four-tank system and pH .

TOTAL: 60 PERIODS

COURSE OUTCOME

- Ability to Apply knowledge of mathematics, science, and engineering to the build and analyze models for flow, level, and thermal processes.
- Ability to determine the advanced Features supported by the Industrial Type PID Controller.
- Ability to Design, tune and implement SISO P/PI/PID Controllers to achieve desired Performance for various processes.
- Ability to Analyze Multivariable Systems and Design Multi-variable and Multi-loop Control Schemes for various processes namely four-tank system, pH process, bio-reactor,distillation column.
- Ability to Identify, formulate, and solve problems in the process control domain.

REFERENCES

1 B.Wayne Bequette, “Process Control: Modeling, Design, and Simulation”, Prentice Hall of India, 2004.
2 George Stephanopolus, "Chemical Process Control", Prentice Hall India, 2006

3 Chidambarm. M, " Computer control of processes", Narosa Publications, Reprint 2006.chennai.
4 Dale E. Seborg , Duncan A. Mellichamp , Thomas F. Edgar, and Francis J. Doyle, III "Process Dynamics and Control", John Wiley and Sons, 3rd Edition, 2010.
5 Jose A. Romagnoli and Ahmet Palazoglu , "Introduction to Process Control", CRC Press, Taylor and Francis Group, Second Edition, First Indian Reprint, 2010.
6 Coleman Brosilow and Babu Joseph, "Techniques of Model-based Control", Prentice Hall International Series, PTR, New Jersey, 2001.

CO7202 INDUSTRIAL PROCESS AUTOMATION LT P C
4 0 0 4

COURSE OBJECTIVES

- To educate on design of signal conditioning circuits for various applications
- To Introduce signal transmission techniques and their design
- Study of components used in data acquisition systems interface techniques
- To educate on the components used in distributed control systems
- To introduce the communication buses used in automation industries.

UNIT I DESIGN OF SIGNAL CONDITIONING AND TRANSMISSION 12
Design of V/I Converter and I/V Converter- Analog and Digital filter design and Adaptive filter design – Signal conditioning circuit for pH measurement, Level Measurement – Temperature measurement: Thermocouple, RTD and Thermistor - Cold Junction Compensation and Linearization – software and Hardware approaches **-** Electrical, Pneumatic and fibre optic transmissions-Digital transmission protocols-Study of 2 wire and 4 wire transmitters – Design of RTD based Temperature Transmitter, Thermocouple based Temperature Transmitter, Capacitance based Level Transmitter and Smart Flow Transmitters-smart sensors

UNIT II DATA ACQUISITION AND INSTRUMENT INTERFACE 12
Programming and simulation of Building block of instrument Automation system – Signal analysis, Design of Interfacing circuit and DAQ, I/O port configuration with instrument bus protocols - ADC, DAC, DIO, counters & timers, PC hardware structure, timing, interrupts, DMA, software and hardware installation, current loop, RS 232/RS485, GPIB, USB protocols,

UNIT III PLC AND SCADA 12
Evolution of PLC – Sequential and Programmable controllers – Architecture – Programming of PLC – Relay logic and Ladder logic – Functional blocks – Communication Networks for PLC. PLC based control of processes – Computer control of liquid level system – heat exchanger – Smart sensors and Field bus.SCADA:- Remote terminal units, Master station, Communication architectures and Open SCADA protocols.

UNIT IV DISTRIBUTED CONTROL SYSTEM 12
P&I diagram of typical process plants Evolution - Different architectures – Local Control unit - Operator Interface – Displays - Engineering interface - Study of any one DCS available in market - Factors to be considered in selecting DCS .

UNIT V COMMUNICATION PROTOCOLS 12

Introduction-Evolution of signal standard– HART communication protocol – Communication modes – Networks – commands – applications OSI models- Fieldbus:- architecture, standard, Fieldbus topology, Interoperability and Interchangeability Profibus:- Introduction, protocol stack, communication model, Communication objects,– Foundation fieldbus & Profibus.- Comparison of CANBUS,LINBUS,MODBUS,INDUSTRIAL ETHERNET.

TOTAL: 60 PERIODS

COURSE OUTCOME

- Ability to design a signal conditioning circuits for various application
- Ability to acquire a detail knowledge on data acquisition system interface and DSC system
- Students will be able to understand the basics and Importance of of communication buses in applied automation Engineering.

REFERENCES

1. Handbook on "Practical Design Techniques for Sensor signal Conditioning" published by Analog Devices, Vernvice hall.
2. David Bailey & Edwin Wright, "Practical SCADA for Idustry'', Elsevier 2010.
3. Alan S Morris "Measurement and Instrumentation Principles", Elsevier, 2006.
4. C.J. Chesmond, P.A. Wilson & M.R.Le pla "Advanced Control System Technology" viva books Private Limited, 1998 .
5. Patrick H.Garrett "High Performance Instrumentation And Automation" CRC Press, Taylor & Francis Group, 2005.

CO7251 NON LINEAR CONTROL LT P C
3 0 0 3

COURSE OBJECTIVES

- To impart knowledge on phase plane analysis of non-linear systems.
- To impart knowledge on Describing function based approach to non-linear systems.
- To educate on stability analysis of systems using Lyapunov's theory.
- To educate on stability analysis of systems using Lyapunov's theory. To introduce the concept of sliding mode control.

UNIT I PHASE PLANE ANALYSIS 9

Concepts of phase plane analysis- Phase portraits- singular points- Symmetry in phase plane portraits-Constructing Phase Portraits- Phase plane Analysis of Linear and Nonlinear Systems-Existence of Limit Cycles. simulation of phase portraits in matlab.

UNIT II DESCRIBING FUNCTION 9

Describing Function Fundamentals-Definitions-Assumptions-Computing Describing Functions-Common Nonlinearities and its Describing Functions-Nyquist Criterion and its Extension-Existence of Limit Cycles-Stability of limit Cycles. simulation of limit cycles in matlab.

UNIT III LYAPUNOV THEORY 9

Nonlinear Systems and Equilibrium Points-Concepts of Stability-Linearization and Local Stability-Lyapunov's Direct Method-Positive definite Functions and Lyapunov Functions-Equilibrium Point Theorems-Invariant Set Theorems-LTI System Analysis based on Lyapunov's Direct Method-Krasovski's Method-Variable Gradient Method-Physically – Control Design based on Lyapunov's Direct Method.

UNIT IV FEEDBACK LINEARIZATION 9

Feedback Linearization and the Canonical Form-Mathematical Tools-Input-State Linearization of SISO Systems- input-Output Linearization of SISO Systems-Generating a Linear Input-Output Relation-Normal Forms-The Zero-Dynamics-Stabilization and Tracking-Inverse Dynamics and Non-Minimum-Phase Systems-Feedback Linearization of MIMO Systems Zero-Dynamics and Control Design. Simulation of tracking problems in matlab.

UNIT V SLIDING MODE CONTROL 9

Sliding Surfaces- Continuous approximations of Switching Control laws-The Modeling/Performance Trade-Offs- MIMO Systems. simulation of sliding mode controller in matlab.

TOTAL : 45 PERIODS

COURSE OUTCOME

- Ability to represent the time-invariant systems in state space form as well as analyze,
- whether the system is stabilizable, controllable, observable and detectable.
- Ability to design state feedback controller and state observers
- Ability to classify singular points and construct phase trajectory using delta and isocline methods.
- Use the techniques such as describing function, Lyapunov Stability, Popov's Stability
- Ability to design a sliding mode controller for a MIMO process and to identify the trade off.

REFERENCES

1. J A E Slotine and W Li, Applied Nonlinear control, PHI, 1991.
2. K. P. Mohandas, Modern Control Engineering, Sanguine, India, 2006
3. Hasan Khalil, "Nonlinear systems and control", Prentice Hall.
4. S H Zak, "Systems and control", Oxford University Press, 2003.
5. Torkel Glad and Lennart Ljung, "Control Theory – Multivariable and Nonlinear Methods", Taylor & Francis, 2002.
6. G. J. Thaler, "Automatic control systems", Jaico publishers, 2006.

CO7211 **NON LINEAR CONTROL LAB** **L T P C**

0 0 2 1

COURSE OBJECTIVES

- To train the students to develop software modules to analyse and design Non-Linear Controllers for some physical system.

PRACTICALS

1. Development of state trajectories and phase portraits.
2. Development of algorithms to construct Describing functions.
3. Performance analysis of non-linear systems using Describing function approach.
4. Simulation and performance evaluation using Input-Output Linearization.
5. Simulation and performance evaluation using Feedback Linearization.
6. Design and performance evaluation of sliding mode controllers.
7. Design of controllers for MIMO systems.
8. Design of controllers for chemical process loops.
9. Design of controllers for power converters.
10. Design of controllers for electro-mechanical systems.

TOTAL : 30 PERIODS

COURSE OUTCOME

- Good knowledge in application of Non-Linear Controller for practical systems.
- Ability to develop software modules for analysis and design of Non-Linear Control systems.

CO7212 **VIRTUAL INSTRUMENTATION LAB** **L T P C**
0 0 4 2

COURSE OBJECTIVE

- To train the students to develop applications using Virtual Instrumentation packages.

PRACTICALS

1. Simulation of transfer function models using virtual Instrumentation packages.
2. Simulation of state space models using virtual Instrumentation packages.
3. Simulation of signal conditioning and processing circuits using circuit design packages.
4. Demonstration of discretisation blocks in the virtual instrumentation package.
5. Configuration of analog and digital data acquisition systems.
6. Development of GUI application for PID control.
7. Development of GUI application to mimic closed loop performance of a physical system.
8. Ladder logic programming using PLC simulator software packages.
9. Simulation of process control loop using PLC with GUI.
10. Simulation of SCADA based control of physical system.
11. Development of PID and Lag-lead control algorithms for microcontroller application.
12. Configuration of simulation of RS232 and SPI interface protocols.
13. Configuration of simulation of instrumentation bus protocols.
14. Simulation of state diagram based application using virtual instrumentation package.
15. Design of complete automation system for a given application.
16. Design of Feed Forward Controller for a given application.

TOTAL : 60 PERIODS

CO7001 ADVANCED NON LINEAR CONTROL

L T P C
3 0 0 3

COURSE OBJECTIVES

- To educate on the theory of perturbation.
- To educate on stability analysis and theory of singular perturbation.
- To educate on gain scheduling and feedback linearization techniques.
- To educate on the concepts input-output stability and passivity.
- To educate on the theory and design of back stepping controllers.

UNIT I PERTURBATION THEORY 9

Vanishing and Non vanishing Perturbations – Continuity of solutions on the infinite interval – Interconnected systems – Slowly varying systems – Perturbation method – Averaging - Weakly nonlinear second-order oscillators – Exercises

UNIT II SINGULAR PERTURBATIONS 9

Standard singular perturbation model – Time scale properties – Singular perturbation on the infinite interval – Slow and fast manifolds – stability analysis – exercises

UNIT III GAIN SCHEDULING AND FEEDBACK LINEARIZATION 9

Control problem – stabilization via linearization – integral control via linearization – gain scheduling – Input output linearization – Full state linearization – state feedback control – tracking- exercises

UNIT IV INPUT-OUTPUT STABILITY 9

L stability – L stability of state models – L_2 gain – feedback system: small gain theorem – exercises – Passivity – State models - L_2 and Lyapunov stability

UNIT V BAKSTEPPING CONTROL ALGORITHMS 9

Passivity based control – High gain observers – stabilization – Regulation via integral control - exercises

TOTAL : 45 PERIODS

COURSE OUTCOME

- Understanding different types of perturbation models.
- Stability analysis of of various perturbation models.
- Able to linearize, control and gain schedule all kind of perturbation systems.
- Capable ot derive State models and find out stability conditions using L stability and lyapunov stability conditions.
- Know about Bakstepping control algorithms.

