ANNA UNIVERSITY, CHENNAI
AFFILIATED INSTITUTIONS
REGULATIONS – 2017
CHOICE BASED CREDIT SYSTEM
M.E. ELECTRICAL DRIVES AND EMBEDDED CONTROL

PROGRAM EDUCATIONAL OUTCOMES

PEO1: Graduates of this program will have technical knowledge, skills and ability to design, develop, test and control electrical drives using embedded processors.

PEO2: Graduates of this program will have skills and knowledge in the field of embedded control of electrical drives to work in the design, fabrication industries and research organizations.

PEO3: Graduates of this program will show confidence and exhibit self-learning capability and demonstrate a pursuit in life-long learning through higher studies and research.

PEO4: Graduates of this program will show involvement and willingness in assuming responsibility in societal and environmental causes.

PROGRAM OUTCOMES

PO1: Acquire sound knowledge in electrical drives and embedded control.

PO2: Analyse electrical drives related engineering problems and synthesize the information for conducting high level of research.

PO3: Think widely to offer creative and innovative solutions of engineering problems that are inconformity with social and environmental factors.

PO4: Extract the new methodologies by carrying out the literature survey, proper design and conduction of experiments, interpret and analyse the data to arrive at meaningful research methodologies in the control of electrical drives using embedded processors.

PO5: Learn and apply modern engineering and IT tools to solve complex engineering problems related to control of electrical drives using embedded processors.

PO6: Ability to form, understand group dynamics and work in inter-disciplinary groups in order to achieve the goal.

PO7: Ability to communicate effectively in appropriate technical forums and understand the concepts and ideas to prepare reports, to make effective presentations.

PO8: Ability to update knowledge and skills through lifelong learning to keep abreast with the technological developments.

PO9: Follow the professional and research ethics, comprehend the impact of research and responsibility in order to contribute to the society.

PO10: Understand the leadership principles and subject oneself to introspection and take voluntary remedial measures for effective professional practice in the control of electrical drives using embedded processors.

PO / PEO	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10
PEO-1	X	X	X	X	X		X	X		
PEO-2	X			X	X	X	X	X	X	X
PEO-3				X	X	X		X	X	
PEO-4	X	X	X						X	X

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CHOICE BASED CREDIT SYSTEM
M.E. ELECTRICAL DRIVES AND EMBEDDED CONTROL (FULL TIME)
CURRICULUM AND SYLLABUS I TO IV SEMESTERS

SEMESTER I

S.No.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	MA5155	Applied Mathematics for Electrical Engineers	FC	4	4	0	0	4
2.	EB5101	Control of DC Drives	PC	3	3	0	0	3
3.	EB5102	Analysis of Converters and Inverters	PC	5	3	2	0	4
4.	ET5152	Design of Embedded Systems	PC	3	3	0	0	3
5.	IN5152	System Theory	PC	5	3	2	0	4
6.		Professional Elective I	PC	3	3	0	0	3
PRACTICALS								
7.	EB5111	Embedded Systems and Drives Laboratory I	PC	4	0	0	4	2
			TOTAL	**27**	**19**	**4**	**4**	**23**

SEMESTER II

S.No.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	EB5201	VLSI Architecture and Design Methodologies	PC	3	3	0	0	3
2.	EB5202	Control of AC Drives	PC	3	3	0	0	3
3.	PX5251	Special Electrical Machines	PC	3	3	0	0	3
4.	ET5251	Real Time Operating Systems	PC	3	3	0	0	3
5.		Professional Elective II	PE	3	3	0	0	3
6.		Professional Elective III	PE	3	3	0	0	3
PRACTICALS								
7.	EB5211	Embedded Systems and Drives Laboratory II	PC	4	0	0	4	2
8.	EB5212	Mini Project	EEC	4	0	0	4	2
			TOTAL	**26**	**18**	**0**	**8**	**22**

SEMESTER III

S.No.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.		Professional Elective IV	PE	3	3	0	0	3
2.		Professional Elective V	PE	3	3	0	0	3
3.		Professional Elective VI	PE	3	3	0	0	3
PRACTICALS								
4.	EB5311	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.	EB5411	Project Work Phase II	EEC	24	0	0	24	12
			TOTAL	**24**	**0**	**0**	**24**	**12**

TOTAL NO. OF CREDITS: 72

FOUNDATION COURSES (FC)

S.No	Course Code	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	MA5155	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.	EB5101	Control of DC Drives	PC	3	3	0	0	3
2.	EB5102	Analysis of Converters and Inverters	PC	5	3	2	0	4
3.	ET5152	Design of Embedded Systems	PC	3	3	0	0	3
4.	IN5152	System Theory	PC	5	3	2	0	4
5.	EB5111	Embedded Systems and Drives Laboratory I	PC	4	0	0	4	2
6.	EB5201	VLSI Architecture and Design Methodologies	PC	3	3	0	0	3
7.	EB5202	Control of AC Drives	PC	3	3	0	0	3
8.	PX5251	Special Electrical Machines	PC	3	3	0	0	3
9.	ET5251	Real Time Operating Systems	PC	3	3	0	0	3
10.	EB5211	Embedded Systems and Drives Laboratory II	PC	4	0	0	4	2

PROFESSIONAL ELECTIVES (PE)*

Semester I
Elective I

S.No	Course Code	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	IN5092	Digital Instrumentation	PE	3	3	0	0	3
2.	ET5151	Microcontroller Based System Design	PE	3	3	0	0	3
3.	EB5001	Real Time Systems	PE	3	3	0	0	3

Semester II
Elective II and III

1.	EB5002	Programming with VHDL	PE	3	3	0	0	3
2.	PX5252	Power Quality	PE	3	3	0	0	3
3.	ET5071	Advanced Digital Signal Processing	PE	3	3	0	0	3
4.	EB5003	Digital Control Systems	PE	3	3	0	0	3
5.	ET5191	Software for Embedded Systems	PE	3	3	0	0	3
6.	ET5091	MEMS Technology	PE	3	3	0	0	3

Semester III
Elective IV, V and VI

1.	IN5074	Optimal Control	PE	3	3	0	0	3
2.	PS5073	Electric Vehicles and Power Management	PE	3	3	0	0	3
3.	PX5072	Power Electronics for Renewable Energy Systems	PE	3	3	0	0	3
4.	IN5091	Soft Computing Techniques	PE	3	3	0	0	3
5.	IN5075	System Identification and Adaptive Control	PE	3	3	0	0	3
6.	PS5092	Solar and Energy Storage Systems	PE	3	3	0	0	3
7.	EB5004	Computer in Networking and Digital Control	PE	3	3	0	0	3
8.	PX5071	Wind Energy Conversion Systems	PE	3	3	0	0	3
9.	IN5073	Robust Control	PE	3	3	0	0	3

***Professional Electives are grouped according to elective number as was done previously.**

EMPLOYABILITY ENHANCEMENT COURSES (EEC)

S.No	Course Code	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	EB5212	Mini Project	EEC	4	0	0	4	2
2.	EB5311	Project Work Phase I	EEC	12	0	0	12	6
3.	EB5411	Project Work Phase II	EEC	24	0	0	24	12

MA5155 APPLIED MATHEMATICS FOR ELECTRICAL ENGINEERS

L	T	P	C
4	0	0	4

OBJECTIVES :

- The main objective of this course is to demonstrate various analytical skills in applied mathematics and extensive experience with the tactics of problem solving and logical thinking applicable for the students of electrical engineering. This course also will help the students to identify, formulate, abstract, and solve problems in electrical engineering using mathematical tools from a variety of mathematical areas, including matrix theory, calculus of variations, probability, linear programming and Fourier series.

UNIT I MATRIX THEORY 12

Cholesky decomposition - Generalized Eigenvectors - 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 – Isoperimetric problems - Direct methods : Ritz and Kantorovich methods.

UNIT III PROBABILITY AND RANDOM VARIABLES 12

Probability – Axioms of probability – Conditional probability – Baye's theorem - 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 – Big M 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 – Eigenvalue problems and orthogonal functions – Regular Sturm - Liouville systems – Generalized Fourier series.

TOTAL : 60 PERIODS

OUTCOMES :

After completing this course, students should demonstrate competency in the following skills:

- Apply various methods in matrix theory to solve system of linear equations.
- Maximizing and minimizing the functional that occur in electrical engineering discipline.
- Computation of probability and moments, standard distributions of discrete and continuous random variables and functions of a random variable.
- Could develop a fundamental understanding of linear programming models, able to develop a linear programming model from problem description, apply the simplex method for solving linear programming problems.
- Fourier series analysis and its uses in representing the power signals.

REFERENCES :

1. Andrews L.C. and Phillips R.L., "Mathematical Techniques for Engineers and Scientists", Prentice Hall of India Pvt. Ltd., New Delhi, 2005.
2. Bronson, R. “Matrix Operation”, Schaum’s outline series, 2nd Edition, McGraw Hill, 2011.
3. Elsgolc, L. D. "Calculus of Variations", Dover Publications, New York, 2007.
4. Johnson, R.A., Miller, I and Freund J., "Miller and Freund’s Probability and Statistics for Engineers", Pearson Education, Asia, 8th Edition, 2015.
5. O’Neil, P.V., "Advanced Engineering Mathematics", Thomson Asia Pvt. Ltd., Singapore, 2003.
6. Taha, H.A., “Operations Research, An Introduction”**,** 9th Edition, Pearson education, New Delhi, 2016.

EB5101	**CONTROL OF DC DRIVES**	**L T P C**
		3 0 0 3

OBJECTIVES:

- To review the fundamentals of DC machines.
- To study and analyze the operation of the converter / chopper fed DC drives, 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 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 II RECTIFIER CONTROL OF DC DRIVES 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 OF DC DRIVES 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 feedback 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 microcomputer control of DC drives – Program, flow chart for constant horse power and load disturbed operation; speed detection and current sensing circuits.

COURSE OUTCOMES **TOTAL : 45 PERIODS**

After completion of this course, the student will be able to:
Students,

- Will be able to know the basics of D.C machines.
- Will be capable to formulate, design and analyze power supplies for D.C machine loads.
- Will get expertise in the design the current and speed controllers for a closed loop DC motor drive
- Will acquire knowledge on the implementation of control algorithms using Microcontrollers and phase locked loop.

