R.M.K. ENGINEERING COLLEGE

(An Autonomous Institution)

R.S.M Nagar, Kavaraipettai, GummidipoondiTaluk,ThiruvallurDistrict,Tamil Nadu- 601206
Affiliated to Anna University, Chennai / Approved by AICTE, New Delhi/ Accredited by NAAC with A+ Grade
An ISO 9001:2015 Certified Institution / All the Eligible UG Programs are Accredited by NBA, New Delhi

Department of Electrical and Electronics Engineering
REGULATIONS – 2020
CHOICE BASED CREDIT SYSTEM

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs):

- The graduates of the program will have the ability and skills to use the latest technology and modern tools to design, develop and test power electronic converters and drives.
- The graduates of the program will have technical knowledge in power electronics and drives to be a competent professional in the industries and research organizations.
- The graduates of the program will demonstrate capability for life-long learning and research.
- The graduates of the program will serve as a professional with environmental and societal responsibility.

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PROGRAMME OUTCOMES (POs):

a. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

b. Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

c. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

d. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

e. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

f. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

g. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

h. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

i. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

j. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

k. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

l. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PEO / PO Mapping:

Programme Educational Objectives	Programme Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
I	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓
II	✓			✓	✓	✓	✓	✓	✓	✓		
III				✓	✓	✓		✓	✓			
IV	✓	✓	✓						✓	✓		

			PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
YEAR 1	**SEM 1**	Analysis of Electrical Machines		✓	✓		✓	✓						
		Analysis and Design of Power Converters	✓	✓			✓	✓						
		Modeling and Design of SMPS	✓	✓		✓	✓		✓					
		Professional Elective I												
		Open Elective I												
		Power Electronic Circuits Laboratory	✓	✓			✓				✓			
		Professional Skill Development								✓	✓	✓	✓	✓
	SEM 2	Analysis of Electrical Drives		✓	✓		✓	✓						
		Special Electrical Machines	✓	✓	✓		✓							
		Vector control of AC Machines	✓	✓	✓		✓							
		Program Elective II												
		Program Elective III												
		Open Elective II												
		Electrical Drives Laboratory			✓	✓	✓				✓	✓		
		Mini project with seminar						✓		✓		✓	✓	✓
YEAR 2	**SEM 3**	Program Elective IV												
		Program Elective V												
		Program Elective VI												
		Project Work Phase I	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
		Industry Internship	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	SEM 4	Project Work Phase II	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

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Department of Electrical and Electronics Engineering
REGULATIONS – 2020
CHOICE BASED CREDIT SYSTEM

M.E. POWER ELECTRONICS AND DRIVES(FULL TIME)
CURRICULUM AND SYLLABUS I TO IV SEMESTERS

SEMESTER I

S.No	COURSE CODE	COURSETITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	20EE121	Analysis of Electrical Machines	PC	4	2	2	0	3
2.	20EE122	Analysis and Design of Power Converters	PC	4	2	2	0	3
3.	20EE123	Modelling and Design of SMPS	PC	3	3	0	0	3
4.	20EE124	DSP Based System Design	PC	3	3	0	0	3
5.		Professional Elective I	PE	3	3	0	0	3
6.		Open Elective I	OE	3	3	0	0	3
PRACTICALS								
7.	20EE131	Power Electronics Circuits Lab	PC	4	0	0	4	2
8.	20EE132	Professional Skills Development	EEC	2	0	0	2	1
			TOTAL	**26**	**16**	**4**	**6**	**21**

SEMESTER II

S.No	COURSE CODE	COURSETITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	20EE221	Analysis of Electrical Drives	PC	3	3	0	0	3
2.	20EE222	Special Electrical Machines	PC	3	3	0	0	3
3.	20EE223	Vector Control of AC Machines	PC	5	3	2	0	4
4.		Open Elective II	OE	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.	20EE231	Electrical Drives Laboratory	PC	4	0	0	4	2
8.	20EE232	Mini Project and Technical Paper Writing	EEC	4	0	0	4	2
			TOTAL	**28**	**18**	**2**	**8**	**23**

SEMESTER III

S.No	COURSE CODE	COURSETITLE	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.	20EE331	Project Work Phase I	EEC	12	0	0	12	6
5.	20EE332	Industry Internship (2 to 4 weeks in II Sem)	EEC					1
			TOTAL	**21**	**9**	**0**	**12**	**16**

SEMESTERIV

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
PRACTICALS								
1.	20EE431	Project Work Phase II	EEC	24	0	0	24	12
			TOTAL	**24**	**0**	**0**	**24**	**12**

TOTAL NO. OF CREDITS: 72

PROFESSIONAL CORE (PC)

S.No	COURSE CODE	COURSETITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	20EE121	Analysis of Electrical Machines	PC	4	2	2	0	3
2.	20EE122	Analysis and Design of Power Converters	PC	4	2	2	0	3
3.	20EE123	Modelling and Design of SMPS	PC	3	3	0	0	3
4.	20EE124	DSP Based System Design	PC	3	3	0	0	3
5.	20EE221	Analysis of Electrical Drives	PC	3	3	0	0	3
6.	20EE222	Special Electrical Machines	PC	3	3	0	0	3
7.	20EE223	Vector Control of AC Machines	PC	5	3	2	0	4
8.	20EE131	Power Electronics Circuits Lab	PC	4	0	0	4	2
9.	20EE231	Electrical Drives Laboratory	PC	4	0	0	4	2

PROFESSIONAL ELECTIVES (PE)*

SEMESTER I
PROFESSIONAL ELECTIVES I

S.No	COURSE CODE	COURSETITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	20EE960	Soft Computing Techniques	PE	3	3	0	0	3
2.	20EE961	Electromagnetic Field Computation and Modelling	PE	3	3	0	0	3
3.	20EE962	Control System Design for Power Electronics	PE	3	3	0	0	3
4.	20EE963	Power Semiconductor Devices	PE	3	3	0	0	3

SEMESTER II
ELECTIVE II AND III

S.No	COURSE CODE	COURSETITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	20EE964	Analog and Digital Controllers	PE	3	3	0	0	3
2.	20EE965	Flexible AC Transmission Systems	PE	3	3	0	0	3
3.	20EE966	Modern Rectifiers and Resonant Converters	PE	3	3	0	0	3
4.	20EE967	Electromagnetic Interference and Compatibility	PE	3	3	0	0	3
5.	20EE968	MEMS Technology	PE	3	3	0	0	3
6.	20EE969	Distributed Generation and Microgrid	PE	3	3	0	0	3

SEMESTER III
ELECTIVE IV, V AND VI

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	20EE970	High Voltage Direct Current Transmission	PE	3	3	0	0	3
2.	20EE971	Solar and Energy Storage Systems	PE	3	3	0	0	3
3.	20EE972	Wind Energy Conversion Systems	PE	3	3	0	0	3
4.	20EE973	Energy Management and Auditing	PE	3	3	0	0	3
5.	20EE974	Electric Vehicles and Power Management	PE	3	3	0	0	3
6.	20EE975	Non Linear Dynamics for Power Electronics Circuits	PE	3	3	0	0	3
7.	20EE976	Smart Grid	PE	3	3	0	0	3
8.	20EE977	Power Electronics for Renewable Energy Systems	PE	3	3	0	0	3
9.	20EE978	Robotics and Control	PE	3	3	0	0	3
10.	20EE979	Non Linear Control	PE	3	3	0	0	3
11.	20EE980	Intelligent Controllers	PE	3	3	0	0	3
12.	20EE981	MEMS Design: Sensors and Actuators	PE	3	3	0	0	3
13.	20EE982	Disaster Management	PE	3	3	0	0	3
14.	20EE983	Automotive Embedded Systems	PE	3	3	0	0	3
15.	20EE984	Energy Efficient Buildings	PE	3	3	0	0	3
16.	20EE985	Unmanned Aerial Vehicle	PE	3	3	0	0	3

***Professional Electives are grouped according to elective number.**

EMPLOYABILITY ENHANCEMENT COURSES(EEC)

S.No	COURSE CODE	COURSETITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	20EE132	Professional Skills Development	EEC	2	0	0	2	1
2.	20EE232	Mini Project and Technical Paper Writing	EEC	4	0	0	4	2
3.	20EE332	Industry Internship	EEC					1
4.	20EE331	Project Work Phase I	EEC	12	0	0	12	6
5.	20EE431	Project Work Phase II	EEC	24	0	0	24	12

SUMMARY

M.E POWER ELECTRONICS AND DRIVES						
SL. NO.	SUBJECT AREA	CREDITS PER SEMESTER				TOTAL CREDITS
		I	II	III	IV	
1.	PC	14	12	0	0	**26**
2.	PE	3	6	9	0	**18**
3.	OE	3	3	0	0	**06**
5.	EEC	1	2	7	12	**22**
	Total Credits	**21**	**23**	**16**	**12**	**72**

SEMESTER I

20EE121 ANALYSIS OF ELECTRICAL MACHINES

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

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

UNIT I PRINCIPLES OF ELECTRO MAGNETIC ENERGY CONVERSION 9

Magnetic circuits, permanent magnet, stored magnetic energy, co-energy-force and torque in singly and doubly excited systems–machine windings and air gap mmf–determination of winding resistances and inductances of machine windings – determination of friction coefficient and moment of inertia of electrical machines.

UNIT II DC MACHINES 9

Elementary DC machine and analysis of steady state operation - Voltage and torque equations–dynamic characteristics of permanent magnet and shunt DC motors–electrical and mechanical time constants - Time domain block diagrams –transfer function of DC motor-responses – digital computer simulation of permanent magnet and shunt DC machines.

UNIT III REFERENCE FRAME THEORY 9

Historical background of Clarke and Park transformations – power invariance and phase transformation and commutator transformation – transformation of variables from stationary toarbitraryreferenceframe-variablesobservedfromseveralframesofreference.

UNIT IV INDUCTION MACHINES 9

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

UNIT V SYNCHRONOUS MACHINES 9

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

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of the course, students will be able to:

CO1: Ability to optimally design magnetic required in power supplies and drive systems.