REFERENCES

1. Hasan Khalil," Nonlinear systems and control", 3rd ed, PHI,
2. Slotine, J A E Slotine and W Li, "Applied Nonlinear control",1991, PHI
3. S.H. Zak," Systems and control", Oxford University Press

CO7002 OPTIMAL CONTROL AND FILTERING

	L	T	P	C
	3	0	0	3

COURSE OBJECTIVES

- To educate on formulation of optimal control problems and introduce the minimum principle.
- To educate on Linear Quadratic tracking problems- in continuous and discrete domain.
- To introduce the numerical techniques used for solving optimal control problems To educate on the concepts of filtering in the presence of noise.
- To educate on the theory and design of Kalman filter.

UNIT I INTRODUCTION 9

Statement of optimal control problem – Problem formulation and forms of optimal Control – Selection of performance measures. Necessary conditions for optimal control – Pontryagin's minimum principle – State inequality constraints – Minimum time problem.

UNIT II LINEAR QUADRATIC TRACKING PROBLEMS 9

Linear tracking problem – LQG problem – Computational procedure for solving optimal control problems – Characteristics of dynamic programming solution – Dynamic programming application to discrete and continuous systems – Hamilton Jacobi Bellman equation.

UNIT III NUMERICAL TECHNIQUES FOR OPTIMAL CONTROL 9

Numerical solution of 2-point boundary value problem by steepest descent and Fletcher Powell method - solution of Ricatti equation by negative exponential and interactive Methods

UNIT IV FILTERING AND ESTIMATION 9

Filtering – Linear system and estimation – System noise smoothing and prediction – Gauss Markov discrete time model – Estimation criteria – Minimum variance estimation – Least square estimation – Recursive estimation.

UNIT V KALMAN FILTER AND PROPERTIES 9

Filter problem and properties – Linear estimator property of Kalman Filter – Time invariance and asymptotic stability of filters – Time filtered estimates and signal to noise ratio improvement – Extended Kalman filter.

TOTAL : 45 PERIODS

COURSE OUTCOME

- Ability to Identify, Formulateand measure the performance of Optimal Control.
- Ability to understand the Linear Quadratic Tracking Problems and implement dynamic programming appilication for discrete and continuous systems.
- Ability to solve Numerical solution of 2-point boundary value problem by steepest descent and Fletcher Powell method.
- Students will be able to identify Filtering problem and their properties ,Linear estimator property of Kalman Filter and Time invariance and asymptotic stability of filters.

REFERENCES:

1. KiRk D.E., 'Optimal Control Theory – An introduction', Prentice hall, N.J., 1970.
2. Sage, A.P., 'Optimum System Control', Prentice Hall N.H., 1968.
3. Anderson, BD.O. and Moore J.B., 'Optimal Filtering', Prentice hall Inc., N.J., 1979.
4. S.M. Bozic, "Digital and Kalman Filtering", Edward Arnould, London, 1979.
5. Astrom, K.J., "Introduction to Stochastic Control Theory", Academic Press, Inc, N.Y., 1970.

CO7071 CONTROL OF ELECTRICAL DRIVES L T P C
3 0 0 3

COURSE OBJECTIVES

- To introduce the PWM converters and their analysis.
- To educate on modeling of dc motor, drives and control techniques To educate on dynamic modeling of Induction motor drive.
- To educate on the V/f and vector control of Induction motor.
- To educate on generation of firing pulses and control algorithms in embedded platforms.

UNIT I POWER ELECTRONIC CONVERTERS FOR DRIVES 9

Power electronic switches-state space representation of switching converters-Fixed frequency PWM-variable frequency PWM- space vector PWM- Hysteresis current control-dynamic analysis of switching converters-PWM modulator model.

UNIT II CONTROL OF DC DRIVES 9

Modelling of DC machines-block diagram/transfer function-phase control-1phase/3phase converter fed DC drives- Chopper fed DC drives-four quadrant chopper circuit-closed loop control-speed control-current control-cascade control –constant torque/power operation-comparison of chopper/converter fed drives- techniques-merits/demits.

UNIT III ANALYSIS AND MODELLING OF INDUCTION MOTOR DRIVE 9

Basics of induction motor drive-classification – equivalent circuit- torque Vs slip characteristics-steady state performance- Dynamic modeling of induction motor, Three phase to two phase transformation-stator, rotor, synchronously rotating reference frame model.

UNIT IV CONTROL OF INDUCTION MOTOR DRIVE 9

VSI fed induction motor drives- waveforms for 1-phase, 3-phase Non-PWM and PWM VSI fed induction motor drives -principles of V/F control- principle of vector control-direct vector control- space vector modulation- indirect vector control .

UNIT V EMBEDDED CONTROL OF DRIVES 9

Generation of firing pulses- generation of PWM pulses using embedded processors-IC control of DC drives- fixed frequency/variable frequency/current control- V/F control using PIC microcontroller-vector control using embedded processors.

TOTAL : 45 PERIODS

COURSE OUTCOME

- Will get a thorough knowledge on Power Electronic Converter Switches and different PWM approach.
- Confidently design and analyze both converter and chopper driven dc drives.
- Will have a thorough understanding of conventional control techniques of Induction motor drive.
- Get a detailed knowledge on V/f Control using PIC MicroController and Vector control usings Embedded processor.

REFERENCES

1. R.Krishnan, “Electric Motor Drives, Modeling, Analysis and Control” Prentice Hall of India, 2002.
2. Thyristor control of Electric drives, Vedam Subrahmanyam, Tata McGraw Hill, 1988
3. Ion Boldea & S.A.Nasar “ELECTRIC DRIVES”, CRC Press, 2006
4. Simon Ang, Alejandro Oliva “POWER SWITCHING CONVERTERS”, CRC Press, 2005
5. Buxbaum, A. Schierau, and K.Staughen, “A design of control systems for DC Drives”, Springer- Verlag, Berlin,1990.

CO7072 MULTI SENSOR DATA FUSION L T P C
3 0 0 3

COURSE OBJECTIVES

- To educate on sensor data inference hierarchy and fusion models.
- To educate on the algorithms used for data fusion.
- To educate on Kalman filter and its application to decision identity fusion.
- To educate on advanced filtering and sensor fusion concepts.
- To introduce various high performance data structures.

UNIT I MULTISENSOR DATA FUSION INTRODUCTION 9

sensors and sensor data, Use of multiple sensors, Fusion applications. The inference hierarchy: output data. Data fusion model. Architectural concepts and issues. Benefits of data fusion, Mathematical tools used:Algorithms, co-ordinate transformations, rigid body motion. Dependability and Markov chains, Meta – heuristics.

UNIT II ALGORITHMS FOR DATA FUSION 9

Taxonomy of algorithms for multisensor data fusion. Data association. Identity declaration.

UNIT III ESTIMATION: 9

Kalman filtering, practical aspects of Kalman filtering, extended Kalmal filters. Decision level identify fusion. Knowledge based approaches.

UNIT IV ADVANCED FILTERING 9

Data information filter, extended information filter. Decentralized and scalable decentralized estimation. Sensor fusion and approximate agreement. Optimal sensor fusion using range trees recursively. Distributed dynamic sensor fusion.

UNIT V HIGH PERFORMANCE DATA STRUCTURES: 9

Tessellated, trees, graphs and function. Representing ranges and uncertainty in data structures. Designing optimal sensor systems with in dependability bounds. Implementing data fusion system.

TOTAL : 45 PERIODS

COURSE OUTCOME

- Ability to explain and use multiple sensor data in data fusion model.
- Capable to use algorithms for data fusion.
- Ability to estimate using kalman filter.
- Ability to estimate using advance filtering such as data, extended information filtering.
- Ability to handle various high performance data structures.

REFERENCES:

1. David L. Hall, Mathematical techniques in Multisensor data fusion, Artech House, Boston, 1992.
2. R.R. Brooks and S.S. Iyengar, Multisensor Fusion: Fundamentals and Applications with Software, Prentice Hall Inc., New Jersey, 1998.
3. Arthur Gelb, Applied Optimal Estimation, The M.I.T. Press, 1982.
4. James V. Candy, Signal Processing: The Model Based Approach, McGraw –Hill Book Company, 1987.

CO7073 ROBOTICS AND CONTROL L T P C
3 0 0 3

COURSE OBJECTIVES

- To introduce robot terminologies and robotic sensors To educate direct and inverse kinematic relations
- To educate on formulation of manipulator Jacobians and introduce path planning techniques
- To educate on robot dynamics
- To introduce robot control techniques

UNIT I INTRODUCTION AND TERMINOLOGIES 9

Definition-Classification-History- Robots components-Degrees of freedom-Robot joints-coordinates-Reference frames-workspace-Robot languages-actuators-sensors-Position, velocity and acceleration sensors-Torque sensors-tactile and touch sensors-proximity and range sensors- vision system-social issues

UNIT II KINEMATICS 9

Mechanism-matrix representation-homogenous transformation-DH representation-Inverse kinematics-solution and programming-degeneracy and dexterity

UNIT III DIFFERENTIAL MOTION AND PATH PLANNING 9

Jacobian-differential motion of frames-Interpretation-calculation of Jacobian-Inverse Jacobian- Robot Path planning

UNIT IV DYNAMIC MODELLING 9

Lagrangian mechanics- Two-DOF manipulator- Lagrange-Euler formulation – Newton- Euler formulation – Inverse dynamics

UNIT V ROBOT CONTROL SYSTEM 9

- Linear control schemes- joint actuators- decentralized PID control- computed torque control – force control- hybrid position force control- Impedance/ Torque control

TOTAL : 45 PERIODS

COURSE OUTCOMES:

- Ability to understand the components and basic terminology of Robotics
- Ability to model the motion of Robots and analyze the workspace and trajectory panning of robots
- Ability to develop application based Robots
- Abiilty to formulate models for the control of mobile robots in various industrial
- applications

REFERENCES

1. R.K. Mittal and I J Nagrath, “ Robotics and Control”, Tata MacGraw Hill, Fourth edition.
2. Saeed B. Niku ,''Introduction to Robotics '', Pearson Education, 2002.
3. Fu, Gonzalez and Lee Mcgrahill ,''Robotics '', international edition.
4. R.D. Klafter, TA Chmielewski and Michael Negin, "Robotic Engineering, An Integrated approach", Prentice Hall of India, 2003.

CO7074 **ROBUST CONTROL** **LT P C**
3 0 0 3

COURSE OBJECTIVES

- To introduce norms, random spaces and robustness measures To educate on H_2 optimal control and estimation techniques.
- To educate on Hinfinity optimal control techniques To educate on the LMI approach of Hinfinity control.
- To educate on synthesis techniques for robust controllers and illustrate through case studies.