TEXT BOOKS:

1. P.C Sen "Thyristor DC Drives", John wiely and sons, New York, 1981
2. Gopal K Dubey, "Power Semiconductor controlled Drives", Prentice Hall Inc., New Jersy, 1989.
3. Gopal K.Dubey, "Fundamentals of Electrical Drives", Narosa Publishing House, New Delhi, Second Edition ,2009
4. Bimal K Bose, "Modern Power Electronics and AC Drives", Pearson Education Asia 2002.
5. R.Krishnan, "Electric Motor Drives – Modeling, Analysis and Control", Prentice-Hall of India Pvt. Ltd., New Delhi, 2010.
6. Vedam Subramanyam, "Electric Drives – Concepts and Applications", Tata McGraw-Hill publishing company Ltd., New Delhi, 2002.

EB5102	ANALYSIS OF CONVERTERS AND INVERTERS	L	T	P	C
		3	2	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 **9**

Uncontrolled, half controlled and fully controlled converters with R-L, R-L-E loads and free wheeling diode - continuous and discontinuous modes of operation – inverter operation –Dual converter – Sequence control of converters – Performance parameters: harmonics, ripple, distortion, power factor – effect of source impedance and overlap.

UNIT II THREE PHASE AC-DC CONVERTER **9**

Semi and fully controlled converter with R, R-L, R-L-E loads and freewheeling diodes – inverter operation and its limit – performance parameters – effect of source impedance and over lap – dual converters

UNIT III DC-DC CONVERTERS **9**

Principles of step-down and step-up converters – Analysis of buck, boost, buck-boost and Cuk converters – time ratio and current limit control– Resonant and Quasi-resonant converters.

UNIT IV AC VOLTAGE CONTROLLERS **9**

Principle of operation of half and full bridge inverters – performance parameters -180 degree and 120 degree conduction mode inverters with star and delta connected loads – Voltage control of three phase inverters using various PWM techniques – Multi level concept.

UNIT V CYCLOCONVERTERS **9**

Principle of operation of AC voltage controllers- Analysis with R and R-L loads - Single phase and three phase Cycloconverters – Introduction to matrix converters.

TOTAL : 45 + 30 = 75 PERIODS

COURSE OUTCOMES

After completion of this course, the student will be able to:

- Will be able to acquire and apply knowledge of mathematics for the analysis of power converters
- Will be capable to model, analyze and understand the power electronic systems
- Will get expertise in the working modes and operation of power converters.

TEXT BOOKS:

1. Rashid M.H., "Power Electronics Circuits, Devices and Applications ", Pierson Prentice Hall India, New Delhi, 2004.
2. Ned Mohan,T.M Undeland and W.P Robbin, "Power Electronics: converters, Application and design" John Wiley and sons.Wiley India edition, 2006.
3. P.C Sen.," Modern Power Electronics ", Wheeler publishing Co, First Edition, New Delhi-1998.
4. Jai P.Agarwal, "Power Electronics Systems", Pearson Education, Second Edition, 2002.
5. Bimal K.Bose, "Modern Power Electronics and AC Drives", Pearson Education, Second Edition, 2003.
6. P.S.Bimbra, "Power Electronics", Khanna Publishers, Eleventh Edition, 2003.

ET5152 DESIGN OF EMBEDDED SYSTEMS L T P C
3 0 0 3

COURSE OBJECTIVES

- To provide a clear understanding on the basic concepts, Building Blocks of Embedded System
- To teach the fundamentals of Embedded processor Modeling , Bus Communication in processors, Input/output interfacing
- To introduce on processor scheduling algorithms , Basics of Real time operating system
- To discuss on aspects required in developing a new embedded processor, different Phases & Modeling of embedded system
- 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 EMBEDDED SYSTEMS 9

Introduction to Embedded Systems –Structural units in Embedded processor, selection of processor & memory devices- DMA, Memory management methods- memory mapping, cache replacement concept, Timer and Counting devices, Watchdog Timer, Real Time Clock

UNIT II EMBEDDED NETWORKING AND INTERRUPTS SERVICE MECHANISM 9

Embedded Networking: Introduction, I/O Device Ports & Buses– Serial Bus communication protocols - RS232 standard – RS485 –USB – Inter Integrated Circuits (I^2C) – interrupt sources , Programmed-I/O busy-wait approach without interrupt service mechanism- ISR concept-– multiple interrupts – context and periods for context switching, interrupt latency and deadline -Introduction to Basic Concept Device Drivers.

UNIT III RTOS BASED EMBEDDED SYSTEM DESIGN 9

Introduction to basic concepts of RTOS- Task, process & threads, interrupt routines in RTOS, Multiprocessing and Multitasking, Preemptive and non-preemptive scheduling, Task communication-shared memory, message passing-, Interprocess Communication – synchronization between processes-semaphores, Mailbox, pipes, priority inversion, priority inheritance-comparison of commercial RTOS features - RTOS Lite, Full RTOS, VxWorks, µC/OS-II, RT Linux,

UNIT IV SOFTWARE DEVELOPMENT TOOLS 9

Software Development environment-IDE, assembler, compiler, linker, simulator, debugger, Incircuit emulator, Target Hardware Debugging, need for Hardware-Software Partitioning and Co-Design.
Overview of UML, Scope of UML modeling, Conceptual model of UML, Architectural, UML basic elements-Diagram- Modeling techniques - structural, Behavioral, Activity Diagrams.

UNIT V EMBEDDED SYSTEM APPLICATION DEVELOPMENT 9

Objectives, different Phases & Modeling of the Embedded product Development Life Cycle (EDLC), Case studies on Smart card- Adaptive Cruise control in a Car -Mobile Phone software for key inputs.

Note: Class Room Discussions and Tutorials can include the following Guidelines for improved Teaching /Learning Process: Practice through any of Case studies through Exercise/Discussions on Design , Development of embedded Products like : Smart card -Adaptive Cruise control in a Car -Mobile Phone -Automated Robonoid

TOTAL: 45 PERIODS

OUTCOMES : After the completion of this course the student will be able to:

- An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
- Describe the differences between the general computing system and the embedded system, also recognize the classification of embedded systems
- Design real time embedded systems using the concepts of RTOS.
- Foster ability to understand the role of embedded systems in industry

REFERENCES

1. Rajkamal, 'Embedded system-Architecture, Programming, Design', TMH,2011.
2. Peckol, "Embedded system Design",JohnWiley&Sons,2010
3. Shibu.K.V, "Introduction to Embedded Systems", TataMcgraw Hill,2009
4. Lyla B Das," Embedded Systems-An Integrated Approach",Pearson2013
5. Elicia White,"Making Embedded Systems",O'Reilly Series,SPD,2011
6. Bruce Powel Douglass,"Real-Time UML Workshop for Embedded Systems,Elsevier,2011
7. Simon Monk, "Make: Action, Movement, Light and Sound with Arduino and Raspberry Pi", O'Reilly Series ,SPD,2016.
8. Tammy Noergaard, "Embedded System Architecture, A comprehensive Guide for Engineers and Programmers", Elsevier, 2006
9. Jonathan W.Valvano,"Embedded Microcomputer Systems ,Real Time Interfacing",Cengage Learning,3rd edition,2012
10. Michael Margolis,"Arduino Cookbook, O'Reilly Series ,SPD,2013.

IN5152	**SYSTEM THEORY**	**L**	**T**	**P**	**C**
		3	**2**	**0**	**4**

OBJECTIVES:

- To understand the fundamentals of physical systems in terms of its linear and nonlinear models.
- To educate on representing systems in state variable form
- To educate on solving linear and non-linear state equations
- To exploit the properties of linear systems such as controllability and observability
- To educate on stability analysis of systems using 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 equations for Dynamic Systems -Time invariance and linearity- Non uniqueness of state model- Physical Systems and State Assignment - free and forced responses- State Diagrams.

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 - State transition matrix and its properties – Evaluation of matrix exponential- System modes- Role of Eigen values and Eigen vectors.

UNIT III STABILITY ANALYSIS OF LINEAR SYSTEMS 9

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

UNIT IV STATE FEEDBACK CONTROL AND STATE ESTIMATOR 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.

UNIT V LYAPUNOV STABILTY ANALYSIS 9

Introduction-Equilibrium Points- BIBO Stability-Stability of LTI Systems- Stability in the sense of Lyapunov - 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 – Krasovskil's and Variable-Gradiant Method.

TOTAL : 45+30 = 75 PERIODS

OUTCOMES:

- 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 Criterion and Circle Criterion to assess the stability of certain class of non-linear system.
- Ability to describe non-linear behaviors such as Limit cycles, input multiplicity and output multiplicity, Bifurcation and Chaos.

TEXT BOOKS:

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.
7. C.T. Chen, "Linear Systems Theory and Design'' Oxford University Press, 3rd Edition, 1999.
8. M. Vidyasagar, "Nonlinear Systems Analysis', 2nd edition, Prentice Hall, Englewood Cliffs, New Jersey.