CO2: Ability to acquire and apply knowledge of mathematics of machine dynamics in Electrical engineering.

CO3: Ability to model, simulate and analyze the dynamic performance of electrical machines using computational software.

CO4: Ability to formulate, design, simulate power supplies and loads for complete electrical machine performance

CO5: Ability to verify the results of the dynamic operation of electrical machine systems

TEXT BOOKS:

1. Paul C.Krause, Oleg Wasyzczuk, Scott S, Sudhoff, "Analysis of Electric Machinery and Drive Systems", John Wiley, Second Edition,2010.
2. R Ramanujam, "Modelling and Analysis of Electrical Machines", I.K International Publishing Pvt. Ltd., New Delhi,2018

REFERENCES:

1. P.S. Bimbhra,"GeneralizedTheoryofElectricalMachines",KhannaPublishers,2008.
2. A.E Fitzgerald, Charles Kingsley, Jr, and Stephan D, Umanx, " Electric Machinery", Tata McGraw Hill, 5thEdition,199

20EE122	ANALYSIS AND DESIGN OF POWER CONVERTERS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To provide the mathematical fundamentals necessary for deep understanding of power converter operating modes.
- To provide the electrical circuit concepts behind the different working modes of power converters so as to enable deep understanding of their operation.
- To provide required skills to formulate and design inverters for generic load and for machine loads.
- 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 PHASEAC-DC CONVERTER 9

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

UNIT II THREE PHASE AC-DC CONVERTER 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 overlap-12 pulse converter

UNIT III SINGLE PHASE INVERTERS 9

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

UNIT IV THREE PHASE INVERTERS 9

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

UNIT V MODERN INVERTERS 9

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

TOTAL : 45 PERIODS

COURSE OUTCOMES:

At the end of the course, students will be able to:

CO1: Ability to acquire and apply knowledge of mathematics in power converter analysis

CO2: Ability to model, analyze and understand power electronic systems and equipment

CO3: Ability to formulate, design and simulate phase controlled rectifiers for generic load and for machine loads

CO4: Ability to formulate, design, simulate switched mode inverters for generic load and for machine loads

CO5: Ability for device selection and calculation of performance parameters of power converters under various operating modes

TEXT BOOKS:

1. Rashid M.H., "Power Electronics Circuits, Devices and Applications ", Prentice Hall India, fourth Edition, New Delhi, 2014.
2. Jai P. Agrawal, "Power Electronics Systems", Pearson Education, Second Edition, 2002.
3. Bimal.K.Bose "Modern Power Electronics and AC Drives", Pearson Education, Second Edition, 2003.
4. Ned Mohan, T.M.Undeland and W.P.Robbins, "Power Electronics: converters, Application and design" John Wiley and sons. Wiley India edition, 2006.
5. Philip T. krein, "Elements of Power Electronics" Oxford University Press-1998

REFERENCES:

1. P.C.Sen, “Modern Power Electronics”, Wheeler Publishing Co,First Edition, New Delhi, 1998.
2. P.S.Bimbhra, “Power Electronics”, Khanna Publishers, Eleventh Edition, 2003.
3. Bin Wu, Mehdi Narimani, "High-power Converters and AC Drives", Wiley, 2nd Edition, 2017.

20EE123	MODELLING AND DESIGN OF SMPS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To perform steady state analysis of non-isolated DC-DC converter.
- To perform steady state analysis of isolated DC-DC converter.
- To understand different converter dynamics.
- To design controllers for DC- DC converters.
- To design magnetics for SMPS applications.

UNIT I ANALYSIS OF NON-ISOLATED DC-DC CONVERTERS 9

Buck, Boost, Buck- Boost and Cuk converters: Principles of operation – Continuous conduction mode–Concepts of volt–sec balance and charge balance– Analysis and design based on steady- state relationships – Introduction to discontinuous conduction mode other topologies, SEPIC topologies – design examples.

UNIT II ANALYSIS OF ISOLATED DC-DC CONVERTERS 9

Introduction-classification-forward-flyback-pushpull-halfbridge-fullbridgetopologies-designof SMPS

UNIT III CONVERTER DYNAMICS 9

AC equivalent circuit analysis – State space averaging – Circuit averaging – Averaged switch modeling–Transfer function model for buck ,boost, buck-boost and cuk converters–Input filters.

UNIT IV CONTROLLER DESIGN 9

Review of P, PI, and PID control concepts – gain margin and phase margin – Bode plot based analysis – Design of controller for buck, boost, buck-boost and cuk converters.

UNIT V DESIGN OF MAGNETICS 9

Basic magnetic theory revision – Inductor design – Design of mutual inductance – Design of transformer for isolated topologies – Ferrite core table and selection of area product – wire table – selection of wire gauge.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

At the end of the course, students will be able to:

CO1: Ability to design Non-Isolated DC-DC.

CO2 :Ability to design Isolated DC-DC converter.

CO3: Ability to derive transfer function of different converters.

CO4: Ability to design controllers for DC DC converters.

CO5: Ability to design magnetics for SMPS applications

TEXT BOOKS:

1. Robert W. Erickson & Dragon Maksimovic, " Fundamentals of Power Electronics", Second Edition, 2001 Springer science and Business media

REFERENCES:

1. John G. Kassakian, Martin F. Schlecht, George C. Verghese, "Principles of Power Electronics", Pearson, India, New Delhi, 2010.
2. Simon Ang and Alejandra Oliva, "Power-Switching Converters", CRC press, 3rd edition, 2011.
3. Philip T Krein, " Elements of Power Electronics", Oxford University Press, 2017.
4. Ned Mohan, "Power Electronics: A first course", John Wiley,2012.
5. Issa Batarseh, Ahmad Harb, "Power Electronics- Circuit Analysis and Design, Second edition.

20EE124	**DSP BASED SYSTEM DESIGN**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To provide the requisite knowledge for the designing of control/triggering/closed loop circuitry employing embedded controller readily available.
- To provide with the requisite knowledge for the interfacing of the digital controllers with power electronics system for better control.
- To understand the architecture, programming methods and their special features as relevant to PE Drives
- TounderstanddesignofDSPcontrolledsystemsespeciallyforthePEinterface.
- To provide knowledge about the digital implementation of conventional controllers.

UNIT I MOTOR CONTROL SIGNAL PROCESSORS 9

Introduction- Core architecture of 2000 family of Digital Signal Processors- System configuration registers - Memory mapping in microcontroller mode.

UNIT II ASSEMBLY LANGUAGE PROGRAMMING 9

Instruction set – Addressing modes-Programming techniques – simple programs: Arithmetic and interfacing examples, program using MAC, SQRA instruction, use of Look-Up Tables.

UNIT III PERIPHERALS OF SIGNAL PROCESSORS 9

General purpose Input / Output (GPIO) Functionality- Interrupts –Built in analog to digital converter and its sequence control.

UNIT IV EVENT MANAGER AND DRIVE CONTROL 9

Event Managers (EVA, EVB), Timers, full compare units, capture units- PWM signal generation- SVPWM features

UNIT V APPLICATIONS OF SIGNAL PROCESSORS 9

Voltage regulation of DC-DC converters- Stepper motor and DC motor control-Clarke's and parks transformation-Space vector PWM-Implementation of digital P, PI and PID controllers

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of the course, students will be able to:

CO1: Ability to understand the features in the core architecture of 2000 family DS Processors

CO2: Ability to write simple assembly language program using Digital signal processor instruction set

CO3: Ability to understand features relevant to power electronic drives in the DS Processors

CO4: Ability to write program for PWM signal generation using event manager ofDS processors.

CO5: Ability to develop programs for the embedded control of electrical drives.

TEXT BOOKS:

1. Hamid A.Toliyat, Steven Campbell, 'DSP based electromechanical motion control', CRC Press,2004.

REFERENCES:

1. SenM.Kuo, Bob H.Lee and WenshunTian, "Real-Time Digital Signal Processing: Implementations and Applications", Second Edition.
2. Avtar Singh, S. Srinivasan, "Digital Signal Processing Implementation", Thomson Press,2004.

20EE131	POWER ELECTRONIC CIRCUITS LABORATORY	L	T	P	C
		0	0	4	2

COURSE OBJECTIVES:

- To provide an insight on the switching behaviours of power electronic switches
- To make the students familiar with the digital tools used in generation of gate pulses for the power electronic switches
- To make the students capable of implementing analog interfacing as well as control circuits used in a closed-loop control for power electronic 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

3. DC source fed resistive load and Resistive-inductive load
4. DC source fed RLC load for different damping conditions
5. DC source fed DC motor load
6. Modeling and System simulation of basic power electronic circuits using MATLAB-SIMULINK/SCILAB
7. AC Source with Single Diode fed Resistive and Resistive-Inductive load
8. AC source with Single SCR fed Resistive and Resistive-Inductive load
9. Modeling and System Simulation of SCR based full converter with different types of load using MATLAB-Simulink /SCILAB
10. Full converter fed resistive load
11. Full converter fed Resistive-Back Emf (RE) load at different firing angles
12. Full Converter fed Resistive-Inductive Load at different firing angles
13. Full converter fed DC motor load at different firing angles
14. Circuit Simulation of Voltage Source Inverter and study of spectrum analysis with and without filter using MATLAB/SCILAB
15. Single phase square wave inverter
16. Three phase sine PWM inverter
17. Generation of PWM gate pulses with duty cycle control using PWM peripheral of microcontroller (TI-C2000 family/PIC18)
18. Duty cycle control from IDE
19. Duty Cycle control using a POT connected to ADC peripheral in a standalone mode
20. 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/PIC18)
21. Design of Driver Circuit usingIR2110
22. Design and testing of signal conditioning circuit to interface voltage/current sensor with microcontroller (TI-C2000 family/PIC18)
23. Interface Hall effect current sensor with microcontroller and display the current waveform in the IDE and validate with actual waveform in DSO
24. Interface Hall effect Voltage sensor with microcontroller and display the current waveform in the IDE and validate with actual waveform in DSO
25. Design of PI controller using OP-AMP
26. Construction and testing of 500 W, 220 V IGBT based Buck converter with control circuit and its performance Evaluation
27. Measurement of Efficiency at different duty cycle with a resistive load
28. Measurement of Efficiency at different duty cycle with a resistive-inductive load
29. PCB design and fabrication of DC power supply using any PCB design software (open source- KiCAD /students version)