UNIT I INTRODUCTION 9

Norms of vectors and Matrices – Norms of Systems – Calculation of operator Norms – vector Random spaces- Specification for feedback systems – Co-prime factorization and Inner functions – structured and unstructured uncertainty- robustness.

UNIT II H_2 OPTIMAL CONTROL 9

Linear Quadratic Controllers – Characterization of H_2 optimal controllers – H_2 optimal estimation-Kalman Bucy Filter – LQG Controller.

UNIT III H-INFINITY OPTIMAL CONTROL-RICCATI APPROACH 9

Formulation – Characterization of H-infinity sub-optimal controllers by means of Riccati equations – H-infinity control with full information – Hinfinity estimation

UNIT IV H-INFINITY OPTIMAL CONTROL- LMI APPROACH 9

Formulation – Characterization of H-infinity sub-optimal controllers by means of LMI Approach – Properties of H-infinity sub-optimal controllers – H-infinity synthesis with pole-placement constraints

UNIT V SYNTHESIS OF ROBUST CONTROLLERS & CASE STUDIES 9

Synthesis of Robust Controllers – Small Gain Theorem – D-K –iteration- Control of Inverted Pendulum- Control of CSTR – Control of Aircraft – Robust Control of Second-order Plant-Robust Control of Distillation Column

TOTAL : 45 PERIODS

COURSE OUTCOME

- Ability to understand the structured and unstructured uncertainty of robustness.
- Ability to design a H_2 optimal controller and to implement kalman Bucy filter .
- Ability to design a H-Infinity optimal control using Riccati and LMI Approach.
- Will be able to synthesis the Robust Controller and small gain theorem.
- Ability to implement a robust Controller for CSTR and Distillation Column.

REFERENCES

1. U. Mackenroth “Robust Control Systems: Theory and Case Studies”,Springer International Edition, 2010.
2. J. B. Burl, “ Linear optimal control H2 and H-infinity methods”, Addison W Wesley, 1998
3. D. Xue, Y.Q. Chen, D. P. Atherton, "Linear Feedback Control Analysis and Design with MATLAB, Advances In Design and Control”, Society for Industrial and Applied Mathematics, 2007.
4. I.R. Petersen, V.A. Ugrinovskii and A. V. Savkin, “Robust Control Design using H-infinity Methods”, Springer, 2000.
5. M. J. Grimble, “Robust Industrial Control Systems: Optimal Design Approach for Polynomial Systems”, John Wiley and Sons Ltd., Publication, 2006.

CO7075 SYSTEM IDENTIFICATION AND ADAPTIVE CONTROL **LT P C**
3 0 0 3

COURSE OBJECTIVE

- To introduce various model structures for system identification.
- To impart knowledge on parametric and non-parametric identification
- To introduce non-linear identification techniques.
- To introduce the concept of adaptation techniques and control.
- To illustrate the identification and adaptive control techniques through case studies.

UNIT I MODELS FOR INDENTIFICATION 9

Models of LTI systems: Linear Models-State space Models-OE model- Model sets, Structures and Identifiability-Models for Time-varying and Non-linear systems: Models with Nonlinearities – Non-linear state-space models-Black box models, Fuzzy models'.

UNIT II NON-PARAMETRIC AND PARAMETRIC IDENTIFICATON 9

Transient response and Correlation Analysis – Frequency response analysis – Spectral Analysis – Least Square – Recursive Least Square –Forgetting factor- Maximum Likelihood – Instrumental Variable methods.

UNIT III NON-LINEAR IDENTIFICATION 9

Open and closed loop identification: Approaches – Direct and indirect identification – Joint input-output identification – Non-linear system identification – Wiener models – Power series expansions - State estimation techniques – Non linear identification using Neural Network and Fuzzy Logic.

UNIT IV ADAPTIVE COTROL AND ADAPTATION TECHNIQUES 9

Introduction – Uses – Auto tuning – Self Tuning Regulators (STR) – Model Reference Adaptive Control (MRAC) – Types of STR and MRAC – Different approaches to self-tuning regulators – Stochastic Adaptive control – Gain Scheduling.

UNIT V CASE STUDIES 9

Inverted Pendulum, Robot arm, process control application: heat exchanger, Distillation column, application to power system, Ship steering control.

TOTAL : 45 PERIODS

COURSE OUTCOME

- Ability to model LTI system and to analyse the Non-linear state-space model of a black box.
- Will be able to analyse frequency, spectral, correlation and transient response of a system.
- Ability to Identify the Open & closed Loop of a Non-linear system by Neural network and Fuzzy Logic controller.
- Ability to Realize different tuning parameters for adaptive control and adaptive technique.

REFERENCES

1. Ljung," System Identification Theory for the User", PHI, 1987.
2. Torsten Soderstrom, Petre Stoica, "System Identification", prentice Hall `International (UK) Ltd,1989.
3. Astrom and Wittenmark," Adaptive Control ", PHI
4. William S. Levine, " Control Hand Book".
5. Narendra and Annasamy," Stable Adaptive Control Systems, Prentice Hall, 1989.

CO7076 **SYSTEM THEORY** **L T P C**

3 0 0 3

COURSE OBJECTIVES

- To educate on modeling and representing systems in state variable form.
- To educate on solving linear and non-linear state equations.
- To illustrate the role of controllability and observability.
- To educate on stability analysis of systems usig Lyapunov's theory.
- To educate on modal concepts and design of state and output feedback controllers and estimators.

UNIT I STATE VARIABLE REPRESENTATION 9

Introduction-Concept of State-State equation for Dynamic Systems -Time invariance and linearity-Non uniqueness of state model-State Diagrams - Physical System and State Assignment.

UNIT II SOLUTION OF STATE EQUATIONS 9

Existence and uniqueness of solutions to Continuous-time state equations-Solution of Nonlinear and Linear Time Varying State equations-Evaluation of matrix exponential-System modes- Role of Eigenvalues and Eigenvectors.

UNIT III CONTROLLABILITY AND OBSERVABILITY 9

Controllability and Observability-Stabilizability and Detectability-Test for Continuous time Systems-Time varying and Time invariant case-Output Controllability-Reducibility-System Realizations.

UNIT IV STABILTY 9

Introduction-Equilibrium Points-Stability in the sense of Lyapunov-BIBO Stability-Stability of LTI Systems-Equilibrium Stability of Nonlinear Continuous Time Autonomous Systems-The Direct Method of Lyapunov and the Linear Continuous-Time Autonomous Systems-Finding Lyapunov Functions for Nonlinear Continuous Time Autonomous Systems-Krasovskii and Variable-Gradiant Method.

UNIT V MODAL CONTROL 9

Introduction-Controllable and Observable Companion Forms-SISO and MIMO Systems – The Effect of State Feedback on Controllability and Observability-Pole Placement by State Feedback for both SISO and MIMO Systems-Full Order and Reduced Order Observers.

TOTAL : 45 PERIODS

COURSE OUTCOME

- Acquire the concept of State-State equation for Dynamic Systems and understand the uniqueness of state model.
- Ability to differentiate the existence and uniqueness of Continuous time state equations.
- Ability to analyse the controllability and observability of a system.
- Acquire detail knowledge on stability analysis of Linear & Nonlinear Continuous Time Autonomous Systems.

REFERENCES:

1. M. Gopal, "Modern Control System Theory", New Age International, 2005.
2. K. Ogatta, "Modern Control Engineering", PHI, 2002.
3. John S. Bay, "Fundamentals of Linear State Space Systems", McGraw-Hill, 1999.
4. D. Roy Choudhury, "Modern Control Systems", New Age International, 2005.
5. John J. D'Azzo, C. H. Houpis and S. N. Sheldon, "Linear Control System Analysis and Design with MATLAB", Taylor Francis, 2003.
6. Z. Bubnicki, "Modern Control Theory", Springer, 2005.

HV7071 APPLICATIONS OF HIGH ELECTRIC FIELDS L T P C
3 0 0 3

OBJECTIVE:
To impart knowledge on,

- different HV applications in industry and food preservation
- different HV applications in cancer treatments and microbial inactivation
- the awareness on hazards and safety issues.

UNIT I APPLICATION IN INDUSTRY 9
Introduction – electrostatic applications- electrostatic precipitation, separation , painting / coating, spraying ,imaging ,printing ,Transport of materials – Sandpaper Manufacture – Smoke particle detector – Electrostatic spinning ,pumping , propulsion – Ozone generation – Biomedical applications.

UNIT II APPLICATION IN MICROBIAL INACTIVATION 9
Introduction-definitions, descriptions and applications-mechanisms of microbial in-activationselectrical breakdown-electroporation-inactivation models -Critical factors-analysis of process, product and microbial factors-pulse generators and treatment chamber design-Research needs

UNIT III APPLICATION IN FOOD PRESERVATION 9
Processing of juices, milk, egg, meat and fish products- Processing of water and waste – Industrial feasibility, cost and efficiency analysis

UNIT IV APPLICATION IN CANCER TREATMENT 9
Different types of cancer – Different types of treatments, anti-cancer drugs – Electrochemotherapy – Electric fields in cancer tissues – Modeling, analysis of cancer tissues

UNIT V SAFETY AND ELECTROSTATIC HAZARDS 9
Introduction – Nature of static electricity – Triboelectric series – Basic laws of Electrostatic electricity– materials and static electricity – Electrostatic discharges (ESD) – Static electricity problems – Hazards of Electrostatic electricity in industry – Hazards from electrical equipment and installations – Static eliminators and charge neutralizers – Lightning protection- safety measures and standards

TOTAL : 45 PERIODS

OUTCOME:

- To prepare the students in application of high electric fields in industries, food preservation, and cancer treatment.
- To provide an opportunity to students to work in multidisciplinary projects.

REFERENCES

1. N.H.Malik, A.A.Ai-Arainy, M.I.Qureshi, “Electrical Insulation in power systems”, Marcel Dekker, inc., 1998.
2. Mazen Abdel-Salam, Hussien Anis, Ahdab EI-Morshedy, “High Voltage Engineering”, Second Edition, Theory and Practice, Marcel Dekker, Inc. 2000,
3. John D.Kraus, Daniel A.Fleisch, “Electromagnetics with Applications” McGraw Hill International Editions, 1992.
4. Shoait Khan, “ Industrial Power System”, CRC Press, Taylor & Francis group, 2008.

5. G.V. Barbosa – Canovas, “Pulsed electric fields in food processing:Fundamental aspects and applications” CRC Publisher Edition March 1 2001.
6. H L M Lelieveld and Notermans.S,et.al., “Food preservation by pulsed electric fields: From research to application”, Woodhead Publishing Ltd. October 2007.
7. Indian Electricity Rules; IS-5216; Electrical Safety Handbook by John Cadick

HV7072 DESIGN OF SUBSTATIONS L T P C
3 0 0 3

OBJECTIVE:

- To provide in-depth knowledge on design criteria of Air Insulated Substation (AIS) and Gas Insulated Substation (GIS).
- To study the substation insulation co-ordination and protection scheme.
- To study the source and effect of fast transients in AIS and GIS.