EB5111	EMBEDDED SYSTEMS AND DRIVES LABORATORY I	L	T	P	C
		0	0	4	2

OBJECTIVES:

- To provide an insight on the switching behaviors of power electronic switches
- To make the students familiar with the embedded tools used in control of electric drive system

- To make the students capable of implementing analog interfacing as well as control circuits used in a closed-loop control for electric drives system
- To make the students acquire knowledge on mathematical modeling of power electronic circuits and implementing the same using simulation tools
- To facilitate the students to design and fabricate a power converter circuits at appreciable voltage/power levels
- To develop skills on PCB design and fabrication among the students

LIST OF EXPERIMENTS

1. Study of switching characteristics of Power electronic switches with and without Snubber (i) IGBT (ii) MOSFET

2. Modeling and system simulation of basic electric circuits using MATLAB-SIMULINK/SCILAB
    a. DC source fed resistive load
    b. DC source fed RL load
    c. DC source fed RLC load for different damping conditions
    d. DC source fed DC motor load
3. Modeling and System simulation of basic power electronic circuits using MATLAB-SIMULINK/SCILAB
    a. AC Source with Single Diode fed Resistive and Resistive-Inductive Load
    b. AC source with Single SCR fed Resistive and Resistive-Inductive Load
4. Modeling and System Simulation of SCR based full converter with different types of load using MATLAB-Simulink/SCILAB
    a. Full converter fed resistive load
    b. Full converter fed Resistive-Back Emf (RE) load at different firing angles
    c. Full Converter fed Resistive-Inductive Load at different firing angles
    d. Full converter fed DC motor load at different firing angles
5. Circuit Simulation of Voltage Source Inverter and study of spectrum analysis with and without filter using MATLAB/SCILAB
    a. Single phase square wave inverter
    b. Three phase sine PWM inverter
6. Generation of PWM gate pulses with duty cycle control using PWM peripheral of microcontroller (TI-C2000 family/ PIC18)
    a. Duty cycle control from IDE
    b. Duty Cycle control using a POT connected to ADC peripheral in a standalone mode
7. Generation of Sine-PWM pulses for a three phase Voltage Source Inverter with control of modulation index using PWM peripheral of microcontroller (TI C2000 family/PIC 18)
8. Design of Driver Circuit using IR2110
9. Design and testing of signal conditioning circuit to interface voltage/current sensor with microcontroller (TI-C2000 family/ PIC18)
    a. Interface Hall effect current sensor with microcontroller and display the current waveform in the IDE and validate with actual waveform in DSO
    b. Interface Hall effect Voltage sensor with microcontroller and display the current waveform in the IDE and validate with actual waveform in DSO
10. Construction and testing of 500 W, 220 V IGBT based Buck converter and its

performance Evaluation

a. Measurement of Efficiency at different duty cycle with a resistive load
b. Measurement of Efficiency at different duty cycle with a resistive-inductive load

11. PCB design and fabrication of DC power supply using any PCB design software (open source- KiCAD/students version)

TOTAL : 60 PERIODS

COURSE OUTCOMES

- Comprehensive understanding on the switching behavior of Power Electronic Switches
- Comprehensive understanding on mathematical modeling of power electronic system and ability to implement the same using simulation tools
- Ability of the student to use microcontroller and its associated IDE* for power electronic applications
- Ability of the student to design and implement analog circuits for electric drives control applications
- Ability to design and fabricate a power converter circuit at an reasonable power level
- Exposure to PCB designing and fabrication
- IDE – Integrate Development Environment (Code Composer Studio for Texas Instrument/MPLAB for PIC microcontrollers etc)

EMBEDDED SYSTEMS AND DRIVES LABORATORY I

<u>REQUIREMENTS FOR A BATCH OF 25 STUDENTS</u>

Exp. No.	Description of Equipment	Quantity
1	1200 V/25 A IGBT, Snubber Capacitor , Resistors, Bread Board, Load Resistors, 1000 V High Voltage Probe, DSO, Gate pulse generation circuit, DC power Supply	1
	600 V/25 A MOSFET , Snubber Capacitor , Resistors, Bread Board, Load Resistors, 1000 V High Voltage Probe, DSO, Gate pulse generation circuit, DC power Supply	1
2,3,4,5	MATLAB-SIMULINK/SCILAB/Any Equivalent Simulation Tool	1
6,7	8/16/32 bit Microcontroller Development Kit with its IDE (Any Microcontroller with ADC peripheral, minimum of 6 PWM outputs)	3
8	Microcontroller based pulse generation circuit, IR 2110 IC, opto coupler IC’s, Resistors, capacitors, bread boards, DC power supply, DSO	1

9	Quad Op- Amp IC's (LM2902/LM324 or its equivalent), 8/16/32 bit Microcontroller Development Kit with its IDE (Any Microcontroller with ADC peripheral), Hall Effect Current Sensor, Hall Effect Voltage Sensor, Resistors, Bread Boards, DSO	1
10	Discrete Components for Fabricating 500 W Buck Converter - 1200 V/25 A IGBT, Heat Sink for IGBT, Snubber Capacitor for IGBT, 350 V Electrolytic Capacitor, 5 Amps High Frequency Inductor, microcontroller based pulse generation circuit, Driver circuit, Resistive Load, Inductive Load, High Voltage Probe, DSO	1
11	Any open Source PCB designing Software (Example Ki-CAD), Copper Clad Board, Capacitors, Regulator IC's, Resistors , Capacitors, Ferric Chloride, Acetone, PCB drilling M/C, Soldering Accessories	1

EB5201 VLSI ARCHITECTURE AND DESIGN METHODOLOGIES LT P C
3 0 0 3

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.
- To study the Logic synthesis and simulation of digital system with Verilog HDL

UNIT I CMOS DESIGN **9**
Overview of digital VLSI design Methodologies-Logic design with CMOS-transmission gate circuits-Clocked CMOS-dynamic CMOS circuits, Bi-CMOS circuits-Layout diagram, Stick diagram-IC fabrications –Trends in IC technology.

UNIT II PROGRAMABLE LOGIC DEVICES **12**
Programming Techniques-Anti fuse-SRAM- –Re-Programmable Devices Architecture-Function blocks, I/O blocks,Interconnects, Xilinx-XC9500,Cool Runner -XC-4000,XC5200, SPARTAN, Virtex -Altera MAX 7000-Flex 10K-Stratix.

UNIT III BASIC CONSTRUCTION, FLOOR PLANNING, PLACEMENT AND ROUTING **6**
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 **6**
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.

UNIT V LOGIC SYNTHESIS AND SIMULATION **12**

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.

TOTAL : 45 PERIODS

COURSE OUTCOMES

- Ability to understand the significance of CMOS technology and fabrication process.
- Gain knowledge on architectural features of programmable logic devices.
- Acquire knowledge on ASIC construction and design algorithms.
- Acquire knowledge on basic analog VLSI design techniques.
- Gain expertise in Logic synthesis and simulation of digital system with Verilog HDL

TEXT BOOKS:

1. M.J.S Smith, “Application Specific integrated circuits”,Addition Wesley Longman Inc.1997.
2. Wayne Wolf, “ Modern VLSI design “ Prentice Hall India,2006.
3. Mohamed Ismail ,Terri Fiez, “Analog VLSI Signal and information Processing”, McGraw Hill International Editions,1994.
4. Kamran Eshraghian,Douglas A.pucknell and Sholeh Eshraghian,”Essentials of VLSI circuits and system”, Prentice Hall India,2005.
5. Samir Palnitkar, “Veri Log HDL, A Design guide to Digital and Synthesis” 2nd Ed,Pearson,2005
6. John P. Uyemera “Chip design for submicron VLSI cmos layout and simulation “, Cengage Learning India Edition”, 2011.

EB5202	**CONTROL OF AC DRIVES**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

OBJECTIVES:

- To review the fundamentals of A.C machines.
- To familiarize the students on the operation of VSI and CSI fed induction motor drives.
- To understand the field oriented control of induction machines.
- To impart knowledge on the control of synchronous motor drives

UNIT I INDUCTION MACHINES **9**

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

UNIT II VSI AND CSI FED INDUCTION MOTOR DRIVES **9**

AC voltage controller circuit – six step inverter voltage control-closed loop variable frequency PWM inverter with dynamic braking-CSI fed variable frequency drives - comparison

UNIT III ROTOR CONTROLLED INDUCTION MOTOR DRIVES 9

Static rotor resistance control - injection of voltage in the rotor circuit – static scherbius drives - power factor considerations – modified Kramer drives

UNIT IV FIELD ORIENTED CONTROL OF INDUCTION MOTOR DRIVES 9

Field oriented control of induction machines – Theory – DC drive analogy – Direct and Indirect methods – Flux vector estimation - Direct torque control of Induction Machines – Torque expression with stator and rotor fluxes, DTC control strategy.

UNIT V SYNCHRONOUS MOTOR DRIVES 9

Wound field cylindrical rotor motor – Equivalent circuits – performance equations for operation from a voltage source – starting and braking - V curves - Self control-margin angle control-torque control-power factor control-Brushless excitation systems

COURSE OUTCOMES TOTAL : 45 PERIODS

After completion of this course, the student:

- Will be able to know the basics of A.C machines
- Will be able to formulate, design and analyze power supplies for generic loads and machine loads.
- Will acquire knowledge on the operation of VSI and CSI fed induction motor drives.
- Will get expertise in the field oriented control of Induction motor drives.
- Will be able to formulate the control schemes for synchronous motor drives.

TEXT BOOKS:

1. Gopal K Dubey, “Power Semiconductor controlled Drives”, Prentice Hall Inc., New Jersy, 1989.
2. Gopal K.Dubey, “Fundamentals of Electrical Drives”, Narosa Publishing House, New Delhi, Second Edition ,2009
3. Bimal K Bose, “Modern Power Electronics and AC Drives”, Pearson Education Asia 2002.
4. R.Krishnan, “Electric Motor Drives – Modeling, Analysis and Control”, Prentice-Hall of India Pvt. Ltd., New Delhi, 2010.
5. Vedam Subramanyam, “Electric Drives – Concepts and Applications”, Tata McGraw-Hill publishing company Ltd., New Delhi, 2002.
6. W.Leonhard, “Control of Electrical Drives”, Narosa Publishing House, 1992.
7. Murphy J.M.D and Turnbull, “Thyristor Control of AC Motors”, Pergamon Press, Oxford, 1988.

PX5251	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 SYNCHROUNOUS 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

OUTCOMES:

- Understand the open loop and closed loop systems stepper motors.
- Understanding the classifications and characteristics of special machines
- Understanding of the control methods of special motors.
- Ability to select the suitable motor for a certain job under given conditions

REFERENCES

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
4. T.Kenjo and S.Nagamori, 'Permanent magnet and Brushless DC motors', Clarendon press, London, 1988
5. R.Krishnan, ' Electric motor drives' , Prentice hall of India,2002.
6. D.P.Kothari and I.J.Nagrath, ' Electric machines', Tata Mc Graw hill publishing company, New Delhi, Third Edition, 2004.
7. Irving L.Kosow, "Electric Machinery and Transformers" Pearson Education, Second Edition, 2007.