TOTAL: 60 PERIODS

COURSE OUTCOMES

At the end of the course, students will be able to:

CO1: Comprehensive understanding on the switching behaviour of Power Electronic Switches

CO2: Comprehensive understanding on mathematical modeling of power electronic system and ability to implement the same using simulation tools

CO3: Ability of the student to use microcontroller and its associated IDE* for power electronic applications

CO4: Ability of the student to design and implement analog circuits for Power electronic control applications

CO5: Ability to design and fabricate a power converter circuit at an reasonable power level

CO6: Exposure to PCB designing and fabrication

* IDE – Integrate Development Environment (Code Composer Studio for Texas Instrument/MPLAB for PIC microcontrollers etc)

20EE132	**PROFESSIONAL SKILLS DEVELOPMENT**	**L**	**T**	**P**	**C**
		0	**0**	**2**	**1**

COURSE OBJECTIVES:

- Enhance the employability and career skills of students.
- Orient the students towards grooming as a professional.
- Make them employable graduates.
- Develop their confidence and help them attend interviews successfully.

TOPIC	**CONTENT**	**TIME LINE**
APTITUDE (MCQ Test)	Quantitative	Week 1
	Verbal	Week 2
	Logical Reasoning	Week 3
PROGRAMMING (Programming and MCQ Tests)	C	Week 4
	Python	Week 5
	Java	Week 6
	SQL	Week 7
	Data Structures	Week 8
SOFT SKILLS	Mock Interview	Week 9 and 10
	Group Discussion	Week 11 and 12

Aptitude and programming sessions will be conducted through Skillrack portal.

COURSE OUTCOMES:

At the end of the course learners will have the ability to:

CO1: Develop adequate aptitude and programming skills

CO2: Attend job interviews and be successful in them.

CO3: Develop adequate Soft Skills required for the workplace

CO4: Participate confidently in Group Discussions.

SEMESTER II

20EE221	ANALYSIS OF ELECTRICAL DRIVES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand steady state operation and transient dynamics of a motor load system
- To study and analyze the operation of the converter / chopper fed DC drive, both qualitatively and quantitatively
- To analyze and design the current and speed controllers for a closed loop solid state DC motor drive.
- To understand the drive characteristics for different load torque profiles and quadrants of operation
- To understand the speed control of induction motor drive from stator and rotor sides.
- To study and analyze the operation of VSI &CSI fed induction motor control and pulse width modulation techniques

UNIT I DC MOTORS FUNDAMENTALS AND MECHANICAL SYSTEMS 9

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

UNIT II CONVERTER ANDCHOPPERCONTROL 9

Principle of phase control– Fundamental relations; Analysis of series and separately excited DC motor with single-phase and three-phase converters – performance parameters, performance characteristics. Introduction to time ratio control and frequency modulation; chopper controlled DC motor – performance analysis, multi-quadrant control - Chopper based implementation of braking schemes; Related problems.

UNIT III CLOSED LOOP CONTROL 9

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

UNIT IV VSI AND CSI FED STATOR CONTROLLED INDUCTION MOTOR CONTROL 9

AC voltage controller–six step inverter voltage control- closed loop variable frequency PWM inverter fed induction motor (IM) with braking-CSI fed IM variable frequency motor drives – pulse width modulation techniques – simulation of closed loop operation of stator controlled induction motor drives.

UNIT V ROTOR CONTROLLED INDUCTION MOTOR DRIVES 9

Static rotor resistance control - injection of voltage in the rotor circuit – static

Scherbius drives – static and modified Kramer drives – sub-synchronous and super-synchronous speed operation of induction machines – simulation of closed loop operation of rotor controlled induction motor drives.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of the course learners will have the ability to:

CO1: Ability to acquire and apply knowledge of mathematics and converter/machine dynamics in Electrical engineering.

CO2: Ability to formulate, design, simulate power supplies for generic load and for machine loads.

CO3: Ability to analyze, comprehend, design and simulate direct current motor based adjustable speed drives.

CO4: Ability to analyze, comprehend, design and simulate induction motor based adjustable speed drives.

CO5: Ability to design a closed loop motor drive system with controllers for the current and speed control operations.

TEXT BOOKS:

1. Gopal K Dubey, "Power Semiconductor controlled Drives", Prentice Hall Inc., NewYersy,1989.
2. R.Krishnan, "Electric Motor Drives–Modeling, Analysis and Control", Prentice-Hall of India Pvt. Ltd., NewDelhi,2010.
3. Bimal K Bose, "Modern Power Electronics and AC Drives", Pearson Education Asia2002.

REFERENCES:

1. GopalK.Dubey, "Fundamentals of Electrical Drives", Narosal Publishing House, New Delhi, Second Edition,2009
2. Vedam Subramanyam, "Electric Drives–Concepts and Applications", TataMcGraw- Hill publishing company Ltd., New Delhi,2002.
3. P.C Sen "Thyristor DC Drives", John Wiely and sons, New York,1981.
4. W.Leonhard, "Control of Electrical Drives", Narosa Publishing House,1992
5. Murphy J.M.D and Turnbull, "Thyristor Control of AC Motors", Pergamon Press, Oxford,1988

20EE222	SPECIAL ELECTRICAL MACHINES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

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

UNIT I PERMANENT MAGNET BRUSHLESS DC MOTORS 9

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

UNIT II PERMANENT MAGNET SYNCHRONOUS MOTORS 9

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

UNIT III SWITCHED RELUCTANCE MOTORS 9

Constructional features –Principle of operation- Torque prediction–Characteristics Power controllers – Control of SRM drive- Sensor less 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

COURSE OUTCOMES:

At the end of the course learners will have the ability to:

CO1: Ability to model and analyze power electronic systems and equipment using computational software.

CO2: Ability to optimally design magnetics required in special machines based drive systems using FEM based software tools.

CO3: Ability to analyse the dynamic performance of special electrical machines

CO4: Ability to understand the operation and characteristics of other special electrical machines.

CO5: Ability to design and conduct experiments towards research.

TEXT BOOKS:

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

REFERENCES:

1. T. Kenjo and S. Nagamori, 'Permanent magnet and Brushless DC motors', Clarendon press, London,1988.
2. R.Krishnan, 'Electric motor drives', Prentice hall ofIndia, 2002.
3. D.P.Kothari and I.J.Nagrath, ' Electric machines', Tata McGraw hill publishing company, New Delhi, ThirdEdition,2004.
4. Irving L.Kosow, "Electric Machinery and Transformers" Pearson Education, Second Edition, 2007.

20EE223 VECTOR CONTROL OF AC MACHINES

L	T	P	C
3	2	0	4

COURSE OBJECTIVES:

- To study the space phasor model of alternating current machines.
- To understand the field oriented control for permanent magnet synchronous machines.
- To analyse the concept of vector control based salient pole machines.
- Toprovidetheknowledgeaboutconceptandcontroltechniquesofinductionmotor.
- To develop the flux oriented control circuit for induction motor.

UNIT I SPACE PHASOR MODEL OFAC MACHINES 12

Introduction-Smooth Air gap machine and salient pole machines- flux linkage space phasors- voltage equation- expression for electromagnetic torque.

UNIT II VECTOR CONTROL OF PM SYNCHRONOUS MACHINE 12

PMSM with surface mounted magnets- control scheme for of rotor oriented controlled PMSM with interior magnets-stator flux oriented control- rotor oriented control

UNIT III VECTOR CONTROL OF SALIENT POLE MACHINE WITH ELECTRICALLY EXCITED ROTOR 12

Magnetizing flux oriented control –variable frequency operation of salient pole synchronous machine-rotor oriented control of reluctance machines-considerations of the effects of main flux saturation

UNIT IV STATOR FLUX ORIENTED CONTROL OF INDUCTION MACHINE 12

Squirrel cage machine -Electromagnetic torque-voltage equations, doubly fed induction machines-control-static converter cascade, magnetizing flux oriented control of induction machine.

UNITV ROTOR FLUX ORIENTED CONTROL OFINDUCTIONMACHINE12

Control by a VSI – voltage equation-decoupling circuits- electromagnetic torque-voltage equations- current controlled PWM inverter- control by CSI – current controlled operation - control of slip ring induction machines

TOTAL: 60 PERIODS

COURSE OUTCOMES:

At the end of the course learners will have the ability to:

CO1: Ability to carry out space phasor model for electrical machines.
CO2: Ability to synthesis the vector controller for permanent magnet synchronous machines.
CO3: Ability to compute and analyse the controllers of salient pole machines.
CO4: Ability to understand and select the various control schemes suitable for induction motor.
CO5: The students acquire the flux oriented control concept of induction motor.

TEXT BOOKS:

1. Peter Vas, “Vector control of AC machines/Peter Vas”, Oxford [England]: Clarendon Press; New York: Oxford University Press, 1990.
2. BimalK.Bose, “Modern Power Electronics and AC Drives”, Prentice Hall PTR, 2002.

REFERENCES:
1. Peter Vas, "Sensorless Vector and Torque Control", Oxford University press, 1998.
2. · PaulC.Krause, Oleg Wasyzczuk, Scott S, Sudhoff, "Analysis of Electric Machinery and Drive Systems", John Wiley, Second Edition, 2010.