UNIT I INTRODUCTION TO AIS AND GIS 9

Introduction – characteristics – comparison of Air Insulated Substation (AIS) and Gas Insulated Substation (GIS) – main features of substations, Environmental considerations, Planning and installation- GIB / GIL

UNIT II MAJOR EQUIPMENT AND LAYOUT OF AIS AND GIS 9

Major equipment – design features – equipment specification, types of electrical stresses, mechanical aspects of substation design- substation switching schemes- single feeder circuits; single or main bus and sectionalized single bus- double main bus-main and transfer bus- main, reserve and transfer bus- breaker-and-a- half scheme-ring bus

UNIT III INSULATION COORDINATION OF AIS AND GIS 9

Introduction – stress at the equipment – insulation strength and its selection – standard BILs – Application of simplified method – Comparison with IEEE and IEC guides.

UNIT IV GROUNDING AND SHIELDING 9

Definitions – soil resistivity measurement – ground fault currents – ground conductor – design of substation grounding system – shielding of substations – Shielding by wires and masts.

UNIT V FAST TRANSIENTS PHENOMENON IN AIS AND GIS 9

Introduction – Disconnector switching in relation to very fast transients – origin of VFTO – propagation and mechanism of VFTO – VFTO characteristics – Effects of VFTO.

TOTAL : 45 PERIODS

OUTCOME:

- Awareness towards substation equipment and their arrangements.
- Ability to design the substation for present requirement with proper insulation coordination and protection against fast transients.

REFERENCES

1. Andrew R. Hileman, “Insulation coordination for power systems”, Taylor and Francis, 1999.

2. M.S. Naidu, “Gas Insulation Substations”, I.K. International Publishing House Private Limited, 2008.
3. Klaus Ragallar, “Surges in high voltage networks” Plenum Press,New York, 1980.
4. “Power Engineer’s handbook”, TNEB Association.
5. Pritindra Chowdhuri, “Electromagnetic transients in power systems”, PHI Learning Private Limited, New Delhi, Second edition, 2004.
6. “Design guide for rural substation”, United States Department of Agriculture, RUS Bulletin, 1724E-300, June 2001.
7. AIEE Committee Report, “Substation One-line Diagrams,” AIEE Trans. on Power Apparatus and Systems, August 1953
8. Hermann Koch , “Gas Insulated Substations”, Wiley-IEEE Press,2014

HV7073 ELECTROMAGNETIC INTERFERENCE AND COMPATIBILITY **L T P C 3 0 0 3**

OBJECTIVE:

- To provide fundamental knowledge on electromagnetic interference and electromagnetic compatibility.
- To study the important techniques to control EMI and EMC.
- To expose the knowledge on testing techniques as per Indian and international standards in EMI measurement.

UNIT I INTRODUCTION 9

Definitions of EMI/EMC -Sources of EMI- Intersystems and Intrasystem- Conducted and radiated interference- Characteristics - Designing for electromagnetic compatibility (EMC)- EMC regulation- typical noise path- EMI predictions and modeling, Cross talk - Methods of eliminating interferences.

UNIT II GROUNDING AND CABLING 9

Cabling- types of cables, mechanism of EMI emission / coupling in cables –capacitive couplinginductive coupling- shielding to prevent magnetic radiation- shield transfer impedance, Grounding – safety grounds – signal grounds- single point and multipoint ground systemshybrid grounds- functional ground layout –grounding of cable shields- -guard shields- isolation, neutralizing transformers, shield grounding at high frequencies, digital grounding- Earth measurement Methods

UNIT III BALANCING, FILTERING AND SHIELDING 9

Power supply decoupling- decoupling filters-amplifier filtering –high frequency filtering- EMI filters characteristics of LPF, HPF, BPF, BEF and power line filter design -Choice of capacitors, inductors, transformers and resistors, EMC design components -shielding – near and far fieldsshielding effectiveness- absorption and reflection loss- magnetic materials as a shield, shield discontinuities, slots and holes, seams and joints, conductive gaskets-windows and coatings - grounding of shields

UNIT IV EMI IN ELEMENTS AND CIRCUITS 9

Electromagnetic emissions, noise from relays and switches, non-linearities in circuits, passive inter modulation, transients in power supply lines, EMI from power electronic equipment, EMI as combination of radiation and conduction

UNIT V ELECTROSTATIC DISCHARGE, STANDARDS AND TESTING TECHNIQUES 9

Static Generation- human body model- static discharges- ESD versus EMC, ESD protection in equipments- standards – FCC requirements – EMI measurements – Open area test site measurements and precautions- Radiated and conducted interference measurements, Control requirements and testing methods

TOTAL : 45 PERIODS

OUTCOME:

- Awareness towards the EMI/EMC in elements and circuits.
- Ability to design and analyze the filtering circuits for the reduction of EMI
- To design and implement the test setup

REFERENCES

1. V.P. Kodali, "Engineering Electromagnetic Compatibility", S. Chand, 1996.
2. Henry W.Ott, " Noise reduction techniques in electronic systems", John Wiley & Sons, 1989.
3. Bernhard Keiser, "Principles of Electro-magnetic Compatibility", Artech House, Inc. (685 canton street, Norwood, MA 020062 USA) 1987.
4. Bridges, J.E Milleta J. and Ricketts.L.W., "EMP Radiation and Protective techniques", John Wiley and sons, USA 1976.
5. William Duff G., & Donald White R. J, "Series on Electromagnetic Interference and Compatibility", Vol.
6. Weston David A., "Electromagnetic Compatibility, Principles and Applications", 1991.

PE7072 POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS LT P C
3 0 0 3

OBJECTIVES :

- To Provide knowledge about the stand alone and grid connected renewable energy systems.
- To equip with required skills to derive the criteria for the design of power converters for renewable energy applications.
- To analyse and comprehend the various operating modes of wind electrical generators and solar energy systems.

- To design different power converters namely AC to DC, DC to DC and AC to AC converters for renewable energy systems.
- To develop maximum power point tracking algorithms.

UNIT I INTRODUCTION 9

Environmental aspects of electric energy conversion: impacts of renewable energy generation on environment (cost-GHG Emission) - Qualitative study of different renewable energy resources ocean, Biomass, Hydrogen energy systems : operating principles and characteristics of: Solar PV, Fuel cells, wind electrical systems-control strategy, operating area.

UNIT II ELECTRICAL MACHINES FOR RENEWABLE ENERGY CONVERSION 9

Review of reference theory fundamentals-principle of operation and analysis: IG, PMSG, SCIG and DFIG.

UNIT III POWER CONVERTERS 9

Solar: Block diagram of solar photo voltaic system : line commutated converters (inversion mode) - Boost and buck-boost converters- selection Of inverter, battery sizing, array sizing.
Wind: three phase AC voltage controllers- AC-DC-AC converters: uncontrolled rectifiers, PWM Inverters, Grid Interactive Inverters-matrix converters.

UNIT IV ANALYSIS OF WIND AND PV SYSTEMS 9

Standalone operation of fixed and variable speed wind energy conversion systems and solar system-Grid connection Issues -Grid integrated PMSG and SCIG Based WECS-Grid Integrated solar system

UNIT V HYBRID RENEWABLE ENERGY SYSTEMS 9

Need for Hybrid Systems- Range and type of Hybrid systems- Case studies of Wind-PVMaximum Power Point Tracking (MPPT).

TOTAL : 45 PERIODS

OUTCOME:

- Ability to design grid connected/standalone renewable energy system employing embedded energy storage and MPPT strategy.

TEXT BOOK

1. S.N.Bhadra, D. Kastha, & S. Banerjee “Wind Electrical Systems”, Oxford University Press, 2009

REFERENCES:

1. Rashid .M. H “power electronics Hand book”, Academic press, 2001.
2. Rai. G.D, “Non conventional energy sources”, Khanna publishes, 1993.
3. Rai. G.D,” Solar energy utilization”, Khanna publishes, 1993.
4. Gray, L. Johnson, “Wind energy system”, prentice hall linc, 1995.
5. Non-conventional Energy sources B.H.Khan Tata McGraw-hill Publishing Company, New Delhi.

PE7151 ANALYSIS AND DESIGN OF POWER CONVERTERS L T P C
4 0 0 4

OBJECTIVES :

- To provide the electrical circuit concepts behind the different working modes of power converters so as to enable deep understanding of their operation.
- To equip with required skills to derive the criteria for the design of power converters starting from basic fundamentals.
- To analyze and comprehend the various operating modes of different configurations of power converters.

UNIT I SINGLE PHASE AC-DC CONVERTER 12

Static Characteristics of power diode, SCR and GTO, half controlled and fully controlled converters with R-L, R-L-E loads and free wheeling diodes – continuous and discontinuous modes of operation - inverter operation –Sequence control of converters – performance parameters: harmonics, ripple, distortion, power factor – effect of source impedance and Overlap-reactive power and power balance in converter circuits

UNIT II THREE PHASE AC-DC CONVERTER 12

Semi and fully controlled converter with R, R-L, R-L-E - loads and free wheeling diodes – inverter operation and its limit – performance parameters – effect of source impedance and over lap – 12 pulse converter.

UNIT III SINGLE PHASE INVERTERS 12

Introduction to self-commutatedswitches : MOSFET and IGBT - Principle of operation of half and full bridge inverters – Performance parameters – Voltage control of single phase inverters using various PWM techniques – various harmonic elimination techniques – forced commutated Thyristor inverters – Design of UPS

UNIT IV THREE PHASE INVERTERS 12

180 degree and 120 degree conduction mode inverters with star and delta connected loads – voltage control of three phase inverters: single, multi pulse, sinusoidal, space vector modulation techniques – Application to drive system – Current source inverters.

UNIT V MODERN INVERTERS 12

Multilevel concept – diode clamped – flying capacitor – cascade type multilevel inverters - Comparison of multilevel inverters - application of multilevel inverters – PWM techniques for MLI – Single phase & Three phase Impedance source inverters - Filters.

TOTAL: 60 PERIODS

OUTCOMES:

- Ability to acquire and apply knowledge of mathematics and converter/machine dynamics in Electrical engineering.
- Ability to model, analyze and understand power electronic systems and equipment
- using computational software.
- Ability to formulate, design, simulate power supplies for generic load and for machine loads.

TEXT BOOKS
1. Rashid M.H., “Power Electronics Circuits, Devices and Applications ", Prentice Hall India, Third Edition, New Delhi, 2004.
2. Jai P.Agrawal, “Power Electronics Systems”, Pearson Education, Second Edition, 2002.
3. Bimal K.Bose “Modern Power Electronics and AC Drives”, Pearson Education, Second Edition, 2003.
4. Ned Mohan,T.MUndeland and W.P Robbin, “Power Electronics: converters, Application and design” John Wiley and sons.Wiley India edition, 2006.
5. Philip T. krein, “Elements of Power Electronics” Oxford University Press -1998.

REFERENCES
1. P.C. Sen, “Modern Power Electronics”, Wheeler Publishing Co, First Edition, New Delhi, 1998.
2. P.S.Bimbra, “Power Electronics”, Khanna Publishers, Eleventh Edition, 2003.

PE7152	**ANALYSIS OF ELECTRICAL MACHINES**	**LT P C**
		3 0 0 3

OBJECTIVES:
- To provide knowledge about the fundamentals of magnetic circuits, energy, force and torque of multi-excited systems.
- To analyze the steady state and dynamic state operation of DC machine through mathematical modeling and simulation in digital computer.
- To provide the knowledge of theory of transformation of three phase variables to two phase variables.
- To analyze the steady state and dynamic state operation of three-phase induction machines using transformation theory based mathematical modeling and digital computer simulation.
- To analyze the steady state and dynamic state operation of three-phase synchronous machines using transformation theory based mathematical modeling and digital computer simulation.