ET5251 **REAL TIME OPERATING SYSTEMS** **LT P C**
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 **9**

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 Synchronisation- Message queues– Mail boxes -pipes – Critical section – Semaphores – Classical synchronisation problem – Deadlocks

UNIT III REAL TIME MODELS AND LANGUAGES **9**

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 – RTOS Porting to a Target – Comparison and Basic study of various RTOS like – VX works – Linux supportive RTOS – C Executive.

UNIT V INTRODUCTION TO EMBEDDED 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: Class room discussions and tutorials can include the following guidelines for improved teaching /learning process: Discussions/Practice on Workbench :on understanding the scheduling techniques, timing circuitary, memory allotment scheme , overview of commercial Embedded OS.

TOTAL : 45 PERIODS

OUTCOMES : After the completion of this course the student will be able to:

- Real-time scheduling and schedulability analysis, including clock-driven and priority-driven scheduling
- Theoretical background (specification/verification) and practical knowledge of real-time operating systems.
- After completing the course students will appreciate the use of multitasking techniques in real-time systems, understand the fundamental concepts of real-time operating systems

- 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. C.M. Krishna, Kang, G.Shin, "Real Time Systems", McGraw Hill, 1997.
6. Marko Gargenta,"Learning Android ",O'reilly 2011.
7. Herma K., "Real Time Systems – Design for distributed Embedded Applications", Kluwer Academic, 1997.
8. Corbet Rubini, Kroah-Hartman, "Linux Device Drivers", O'reilly, 2016.
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

EB5211	EMBEDDED SYSTEMS AND DRIVES LABORATORY II	L	T	P	C
		0	0	4	2

OBJECTIVES:

- To provide an exposure to different electrical drives system
- To study and analyze the performance of different electrical drive system
- To provide an hands-on experience in testing of electrical drives
- To provide an hands-on experience in the FPGA platform

LIST OF EXPERIMENTS

1. Speed control of SCR based single phase full converter fed DC motor
2. Microcontroller Based Speed control of IGBT based Chopper fed DC motor
3. Microcontroller based V/F control of Three phase Voltage Source Inverter fed Induction motor
4. DSP based Speed Control of BLDC Motor
5. DSP based Speed Control of SRM motor
6. Simulation of four quadrant operation of VSI fed three phase Induction Motor
7. Simulation of closed loop speed control of Chopper fed DC motor with varying load
8. Simulation of closed loop speed control of BLDC drive with varying load
9. VHDL Programming Examples - Realization of simple Boolean functions using FPGA
10. Verilog HDL Programming Examples - Realization of simple Boolean functions using FPGA
11. Generation of PWM pulses for single phase voltage source inverter using FPGA (i) Square wave inverter (ii) Sine PWM inverter
12. Generation of Sine PWM pulses for three phase voltage source inverter using FPGA

TOTAL : 60 PERIODS

COURSE OUTCOMES

- Comprehensive understanding on the operation and characteristics of electrical drives based on different electric machines

- Comprehensive understanding on performance analysis of different kind of electrical drives
- Ability of the student to test a electric drive system and analyze its performance
- Ability of the student to design a electric drive and implement in simulation using MATLAB/SCILAB
- Ability of the student to use FPGA for the control of electric drives

EMBEDDED SYSTEMS AND DRIVES LABORATORY II

REQUIREMENTS FOR A BATCH OF 25 STUDENTS

1	Power module for DC converter for separately excited DC machine 0.5HP Speed Sensor, display meters, controller circuit, DSO	1
2	Power module for DC chopper for separately excited DC machine 0.5HP Speed Sensor, display meters, microcontroller based control circuit, DSO	1
3	IGBT inverter power module , 3 phase induction Motor 0.5HP, Microcontroller based control circuit, display meters, Current Probe, High Voltage Probe, DSO	1
4	Power module, BLDC motor(0.5HP), DSP based control circuit, sensor circuit, display meter, DSO	1
5	SRM motor-0.5 HP, PIC DSP/TMS DSP Processor based control circuit, speed sensor, Power module, Display meter, DSO	1
6,7,8	Simulation Package Like MATLAB/SCILAB	3
9,10,11,12	FPGA Development Kit	4

IN5092 **DIGITAL INSTRUMENTATION** **LT 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/Exercise onto revising & familiarizing the concepts acquired over the 5 Units of the subject for improved employability skills

UNIT I DATA ACQUISITION SYSTEMS 10

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 storage Oscilloscope-digital display interface.

UNIT II INSTRUMENT COMMUNICATION 10

Introduction, Modem standards, Data transmission systems- Time Division Multiplexing (TDM) – Digital Modulation Basic requirements of Instrument Bus Communications standards, interrupt and data handshaking , serial bus- basics, Message transfer, - RS-232, USB, RS-422, Ethernet Bus- CAN standards interfaces .General considerations -advantages and disadvantages-Instrumentation network design ,advantages and limitations ,general considerations, architecture, model, and system configuration of : HART network, Mod Bus, Fieldbus

UNIT III VIRTUAL INSTRUMENTATION BASICS 12

Block diagram ,role,and Architecture for VI–– tool bar,Graphical system design &programming usingGUI – Virtual Instrumentation for test, control design-modular programming-conceptual and prog approaches for creation of panels,icons-Loops-Arrays-clusters-plotting data-structures-strings and File I/O- Instrument Drivers

UNIT IV CONFIGURING PROGRAMMABLE INSTRUMENTATION 7

Microprocessor based system design –Peripheral Interfaces systems and instrument communication standards –Data acquisition with processor and with VI – Virtual Instrumentation Software and hardware simulation of I/O communication blocks-peripheral interface – ADC/DAC – Digital I/O – Counter , Timer-servo motor control-PID control.

UNIT V CASE STUDIES 6

Processor based DAS, Data loggers, VI based process measurements like temperature, pressure and level development system- DSO interface -digital controller for colour video display.

Note: Class room discussions and tutorials can include the following guidelines for improved teaching /learning process :Discussions/Exercise/Practice on Workbench for Digital Control of Relays/Solenoids, Digital I/O – Counter , Timer-servo motor control-PID control.
/ LCD graphics Interface/storage interface.

TOTAL : 45 PERIODS

OUTCOMES : After the completion of this course the student will be able to:

- Use digital integrated circuit logic family chips.

- Perform computational and measurement activities using digital techniques, build sequential and combinational logic circuits.
- Analyse working of A/D and D/A converters, use display devices for digital circuits, use digital meters for measurements.
- Graduates will understand the fundamental principles of electrical and electronics circuits and instrumentation, enabling them to understand current technology and to adapt to new devices and technologies.
- Improved Employability and entrepreneurship capacity due to knowledge up gradation on recent trends in embedded systems design.

REFERENCES:

1. Mathivanan, “PC based Instrumentation Concepts and practice”, Prentice-Hall India, 2009
2. Jovitha Jerome,”Virtual Instrumentation using Labview”PHI,2010.
3. Gregory J. Pottie / William J. Kaiser, Principles Of Embedded Networked Systems Design, CAMBRIDGE UNIVERSITY PRESS (CUP),2016
4. Jonathan W Valvano, “Embedded Microcomputer systems”, Brooks/Cole, Thomson, 2010.
5. Cory L.Clark,”Labview Digital Signal Processing & Digital Communication,TMcH,2005
6. Lisa K. wells & Jeffrey Travis, Lab VIEW for everyone, Prentice Hall, New Jersey,1997.
7. H S Kalsi, “Electronic Instrumentation” Second Edition, Tata McGraw-Hill,2006.
8. K.Padmanabhan, S.Ananthi A Treatise on Instrumentation Engineering ,I K Publish,2011
9. Gary Johnson, LabVIEW Graphical Programming, Second edition, McG Hill,Newyork, 1997.

ET5151 MICROCONTROLLER BASED SYSTEM DESIGN LT P C
3 0 0 3

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 9

Assembly language programming – Arithmetic Instructions – Logical Instructions –Single bit Instructions – Timer Counter Programming – Serial Communication Programming, Interrupt Programming, LCD digital clock, thermometer – Significance of RTOS for 8051

UNIT III PIC MICROCONTROLLER 9

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 9

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 9

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: Class room discussions and tutorials can include the following guidelines for improved teaching /learning process :
Discussions/Practice on Workbench : 8051/PIC/ATMEL/other Microcontroller based Assembly/C language programming – Arithmetic Programming– Timer Counter Programming – Serial Communication- Programming Interrupt –RTOS basis in Task creation and run – LCD digital clock/thermometer- Motor Control

TOTAL : 45 PERIODS

OUTCOMES : After the completion of this course the student will be able to:

- 8-bit microcontrollers, learn assembly and C-programming of PIC.
- learn Interfacing of Microcontroller.
- Learners will study about PIC microcontroller and system design.
- The course would enable students to enrich their knowledge with hands on experiments and project based learning
- Effectively utilize microcontroller software development tools such as a compiler, make files, or compile scripts

REFERENCES:

1. Muhammad Ali Mazidi, Rolin D. Mckinlay, Danny Causey ' PIC Microcontroller and Embedded Systems using Assembly and C for PIC18', Pearson Education 2008
2. Rajkamal,"Microcontrollers Architecture, Programming Interfacing,& System Design, Pearson,2012.
3. Muhammad Ali Mazidi, Sarmad Naimi ,Sepehr Naimi' AVR Microcontroller and Embedded Systems using Assembly and C", Pearson Education 2014.
4. Muhammad Ali Mazidi, Janice G. Mazidi and Rolin D. McKinlay, 'The 8051 Microcontroller and Embedded Systems' Prentice Hall, 2005.
5. John Iovine, 'PIC Microcontroller Project Book ', McGraw Hill 2000
6. Senthil Kumar,Saravanan, Jeevanathan,"microprocessor & microcontrollers,Oxford,2013.
7. Myke Predko, "Programming and customizing the 8051 microcontroller", TMcGraw Hill 2001.