20EE231	**ELECTRICAL DRIVES LABORATORY**	**L**	**T**	**P**	**C**
		0	**0**	**4**	**2**

COURSE OBJECTIVES:

To impart the theoretical and practical knowledge on

- To design and analyse the various DC and AC drives.
- To generate the firing pulses for converters and inverters using digital processors
- Design of controllers for linear and nonlinear systems
- Implementation of closed loop system using hardware simulation

LIST OF EXPERIMENTS

1. Speed control of Converter fed DC motor.
2. Speed control of Chopper fed DC motor.
3. V/f control of three-phase induction motor.
4. Micro controller based speed control of Stepper motor.
5. Speed control of BLDC motor.
6. DSP based speed control of SRM motor.
7. Voltage Regulation of three-phase Synchronous Generator.
8. Cycloconverter fed Induction motor drives
9. Single phase Multi Level Inverter based induction motor drive
10. Study of power quality analyzer

TOTAL: 60 PERIODS

COURSE OUTCOMES:

At the end of the course learners will have the ability to:

CO1: Ability to simulate different types of machines, converters in as ystem.
CO2: Analyze the performance of various electric drive systems.
CO3: Ability to perform both hardware and software simulation.

20EE232	**MINI PROJECT AND TECHNICAL PAPER WRITING**	**L**	**T**	**P**	**C**
		0	**0**	**4**	**2**

COURSE OBJECTIVES:

- To develop the ability to solve a specific problem right from its identification and literature review till the successful solution of the same.
- To train the students in preparing project reports and to face reviews and viva voce examination.

A project to be developed based on one or more of the following concepts.

1. Rectifiers, DC-DC Converters, Inverters, cycloconverters, DC drives, AC drives, Special Electrical Machines, Renewable Energy Systems, Linear and non-linear control

systems, Power supply design for industrial and other applications, AC-DC power factor circuits, micro grid, smart grid and robotics.

MINI PROJECT weekly 3 hours

TECHNICAL PAPER WRITING weekly 1 hour

TECHNICAL PAPER WRITING

TOPICS	CONTENT	TIME LINE
Library Research	Identifying relevant publications of various journals in the field or area of specialization	Week 1
Title Selection	Analysing published papers and Selection of topic - Brainstorming topics, narrowing the scope, finalizing	Week 2
Review of literature	Preparation of review of literature –Accumulating research materials and organizing content	Week 3
Planning and Outlining	Preparation of framework of the intended work – guideline and objectives with timeline	Week 4
Finalizing framework	Preparation of draft abstract -final outlining of intended work	Week 5
Introduction	Preparation of introduction - explaining the prevalent situation, describing the problems and limitations,	Week 6
Body of the paper	Writing the paper based on the guideline - explaining the methods, processes, results with suitable figures and tables, conclusions and future scopes	Weeks 7, 8 and 9
Finalizing documentation	Revising and proofreading	Weeks 10 and 11
Presentation of the work	Paper Presentation in slides	Week 12

Evaluation:

Mini Project 80 %

Technical Paper Preparation 10%

Technical Paper Presentation 10%

TOTAL: 60 PERIODS

COURSE OUTCOMES:

At the end of the course learners will have the ability to:

- Acquire practical knowledge within the chosen area of technology for project development
- Identify, analyze, formulate and handle programming projects with a comprehensive and systematic approach
  - Contribute as an individual or in a team in development of technical projects
  - Develop effective communication skills for presentation of project related activities
- Develop skills for publication of technical papers

PROFESSIONAL ELECTIVES

SEMESTER I

ELECTIVE I

		L	T	P	C
20EE960	**SOFT COMPUTING TECHNIQUES**	**3**	**0**	**0**	**3**

COURSE OBJECTIVES:

• To expose the concepts of feed forward neural networks.
• To provide adequate knowledge about feedback 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

COURSE OUTCOMES:

At the end of the course learners will have the ability to:

CO1: Will be able to know the basic ANN architectures, algorithms and their limitations.
CO2: Also will be able to know the different operations on the fuzzy sets.
CO3: Will be capable of developing ANN based models and control schemes for non-linear system.
CO4: Will get expertise in the use of different ANN structures and online training algorithm.
CO5: Will be knowledgeable to use Fuzzy logic for modeling and control of non-linear systems.
CO6: 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.

20EE961 ELECTROMAGNETIC FIELD COMPUTATION AND MODELLING

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- To refresh the fundamentals of Electromagnetic Field Theory.
- To provide foundation in formulation and computation of Electromagnetic Fields using analytical and numerical methods.
- To impart in-depth knowledge on Finite Element Method in solving Electromagnetic field problems.
- To introduce the concept of mathematical modeling and design of electrical apparatus.

UNIT I INTRODUCTION 9

Review of basic field theory – Maxwell's equations – Constitutive relationships and Continuity equations – Laplace, Poisson and Helmholtz equation – principle of energy conversion – force/torque calculation.

UNIT II BASIC SOLUTION METHODS FOR FIELD EQUATIONS 9

Limitations of the conventional design procedure, need for the field analysis based design, problem definition, boundary conditions, solution by analytical methods-direct integration method – variable separable method – method of images, solution by numerical methods- Finite Difference Method.

UNIT III FORMULATION OF FINITE ELEMENTMETHOD (FEM) 9

Variational Formulation – Energy minimization – Discretization – Shape functions –Stiffness matrix – 1D and 2D planar and axial symmetry problems.

UNIT IV COMPUTATION OF BASIC QUANTITIES USINGFEM PACKAGES 9

Basic quantities – Energy stored in Electric Field – Capacitance – Magnetic Field – Linked Flux – Inductance – Force – Torque – Skin effect – Resistance.

UNI TV DESIGN APPLICATIONS 9

Design of Insulators – Cylindrical magnetic actuators – Transformers – Rotating machines

TOTAL : 45 PERIODS

COURSE OUTCOMES:

At the end of the course learners will have the ability to:

CO1: Understand the concepts of electromagnetic.
CO2: Ability to formulate the FEM method and use of the package
CO3: Apply the concepts in the design of rotating machines

REFERENCES

1. Matthew. N.O. Sadiku, "Elements of Electromagnetics", Fourth Edition, Oxford University Press, First Indian Edition2007
2. K.J.Binns, P.J.Lawrenson, C.W Trowbridge, "The analytical and numerical solution of Electric and magnetic fields", John Wiley & Sons,1993.
3. Nicola Biyanchi , "Electrical Machine analysis using Finite Elements", Taylor and Francis Group, CRC Publishers, 2005. 4
4. Nathan Ida, Joao P.A.Bastos , "Electromagnetics and calculation of fields", SpringerVerlage,1992.
5. S.J Salon, "Finite Element Analysis of Electrical Machines" Kluwer Academic Publishers, London, 1995, distributed by TBH Publishers & Distributors, Chennai,India

6. .Silvester and Ferrari, “Finite Elements for Electrical Engineers” Cambridge University press,1983.

20EE962 CONTROL SYSTEM DESIGN FOR POWER ELECTRONICS

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- To explore conceptual bridges between the fields of Control Systems and Power Electronics
- To Study Control theories and techniques relevant to the design of feedback controllers in Power Electronics

UNIT I MODELLING OF DC-TO-DCPOWERCONVERTERS 9

Modelling of Buck Converter , Boost Converter ,Buck-Boost Converter, Cuk Converter ,Sepic Converter, Zeta Converter, Quadratic Buck Converter ,Double Buck-Boost Converter, Boost- Boost Converter General Mathematical Model for Power Electronics Devices

UNIT II SLIDING MODECONTROLLERDESIGN 9

Variable Structure Systems. Single Switch Regulated Systems Sliding Surfaces, Accessibility of the Sliding SurfaceSliding Mode Control Implementation of Boost Converter ,Buck-Boost Converter, Cuk Converter ,Sepic Converter, Zeta Converter, Quadratic Buck Converter ,Double Buck-Boost Converter, Boost-Boost Converter

UNIT III APPROXIMATE LINEARIZATIONCONTROLLER DESIGN 9

Linear Feedback Control, Pole Placement by Full State Feedback , Pole Placement Based on Observer Design ,Reduced Order Observers , Generalized Proportional Integral Controllers, Passivity Based Control , Sliding Mode Control Implementation of Buck Converter , Boost Converter ,Buck-Boost Converter

UNIT IV NONLINEAR CONTROLLER DESIGN 9

Feedback Linearization Isidori’s Canonical Form ,Input-Output Feedback Linearization ,State Feedback Linearization,Passivity Based Control , Full Order Observers , Reduced Order Observers

UNIT V PREDICTIVE CONTROL OFPOWER CONVERTERS 9

Basic Concepts, Theory, and Methods, Application of Predictive Control in Power Electronics, AC-DC-AC Converter System, Faults and Diagnosis Systems in Power Converters.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

At the end of the course learners will have the ability to:

CO1: Ability to understand an overview on modern linear and nonlinear control strategies for power electronics devices
CO2: Ability to model modern power electronic converters for industrial applications
CO3: Ability to design appropriate controllers for modern power electronics devices.

REFERENCES

1. Hebertt Sira-Ramírez PhD, Ramón Silva-Ortigoza, “Control Design Techniques in Power Electronics Devices”, Springer2012
2. Mahesh Patil, PankajRodey, “Control Systems for Power Electronics: A Practical Guide”, Springer India,2015.
3. Blaabjerg José Rodríguez, “Advanced and Intelligent Control in Power Electronics and

Drives" , Springer,2014

4. Enrique Acha, VassiliosAgelidis, Olimpo Anaya, TJE Miller, "Power Electronic Control in Electrical Systems", Newnes, 2002

5. Marija D. Aranya Chakrabortty, Marija , "Control and Optimization Methods for Electric Smart Grids", Springer,2012.

20EE963	POWER SEMICONDUCTOR DEVICES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To select proper power semiconductor device for power electronic circuit applications.
- To understand the static and dynamic characteristics of current controlled power semiconductor devices.
- Tounderstandthestaticanddynamiccharacteristicsofvoltagecontrolledpower
- To understand the protection and firing circuit for different devices.
- To know about the wide band gap power switching devices.

UNIT I INTRODUCTION 9

Power switching devices overview– attributes of an ideal switch, application requirements, circuit symbols; Power handling capability – (SOA); Device selection strategy – On-state and switching losses – EMI due to switching - Power diodes - Types, forward and characteristics, switching characteristics –rating.