UNITI PRINCIPLES OF ELECTROMAGNETIC ENERGY CONVERSION 9
Magnetic circuits, permanent magnet, stored magnetic energy, co-energy - force and torque in singly and doubly excited systems – machine windings and air gap mmf - winding inductances and voltage equations.

UNIT II DC MACHINES 9
Elementary DC machine and analysis of steady state operation - Voltage and torque equations – dynamic characteristics of permanent magnet and shunt d.c. motors – Time domain block diagrams - solution of dynamic characteristic by Laplace transformation – digital computer simulation of permanent magnet and shunt d.c. machines.

UNIT III REFERENCE FRAME THEORY **9**

Historical background – phase transformation and commutator transformation – transformation of variables from stationary to arbitrary reference frame - variables observed from several frames of reference.

UNIT IV INDUCTION MACHINES **9**

Three phase induction machine, equivalent circuit and analysis of steady state operation – free acceleration characteristics – voltage and torque equations in machine variables and arbitrary reference frame variables – analysis of dynamic performance for load torque variations – digital computer simulation.

UNIT V SYNCHRONOUS MACHINES **9**

Three phase synchronous machine and analysis of steady state operation - voltage and torque equations in machine variables and rotor reference frame variables (Park's equations) – analysis of dynamic performance for load torque variations – digital computer simulation.

TOTAL : 45 PERIODS

OUTCOMES:

- Ability to acquire and apply knowledge of mathematics and converter/machine dynamics in Electrical engineering.
- Ability to model and analyze power electronic systems and equipment using computational software.
- Ability to formulate, design, simulate power supplies for generic load and for machine loads.
- Ability to optimally design magnetics required in power supplies and drive systems.

TEXT BOOKS

1. Paul C.Krause, Oleg Wasyzczuk, Scott S, Sudhoff, "Analysis of Electric Machinery and Drive Systems", John Wiley, Second Edition, 2010.

REFERENCES

1. P S Bimbhra, "Generalized Theory of Electrical Machines", Khanna Publishers, 2008.
2. A.E, Fitzgerald, Charles Kingsley, Jr, and Stephan D, Umanx, " Electric Machinery", Tata McGraw Hill, 5th Edition, 1992.

PE7253 **SOLID STATE DC DRIVES** **LT P C**
3 0 0 3

OBJECTIVES:

- To understand steady state operation and transient dynamics of a motor load system
- To study and analyze the operation of the converter / chopper fed DC drive, both qualitatively and quantitatively.
- To analyze and design the current and speed controllers for a closed loop solid state DC motor drive.

- To understand the implementation of control algorithms using microcontrollers and phase locked loop.

UNIT I DC MOTORS FUNDAMENTALS AND MECHANICAL SYSTEMS 9

DC motor- Types, induced emf, speed-torque relations; Speed control – Armature and field speed control; Ward Leonard control – Constant torque and constant horse power operation -Introduction to high speed drives and modern drives. Characteristics of mechanical system – dynamic equations, components of torque, types of load; Requirements of drives characteristics - stability of drives – multi-quadrant operation; Drive elements, types of motor duty and selection of motor rating.

UNIT II CONVERTER CONTROL 9

Principle of phase control – Fundamental relations; Analysis of series and separately excited DC motor with single-phase and three-phase converters – waveforms, performance parameters, performance characteristics. Continuous and discontinuous armature current operations; Current ripple and its effect on performance; Operation with freewheeling diode; Implementation of braking schemes; Drive employing dual converter.

UNIT III CHOPPER CONTROL 9

Introduction to time ratio control and frequency modulation; Class A, B, C, D and E chopper controlled DC motor – performance analysis, multi-quadrant control - Chopper based implementation of braking schemes; Multi-phase chopper; Related problems.

UNIT IV CLOSED LOOP CONTROL 9

Modeling of drive elements – Equivalent circuit, transfer function of self, separately excited DC motors; Linear Transfer function model of power converters; Sensing and feeds back elements - Closed loop speed control – current and speed loops, P, PI and PID controllers – response comparison. Simulation of converter and chopper fed d.c drive.

UNIT V DIGITAL CONTROL OF D.C DRIVE 9

Phase Locked Loop and micro-computer control of DC drives – Program flow chart for constant horse power and load disturbed operations; Speed detection and current sensing circuits.

TOTAL : 45 PERIODS

OUTCOME:

- Ability to acquire and apply knowledge of mathematics and converter/machine dynamics in Electrical engineering.
- Ability to formulate, design, simulate power supplies for generic load and for machine loads.
- Ability to analyze, comprehend , design and simulate direct current motor based adjustable speed drives.

TEXT BOOKS

1. Gopal K Dubey, “Power Semiconductor controlled Drives”, Prentice Hall Inc., New Yersy, 1989.
2. R.Krishnan, “Electric Motor Drives – Modeling, Analysis and Control”, Prentice-Hall of India Pvt. Ltd., New Delhi, 2010.

REFERENCES

1. GobalK.Dubey, “Fundamentals of Electrical Drives”, Narosal Publishing House, New Delhi, Second Edition ,2009
2. VedamSubramanyam, “Electric Drives – Concepts and Applications”, Tata McGraw-Hill publishing company Ltd., New Delhi, 2002.
3. P.C Sen “Thyristor DC Drives”, John wiely and sons, New York, 1981

PE7351 SPECIAL ELECTRICAL MACHINES L T P C
3 0 0 3

OBJECTIVES

- To review the fundamental concepts of permanent magnets and the operation of permanent magnet brushless DC motors.
- To introduce the concepts of permanent magnet brushless synchronous motors and synchronous reluctance motors.
- To develop the control methods and operating principles of switched reluctance motors.
- To introduce the concepts of stepper motors and its applications.
- To understand the basic concepts of other special machines.

UNIT I PERMANENT MAGNET BRUSHLESS DC MOTORS 9

Fundamentals of Permanent Magnets- Types- Principle of operation- Magnetic circuit analysis-EMF and Torque equations- Characteristics and control

UNIT II PERMANENT MAGNET SYNCHRONOUS MOTORS 9

Principle of operation – EMF and Torque equations - Phasor diagram - Power controllers – Torque speed characteristics – Digital controllers – Constructional features, operating principle and characteristics of synchronous reluctance motor.

UNIT III SWITCHED RELUCTANCE MOTORS 9

Constructional features –Principle of operation- Torque prediction–Characteristics Power controllers – Control of SRM drive- Sensorless operation of SRM – Applications.

UNIT IV STEPPER MOTORS 9

Constructional features –Principle of operation –Types – Torque predictions – Linear and Non-linear analysis – Characteristics – Drive circuits – Closed loop control –Applications.

UNIT V OTHER SPECIAL MACHINES 9

Principle of operation and characteristics of Hysteresis motor – AC series motors – Linear motor – Applications.

TOTAL: 45 PERIODS

OUTCOME:

a) Ability to model and analyze power electronic systems and equipment using computational software.
b) Ability to optimally design magnetics required in special machines based drive systems using FEM based software tools.
c) Ability to design and conduct experiments towards research.

TEXT BOOKS:

1. T.J.E. Miller, 'Brushless magnet and Reluctance motor drives', Claredon press, London, 1989.
2. R.Krishnan, ' Switched Reluctance motor drives' , CRC press, 2001.
3. T.Kenjo, ' Stepping motors and their microprocessor controls', Oxford University press, New Delhi, 2000.

REFERENCES:

1. T.Kenjo and S.Nagamori, 'Permanent magnet and Brushless DC motors', Clarendon ' press, London, 1988.
2. R.Krishnan, ' Electric motor drives' , Prentice hall of India,2002.

3. D.P.Kothari and I.J.Nagrath, ‘ Electric machines’, Tata McGraw hill publishing company, New Delhi, Third Edition, 2004.
4. Irving L.Kosow, “Electric Machinery and Transformers” Pearson Education, Second Edition, 2007.

PS7073 OPTIMISATION TECHNIQUES L T P C
3 0 0 3

COURSE OBJECTIVES

- To introduce the different optimization problems and techniques
- To study the fundamentals of the linear and non-linear programming problem.
- To understand the concept of dynamic programming and genetic algorithm technique

UNIT I INTRODUCTION 9

Definition, Classification of optimization problems, Classical Optimization Techniques, Single and Multiple Optimization with and without inequality constraints.

UNIT II LINEAR PROGRAMMING (LP) 9

Simplex method of solving LPP, revised simplex method, duality, Constrained optimization, Theorems and procedure, Linear programming, mathematical model, solution technique, duality.

UNIT III NON LINEAR PROGRAMMING 9

Steepest descent method, conjugates gradient method, Newton’s Method, Sequential quadratic programming, Penalty function method, augmented Lagrange multiplier method.,

UNIT IV DYNAMIC PROGRAMMING (DP) 9

Multistage decision processes, concept of sub-optimization and principle of optimality, Recursive relations, Integer Linear programming, Branch and bound algorithm

UNIT V GENETIC ALGORITHM 9

Introduction to genetic Algorithm, working principle, coding of variables, fitness function, GA operators; Similarities and differences between Gas and traditional methods; Unconstrained and constrained optimization using genetic Algorithm, real coded gas, Advanced Gas, global optimization using GA, Applications to power system.

TOTAL : 45 PERIODS

OUTCOMES

- Students will learn about different classifications of optimization problems and techniques.
- Students will attain knowledge on linear programming concepts
- Students will understand the application of non- linear programming in optimization techniques
- Students will understand the fundamental concepts of dynamic programming
- Students will have knowledge about Genetic algorithm and its application to optimization in power system.

TEXT BOOKS
1. S.S. Rao ,"Optimization – Theory and Applications", Wiley-Eastern Limited, 1984.
2. G.Luenberger," Introduction of Linear and Non-Linear Programming" , Wesley Publishing Company, 2011.

REFERENCE BOOKS:
1. Computational methods in Optimization, Polak , Academic Press,1971.
2. Optimization Theory with applications, Pierre D.A., Wiley Publications,1969.
3. Taha, H. A., Operations Research: An Introduction, Seventh Edition, Pearson Education Edition, Asia, New Delhi ,2002.

PS7074 SOLAR AND ENERGY STORAGE SYSTEM L T P C
3 0 0 3

COURSE OBJECTIVES
- To Study about solar modules and PV system design and their applications
- To Deal with grid connected PV systems
- To Discuss about different energy storage systems

UNIT I INTRODUCTION 9
Characteristics of sunlight – semiconductors and P-N junctions –behavior of solar cells – cell properties – PV cell interconnection

UNIT II STAND ALONE PV SYSTEM 9
Solar modules – storage systems – power conditioning and regulation - protection – stand alone PV systems design – sizing

UNIT III GRID CONNECTED PV SYSTEMS 9
PV systems in buildings – design issues for central power stations – safety – Economic aspect – Efficiency and performance - International PV programs

UNIT IV ENERGY STORAGE SYSTEMS 9
Impact of intermittent generation – Battery energy storage – solar thermal energy storage – pumped hydroelectric energy storage

UNIT V APPLICATIONS 9
Water pumping – battery chargers – solar car – direct-drive applications –Space – Telecommunications.