EB5001	REAL TIME SYSTEMS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To expose the students to the fundamentals of Real Time systems
- To teach the fundamentals of Scheduling and features of programming languages
- To study the data management system for real time
- To introduce the fundamentals of real time communication
- To teach the different algrorithms and techniques used for real time systems

UNIT I INTRODUCTION 9

Introduction – Issues in Real Time Computing – Structure of a Real Time System – Task classes – Performance Measures for Real Time Systems – Estimating Program Run Times – Task Assignment and Scheduling – Classical uniprocessor scheduling algorithms – Uniprocessor scheduling of IRIS tasks – Task assignment – Mode changes and Fault Tolerant Scheduling.

UNIT II PROGRAMMING LANGUAGES AND TOOLS 9

Programming Languages and Tools – Desired language characteristics – Data typing – Control structures – Facilitating Hierarchical Decomposition, Packages, Run time (Exception) Error handling – Overloading and Generics – Multitasking – Low level programming – Task Scheduling – Timing Specifications – Programming Environments – Run – time support.

UNIT III REAL TIME DATABASES 9

Real time Databases – Basic Definition, Real time Vs General Purpose Databases, Main Memory Databases, Transaction priorities, Transaction Aborts, Concurrency control issues, Disk Scheduling Algorithms, Two – phase Approach to improve Predictability – Maintaining Serialization Consistency – Databases for Hard Real Time Systems.

UNIT IV COMMUNICATION 9

Real – Time Communication – Communications media, Network Topologies Protocols, Fault Tolerant Routing. Fault Tolerance Techniques – Fault Types – Fault Detection. Fault Error containment Redundancy – Data Diversity – Reversal Checks – Integrated Failure handling.

UNIT V EVALUATION TECHNIQUES 9

Reliability Evaluation Techniques – Obtaining parameter values, Reliability models for Hardware Redundancy – Software error models. Clock Synchronization – Clock, A Nonfault – Tolerant Synchronization Algorithm – Impact of faults – Fault Tolerant Synchronization in Hardware – Fault Tolerant Synchronization in software.

TOTAL : 45 PERIODS

COURSE OUTCOMES

After completion of this course, the student will be able to:

- Understand the basics and importance of real-time systems
- Understand the fundamentals of Scheduling and features of programming languages.
- Study the data management system for real time
- Acquire the knowledge on fundamentals of real time communication
- Acquire the knowledge on different algorithms and techniques used for real time systems

TEXT BOOKS:

1. C.M. Krishna, Kang G. Shin, “Real – Time Systems”, McGraw – Hill International Editions, 1997.
2. Rajib Mall, ”Real-time systems: theory and practice”, Pearson Education, 2007
3. Peter D.Lawrence, “Real Time Micro Computer System Design – An Introduction”, McGraw Hill, 1988.
4. Stuart Bennett, “Real Time Computer Control – An Introduction”, Prentice Hall of India, 1998.
5. S.T. Allworth and R.N.Zobel, “Introduction to real time software design”, Macmillan 2nd Edition, 1987
6. R.J.A Buhur, D.L Bailey, “An Introduction to Real – Time Systems”, Prentice – Hall

International, 1999.
7. Philip.A.Laplante, “Real Time System Design and Analysis”, Prentice Hall of India, 3rd Edition, April 2004

EB5002	PROGRAMMING WITH VHDL	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To give an insight to the students about the significance of VHDL Programming
- To teach the importance and architectural modelling of programmable logic devices.
- To introduce the construction and design programming
- To teach the basic VLSI design configurations
- To study the Logic synthesis and simulation of digital system with PLD.

UNIT I VHDL FUNDAMENTALS 9

Fundamental concepts- Modeling digital system-Domain and levels of modeling-modeling languages-VHDL modeling concepts-Scalar Data types and operations- constants and Variable Scalar Types- Type Classification-Attributes and scalar types-expression and operators Sequential statements.

UNIT II DATA TYPES AND BASIC MODELING CONSTRUCTS 9

Arrays- unconstrained array types-array operations and referencing- records - Access Types Abstract Date types- -basic modeling constructs-entity declarations-Architecture bodies behavioral description-structural descriptions- design Processing, case study: A pipelined Multiplier accumulator.

UNIT III SUBPROGRAMS , PACKAGES AND FILES 9

Procedures-Procedure parameters- Concurrent procedure call statements –Functions –Overloading –visibility of Declarations-packages and use clauses- Package declarations package bodies-use clauses-Predefined aliases-Aliases for Data objects-Aliases for Non-Data items-Files- I/O-Files. Case study: A bit vector arithmetic Package.

UNIT IV SIGNALS, COMPONENTS, CONFIGURATIONS 9

Basic Resolved Signals-IEEE std_Logic_1164 resolved subtypes- resolved Signal Parameters -Generic Constants- Parameterizing behavior- Parameterizing structure-components and configurations-Generate Statements-Generating Iterative structure-Conditionally generating structure-Configuration of generate statements-case study: DLX computer Systems.

UNIT V DESIGN WITH PROGRAMMABLE LOGIC DEVICES 9

Realization of -Micro controller CPU.- Memories- I/O devices-MAC-Design,synthesis,simulation and testing.

TOTAL : 45 PERIODS

COURSE OUTCOMES

After completion of this course, the student will be able to:

- Model complex digital systems at several level of abstractions; behavioral and structural, synthesis and rapid system prototyping.
- Develop and simulate register-level models of hierarchical digital systems
- Develop a formal test bench from informal system requirements
- Design and model complex digital system independently or in a team

TEXT BOOKS:

1. Peter J.Ashenden, “The Designer’s guide to VHDL”, Morgan Kaufmann publishers,San Francisco,Second Edition, May 2001.
2. Zainalabedin navabi, “VHDL Analysis ans modeling of Digital Systems”, McGraw Hill international Editions, Second Editions, 1998.
3. Charles H Roth, Jr. “Digital system Design using VHDL”, Thomson ,2006.
4. Douglas Perry, “VHDL Programming by Example”, Tata McGraw Hill,4th Edition 2002.
5. Navabi.Z., “VHDL Analysis and Modeling of Digital Systems”, McGraw International, 1998.
6. Peter J Ashendem, “The Designers Guide to VHDL”, Harcourt India Pvt Ltd, 2002
7. Skahill. K, “VHDL for Programmable Logic”, Pearson education, 1996.

PX5252 POWER QUALITY L T P C
3 0 0 3

OBJECTIVES:

- To understand the various power quality issues.
- To understand the concept of power and power factor in single phase and three phase
- systems supplying nonlinear loads.
- To understand the conventional compensation techniques used for power factor correction and load voltage regulation.
- To understand the active compensation techniques used for power factor correction.
- To understand the active compensation techniques used for load voltage regulation.

UNIT I INTRODUCTION 9

Introduction – Characterisation of Electric Power Quality: Transients, short duration and long duration voltage variations, Voltage imbalance, waveform distortion, Voltage fluctuations, Power frequency variation, Power acceptability curves – power quality problems: poor load power factor, Non linear and unbalanced loads, DC offset in loads, Notching in load voltage, Disturbance in supply voltage – Power quality standards.

UNIT II ANALYSIS OF SINGLE PHASE AND THREE PHASE SYSTEM 9

Single phase sinusoidal, non sinusoidal source supplying linear and nonlinear loads – Three phase Balance system – Three phase unbalanced system – Three phase unbalanced and distorted source supplying non linear loads – Concept of PF – Three phase three wire – Three phase four wire system.

UNIT III CONVENTIONAL LOAD COMPENSATION METHODS 9

Principle of Load compensation and Voltage regulation – Classical load balancing problem : Open loop balancing – Closed loop balancing, Current balancing – Harmonic reduction and voltage sag reduction – Analysis of unbalance – instantaneous real and reactive powers – Extraction of fundamental sequence component.

UNIT IV LOAD COMPENSATION USING DSTATCOM 9

Compensating single phase loads – Ideal three phase shunt compensator structure – Generating reference currents using instantaneous PQ theory – Instantaneous symmetrical components theory – Generating reference currents when the source is unbalanced – Realization and control of DSTATCOM – DSTATCOM in Voltage control mode.

UNIT V SERIES COMPENSATION OF POWER DISTRIBUTION SYSTEM 9

Rectifier supported Dynamic Voltage Restorer – DC Capacitor supported DVR – DVR Structure – voltage Restoration – Series Active Filter – Unified Power Quality Conditioner.

TOTAL : 45 PERIODS

OUTCOMES:

- Ability to formulate, design and simulate power supplies for generic load and machine loads.
- Ability to conduct harmonic analysis and load tests on power supplies and drive systems.
- Ability to understand and design load compensation methods useful for mitigating power quality problems.

TEXT BOOKS:

1 ArindamGhosh "Power Quality Enhancement Using Custom Power Devices", Kluwer Academic Publishers, 2002

2 R.C. Duggan, Mark.F.McGranaghan,SuryaSantoas and H.WayneBeaty, "Electrical Power System Quality", McGraw-Hill, 2004.

3 G.T.Heydt, "Electric Power Quality", Stars in a Circle Publications, 1994.

4 Bhim Singh, Ambrish Chandra, Kamal Al-Haddad , "Power Quality: Problems and Mitigation Techniques", John Wiley & Sons,2015.

REFERENCES

1 Jos Arrillaga and Neville R. Watson ,“ Power system harmonics”,Wiley,2003.

2 Derek A. Paice , "Power Electronics Converter Harmonics :Multipulse Methods for Clean Power",Wiley,1999.

3 Ewald Fuchs, Mohammad A. S. Masoum Power Quality in Power Systems and Electrical Machines,Elseveir academic press publications,2011.

ET5071 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
- 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 FUNDAMENTALS OF DSP 12

Frequency interpretation, sampling theorem, aliasing, discrete-time systems, constant-coefficient difference equation. Digital filters: FIR filter design – rectangular,Hamming,Hanning windowing technique. IIR filter design – Butterworth filter, bilinear transformation method, frequency transformation. Fundamentals of multirate processing – decimation and interpolation.