UNIT II CURRENT CONTROLLED DEVICES 9

BJT's – Construction, static characteristics, switching characteristics; Power Darlington- Thyristors–Physical and electrical principle underlying operating mode, Two transistor analogy–concept of latching; Gate and switching characteristics; converter grade and inverter grade and other types; series and parallel operation; comparison of BJT and Thyristor – steady state and dynamic models of BJT & Thyristor-driving circuit for BJT and Thyristor.

UNIT III VOLTAGE CONTROLLED DEVICES 9

Power MOSFETs and IGBTs – Principle of voltage controlled devices, construction, types, static and switching characteristics, steady state and dynamic models of MOSFET and IGBTs –driving circuits-Basics of GTO, MCT, FCT, RCT and IGCT.

UNIT IV DEVICE PROTECTION 9

Necessity of isolation- Overvoltage, overcurrent and gate protections; Design of snubbers. Heat transfer – conduction, convection and radiation; Cooling – liquid cooling, vapour – phase cooling; Guidance for heat sink selection–Electrical analogy of thermal components, heat sink types and design – Mounting types.

UNITV WIDE BANDGAP DEVICES 9

Features of silicon carbide and gallium nitride devices. SiC JFET- SiC MOSFET-GaN based transistors-Applications of SiC and GaN based devices.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of the course learners will have the ability to:

CO1: Ability to select the switching device suitable for given power electronic converter.
CO2: To be able to understand the principle of voltage controlled devices.
CO3: To be able to understand the principle of current controlled devices.
CO4: Ability to understand the control protection and firing circuits required for different switching devices
CO5: Ability to know about wide band gap devices.

TEXTBOOKS:

1. B.W Williams 'Power Electronics Circuit Devices and Applications'.
2.Rashid M.H., "Power Electronics Circuits, Devices and Applications ", Prentice Hall India, Third Edition, New Delhi, 2004.
3. B. JayantBaliga, Silicon Carbide Power Devices, World Scientific,2005
4. Josef Lutz, Heinrich Schlangenotto, UweScheuermann, Rik De Doncker, Semiconductor Power Devices Physics, Characteristics, Reliability, Second Edition,Springer,2018.

REFERENCES:

1. Robert Perret, Power Electronics Semiconductor Devices, ISTE Ltd,2009
2. Mohan, Undeland and Robins, "Power Electronics – Concepts, applications and Design, John Wiley and Sons, Singapore, 2000.
3. AlexLidow, Johan Strydom, Michael de Rooij, David Reusch, GaNTransistors for Efficient Power Conversion, Second Edition, Wiley, 2015.

20EE964	ANALOG AND DIGITAL CONTROLLERS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- To provide a overview of the control system and converter control methodologies
- To provide an insight to the analog controllers generally used in practice
- To introduce embedded processors for digital control
- To study on the driving techniques, isolation requirements, signal conditioning and protection methods
- To provide a Case Study by implementing an analog and a digital controller on a converter

UNIT I CONTROL SYSTEM-OVERVIEW 9

Feedback and Feed-forward control, Right Half Plane Zero, Gain margin and Phase Margin, Stability, Analysis and Transfer function of PI and PID controllers and its effects. Voltage mode control, Peak Current mode Control, Average Current mode Control for Converters – Need, advantages and disadvantages.

UNIT II ANALOG CONTROLLERS 9

Major components of a controller – Op-Amp based PI and PID controller – Proportional, Integral and Differential gains in terms of Resistance and Capacitance, Error Amplifiers, PWM generator using Ramp or Triangular generator and comparator, and Driver, Voltage mode controller design using

UC3524, Peak Current mode controller design using UC3842, Average Current mode controller design using UC3854.

UNIT III DIGITAL CONTROLLERS 9

Micro Controllers and Digital Signal Controllers for Converter Control Application, Interface Modules for Converter Control – A/D, Capture, Compare and PWM, Analog Comparators for instantaneous over current detection, interrupts, Discrete PI and PID equations, Algorithm for PI and PID implementation, Example Code for PWM generation.

UNIT IV SIGNAL CONDITIONING, DRIVER, ISOLATION AND PROTECTION 9

Voltage feedback sensing circuits, Hall effect sensors and Shunts for current feedback sensing, Low offset Op-Amps for signal conditioning, Single and dual supply op-amps, Totem pole drivers, Need for isolated drivers, Optically isolated drivers, low side drivers, high side drivers with bootstrap power supply, Vce sat sensing, CT based Device current sensing and pulse blocking.

UNIT V CONTROLLER IMPLEMENTATION 9

Analog and Digital Controller Design for Buck Converter – Power circuit transfer function and bode plot, PI controller bode plot, Combined bode plot with required Gain and Phase margins, Implementation of Analog controller and Digital controller.

TOTAL : 45 PERIODS

REFERENCES

1. I.J. Nagrath and M. Gopal, "Control Systems Engineering", New Age International Publishers
2. TI Application notes, Reference Manuals and Data Sheets.
3. Agilent Data Sheets
4. Microchip Application notes, Reference Manuals and Data Sheets.

SEMESTER II

ELECTIVES II and III

20EE965	FLEXIBLE AC TRANSMISSION SYSTEMS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To emphasis the need for FACTS controllers.
- To learn the characteristics, applications and modelling of series and shunt FACTS controllers.
- To analyze the interaction of different FACTS controller and perform control coordination

UNIT I INTRODUCTION 9

Review of basics of power transmission networks-control of power flow in AC transmission line Analysis of uncompensated AC Transmission line- Passive reactive power compensation: Effect of series and shunt compensation at the mid-point of the line on power transfer- Need for FACTS controllers- types of FACTS controllers.

UNIT II STATIC VAR COMPENSATOR (SVC) 9

Configuration of SVC- voltage regulation by SVC- Modelling of SVC for load flow analysis Modelling of SVC for stability studies-Design of SVC to regulate the mid-point voltage of a SMIB system-Applications: transient stability enhancement and power oscillation damping of SMIB system with

SVC connected at the mid-point of the line.

UNIT III THYRISTOR AND GTO THYRISTOR CONTROLLED SERIES CAPACITORS (TCSC and GCSC) 9

Concepts of Controlled Series Compensation – Operation of TCSC and GCSC- Analysis of TCSC-GCSC – Modelling of TCSC and GCSC for load flow studies- modeling TCSC and GCSC for stability studied- Applications of TCSC and GCSC.

UNIT IV VOLTAGE SOURCE CONVERTER BASED FACTS CONTROLLERS 9

Static synchronous compensator(STATCOM)- Static synchronous series compensator(SSSC)-

Operation of STATCOM and SSSC-Power flow control with STATCOM and SSSC- Modelling of STATCOM and SSSC for power flow and transient stability studies –operation of Unified and Interline power flow controllers(UPFC and IPFC)- Modelling of UPFC and IPFC for load flow and transient stability studies- Applications.

UNIT V CONTROLLERS AND THEIR COORDINATION 9

FACTS Controller interactions – SVC–SVC interaction - co-ordination of multiple controllers using linear control techniques – Quantitative treatment of control coordination.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

At the end of the course learners will have the ability to:

CO1: Ability to understand the operation of the compensator and its applications in power system.
CO2: Ability to understand the various emerging Facts controllers.
CO3: Ability to know about the genetic algorithm used in Facts controller coordination.

REFERENCES

1. A.T.John, "Flexible AC Transmission System", Institution of Electrical and Electronic Engineers (IEEE),1999.
2. NarainG.Hingorani, Laszio. Gyugyl, "Understanding FACTS Concepts and Technology of Flexible AC Transmission System", Standard Publishers, Delhi2001.
3. V. K.Sood, "HVDC and FACTS controllers- Applications of Static Converters in Power System", 2004, Kluwer AcademicPublishers.
4. Mohan Mathur, R., Rajiv. K. Varma, "Thyristor – Based Facts Controllers for Electrical Transmission Systems", IEEE press and John Wiley & Sons,Inc.
5. K.R.Padiyar," FACTS Controllers in Power Transmission and Distribution", New Age International(P) Ltd., Publishers New Delhi, Reprint2008,

20EE966	MODERN RECTIFIERS AND RESONANT CONVERTERS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To gain knowledge about the harmonics standards and operation of rectifiers in CCM & DCM.
- To analyze and design power factor correction rectifiers for UPS applications.
- To know the operation of resonant converters for SMPS applications.
- To carry out dynamic analysis of DC- DC Converters.

- To introduce the source current shaping methods for rectifiers

UNIT I POWER SYSTEM HARMONICS & LINE COMMUTATED RECTIFIERS 9

Average power- RMS value of waveform– Effect of Power factor-. current and voltage harmonics – Effect of source and load impedance - AC line current harmonic standards IEC1000-IEEE 519-CCM and DCM operation of single phase full wave rectifier- Behaviour of full wave rectifier for large and small values of capacitance - CCM and DCM operation of three phase full wave rectifier- 12 pulse converters - Harmonic trap filters.

UNIT II PULSE WIDTH MODULATED RECTIFIERS 9

Properties of Ideal single phase rectifiers-Realization of nearly ideal rectifier-. Single-phase converter systems incorporating ideal rectifiers - Losses and efficiency in CCM high quality rectifiers -single-phase PWM rectifier -PWM concepts - device selection for rectifiers - IGBT based PWM rectifier, comparison with SCR based converters with respect to harmonic content - applications of rectifiers.

UNIT III RESONANTCONVERTERS 9

Soft Switching - classification of resonant converters - Quasi resonant converters- basics of ZVS and ZCS- half wave and full wave operation (qualitative treatment) - multi resonant converters - operation and analysis of ZVS and ZCS multi resonant converter - zero voltage transition PWM converters -zero current transition PWM converters

UNIT IV DYNAMIC ANALYSIS OF SWITCHING CONVERTERS 9

Review of linear system analysis-State Space Averaging-Basic State Space Average Model- State Space Averaged model for an ideal Buck Converter, ideal Boost Converter, ideal Buck Boost Converter and an ideal Cuk Converter. Pulse Width modulation - Voltage Mode PWM Scheme - Current Mode PWM Scheme - design of PI controller.