TOTAL : 45 PERIODS

OUTCOME
- Students will develop more understanding on solar energy storage systems
- Students will develop basic knowledge on standalone PV system
- Students will understand the issues in grid connected PV systems
- Students will study about the modelling of different energy storage systems and their performances
- Students will attain more on different applications of solar energy

TEXT BOOKS

1. Eduardo Lorenzo G. Araujo, Solar electricity engineering of photovoltaic systems, Progensa,1994.
2. Stuart R.Wenham, Martin A.Green, Muriel E. Watt and Richard Corkish, Applied Photovoltaics, 2007,Earthscan, UK.

REFERENCES:

1. Frank S. Barnes & Jonah G. Levine, Large Energy storage Systems Handbook , CRC Press, 2011.
2. Solar & Wind energy Technologies – McNeils, Frenkel, Desai, Wiley Eastern, 1990
3. Solar Energy – S.P. Sukhatme, Tata McGraw Hill,1987.

PS7255	SMART GRIDS	L T P C
		3 0 0 3

COURSE OBJECTIVES

- To Study about Smart Grid technologies, different smart meters and advanced metering infrastructure.
- To familiarize the power quality management issues in Smart Grid.
- To familiarize the high performance computing for Smart Grid applications

UNIT I INTRODUCTION TO SMART GRID 9

Evolution of Electric Grid, Concept, Definitions and Need for Smart Grid, Smart grid drivers, functions, opportunities, challenges and benefits, Difference between conventional & Smart Grid, National and International Initiatives in Smart Grid.

UNIT II SMART GRID TECHNOLOGIES (Transmission) 9

Technology Drivers, Smart energy resources, Smart substations, Substation Automation, Feeder Automation ,Transmission systems: EMS, FACTS and HVDC, Wide area monitoring, Protection and control

UNIT III SMART GRID TECHNOLOGIES (Distribution) 9

DMS, Volt/VAr control,Fault Detection, Isolation and service restoration, Outage management, High-Efficiency Distribution Transformers, Phase Shifting Transformers, Plug in Hybrid Electric Vehicles (PHEV).

UNIT IV SMART METERS AND ADVANCED METERING INFRASTRUCTURE 9

Introduction to Smart Meters, Advanced Metering infrastructure (AMI) drivers and benefits, AMI protocols, standards and initiatives, AMI needs in the smart grid, Phasor Measurement Unit(PMU), Intelligent Electronic Devices(IED) & their application for monitoring & protection.

UNIT V HIGH PERFORMANCE COMPUTING FOR SMART GRID APPLICATIONS 9

Local Area Network (LAN), House Area Network (HAN), Wide Area Network (WAN), Broadband over Power line (BPL), IP based Protocols, Basics of Web Service and CLOUD Computing to make Smart Grids smarter, Cyber Security for Smart Grid.

TOTAL : 45 PERIODS

OUTCOMES

- Students will develop more understanding on the concepts of Smart Grid and its present developments.
- Students will study about different Smart Grid technologies.
- Students will acquire knowledge about different smart meters and advanced metering infrastructure.
- Students will have knowledge on power quality management in Smart Grids
- Students will develop more understanding on LAN, WAN and Cloud Computing for Smart Grid applications.

TEXT BOOKS

1. Stuart Borlase "Smart Grid :Infrastructure, Technology and Solutions",CRC Press 2012.
2. Janaka Ekanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama, "Smart Grid: Technology and Applications", Wiley.

REFERENCES*:*

1. Vehbi C. Güngör*,* DilanSahin, TaskinKocak, Salih Ergüt, Concettina Buccella*,* Carlo Cecati*,* and Gerhard P. Hancke*,* Smart Grid Technologies: Communication Technologies and Standards IEEE Transactions On Industrial Informatics, Vol. 7, No. 4, November 2011.
2. Xi Fang, Satyajayant Misra, Guoliang Xue, and Dejun Yang "Smart Grid – The New and Improved Power Grid: A Survey" , IEEE Transaction on Smart Grids,

ET7071 ADVANCED DIGITAL SIGNAL PROCESSING L T P C
3 0 0 3

COURSE OBJECTIVES

- To expose the students to the fundamentals of digital signal processing in frequency domain& its application
- To teach the fundamentals of digital signal processing in time-frequency domain& its application
- To compare Architectures & features of Programmable DSprocessors & develop logical functions of DSProcessors with Re-Programmable logics &Devices
- To discuss on Application development with commercial family of DS Processors
- To involve Discussions/ Practice/Exercise onto revising & familiarizing the concepts acquired over the 5 Units of the subject for improved employability skills

UNIT I INTRODUCTION TO DIGITAL SIGNAL PROCESSING 12

Introduction, A Digital Signal-Processing System, The Sampling Process, Discrete Time Sequences, Discrete Fourier Transform (DFT) and Fast Fourier Transform (FFT), Linear Time-Invariant Systems, Decimation and Interpolation, Basics of Digital Filters, FIR Filters, IIR Filters.

UNIT II WAVELET TRANSFORM 6

Introduction to continuous wavelet transform- discrete wavelet transform -orthogonal wavelet decomposition- Multiresolution Analysis-Wavelet function-DWT,bases,orthogonal Basis-Scaling function, Wavelet coefficients- ortho normal wavelets and their relationship to filter banks- Digital filtering interpolation (i) Decomposition filters, (ii) reconstruction, the signal- Example MRA- Haar & Daubechies wavelet.

UNIT III ARCHITECTURES OF COMMERCIAL DIGITAL SIGNAL PROCESSORS 12

Introduction, categorization of DSP Processors, Fixed Point (Blackfin),Floating Point (SHARC),TI TMS 320c6xxx & OMAP processors TMS320C54X & 54xx on Basic Architecture – study : of functional variations of Computational building blocks(with comparison onto their MAC, Bus Architecture and memory, Interrupt- I/O interface, Memory Interface, DMA through one example Architecture in each of these case studies).

UNIT IV INTERFACING I/O PERIPHERALS FOR DSP BASED APPLICATIONS 6

Introduction, External Bus Interfacing Signals, Memory Interface, I/O Interface, Programmed I/O, Interrupts and I / O Direct Memory Access (DMA).**-**Introduction, Design of Decimation and Interpolation Filter, FFT Algorithm, PID Controller ,Application for Serial Interfacing, DSP based Power Meter, Position control

UNIT V VLSI IMPLEMENTATION 9

Low power Design-need for Low power VLSI chips-Basics of DSP system architecture design of functional units, Filter using VHDL programming, Mapping of DSP algorithm onto hardware.

NOTE

Discussions/Exercise/Practice on Workbench : Signal analysis transforms, Filter design concepts with simulation tools as Matlab /Labview/ CCS suites to understand the commercial DSP processor technology.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

- The conceptual aspects of Signal processing Transforms are introduced.
- The comparison on commercial available DSProcessors helps to understand system design through processor interface
- The possibility to develop system on chip design will be explored.

REFERENCES:

1. John G. Proaks, Dimitris G. Manolakis, “Digital Signal Processing”, Pearson Education 2002.
2. Avatar Sing, S. Srinivasan, “Digital Signal Processing- Implementation using DSP Microprocessors with Examples from TMS320C54xx”, Thomson India,2004.
3. Lars Wanhammer, “DSP Integrated Circuits”, Academic press, 1999,NewYork.
4. Lyla B Das,” Embedded Systems-An Integrated Approach”,Pearson2013
5. Ashok Ambardar,”Digital Signal Processing: A Modern Introduction”,Thomson India edition, 2007.
6. Raghuveer M.Rao and Ajit S. Bapardikar, Wavelet transforms- Introduction to theory and applications, Pearson Education, 2000.

7. K.P. Soman and K.L. Ramchandran,Insight into WAVELETS from theory to practice, Eastern Economy Edition, 2008
8. Ifeachor E. C., Jervis B. W ,"Digital Signal Processing: A practical approach, Pearson-Education, PHI/ 2002
9. B Venkataramani and M Bhaskar **"**Digital Signal Processors**"**, TMH, 2nd, 2010
10. Peter Pirsch **"**Architectures for Digital Signal Processing", John Weily, 2007
11. Vinay K.Ingle,John G.Proakis,"DSP-A Matlab Based Approach",Cengage Learning,2010
12. Taan S.Elali,"Discrete Systems and Digital Signal Processing with Matlab",CRC Press2009.

ET7073 DIGITAL INSTRUMENTATION L T P C
3 0 0 3

COURSE OBJECTIVES

- To discuss to the students on the fundamentals building blocks of a digital instrument
- To teach the digital data communication techniques
- To study on bus communication standards and working principles
- To teach Graphical programming using GUI for instrument building
- To involve Discussions/ Practice onto revising & familiarizing the concepts acquired over the 5 Units of the subject for improved employability skills

UNIT I DATA ACQUISITION SYSTEMS 9

Overview of A/D converter, types and characteristics –Sampling, Errors. Objective – Building blocks of Automation systems -Calibration, Resolution, Data acquisition interface requirements.–Counters – Modes of operation- Frequency, Period, Time interval measurements, Prescaler, Heterodyne converter for frequency measurement, Single and Multi channel Data Acquisition systems- Digital Modulation - Digital Displays for Instrumentation.

UNIT II INSTRUMENT COMMUNICATION 15

Introduction, Modem standards, Basic requirements of Instrument Bus Communications standards, interrupt and data handshaking , serial bus- basics, Message transfer, Fault confinement –comparison of RS-232, USB, RS-422, RS-485,Ethernet Bus- CAN standards interfaces - Interface systems and standards, Instrument Drivers-Field bus: general considerations, network design with Use of field buses in industrial plants, functions, international standards, performance- use of Ethernet networks, field bus advantages and disadvantages-Instrumentation network design ,advantages and limitations of open networks, HART network and Foundation field bus network general considerations, network design- Mod Bus, PROFIBUS-PA: Basics, architecture, model, network design and system configuration.

UNIT III PROGRAMMABLE LOGIC CONTROLLERS, 6

Need for PLC, Ladder Diagram, role of PLC for Industrial instrumentation and automation.

UNIT IV VIRTUAL INSTRUMENTATION: 10

Block diagram and Architecture – Data flow techniques – Graphical programming using GUI – Real time Embedded system –Intelligent controller – Software and hardware simulation of I/O communication blocks-peripheral interface – ADC/DAC – Digital I/O – Controller, Timer.

UNIT V CASE STUDIES 5

PC based DAS, Data loggers, PC based process measurements using sensors, actuators, CRT interface and controller with monochrome and colour video display.

NOTE

Discussions/Exercise/Practice on Workbench : on Digital Control of sensors, Relays,Solenoids, DC/ STEPPER motor, LCD graphics Interface, SD Card storage interface

TOTAL : 45 PERIODS

COURSE OUTCOMES:

- The learning process delivers insight onto role of various communication standards applicable in building instrument based automation during data transfer and communication in systems like large industrial processes.
- Improved Employability and entrepreneurship capacity due to knowledge upgradation on recent trends in embedded systems design .