UNIT II TRANSFORMS AND PROPERTIES 9

Discrete Fourier transform (DFT): - properties, Fast Fourier transform (FFT), DIT-FFT, and DIF-FFT. Wavelet transforms:Introduction, wavelet coefficients – orthonormal wavelets and their relationship to filter banks, multi-resolution analysis, and Haar and Daubechies wavelet.

UNIT III ADAPTIVE FILTERS 9

Wiener filters – an introduction. Adaptive filters: Fundamentals of adaptive filters, FIR adaptive filter – steepest descent algorithm, LMS algorithm, NLMS, applications – channel equalization. Adaptive recursive filters – exponentially weighted RLS algorithm.

UNIT IV ARCHITECTURE OF COMMERCIAL DIGITAL SIGNAL PROCESSORS 9

Introduction to commercial digital signal processors, Categorization of DSP processor – Fixed point and floating point, Architecture and instruction set of the TI TMS 320 C54xx and TMS 320 C6xxx DSP processors, On-chip and On-board peripherals – memory (Cache, Flash, SDRAM), codec, multichannel buffered I/O serial ports (McBSPs), interrupts, direct memory access (DMA), timers and general purpose I/Os.

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

Introduction, External Bus Interfacing Signals, Memory Interface, I/O Interface, Programmed I/O, Interrupts, Design of Filter, FFT Algorithm, ,Application for Serial Interfacing, DSP based Power Meter, Position control , CODEC Interface .

TOTAL : 45 PERIODS

Note: Discussions / Exercise / practice on signal analysis, transforms, filter design concepts with simulation tools such as Matlab / Labview / CC studio will help the student understand signal processing concepts and DSP processors.
Overview of TMS320C54xx and TMS320C67xx /other DSP Starter Kits, Introduction to code composer studio (CCS), Board support library, Chip support library and Runtime support library, Generating basic signals, Digital filter design, Spectrum analysis, Adaptive filters, Speech and Audio processing applications.

OUTCOMES : After the completion of this course the student will be able to:

- Students will learn the essential advanced topics in DSP that are necessary for successful Postgraduate level research.
- Students will have the ability to solve various types of practical problems in DSP
- Comprehend the DFTs and FFTs, design and Analyze the digital filters, comprehend the Finite word length effects in Fixed point DSP Systems.
- The conceptual aspects of Signal processing Transforms are introduced.
- The comparison on commercial available DSProcessors helps to understand system design through processor interface.
- Improved Employability and entrepreneurship capacity due to knowledge up gradation on recent trends in embedded systems design.

REFERENCES:

1. John. G. Proakis, Dimitris G. Manolakis, “Digital signal processing”, Pearson Edu, 2002
2. Sen M.Kuo,Woon-Seng S.Gan, “Digital Signal Processors- Pearson Edu, 2012
3. Ifeachor E. C., Jervis B. W ,”Digital Signal Processing: A practical approach, Pearson-Education, PHI/ 2002

4. Shaila D. Apte, “ Digital Signal Processing”, Second Edition, Wiley, 2016.
5. Robert J.Schilling,Sandra L.Harris,”Introd. To Digital Signal Processing with Matlab”,Cengage,2014.
6. Steven A. Tretter, “Communication System Design Using DSP Algorithms with Laboratory Experiments for the TMS320C6713™ DSK”, Springer, 2008.
7. RulphChassaing and Donald Reay, “Digital Signal Processing and Applications with the TMS320C6713 and TMS320C6416 DSK”, John Wiley & Sons, Inc., Hoboken, New Jersey, 2008.
8. K.P. Soman and K.L. Ramchandran,Insight into WAVELETS from theory to practice, Eastern Economy Edition, 2008
9. B Venkataramani and M Bhaskar **“**Digital Signal Processors**”**, TMH, 2nd, 2010
10. Vinay K.Ingle,John G.Proakis,”DSP-A Matlab Based Approach”,Cengage Learning,2010
11. Taan S.Elali,”Discrete Systems and Digital Signal Processing with Matlab”,CRC Press2009.
12. Monson H. Hayes, “Statistical Digital signal processing and modelling”, John Wiley & Sons, 2008.
13. Avatar Sing, S. Srinivasan, “Digital Signal Processing- Implementation using DSP Microprocessors with Examples from TMS320C54xx”, Thomson India,2004.

EB5003	DIGITAL CONTROL SYSTEMS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To study the importance of sample data control system.
- To give adequate knowledge about signal processing in digital control.
- To study the importance of modeling of discrete systems and stability analysis of discrete data system.
- To study the importance of state space representation for discrete data system.
- To introduce the design concept for digital controllers.

UNIT I COMPUTER CONTROLLED SYSTEM 9

Configuration of the basic digital control scheme – general sampled data system variables – signal classifications – Significance of digital control system –Advantages – disadvantages – examples of discrete data and digital control systems.

UNIT II SIGNAL PROCESSING IN DIGITAL CONTROL 9

Sampling process – Frequency domain analysis –ideal samples– Shanon’s sampling theorem – generation and solution of process –linear difference equations –Data reconstruction process – Frequency domain characteristics.

UNIT III DISCRETE SYSTEM MODELLING 9

Determination of the Z transform – Mapping between s and Z domains-Z transform of system equations –Open loop Hybrid sampled Data Control Systems –Open loop discrete Input Data Control System –Closed loop sampled data control system –modified Z transform method – Response between sampling instants –Stability on the Z-plane and Jury’s stability test –Steady state error analysis for stable systems

UNIT IV STATE VARIABLE ANALYSIS OF DIGITAL CONTROL SYSTEMS 9

State descriptions of digital process –Conversion of state variable models to transfer function – Conversion of transfer functions to canonical state variable models – Companion forms –Jordon Canonical form – State description of sampled continuous time plants –Solution of state difference equations –State transition matrix –Caley Hamilton Technique –Concepts of controllability and observability - Loss of controllability and observability due to sampling.

UNIT V DESIGN OF DIGITAL CONTROL 9

Digital PI, PD and PID Controller – Position and velocity forms –State regulator design – Design of state observers – Dead beat controller design by state feedback and Design of Dead beat observers.

TOTAL : 45 PERIODS

COURSE OUTCOMES

- Acquire the concept of digital control system.
- Acquire the concept of sampling and data reconstruction processes.
- Acquire detail knowledge on Z-Transforms.
- Ability to obtain the different types of companion forms and to analyze controllability and observability of a discrete system.
- Acquire detail knowledge on design of PID controllers, state regulator, state observer Dead beat controller and Dead beat observers.

TEXT BOOKS:

1. M.Gopal, 'Digital Control and State Variables Methods', Tata McGraw HILL, 2ndEdition, 2003.
2. B.C. Kuo, "Digital control systems", Second Edition, Oxford University press, 1992.
3. Katsuhiko Ogata, "Discrete-Time Control Systems", PHI, 1995.
4. Franklin, Powell, and Workman,"Digital Control of Dynamic Systems", Addison – Wesley,1998.
5. P.B. Deshpande and R.H. Ash, 'Computer Process Control', ISA Publication, USA, 1995.
6. Ioan D. Landau and Gianluca Zito Digital Control Systems: Design, Identification and Implementation Springer-Verlag , 2006.
7. C.M. Houpis, G.B. Lamount, 'Digital Control Systems-Theory, Hardware, Software', International Student Edition, McGraw Hill Book Co., 1985..

ET5191 SOFTWARE FOR EMBEDDED SYSTEMS LT P C
3 0 0 3

COURSE OBJECTIVES

- To expose the students to the fundamentals of embedded Programming.
- To Introduce the GNU C Programming Tool Chain in Linux.
- To study basic concepts of embedded C , Embedded OS&Python Programming
- 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 9

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 TOOL CHAIN IN LINUX 9**

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 9

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 9

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 9

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: Class room discussions and tutorials can include the following guidelines for improved teaching /learning process:
Discussions/Practice on Workbench : Program Development and practice in exercises with C, C++ Linux and Python Programming Environments.

TOTAL : 45 PERIODS

OUTCOMES : After the completion of this course the student will be able to:

- Ability to use GNU C to develop embedded software.
- knowledge and understanding of fundamental embedded systems design paradigms, architectures, possibilities and challenges, both with respect to software and hardware
- 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. Michael J Pont, "Embedded C", Pearson Education, 2007.
3. Christian Hill, Learning Scientific Programming with Python , CAMBRIDGE UNIVERSITY PRESS ,2016.
4. Wesley J.Chun, "Core python application Programming 3rd Edition", Pearson Educat, 2016.
5. Mark J.Guzdial," introduction to computing and programming in python – a Multimedia approach ,4th edition, Pearson Education, 2015.
6. Stephen Kochan, "Programming in C", 3rd Edition, Sams Publishing, 2009.
7. Mark Lutz,"Learning Python,Powerful OOPs,O'reilly,2011.
8. Peter Prinzs, Tony Crawford, "C in a Nutshell",O'Reilly,2016.
9. Dr.Bandu Meshram, "Object Oriented Paradigm C++ BeginnersGuide C&C++",SPD, 2016.
10. David Griffiths, Dawn Griffiths, "Head First C", O'reilly,2015.

ET5091 **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 CONCEPTS 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 piezoelectric 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: Class room discussions and tutorials can include the following guidelines for improved teaching /learning process: Discussions/Exercise/Practice on Workbench: on the basics /device model design aspects of thermal/peizo/resistive sensors etc.

TOTAL : 45 PERIODS

OUTCOMES : After the completion of this course the student will be able to:

- Understand basics of microfabrication, develop models and simulate electrostatic and electromagnetic sensors and actuators
- Understand material properties important for MEMS system performance, analyze dynamics of resonant micromechanical structures
- The learning process delivers insight onto design of micro sensors, embedded sensors & actuators in power aware systems like grid.
- Understand the design process and validation for MEMS devices and systems, and learn the state of the art in optical microsytems
- 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.