UNITV SOURCE CURRENT SHAPING OF RECTIFIERS 9

Need for current shaping - power factor - functions of current shaper - input current shaping methods - passive shaping methods -input inductor filter - resonant input filter - active methods - boost rectifier employing peak current control - average current control - Hysteresis control- Nonlinear carrier control.

TOTAL 45 PERIODS

COURSE OUTCOMES:

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

CO1: Apply the concept of various types of rectifiers.
CO2: Simulate and design the operation of resonant converter and its importance.
CO3: Identify the importance of linear system, state space model, PI controller.
CO4: Design the DC power supplies using advanced techniques.
CO5: Understand the standards for supply current harmonics and its significance.

REFERENCES

1. Robert W. Erickson and Dragon Maksimovic, "Fundamentals of Power Electronics", Second Edition, Springer science and Business media,2001.
2. William Shepherd and Li zhang, "Power Converters Circuits", MarceldEkkerin,C,2005.
3. Simon Ang and Alejandro Oliva, "Power Switching Converters", Taylor & Francis Group, 2010.
4. Andrzej M. Trzynadlowski, " Introduction To Modern Power Electronics", John Wiley & Sons, 2016.
5. Marian.K.Kazimierczuk and DariuszCzarkowski, "Resonant Power Converters", John Wiley &

Sons limited,2011.
6 Keng C .Wu, "Switch Mode Power Converters – Design and Analysis" Elseveir academic press,2006.
7 Abraham I.Pressman, Keith Billings and Taylor Morey, " Switching Power Supply Design" McGraw-Hill,2009
8 V.Ramanarayanan, "Course Material on Switched Mode Power Conversion" IISC, Banglore, 2007.
9 Christophe P. Basso, Switch-Mode Power Supplies, McGraw-Hill,2014

20EE967 ELECTROMAGNETIC INTERFERENCE AND COMPATIBILITY

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

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

UNIT I INTRODUCTION 9

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

UNIT II GROUNDINGAND CABLING 9

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

UNIT III BALANCING, FILTERING AND SHIELDING 9

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

UNIT IV EMI IN ELEMENTS AND CIRCUITS 9

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

UNIT V ELECTROSTATIC DISCHARGE, STANDARDS AND TESTING TECHNIQUES 9

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

TOTAL : 45 PERIODS

COURSE OUTCOMES:

At the end of the course learners will have the ability to:

CO1: Recognize the sources of Conducted and radiated EMI in Power Electronic Converters and consumer appliances and suggest remedial measures to mitigate the problems
CO2: Assess the insertion loss and design EMI filters to reduce the loss
CO3: Design EMI filters, common-mode chokes and RC-snubber circuits measures to keep the interference within tolerable limits

REFERENCES

1. V.P. Kodali, "Engineering Electromagnetic Compatibility", S. Chand,1996
2. Henry W.Ott, " Noise reduction techniques in electronic systems", John Wiley & Sons, 1989
3. Bernhard Keiser, "Principles of Electro-magnetic Compatibility", Artech House, Inc. (685 canton street, Norwood, MA 020062 USA)1987
4. Bridges, J.E Milleta J. and Ricketts.L.W., "EMP Radiation and Protective techniques", John Wiley and sons, USA1976
5. William Duff G., & Donald White R. J, "Series on Electromagnetic Interference and Compatibility", Vol.
6. Weston David A., "Electromagnetic Compatibility, Principles and Applications", 1991.
7.

20EE968	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

Piezo resistive 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

COURSE OUTCOMES :

At the end of the course learners will have the ability to:

CO1: Understand basics of micro fabrication, develop models and simulate electrostatic and electromagnetic sensors and actuators

CO2: Understand material properties important for MEMS system performance, analyze dynamics of resonant micro mechanical structures

CO3: The learning process delivers insight onto design of micro sensors, embedded sensors & actuators in power aware systems like grid.

CO4: Understand the design process and validation for MEMS devices and systems, and learn the state of the art in optical micro systems

CO5: 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.

20EE969	DISTRIBUTED GENERATION AND MICROGRID	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To illustrate the concept of distributed generation
- To analyze the impact of grid integration.
- To study concept of Microgrid and its configuration

UNIT I INTRODUCTION 9

Conventional power generation: advantages and disadvantages, Energy crises, Non- conventional energy (NCE) resources: review of Solar PV, Wind Energy systems, Fuel Cells, micro-turbines, biomass, and tidal sources.

UNIT II DISTRIBUTED GENERATIONS (DG) 9

Concept of distributed generations, topologies, selection of sources, regulatory standards/ framework, Standards for interconnecting Distributed resources to electric power systems: IEEE

1547. DG installation classes, security issues in DG implementations. Energy storage elements: Batteries, ultra-capacitors, flywheels. Captive power plants

UNIT III IMPACT OF GRID INTEGRATION 9

Requirements for grid interconnection, limits on operational parameters,: voltage, frequency, THD, response to grid abnormal operating conditions, islanding issues. Impact of grid integration with NCE sources on existing power system: reliability, stability and power quality issues.

UNIT IV BASICS OF A MICROGRID 9

Concept and definition of microgrid, microgrid drivers and benefits, review of sources of microgrids, typical structure and configuration of a microgrid, AC and DC microgrids, Power Electronics interfaces in DC and AC microgrids

UNIT V CONTROL AND OPERATION OF MICROGRID 9

Modes of operation and control of microgrid: grid connected and islanded mode, Active and reactive power control, protection issues, anti-islanding schemes: passive, active and communication based techniques, microgrid communication infrastructure, Power quality issues in microgrids, regulatory standards, Microgrid economics, Introduction to smart microgrids.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of the course learners will have the ability to:

CO1: Learners will attain knowledge on the various schemes of conventional and nonconventional power generation.

CO2: Learners will have knowledge on the topologies and energy sources of distributed generation.

CO3: Learners will learn about the requirements for grid interconnection and its impact with NCE sources

CO4: Learners will understand the fundamental concept of Microgrid.

REFERENCES

1. Amirnaser Yezdani, and Reza Iravani, "Voltage Source Converters in Power Systems: Modeling, Control and Applications", IEEE John Wiley Publications,2010.
2. DorinNeacsu, "Power Switching Converters: Medium and High Power", CRC Press, Taylor & Francis,2006
3. Chetan Singh Solanki, "Solar Photo Voltaics", PHI learning Pvt. Ltd., NewDelhi,2009
4. J.F. Manwell, J.G. McGowan "Wind Energy Explained, theory design and applications", Wiley publication2010.
5. D. D. Hall and R. P. Grover, "Biomass Regenerable Energy", John Wiley, New York, 1987.
6. John Twidell and Tony Weir, "Renewable Energy Resources" Tyalor and Francis Publications, Second edition 2006.

SEMESTER III
ELECTIVES IV, V and VI

20EE970 HIGH VOLTAGE DIRECT CURRENT TRANSMISSION

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- To impart knowledge on operation, modelling and control of HVDC link.
- To perform steady state analysis of AC/DC system.
- To expose various HVDC simulators.

UNIT I DC POWER TRANSMISSION TECHNOLOGY 9

Introduction - Comparison of AC and DC transmission – Application of DC transmission – Description of DC transmission system - Planning for HVDC transmission – Modern trends in DC transmission – DC breakers – Cables, VSC based HVDC.

UNIT II THYRISTOR BASED HVDC CONVERTERS AND HVDC SYSTEM CONTROL 9

Pulse number, choice of converter configuration – Simplified analysis of Graetz circuit - Converter bridge characteristics – characteristics of a twelve pulse converter- detailed analysis of converters. General principles of DC link control – Converter control characteristics – System control hierarchy - Firing angle control – Current and extinction angle control – Generation of harmonics and filtering - power control – Higher level controllers-Valve tests.

UNIT III MULTITERMINAL DC SYSTEMS 9

Introduction – Potential applications of MTDC systems - Types of MTDC systems - Control and protection of MTDC systems - Study of MTDC systems.

UNIT IV POWER FLOW ANALYSIS IN AC/DC SYSTEMS 9

Per unit system for DC Quantities - Modelling of DC links - Solution of DC load flow - Solution of AC-DC power flow – Unified, Sequential and Substitution of power injection method

UNIT V SIMULATION OF HVDC SYSTEMS 9

Introduction – DC LINK Modelling , Converter Modeling and State Space Analysis , Philosophy and tools – HVDC system simulation, Online and OFFline simulators –– Dynamic interactions between DC and AC systems.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

At the end of the course, students will be able to:

CO1: Understand the concept, planning of DC power transmission and comparison with AC power transmission.
CO2: Analyze HVDC converters.
CO3: Understand about MTDC system.
CO4: Analyze harmonics and design of filters.
CO5: Understand about HVDC cables and reactive power control.
CO6: Apply concepts for simulation of HVDC systems

REFERENCES

1 P. Kundur, "Power System Stability and Control", McGraw-Hill, 2014
2 K.R.Padiyar, , "HVDC Power Transmission Systems", New Age International (P) Ltd., New Delhi, 2017
3 J.Arrillaga, , "High Voltage Direct Current Transmission", Peter Pregrinus, London, 1998
4 Erich Uhlmann, " Power Transmission by Direct Current", BS Publications, 2004.
5 V.K.Sood,HVDC and FACTS controllers – Applications of Static Converters in Power System, , Kluwer Academic Publishers, 2013.