REFERENCES:

1. Jonathan W Valvano, "Embedded Microcomputer systems", Brooks/Cole, Thomson, 2010.
2. Mathivanan, "PC based Instrumentation Concepts and practice", Prentice-Hall India, 2009
3. W.Bolton,Programmable Logic Controllers,5th Ed,Elseiver,2010.
4. Joseph J. Carr, "Elements of Electronic Instrumentation and Measurement", Pearson Education, 2003.
5. K.Padmanabhan, S.Ananthi A Treatise on Instrumentation Engineering ,I K Publish,2011
6. A.J. Bouwens, "Digital Instrumentation" , TATA McGraw-Hill Edition, 1998.
7. Cory L.Clark,"Labview Digital Signal Processing & Digital Communication,TMcH,2005
8. Lisa K. wells & Jeffrey Travis, Lab VIEW for everyone, Prentice Hall, New Jersey,1997.
9. Kevin James, PC Interfacing and Data Acquisition: Techniques for Measurement, Instrumentation and Control, Newnes, 2000.
10. Noltingk B.E., "Instrumentation Reference Book", 2nd Edition, Butterworth Heinemann, 1995.
11. H S Kalsi, "Electronic Instrumentation" Second Edition, Tata McGraw-Hill,2006.

ET7074 MEMS TECHNOLOGY L T P C
3 0 0 3

COURSE OBJECTIVES

- To teach the students properties of materials ,microstructure and fabrication methods.
- To teach the design and modeling of Electrostatic sensors and actuators.
- To teach the characterizing thermal sensors and actuators through design and modeling
- To teach the fundamentals of piezoelectric sensors and actuators through exposure to different MEMS and NEMS devices

- To involve Discussions/ Practice/Exercise onto revising & familiarizing the concepts acquired over the 5 Units of the subject for improved employability skills

UNIT I MICRO-FABRICATION, MATERIALS AND ELECTRO-MECHANICAL CONEPTS 9

Overview of micro fabrication – Silicon and other material based fabrication processes – Concepts: Conductivity of semiconductors-Crystal planes and orientation-stress and strain-flexural beam bending analysis-torsional deflections-Intrinsic stress- resonant frequency and quality factor.

UNIT II ELECTROSTATIC SENSORS AND ACTUATION 9

Principle, material, design and fabrication of parallel plate capacitors as electrostatic sensors and actuators-Applications

UNIT III THERMAL SENSING AND ACTUATION 9

Principle, material, design and fabrication of thermal couples, thermal bimorph sensors, thermal resistor sensors-Applications.

UNIT IV PIEZOELECTRIC SENSING AND ACTUATION 9

Piezoelectric effect-cantilever piezo electric actuator model-properties of piezoelectric materials-Applications.

UNIT V CASE STUDIES 9

Piezoresistive sensors, Magnetic actuation, Micro fluidics applications, Medical applications, Optical MEMS.-NEMS Devices

NOTE

Discussions/Exercise/Practice on Workbench : on the basics /device model design aspects of thermal/peizo/resistive sensors etc.

TOTAL : 45 PERIODS

COURSE OUTCOME:

- The learning process delivers insight onto design of micro sensors, embedded sensors & actuators in power aware systems like grid
- Improved Employability and entrepreneurship capacity due to knowledge up gradation on recent trends in embedded systems design.

REFERENCES

1. Chang Liu, “Foundations of MEMS”, Pearson International Edition, 2006.
2. Marc Madou , “Fundamentals of microfabrication”,CRC Press, 1997.
3. Boston , “Micromachined Transducers Sourcebook”,WCB McGraw Hill, 1998.
4. M.H.Bao “Micromechanical transducers :Pressure sensors, accelerometers and gyroscopes”, Elsevier, Newyork, 2000.

ET7075 VLSI BASED DESIGN METHODOLOGIES L T P C
3 0 0 3

COURSE OBJECTIVES

- To give an insight to the students about the significance of CMOS technology and fabrication process.
- To teach the importance and architectural features of programmable logic devices.
- To introduce the ASIC construction and design algorithms
- To teach the basic analog VLSI design techniques, Logic synthesis and simulation of digital system with Verilog HDL
- To involve Discussions/ Practice/Exercise onto revising & familiarizing the concepts acquired over the 5 Units of the subject for improved employability skills

UNIT I CMOS DESIGN 9

Overview of I VLSI design Methodologies- Logic design with CMOS-transmission gate circuits-Clocked CMOS-dynamic CMOS circuits, Bi-CMOS circuits- Layout diagram, Stick diagram-IC fabrications – Low Power VLSI techniques-Trends in IC technology.

UNIT II PROGRAMABLE LOGIC DEVICES 9

Programming Techniques-Anti fuse-SRAM-EPROM and EEPROM technology –Re-Programmable Devices Architecture- Logical blocks, I/O blocks, Interconnects, Xilinx- XC9500,Cool Runner - XC5200, SPARTAN, Virtex - Altera MAX 7000-Flex 10K-Cyclone,Stratix.

UNIT III ASIC CONSTRUCTION, FLOOR PLANNING, PLACEMENT AND ROUTING 9

System partition – FPGA partitioning – Partitioning methods- floor planning – placement- physical design flow – global routing – detailed routing – special routing- circuit extraction – DRC.

UNIT IV ANALOG VLSI DESIGN 9

Introduction to analog VLSI- Design of CMOS 2stage-3 stage Op-Amp –High Speed and High frequency op-amps-Super MOS- Analog primitive cells-realization of neural networks- Introduction to FPAA.

UNIT V LOGIC SYNTHESIS AND SIMULATION 9

Overview of digital design with Verilog HDL, hierarchical modelling concepts, modules and port definitions, gate level modelling, data flow modelling, behavioural modelling, task & functions, Verilog and logic synthesis-simulation-Design examples,Ripple carry Adders, Carry Look ahead adders, Multiplier, ALU, Shift Registers, Multiplexer, Comparator, Test Bench.

NOTE
Discussions/Practice on Workbench : Practice Digital design with Verilog HDL, gate level modelling, -simulation-Design examples like say Ripple carry Adders, Carry Look ahead adders, Multiplier, ALU, Shift Registers, Multiplexer, Comparator, on Xilinx Platform/Processor Supported Test Bench

TOTAL: 45 PERIODS

COURSE OUTCOMES:

- The learning process delivers insight into developing design logic/arithmetic functionalities of various embedded & computational arithmetic/logic functionalities evolvable in processors with improved design strategies.
- Improved Employability and entrepreneurship capacity due to knowledge up gradation on recent trends in embedded systems design .

REFERENCES:
1. M.J.S Smith, "Application Specific integrated circuits",Addition Wesley Longman Inc.1997.
2. Kamran Eshraghian,Douglas A.pucknell and Sholeh Eshraghian,"Essentials of VLSI circuits and system", Prentice Hall India,2005.
3. Wayne Wolf, " Modern VLSI design " Prentice Hall India,2006.
4. Mohamed Ismail ,Terri Fiez, "Analog VLSI Signal and information Processing", McGraw Hill International Editions,1994.
5. Samir Palnitkar, "Veri Log HDL, A Design guide to Digital and Synthesis" 2^{nd} Ed,Pearson,2005.

ET7151 ADVANCED DIGITAL PRINCIPLES AND DESIGN L T P C
4 0 0 4

COURSE OBJECTIVES
- To expose the students to the fundamentals of sequential system design, Asynchronous circuits, switching errors .
- To teach the fundamentals of modeling through comparative study on the classification of commercial family of Programmable Device
- To study on Fault identification in digital switching circuits
- To introduce logics for design of Programmable Devices
- To involve Discussions/ Practice/Exercise onto revising & familiarizing the concepts acquired over the 5 Units of the subject for improved employability skills

UNIT I SEQUENTIAL CIRCUIT DESIGN 12
Analysis of Clocked Synchronous Sequential Networks (CSSN) Modelling of CSSN – State Stable Assignment and Reduction – Design of CSSN – ASM Chart – ASM Realization.

UNIT II ASYNCHRONOUS SEQUENTIAL CIRCUIT DESIGN 12
Analysis of Asynchronous Sequential Circuit (ASC) – Flow Table Reduction – Races in ASC – State Assignment Problem and the Transition Table – Design of ASC – Static and Dynamic Hazards – Essential Hazards – Designing Vending Machine Controller

UNIT III FAULT DIAGNOSIS AND TESTABILITY ALGORITHMS 12
Fault Table Method – Path Sensitization Method – Boolean Difference Method – Kohavi Algorithm – Tolerance Techniques-Built-in Self Test.

UNIT IV SYNCHRONOUS DESIGN USING PROGRAMMABLE DEVICES 12
Programming Techniques - Re-Programmable Devices Architecture- Function blocks, I/Oblocks, Interconnects, Realize combinational, Arithmetic, Sequential Circuit with Programmable Array Logic; Architecture and application of Field Programmable Logic Sequence**.**

UNIT V ARCHITECTURES AND PROGRAMMING PROGRAMMABLE LOGIC DEVICES 12
Architecture of EPLD, Programmable Electrically Erasable Logic – Xilinx FPGA – Xilinx 2000 - Xilinx 4000 family.

NOTE

Discussions/Practice on Workbench : Logic Synthesis And Simulation for digital design with VHDL, hierarchical modeling concepts, modules and port definitions, gate level modeling, data flow modeling, behavioral modeling task & functions, logic synthesis-simulation-Design examples, Ripple carry Adders, Carry Look ahead adders, Design of Arithmetic circuits for Fast adder, Array Multiplier, ALU, Shift Registers, Multiplexer, Comparator/other examples on Test Bench.

TOTAL : 60 PERIODS

COURSE OUTCOMES:

- The learning process delivers insight into incorporating switching logics,with improved design strategies. Error free circuitry design of computation logics of processors.
- Improved Employability and entrepreneurship capacity due to knowledge upgradation on recent trends in digital design for embedded systems.

REFERENCES

1. Donald G. Givone, “Digital principles and Design”, Tata McGraw Hill 2002.
2. Stephen Brown and Zvonk Vranesic, “Fundamentals of Digital Logic with VHDL Deisgn”, Tata McGraw Hill, 2002
3. Charles H. Roth Jr., “Digital Systems design using VHDL”, Cengage Learning, 2010.
4. Mark Zwolinski, “Digital System Design with VHDL”, Pearson Education, 2004
5. Parag K Lala, “Digital System design using PLD”, BS Publications, 2003
6. John M Yarbrough, “Digital Logic applications and Design”, Thomson Learning,2001
7. Nripendra N Biswas, “Logic Design Theory”, Prentice Hall of India, 2001
8. Charles H. Roth Jr., “Fundamentals of Logic design”, Thomson Learning, 2004.
9. John V.Oldfeild,Richard C.Dorf,”Field Programmable Gate Arrays”,Wiley India Edition,2008

ET7152	MICROCONTROLLER BASED SYSTEM DESIGN	L T P C
		4 0 0 4

COURSE OBJECTIVES

- To introduce the fundamentals of microcontroller based system design.
- To teach I/O and RTOS role on microcontroller.
- To know Microcontroller based system design, applications.
- To teach I/O interface in system Design
- To involve Discussions/ Practice/Exercise onto revising & familiarizing the concepts acquired over the 5 Units of the subject for improved employability skills

UNIT I 8051 ARCHITECTURE 9

Architecture – memory organization – addressing modes – instruction set – Timers - Interrupts - I/O ports, Interfacing I/O Devices – Serial Communication.