IN5074	OPTIMAL CONTROL	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To highlight the significance of optimal control in process industries and the different methods of optimization
- To introduce the concept of variational approach for the design of optimal control system
- To formulate linear quadratic optimal control strategy with specified degree of stability
- To impart knowledge about discrete time linear state regulator system and discrete time linear quadratic tracking system
- To illustrate the application of dynamic programming and HJB equation for the design of constrained and time optimal control systems

UNIT I INTRODUCTION TO OPTIMAL CONTROL 9

Statement of optimal Control problem - problem formulation and forms of optimal control - performance measures - various methods of optimization - Linear programming - nonlinear programming.

UNIT II CALCULUS OF VARIATIONS 9

Basic concepts – variational problem - Extreme functions with conditions - variational approach to optimal control systems.

UNIT III LINEAR QUADRATIC OPTIMAL CONTROL SYSTEM 9

Problem formulation - finite time LQR - infinite time LQR - Linear Quadratic tracking system – LQR with a specified degree of stability.

UNIT IV DISCRETE TIME OPTIMAL CONTROL SYSTEM 9

Variational calculus for DT system – DT optimal control system - DT linear state regulator system -- DT linear quadratic tracking system .

UNIT V PONTRYAGIN MINIMUM PRINCIPLE 9

Pontryagin minimum principle - Dynamic programming – Hamilton - Jacobi - Bellman equation - LQR system using HJB equation – Time optimal control – fuel optimal control system - optimal control system with constraints

TOTAL : 45 PERIODS

OUTCOMES:

After completing the course ,the student will be able to

- Formulate the optimization problem based on the requirements and evaluate the

- performance of optimal controller
- Apply the variational approach for optimal control systems with conditions
- Differentiate finite time LQR and infinite time LQR and design linear quadratic tracking system
- Analyze discrete time optimal control systems used in different applications
- Design constrained optimal control system and time optimal control system

TEXT BOOKS:

1. Naidu D.S, "Optimal Control System", CRC Press, 2003
2. Kirk D.E, "Optimal Control Theory", Dover publication, 2004
3. Lewis F.L. Draguna Vrabia, Syrmos V.L, "Optimal control", John Wiley & sons, 2012.

PS5073	ELECTRIC VEHICLES AND POWER MANAGEMENT	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand the concept of electrical vehicles and its operations
- To understand the need for energy storage in hybrid vehicles
- To provide knowledge about various possible energy storage technologies that can be
- used in electric vehicles

UNIT I ELECTRIC VEHICLES AND VEHICLE MECHANICS 9

Electric Vehicles (EV), Hybrid Electric Vehicles (HEV), Engine ratings, Comparisons of EV with internal combustion Engine vehicles, Fundamentals of vehicle mechanics

UNIT II ARCHITECTURE OF EV's AND POWER TRAIN COMPONENTS 9

Architecture of EV's and HEV's – Plug-n Hybrid Electric Vehicles (PHEV)- Power train components and sizing, Gears, Clutches, Transmission and Brakes

UNIT III CONTROL OF DC AND AC DRIVES 9

DC/DC chopper based four quadrant operations of DC drives – Inverter based V/f Operation (motoring and braking) of induction motor drive system – Induction motor and permanent motor based vector control operation – Switched reluctance motor (SRM) drives

UNIT IV BATTERY ENERGY STORAGE SYSTEM 9

Battery Basics, Different types, Battery Parameters, Battery modeling, Traction Batteries

UNIT V ALTERNATIVE ENERGY STORAGE SYSTEMS 9

Fuel cell – Characteristics- Types – hydrogen Storage Systems and Fuel cell EV – Ultra capacitors

TOTAL : 45 PERIODS

OUTCOMES:

Learners will understand the operation of Electric vehicles and various energy storage technologies for electrical vehicles

REFERENCES

1 Iqbal Hussain, "**Electric and Hybrid Vehicles: Design Fundamentals, Second**

Edition” CRC Press, Taylor & Francis Group, Second Edition (2011).

2 Ali Emadi, Mehrdad Ehsani, John M.Miller, “Vehicular Electric Power Systems”, Special Indian Edition, Marcel dekker, Inc 2010.

PX5072	POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS	L	T	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 ELECTRONICS FOR SOLAR **9**

Block diagram of solar photo voltaic system : line commutated converters (inversion-mode) - Boost and buck-boost converters-selection of inverter, battery sizing, array sizing- standalone PV systems - Grid tied and grid interactive inverters- grid connection issues.

UNIT IV POWER ELECTRONICS FOR WIND **9**

Three phase AC voltage controllers-AC-DC-AC converters: uncontrolled rectifiers, PWM Inverters, matrix converters- Stand alone operation of fixed and variable speed wind energy conversion systems- Grid connection Issues -Grid integrated PMSG and SCIG Based WECS.

UNIT V HYBRID RENEWABLE ENERGY SYSTEMS **9**

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

TOTAL : 45 PERIODS

Course Outcomes

After completion of this course, the student will be able to:

- Analyze the impacts of renewable energy generation on environment.
- Understand the importance and qualitative analysis of solar and wind energy sources.
- Apply the principle of operation of electrical machines for wind energy conversion and their performance characteristics.
- Design suitable power converters for solar PV and wind energy systems.

REFERENCES

1. S.N.Bhadra, D. Kastha, & S. Banerjee “Wind Electrical Systems”, Oxford University Press, 2009.
2. Rashid .M. H “power electronics Hand book”, Academic press, 2001.
3. Rai. G.D, “Non conventional energy sources”, Khanna publishes, 1993.
4. Rai. G.D,” Solar energy utilization”, Khanna publishes, 1993.
5. Gray, L. Johnson, “Wind energy system”, prentice hall linc, 1995.
6. B.H.Khan, " Non-conventional Energy sources", Tata McGraw-hill Publishing Company.
7. P.S.Bimbhra,“Power Electronics”,Khanna Publishers, 3rd Edition,2003.
8. Fang Lin Luo Hong Ye, " Renewable Energy systems", Taylor & Francis Group,2013.
9. R.Seyezhai and R.Ramaprabha, “Power Electronics for Renewable Energy Systems”, Scitech Publications, 2015.

IN5091	**SOFT COMPUTING TECHNIQUES**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

OBJECTIVES:

• To expose the concepts of feed forward neural networks.
• To provide adequate knowledge about feed back neural networks.
• To teach about the concept of fuzziness involved in various systems.
• To expose the ideas about genetic algorithm
• To provide adequate knowledge about of FLC and NN toolbox

UNIT I INTRODUCTION AND ARTIFICIAL NEURAL NETWORKS 9

Introduction to intelligent systems- Soft computing techniques- Conventional Computing versus Swarm Computing - Classification of meta-heuristic techniques - Properties of Swarm intelligent Systems - Application domain - Discrete and continuous problems - Single objective and multi-objective problems -Neuron- Nerve structure and synapse- Artificial Neuron and its model- activation functions- Neural network architecture- single layer and multilayer feed forward networks- Mc Culloch Pitts neuron model- perceptron model- Adaline and Madaline- multilayer perception model- back propogation learning methods- effect of learning rule coefficient -back propagation algorithm- factors affecting back propagation training- applications.

UNIT II ARTIFICIAL NEURAL NETWORKS AND ASSOCIATIVE MEMORY 9

Counter propagation network- architecture- functioning & characteristics of counter Propagation network- Hopfield/ Recurrent network configuration - stability constraints associative memory and characteristics- limitations and applications- Hopfield v/s Boltzman machine- Adaptive Resonance Theory- Architecture- classifications- Implementation and training - Associative Memory.

UNIT III FUZZY LOGIC SYSTEM 9

Introduction to crisp sets and fuzzy sets- basic fuzzy set operation and approximate reasoning. Introduction to fuzzy logic modeling and control- Fuzzification inferencing and defuzzification-Fuzzy knowledge and rule bases-Fuzzy modeling and control schemes for nonlinear systems. Self organizing fuzzy logic control- Fuzzy logic control for nonlinear time delay system.

UNIT IV GENETIC ALGORITHM 9

Evolutionary programs – Genetic algorithms, genetic programming and evolutionary programming - Genetic Algorithm versus Conventional Optimization Techniques - Genetic representations and selection mechanisms; Genetic operators- different types of crossover and mutation operators - Optimization problems using GA-discrete and continuous - Single objective and multi-objective problems - Procedures in evolutionary programming.

UNIT V HYBRID CONTROL SCHEMES 9

Fuzzification and rule base using ANN–Neuro fuzzy systems-ANFIS – Fuzzy Neuron - Optimization of membership function and rule base using Genetic Algorithm –Introduction to Support Vector Machine- Evolutionary Programming-Particle Swarm Optimization - Case study – Familiarization of NN, FLC and ANFIS Tool Box.

TOTAL : 45 PERIODS

OUTCOMES:

- 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 and support vector Regressive.
-

TEXT BOOKS:

1. Laurene V. Fausett, “Fundamentals of Neural Networks: Architectures, Algorithms And Applications”, Pearson Education.
2. Timothy J. Ross, “Fuzzy Logic with Engineering Applications” Wiley India, 2008.
3. Zimmermann H.J. "Fuzzy set theory and its Applications" Springer international edition, 2011.
4. David E.Goldberg, “Genetic Algorithms in Search, Optimization, and Machine Learning”, Pearson Education, 2009.
5. W.T.Miller, R.S.Sutton and P.J.Webrose, “Neural Networks for Control” MIT Press”, 1996.
6. T. Ross, “Fuzzy Logic with Engineering Applications”, Tata McGraw Hill, New Delhi, 1995.
7. Ethem Alpaydin, “Introduction to Machine Learning (Adaptive Computation and Machine Learning Series)”, MIT Press, 2004.
8. Corinna Cortes and V. Vapnik, " Support - Vector Networks, Machine Learning ” 1995.

IN5075	SYSTEM IDENTIFICATION AND ADAPTIVE CONTROL	L	T	P	C
		3	0	0	3

OBJECTIVES:

To give an overview on the different data driven identification methods

- To make the student understand the principles of relay based identification
- To enable the student to select a suitable model for identification
- To elaborate the concept of estimating the parameters of the selected
- models using parameter estimation algorithm
- To provide the background on the practical aspects of conducting experiments for real time system identification

UNIT I INTRODUCTION 9

System Identification - motivation and overview - Non-parametric methods: Impulse response, step response and Frequency response methods, correlation and spectral analysis methods.