20EE971	**SOLAR AND ENERGY STORAGE SYSTEMS**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

•To study about solar modules and PV system design and their applications
•To deal with grid connected PV systems
•To discuss about different energy storage systems

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

UNIT II STAND ALONE PV SYSTEM 9
Solar modules – storage systems – power conditioning and regulation - MPPT- protection – standalone 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

COURSE OUTCOMES:
At the end of the course, students will be able to:
CO1: Develop more understanding on solar energy storage systems
CO2: Develop basic knowledge on standalone PV system
CO3: Understand the issues in grid connected PV systems
CO4: Understand about the modeling of different energy storage systems and their performances
CO5: Interpret 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.
3. Eduardo Lorenzo G. Araujo, "Solar electricity engineering of photovoltaic systems", Progensa, 1994.
4. Frank S. Barnes & Jonah G. Levine, "Large Energy storage Systems Handbook", CRC Press, 2011.
5. McNeils, Frenkel, Desai, "Solar & Wind Energy Technologies", Wiley Eastern, 1990
6. S.P. Sukhatme, "Solar Energy", Tata McGraw Hill, 2017.

20EE972	WIND ENERGY CONVERSION SYSTEMS	L	T	P	C
		3	0	0	3

COURSE 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 modelling - 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

COURSE OUTCOMES:

At the end of the course, students will be able to:

CO1: Acquire knowledge on the basic concepts of Wind energy conversion system.
CO2: Understand the mathematical modeling and control of the Wind turbine
CO3: Develop more understanding on the design of fixed speed system
CO4: Study about the need of Variable speed system and its modeling.
CO5: Understand 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,2018.
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.

20EE973	ENERGY MANAGEMENT AND AUDITING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:
•To study the concepts behind economic analysis and Load management.
•To emphasize the energy management on various electrical equipment and metering.
•To illustrate the concept of lighting systems and cogeneration.

UNIT I INTRODUCTION 9
Need for energy management - energy basics- designing and starting an energy management program – energy accounting -energy monitoring, targeting and reporting-energy audit process.

UNIT II ENERGY COST AND LOAD MANAGEMENT 9
Important concepts in an economic analysis - Economic models-Time value of money-Utility rate structures- cost of electricity-Loss evaluation- Load management: Demand control techniques-Utility monitoring and control system-HVAC and energy management-Economic justification.

UNIT III ENERGY MANAGEMENT FOR MOTORS, SYSTEMS, AND ELECTRICAL EQUIPMENT 9
Systems and equipment- Electric motors-Transformers and reactors-Capacitors and synchronous machines.

UNIT IV METERING FOR ENERGY MANAGEMENT 9
Relationships between parameters-Units of measure-Typical cost factors- Utility meters - Timing of meter disc for kilowatt measurement - Demand meters - Paralleling of current transformers - Instrument transformer burdens-Multitasking solid-state meters - Metering

location vs. requirements- Metering techniques and practical examples.

UNIT V LIGHTING SYSTEMS & COGENERATION 9

Concept of lighting systems - The task and the working space -Light sources - Ballasts - Luminaries - Lighting controls-Optimizing lighting energy - Power factor and effect of harmonics on power quality - Cost analysis techniques-Lighting and energy standards Cogeneration: Forms of cogeneration - feasibility of cogeneration- Electrical interconnection.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

At the end of the course, students will be able to:

CO1: Understand about the need for energy management and auditing process

CO2: Understand basic concepts of economic analysis and load management.

CO3: Understand the energy management on various electrical equipment.

CO4: Interpret the concepts of metering and factors influencing cost function

CO5: Interpret the concept of lighting systems, light sources and various forms of cogeneration

REFERENCES

1. Barney L. Capehart, Wayne C. Turner, and William J. Kennedy, "Guide to Energy Management", Fifth Edition, The Fairmont Press, Inc., 2016

2. Eastop T.D & Croft D.R, "Energy Efficiency for Engineers and Technologists", Logman Scientific & Technical, 1990.

3. Reay D.A, "Industrial Energy Conservation", 1st edition, Pergamon Press, 1979.

"IEEE Recommended Practice for Energy Management in Industrial and Commercial Facilities", IEEE, 1996

4. Amit K. Tyagi, "Handbook on Energy Audits and Management", TERI, 2009.

20EE974	ELECTRIC VEHICLES AND POWER MANAGEMENT	L	T	P	C
		3	0	0	3

COURSE 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 beused 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

COURSE OUTCOMES:

At the end of the course, students will be able to:

CO1: At the end of the course, students will be able to:

CO2: Understand the operation of electric vehicles

CO3: Interpret various electric vehicles architectures and power train components

CO4: Apply control of DC and AC drives for electrical vehicles

CO5: Analyze various energy storage technologies for electrical vehicles

CO6: Interpret alternate energy storage systems for electric vehicles

REFERENCES:

1 Iqbal Hussain, "Electric and Hybrid Vehicles: Design Fundamentals, Second Edition" CRC Press, Taylor & Francis Group, Second Edition, 2013.

2 Ali Emadi, MehrdadEhsani, John M.Miller, "Vehicular Electric Power Systems", Special Indian Edition, Marcel dekker, Inc, 2010.

		L	T	P	C
20EE975	**NON LINEAR DYNAMICS FOR POWER ELECTRONIC CIRCUITS**	**3**	**0**	**0**	**3**

COURSE OBJECTIVES:

- To determine the non-linear phenomena
- To analyze the behavior of non-linearity in DC-DC Converters
- To understand the concepts of chaos in power converters.

UNIT I BASICS OF NONLINEAR DYNAMICS 9

Basics of Nonlinear Dynamics: System, state and state space model, Vector field- Modeling of Linear, nonlinear and Linearized systems, Attractors , chaos, Poincare map, Dynamics of Discrete time system, Lyapunov Exponent, Bifurcations, Bifurcations of smooth map, Bifurcations in piece wise smooth maps, border crossing and border collision bifurcation.

UNIT II TECHNIQUES FOR INVESTIGATION OF NONLINEAR PHENOMENA 9

Techniques for experimental investigation, Techniques for numerical investigation, Computation of averages under chaos, Computations of spectral peaks, Computation of the bifurcation and analyzing stability

UNIT III NONLINEAR PHENOMENA IN DC-DC CONVERTERS 9

Border collision in the Current Mode controlled Boost Converter, Bifurcation and chaos in the Voltage controlled Buck Converter with latch, Bifurcation and chaos in the Voltage controlled Buck Converter without latch, Bifurcation and chaos in Cuk Converter. Nonlinear phenomenon in the inverter under tolerance band control.

UNIT IV NONLINEAR PHENOMENA IN DRIVES 9

Nonlinear Phenomenon in Current controlled and voltage controlled DC Drives, Nonlinear Phenomenon in PMSM Drives

UNIT V CONTROL OF CHAOS 9

Hysteresis control, Sliding mode and switching surface control, OGY Method, Pyragas method, Time Delay control. Application of the techniques to the Power electronics circuit and drives.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of the course, students will be able to:

CO1: Understand the nonlinear behavior of power electronic converters.

CO2: Understand the techniques for investigation on nonlinear behavior of power electronic converters

CO3: Analyze the nonlinear phenomena in DC to DC converters.

CO4: Analyze the nonlinear phenomena in AC and DC Drives.

CO5: Understandvarious chaos control techniques

CO6: Apply the techniques for control of nonlinear behavior in power electronic systems.

REFERENCES

1. George C. Vargheese, July 2001 Wiley – IEEE Press S Banerjee, Nonlinear Phenomena in Power Electronics, IEEE Press 3, 2001.
2. Steven H Strogatz, Nonlinear Dynamics and Chaos, Westview Press, 2014.
3. C.K.TSE Complex Behaviour of Switching Power Converters, CRC Press, 2005.

20EE976	SMART GRID	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

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

UNIT I INTRODUCTION TO SMART GRID 9

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

UNIT II SMART GRID TECHNOLOGIES 9

Technology Drivers, Smart energy resources, Smart substations, Substation Automation, Feeder Automation ,Transmission systems: EMS, FACTS and HVDC, Wide area monitoring, Protection and control, Distribution systems: DMS, Volt/Var control, Fault Detection, Isolation and service restoration, Outage management, High-Efficiency Distribution Transformers, Phase Shifting Transformers, Plug in Hybrid Electric Vehicles (PHEV).

UNIT III SMART METERS AND ADVANCED METERING INFRASTRUCTURE 9

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

UNIT IV POWER QUALITY MANAGEMENT IN SMART GRID 9

Power Quality & EMC in Smart Grid, Power Quality issues of Grid connected Renewable Energy Sources, Power Quality Conditioners for Smart Grid, Web based Power Quality monitoring, Power Quality Audit.

UNIT V HIGH PERFORMANCE COMPUTING FOR SMART GRID APPLICATIONS 9

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

TOTAL : 45 PERIODS

COURSE OUTCOMES:

At the end of the course, students will be able to:

CO1: Understanding on the concepts of Smart Grid and its present developments.

CO2: Understand about different Smart Grid technologies.

CO3: Interpret different smart meters and advanced metering infrastructure.

CO4: Analysepower quality management in Smart Grids

CO5: Understand on LAN, WAN and Cloud Computing for Smart Grid applications.

CO6: Understand cloud computing and cyber security for Smart Grid.

REFERENCES

1 Stuart Borlase "Smart Grid :Infrastructure, Technology and Solutions", CRC Press 2012.

2 JanakaEkanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama, "Smart Grid: Technology and Applications", Wiley 2012.

3 Vehbi C. Güngör, DilanSahin, TaskinKocak, SalihErgüt, ConcettinaBuccella, Carlo Cecati, and Gerhard P. Hancke, "Smart Grid Technologies:CommunicationTechnologies and Standards" IEEE Transactions On Industrial Informatics, Vol. 7, No. 4, November 2011.

4 Xi Fang, SatyajayantMisra, GuoliangXue, and Dejun Yang "Smart Grid – The New and Improved Power Grid: A Survey" , IEEE Transaction on Smart Grids, vol. 14, 2012.

20EE977	POWER ELECTRONICS FOR RENEWABLE ENERGYSYSTEMS	L	T	P	C
		3	0	0	3

COURSE 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) –Multi input power electronic converters.

TOTAL:45PERIODS

COURSE OUTCOMES:

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

CO1: Analyze the impacts of renewable energy generation on environment.