UNIT II 8051 PROGRAMMING 12

Assembly language programming – Arithmetic Instructions – Logical Instructions –Single bit Instructions – Timer Counter Programming – Serial Communication Programming Interrupt Programming – RTOS for 8051 – RTOSLite – FullRTOS – Task creation and run – LCD digital clock/thermometer using FullRTOS

UNIT III PIC MICROCONTROLLER 12

Architecture – memory organization – addressing modes – instruction set – PIC progrmming in Assembly & C –I/O port, Data Conversion, RAM & ROM Allocation, Timer programming, practice in MP-LAB.

UNIT IV PERIPHERAL OF PIC MICROCONTROLLER 12

Timers – Interrupts, I/O ports- I2C bus-A/D converter-UART- CCP modules -ADC, DAC and Sensor Interfacing –Flash and EEPROM memories.

UNIT V SYSTEM DESIGN – CASE STUDY 15

Interfacing LCD Display – Keypad Interfacing - Generation of Gate signals for converters and Inverters - Motor Control – Controlling DC/ AC appliances – Measurement of frequency - Stand alone Data Acquisition System.

NOTE

Discussions/Practice on Workbench : 8051/PIC/ATMEL/other Microcontroller based Assembly/C language programming – Arithmetic Programming– Timer Counter Programming – Serial Communication- Programming Interrupt –use of RTOS basis in Task creation and run – Keil IDE Basics-LCD digital clock/thermometer- Motor Control

TOTAL : 60 PERIODS

COURSE OUTCOMES*:*

- The learning process delivers insight into involving the capacities of a programmable microcontroller for system interface & automation of processes with improved design strategies.
- Improved Employability and entrepreneurship capacity due to knowledge up gradation on recent trends in embedded systems design*.*

REFERENCES

1. Muhammad Ali Mazidi, Rolin D. Mckinlay, Danny Causey ‘ PIC Microcontroller and Embedded Systems using Assembly and C for PIC18’, Pearson Education
2. 2008
3. Rajkamal,”Microcontrollers Architecture, Programming,Interfacing,&System Design,Pearson,2012
4. Myke Predko, “Programming and customizing the 8051 microcontroller”, Tata McGraw Hill 2001.
5. Muhammad Ali Mazidi,Sarmad Naimi,Sepehr Naimi,” The AVR Microcontroller and Embedded Systems’ Using Assembly & C, Pearson Education,2014
6. Muhammad Ali Mazidi, Janice G. Mazidi and Rolin D. McKinlay, ‘The 8051 Microcontroller and Embedded Systems’ Prentice Hall, 2005.
7. John Iovine, ‘PIC Microcontroller Project Book ’, McGraw Hill 2000

ET7251 REAL TIME OPERATING SYSTEM

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3	0	0	3

COURSE OBJECTIVES

- To expose the students to the fundamentals of interaction of OS with a computer and User computation.
- To teach the fundamental concepts of how process are created and controlled with OS.
- To study on programming logic of modeling Process based on range of OS features
- To compare types and Functionalities in commercial OS, application development using RTOS
- To involve Discussions/ Practice/Exercise onto revising & familiarizing the concepts acquired over the 5 Units of the subject for improved employability skills

UNIT I REVIEW OF OPERATING SYSTEMS 12

Basic Principles - Operating System structures – System Calls – Files – Processes – Design and Implementation of processes – Communication between processes – Introduction to Distributed operating system – issues in distributed system:states,events,clocks-Distributed scheduling-Fault &recovery.

UNIT II OVERVIEW OF RTOS 9

RTOS Task and Task state –Multithreaded Preemptive scheduler- Process Synchronization- Message queues– Mail boxes -pipes – Critical section – Semaphores – Classical synchronization problem – Deadlocks

UNIT III REAL TIME MODELS AND LANGUAGES 6

Event Based – Process Based and Graph based Models – Real Time Languages – RTOS Tasks – RT scheduling - Interrupt processing – Synchronization – Control Blocks – Memory Requirements.

UNIT IV REAL TIME KERNEL 6

Principles – Design issues – Polled Loop Systems – RTOS Porting to a Target – Comparison and Basic study of various RTOS like – VX works – Linux supportive RTOS – C Executive.

UNIT V APPLICATION DEVELOPMENT USING OS 12

Discussions on Basics of Linux supportive RTOS – uCOS-C Executive for development of RTOS Application –introduction to Android Environment -The Stack – Android User Interface – Preferences, the File System, the Options Menu and Intents,with one Case study

NOTE

Discussions/Practice on Workbench :on understanding the scheduling techniques, timing circuitary, memory allotment scheme , overview of commercial Embedded OS.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

- The learning process delivers insight into scheduling, disciplining various embedded & computational processes with improved design strategies.
- Improved Employability and entrepreneurship capacity due to knowledge up gradation on recent trends in embedded systems design.

REFERENCES:
1. Silberschatz,Galvin,Gagne" Operating System Concepts,6th ed,John Wiley,2003
2. Charles Crowley, "Operating Systems-A Design Oriented approach" McGraw Hill,1997
3. Raj Kamal, "Embedded Systems- Architecture, Programming and Design" Tata McGraw Hill,2006.
4. Karim Yaghmour,Building Embedded Linux System",O'reilly Pub,2003
5. Marko Gargenta,"Learning Android ",O'reilly 2011.
6. Herma K., "Real Time Systems – Design for distributed Embedded Applications", Kluwer Academic, 1997.
7. C.M. Krishna, Kang, G.Shin, "Real Time Systems", McGraw Hill, 1997.
8. Raymond J.A.Bhur, Donald L.Bailey, "An Introduction to Real Time Systems", PHI,1999
9. Mukesh Sighal and N G Shi "Advanced Concepts in Operating System", McGraw Hill,2000
10. D.M.Dhamdhere," Operating Systems,A Concept-Based Approch,TMH,2008

ET7252	**SOFTWARE FOR EMBEDDED SYSTEMS**	**L**	**T**	**P**	**C**
		4	**0**	**0**	**4**

COURSE OBJECTIVES
- To expose the students to the fundamentals of embedded Programming.
- To Introduce the GNU C Programming Tool Chain in Linux.
- To study the basic concepts of embedded C and Embedded OS
- To introduce time driven architecture, Serial Interface with a case study.
- To involve Discussions/ Practice/Exercise onto revising & familiarizing the concepts acquired over the 5 Units of the subject for improved employability skills

UNIT I EMBEDDED PROGRAMMING 12

C and Assembly - Programming Style - Declarations and Expressions - Arrays, Qualifiers and Reading Numbers - Decision and Control Statements - Programming Process - More Control Statements - Variable Scope and Functions - C Preprocessor - Advanced Types - Simple Pointers - Debugging and Optimization – In-line Assembly.

UNIT II C PROGRAMMING TOOLCHAIN IN LINUX 12

C preprocessor - Stages of Compilation - Introduction to GCC - Debugging with GDB - The Make utility - GNU Configure and Build System - GNU Binary utilities - Profiling - using *gprof* - Memory Leak Detection with *valgrind* - Introduction to GNU C Library

UNIT III EMBEDDED C 12

Adding Structure to 'C' Code: Object oriented programming with C, Header files for Project and Port, Examples. Meeting Real-time constraints: Creating hardware delays - Need for timeout mechanism - Creating loop timeouts - Creating hardware timeouts.

UNIT IV EMBEDDED OS **12**

Creating embedded operating system: Basis of a simple embedded OS, Introduction to sEOS, Using Timer 0 and Timer 1, Portability issue, Alternative system architecture, Important design considerations when using sEOS**-** Memory requirements - embedding serial communication & scheduling data transmission - Case study: Intruder alarm system.

UNIT V PYTHON PROGRAMMING **12**

Basics of PYTHON Programming Syntax and Style – Python Objects– Dictionaries – comparison with C programming on Conditionals and Loops – Files – Input and Output – Errors and Exceptions – Functions – Modules – Classes and OOP – Execution Environment.

NOTE

Discussions/Practice on Workbench : Program Development and practice in exercises with C, C++ and Python Programming Environments.

TOTAL : 60 PERIODS

COURSE OUTCOMES:

- The learning process delivers insight into various programming languages/softwares compatible to embedded process development with improved design & programming skills.
- Improved Employability and entrepreneurship capacity due to knowledge up gradation on recent trends in embedded systems design.

REFERENCES

1. Steve Oualline, ‘Practical C Programming 3rd Edition’, O’Reilly Media, Inc, 2006.
2. Stephen Kochan, “Programming in C”, 3rd Edition, Sams Publishing, 2009.
3. Michael J Pont, “Embedded C”, Pearson Education, 2007.
4. Mark Lutz,”Learning Python,Powerful OOPs,O’reilly,2011.

PW7251 SCADA SYSTEM AND APPLICATIONS MANAGEMENT **LT P C**
3 0 0 3

COURSE OBJECTIVE:

- To understand about the SCADA system components and SCADA communication protocols
- To provide knowledge about SCADA applicatios in power system

UNIT I INTRODUCTION TO SCADA **9**

Evolution of SCADA, SCADA definitions, SCADA Functional requirements and Components, SCADA Hierarchical concept, SCADA architecture, General features, SCADA Applications, Benefits

UNIT II SCADA SYSTEM COMPONENTS **9**

Remote Terminal Unit (RTU), Interface units, Human- Machine Interface Units (HMI), Display

Monitors/Data Logger Systems, Intelligent Electronic Devices (IED), Communication Network, SCADA Server, SCADA Control systems and Control panels

UNIT III SCADA COMMUNICATION 9

SCADA Communication requirements, Communication protocols: Past, Present and Future, Structure of a SCADA Communications Protocol, Comparison of various communication protocols, IEC61850 based communication architecture, Communication media like Fiber optic, PLCC etc. Interface provisions and communication extensions, synchronization with NCC, DCC.

UNIT IV SCADA MONITORING AND CONTROL 9

Online monitoring the event and alarm system, trends and reports, Blocking list, Event disturbance recording. Control function: Station control, bay control, breaker control and disconnector control.

UNIT V SCADA APPLICATIONS IN POWER SYSTEM 9

Applications in Generation, Transmission and Distribution sector, Substation SCADA system Functional description, System specification, System selection such as Substation configuration, IEC61850 ring configuration, SAS cubicle concepts, gateway interoperability list, signal naming concept. System Installation, Testing and Commissioning.

CASE STUDIES:

SCADA Design for 66/11KV and 132/66/11KV or 132/66 KV any utility Substation and IEC 61850 based SCADA Implementation issues in utility Substations,

TOTAL: 45 PERIODS

OUTCOME:

- This course gives knowledge about various system components and communication protocols of SCADA system and its applications.

REFERENCES:

1. Stuart A. Boyer: SCADA-Supervisory Control and Data Acquisition, Instrument Society of America Publications,USA,2004
2. Gordon Clarke, Deon Reynders: Practical Modern SCADA Protocols: DNP3, 60870.5 and Related Systems, Newnes Publications, Oxford, UK,2004
3. William T. Shaw, Cybersecurity for SCADA systems, PennWell Books, 2006
4. David Bailey, Edwin Wright, Practical SCADA for industry, Newnes, 2003
5. Michael Wiebe, A guide to utility automation: AMR, SCADA, and IT systems for electric Power, PennWell 1999
6. Dieter K. Hammer, Lonnie R. Welch, Dieter K. Hammer, “Engineering of Distributed Control Systems”, Nova Science Publishers, USA, 1st Edition, 2001