UNIT II PARAMETER ESTIMATION METHODS 9

Parametric model structures-ARX, ARMAX, OE, BJ models -Linear regression -Least square estimates, statistical properties of LS Estimates. maximum likelihood estimation, Prediction error methods, Instrumental variable methods, Recursive Least squares method -Exercises using system identification toolbox.

UNIT III RELAY FEEDBACK IDENTIFICATION 9

A generalized relay feedback identification method – model; structure selection - relay feedback identification of stable processes: FOPDT and SOPDT model. Illustrative examples

UNIT IV CLOSED-LOOP IDENTIFICATION 9

Identification of systems operating in closed loop: Identifiability considerations – direct identification – indirect identification -Subspace Identification methods : classical and innovation forms, Joint input–output identification

UNIT V PRACTICAL ASPECTS OF IDENTIFICATION 9

Practical aspects: experimental design –input design for identification, notion for persistent excitation, drifts and de-trending–outliers and missing data –pre-filtering –Model validation and Model structure determination-case studies : identification of simple FOPDT and SOPDT systems.

TOTAL : 45 PERIODS

OUTCOMES:

- Ability to develop various models from the experimental data
- Will be able to select a suitable model and parameter estimation algorithm for the identification of systems
- Will be able to carry out the verification and validation of identified model
- Will gain expertise on using the model for prediction and simulation purposes and for developing suitable control schemes

TEXT BOOKS:

1. Karel J. Keesman, “System Identification an Introduction ”,Springer, 2011.
2. Lennart Ljung, “System Identification: Theory for the user”, Prentice Hall, Second edition, 1999.
3. Tao Liu, Furong Gao, “Industrial Process Identification and control design, Step-test and relay-experiment-based methods”, Springer-Verilog London Ltd, 2012.
4. T. S. Soderstrom, Petre G. Stoica, “System Identification”, Prentice Hall, 1989 .

PS5092 SOLAR AND ENERGY STORAGE SYSTEMS

L	T	P	C
3	0	0	3

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 - MPPT- 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

OUTCOMES:

- 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 modeling of different energy storage systems and their performances
- Students will attain more on different applications of solar energy

REFERENCES

1 Solanki C.S., “Solar Photovoltaics: Fundamentals, Technologies And Applications”, PHI Learning Pvt. Ltd.,2015.
2 Stuart R.Wenham, Martin A.Green, Muriel E. Watt and Richard Corkish, “Applied Photovoltaics”, 2007,Earthscan, UK.
Eduardo Lorenzo G. Araujo, “Solar electricity engineering of photovoltaic systems”, Progensa,1994.
3 Frank S. Barnes & Jonah G. Levine, “Large Energy storage Systems Handbook”, CRC Press, 2011.
4 McNeils, Frenkel, Desai, “Solar & Wind Energy Technologies”, Wiley Eastern, 1990
5 S.P. Sukhatme , “Solar Energy”, Tata McGraw Hill,1987.

EB5004 COMPUTER IN NETWORKING AND DIGITAL CONTROL

L	T	P	C
3	0	0	3

OBJECTIVES:

- To discuss on the fundamentals of Network Layers for Data Communications
- To teach the digital data communication techniques
- To teach Graphical programming using GUI for instrument building
- To study on internet based communication standards and working principles
- The case studies to be developed/ discussed in Virtual Environment Tools

UNIT I NETWORK FUNDAMENTALS 9

Data communication networking – Data transmission concepts – Communication networking - Overview of OSI- TCP/IP layers – IP addressing - DNS – Packet Switching – Routing – Fundamental concepts in SMTP, POP, FTP, Telnet, HTML, HTTP, URL, SNMP,ICMP.

UNIT II DATA COMMUNICATION 9

Sensor data acquisition, Sampling, Quantization, Filtering ,Data Storage, Analysis using compression techniques, Data encoding – Data link control – Framing, Flow and Error control, Point to point protocol, Routers, Switches , Bridges – MODEMs, Network layer – Congestion control , Transport layer- Congestion control, Connection establishment.

UNIT III VIRTUAL INSTRUMENTATION 9

Block diagram and Architecture – Data flow techniques – Graphical programming using GUI – Real time system – Embedded controller – Instrument drivers – Software and hardware simulation of I/O communication blocks – ADC/DAC – Digital I/O – Counter , Timer, Data communication ports.

UNIT IV MEASUREMENT AND CONTROL THROUGH INTERNET 9

Web enabled measurement and control-data acquisition for Monitoring of plant parameters through Internet – Calibration of measuring instruments through Internet, Web based control – Tuning of controllers through Internet

UNIT V VI BASED MEASUREMENT AND CONTROL 9

Simulation of signal analysis & controller logic modules for Virtual Instrument control – Case study of systems using VI for data acquisition, Signal analysis, controller design, Drives control.

TOTAL : 45 PERIODS

COURSE OUTCOMES

After completion of this course, the student will be able to:

- Comprehend the fundamentals of Network Layers for Data Communications.
- Attain knowledge on digital data communication techniques.
- Acquire knowledge on Graphical programming using GUI for instrument building.
- Attain knowledge on internet based communication standards and working principles.

TEXT BOOKS:

1. Wayne Tomasi, “Introduction to Data communications and Networking” Pearson Education, 2007.
2. Al Williams, “Embedded Internet Design”, Second Edition, TMH, 2007.
3. Douglas E.Comer, “Internetworking with TCP/IP, Vol. 1”, Third Edition, Prentice Hall, 1999.
4. Cory L. Clark, “LabVIEW Digital Signal Processing and Digital Communication”, TMH

edition 2005.
5. Behrouza A Forouzan,”Data Communications and Networking” Fourth edition, TMH, 2007.
6. Krishna Kant,”Computer based Industrial control”,PHI,2002.
7. Gary Johnson, “LabVIEW Graphical Programming”, Second edition, McGraw Hill, Newyork, 1997.
8. Kevin James, ”PC Interfacing and Data Acquisition: Techniques for measurement, Instrumentation and control, Newnes, 2000.
9. Cory L. Clark,”LabVIEW Digital Signal processing and Digital Communications” Tata McGRAW-HILL edition, 2005.

PX5071	WIND ENERGY CONVERSION SYSTEMS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To learn the design and control principles of Wind turbine.
- To understand the concepts of fixed speed and variable speed, wind energy conversion systems.
- To analyze the grid integration issues.

UNIT I INTRODUCTION 9

Components of WECS-WECS schemes-Power obtained from wind-simple momentum theory-Power coefficient-Sabinin’s theory-Aerodynamics of Wind turbine.

UNIT II WIND TURBINES 9

HAWT-VAWT-Power developed-Thrust-Efficiency-Rotor selection-Rotor design considerations-Tip speed ratio-No. of Blades-Blade profile-Power Regulation-yaw control-Pitch angle control-stall control-Schemes for maximum power extraction.

UNIT III FIXED SPEED SYSTEMS 9

Generating Systems- Constant speed constant frequency systems -Choice of Generators-Deciding factors-Synchronous Generator-Squirrel Cage Induction Generator- Model of Wind Speed- Model wind turbine rotor - Drive Train model- Generator model for Steady state and Transient stability analysis.

UNIT IV VARIABLE SPEED SYSTEMS 9

Need of variable speed systems-Power-wind speed characteristics-Variable speed constant frequency systems synchronous generator- DFIG- PMSG -Variable speed generators modeling - Variable speed variable frequency schemes

UNIT V GRID CONNECTED SYSTEMS 9

Wind interconnection requirements, low-voltage ride through (LVRT), ramp rate limitations, and supply of ancillary services for frequency and voltage control, current practices and industry trends wind interconnection impact on steady-state and dynamic performance of the power system including modeling issue.

TOTAL : 45 PERIODS

OUTCOMES:

- Acquire knowledge on the basic concepts of Wind energy conversion system.
- Understand the mathematical modeling and control of the Wind turbine
- Develop more understanding on the design of Fixed speed system

- Study about the need of Variable speed system and its modeling.
- Able to learn about Grid integration issues and current practices of wind interconnections with power system.

REFERENCES

1. L.L.Freris "Wind Energy conversion Systems", Prentice Hall, 1990
2. S.N.Bhadra, D.Kastha,S.Banerjee,"Wind Electrical Sytems",Oxford University Press,2010.
3. Ion Boldea, "Variable speed generators", Taylor & Francis group, 2006.
4. E.W.Golding "The generation of Electricity by wind power", Redwood burn Ltd.,Trowbridge,1976.
5. N. Jenkins," Wind Energy Technology" John Wiley & Sons,1997
6. S.Heir "Grid Integration of WECS", Wiley 1998.

IN5073	ROBUST CONTROL	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To introduce norms, random spaces and robustness measures.
- To educate the students on H2 optimal control and estimation techniques.
- To educate the students on H-infinity optimal control techniques.
- To educate the students on the LMI approach of H-infinity control.
- To educate the students 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 H2 optimal controllers – H2 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 – H-infinity 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 distillation column.

TOTAL : 45 PERIODS

OUTCOMES:

- Ability to design and detect sensor and actuators faults using structured residual approach as well as directional structured residual approach

- Ability to design and detect faults in sensor and actuators using GLR and MLR based Approaches
- Ability to explain various types of fault tolerant control schemes such as Passive and active approaches
- Ability to Design fault-tolerant control scheme in the presence of actuator failures

TEXT BOOKS:

1. Sinha A, “Linear Systems: Optimal and Robust Control”, CRC Press, 2007.
2. Da-Wei G, Petkov PH & Konstantinov MM “Robust Control Design with MATLAB”, New Age International, 2006.
3. Cheng D, Sun Y, Shen T & Ohmori H, “Advanced Robust And Adaptive Control Theory And Applications”, New Age International, 2010.
4. Green M & Limebeer DJN, “Linear Robust Control, Dover Publications Inc., 2012.
5. Xue D, Chen YQ & Atherton, DP, “Linear Feedback Control: Analysis and Design with MATLAB”, Society for Industrial and Applied Mathematics (SIAM), 2007.