CO2: Apply the principle of operation of electrical machines for wind energy conversion and their performance characteristics.

CO3: Understand the importance and qualitative analysis of solar energy sources.

CO4: Understand the importance and qualitative analysis of wind energy sources.

CO5: Design suitable power converters for solar PV and wind energy systems.

CO6: Understand hybrid renewable energy systems

REFERENCES

1 S.N.Bhadra, D. Kastha, & S. Banerjee “Wind Electrical Systems”, Oxford University Press, 2018.

2 Rashid .M. H "power electronics Hand book", Academic press, 2009.
3 Rai. G.D, "Non-conventional energy sources", Khanna publishes, 2017.
4 Rai. G.D," Solar energy utilization", Khanna publishes, 2006.
5 Gray, L. Johnson, "Wind energy system", prentice hall linc, 1995.
6 B.H.Khan, "Non-conventional Energy sources", TataMcGraw-hill Publishing Company, 2017
7 P.S.Bimbhra,"Power Electronics",Khanna Publishers, 3rd Edition,2014.
8 Fang Lin Luo Hong Ye, "Renewable Energy systems", Taylor & Francis Group, 2017.
9 R.Seyezhai and R.Ramaprabha, "Power Electronics for Renewable Energy Systems", Scitech Publications, 2017.

20EE978	ROBOTICS AND CONTROL	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

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

UNIT I INTRODUCTION AND TERMINOLOGIES 9

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

UNIT II KINEMATICS 9

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

UNIT III DIFFERENTIAL MOTION AND PATH PLANNING 9

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

UNIT IV DYNAMIC MODELLING 9

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

UNIT V ROBOT CONTROL SYSTEM 9

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

TOTAL : 45 PERIODS

COURSE OUTCOMES:

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

CO1: Understand the components and basic terminology of Robotics

CO2: Model the motion of Robots

CO3: Analyze the workspace and trajectory panning of robots
CO4: Understand dynamic modelling of robots
CO5: Develop application based Robots
CO6: Formulate models for the control of mobile robots in various industrial applications

REFERENCES

1. R.K. Mittal and I J Nagrath, "Robotics and Control", Tata MacGraw Hill, Fourth edition, 2017.
2. Saeed B. Niku ,"Introduction to Robotics ", Wiley, 2011.
3. Fu, Gonzalez and Lee Mcgrahill ,"Robotics ", International edition, 2017.
4. R.D. Klafter, TA Chmielewski and Michael Negin, "Robotic Engineering, An Integrated approach",Prentice Hall of India, 2007.

20EE979	NON LINEAR CONTROL	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

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

UNIT I PHASE PLANE ANALYSIS 9

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

UNIT II DESCRIBING FUNCTION 9

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

UNIT III LYAPUNOV THEORY 9

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

UNIT IV FEEDBACK LINEARIZATION 9

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

Dynamics and Control Design. Simulation of tracking problems in MATLAB.

UNIT V SLIDING MODE CONTROL 9

Modeling/Performance Trade-Offs- MIMO Systems. simulation of sliding mode controller in Matlab.

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TOTAL : 45 PERIODS

COURSE OUTCOMES:

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

CO1: Understand the concepts of non-linear control system.

CO2: Analyze describing function based approach to non-linear systems

CO3: Analyze stability of systems using Lyapunov's theory.

CO4: Analyze feedback linearization of systems

CO5: Simulate tracking problems using MATLAB

CO6: Illustrate the sliding mode control and implementation in MATLAB.

REFERENCES

1. J A E Slotine and W Li, Applied Nonlinear control, PHI, 1991.
2. K. P. Mohandas, Modern Control Engineering, Sanguine, India, 2016
3. Hasan Khalil, "Nonlinear systems and control", Prentice Hall.
4. S H Zak, "Systems and control", Oxford University Press, 2003.
5. Torkel Glad and Lennart Ljung, "Control Theory – Multivariable and Nonlinear Methods",Taylor& Francis, 2018.
6. G. J. Thaler, "Automatic control systems", Jaico publishers, 2006.

20EE980	INTELLIGENTCONTROLLERS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- To design of ANN and fuzzy set theory.
- To analyse and implement ANN and Fuzzy logic for modeling and control of Non-linear system and to get familiarized with the Matlab toolbox.
- To impart the knowledge of various optimization techniques and hybrid schemes with the ANFIS tool box.

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

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

UNIT II NEURAL NETWORKS FOR MODELLING AND CONTROL 9

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

UNIT III FUZZY LOGIC FOR MODELLING AND CONTROL 9

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

UNIT IV GENETIC ALGORITHM 9

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

UNIT V HYBRID CONTROL SCHEMES 9

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

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of this course, the students will be able to:

CO1: Understand the basic architectures of NN and Fuzzy sets

CO2: Design and implement ANN architectures, algorithms and know their limitations.

CO3: Identify and work with different operations on the fuzzy sets.

CO4: Develop ANN and fuzzy logic based models and control schemes for non-linear systems.

CO5: Understand control usinggenetic algorithm, search techniques and PSO

CO6: Understand and explore hybrid control schemes

REFERENCES:

1. LaureneV.Fausett, "Fundamentals of Neural Networks, Architecture, Algorithms, and Applications", Pearson Education, 2009.
2. Timothy J.Ross, "Fuzzy Logic with Engineering Applications", Wiley, Third Edition, 2011.
3. David E.Goldberg, "Genetic Algorithms in Search, Optimization, and Machine Learning", Pearson Education, 2013.
4. W.T.Miller, R.S.Sutton and P.J.Webrose, "Neural Networks for Control", MIT Press, 1996.
5. George J.Klir and Bo Yuan, "Fuzzy Sets and Fuzzy Logic: Theory and Applications", Prentice HalI, First Edition, 2015.

20EE981	MEMS DESIGN OF SENSORSANDACTUATORS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

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

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 piezo electric actuator model-properties of piezoelectric materials Applications.

UNIT V CASE STUDIES 9

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

TOTAL: 45 PERIODS

COURSEOUTCOMES:

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

CO1: Understand design process of micro sensors, embedded sensors & actuators

CO2: Analyse the electrostatic sensors and actuators through MEMS and NEMS devices

CO3: Analyse the thermal sensors and actuators through MEMS and NEMS devices

CO4: Analyse the piezoelectric sensors and actuators through MEMS and NEMS

CO5:Analyse piezoresistive sensors for biomedical and micro fluidic applications

CO6: Analyse optical MEMS and NEMS devices

REFERENCES

1. Chang Liu, "Foundations of MEMS", Pearson International Edition, 2011.
2. Marc Madou , "Fundamentals of microfabrication",CRC Press, 1997.
3. Boston , "Micromachined Transducers Source book",WCB McGraw Hill, 1998.
4. M.H.Bao "Micromechanical transducers: Pressure sensors, accelerometers and gyroscopes", Elsevier, Newyork, 2000.

20EE982 DISASTER MANAGEMENT

L	T	P	C
3	0	0	3

COURSE OBJECTIVES

- Summarize basics of disaster
- Explain a critical understanding of key concepts in disaster risk reduction and humanitarian response.
- Illustrate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
- Describe an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
- Develop the strengths and weaknesses of disaster management approaches

UNIT I INTRODUCTION 9

Disaster: Definition, Factors and Significance; Difference between Hazard And Disaster; Natural and Manmade Disasters: Difference, Nature, Types and Magnitude.

UNIT II REPERCUSSIONS OF DISASTERS AND HAZARDS 9

Economic Damage, Loss of Human and Animal Life, Destruction Of Ecosystem. Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts.

UNIT III DISASTER PRONE AREAS IN INDIA 9

Study of Seismic Zones; Areas Prone To Floods and Droughts, Landslides And Avalanches; Areas Prone To Cyclonic and Coastal Hazards with Special Reference To Tsunami; Post-Disaster Diseases and Epidemics

UNIT IV DISASTER PREPAREDNESS AND MANAGEMENT 9

Preparedness: Monitoring Of Phenomena Triggering a Disaster or Hazard; Evaluation of Risk: Application of Remote Sensing, Data from Meteorological And Other Agencies, Media Reports: Governmental and Community Preparedness.

UNIT V RISK ASSESSMENT 9

Disaster Risk: Concept and Elements, Disaster Risk Reduction, Global and National Disaster Risk Situation. Techniques of Risk Assessment, Global Co-Operation in Risk Assessment and Warning, People's Participation in Risk Assessment. Strategies for Survival

TOTAL : 45 PERIODS

COURSE OUTCOMES:

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

CO1: Understand basics of disaster

CO2: Explain a critical understanding of key concepts in disaster risk reduction and humanitarian response.

CO3: Illustrate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
CO4: Identify disaster prone zones
CO5: Describe an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
CO6: Develop the strengths and weaknesses of disaster management approaches

REFERENCES

1. Goel S. L., Disaster Administration And Management Text And Case Studies",Deep& Deep Publication Pvt. Ltd., New Delhi,2009.
2. NishithaRai, Singh AK, "Disaster Management in India: Perspectives, issues and strategies "'NewRoyal book Company,2007.
3. Sahni, PardeepEt.Al. ," Disaster Mitigation Experiences And Reflections", Prentice Hall OfIndia, New Delhi, 2001.

20EE983	**AUTOMOTIVE EMBEDDED SYSTEM**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES

- To expose the students to the fundamentals and building of Electronic Engine Control systems.
- To teach on functional components and circuits for vehicles
- To discuss on programmable controllers for vehicles
- To teach logics of automation & commercial techniques for vehicle communication
- To involve Discussions/ Practice/Exercise onto revising & familiarizing the concepts acquired for improved employability skills

UNIT I BASICS OF ELECTRONIC ENGINE CONTROL SYSTEMS 9

Motivation ,concept for electronic engine controls and management-Standards; introduction to fuel economy- automobile sensors-volumetric, thermal, air-fuel ratio, solenoid ,hall effect-exhaust gas oxygen sensors, Oxidizing catalytic efficiency, emission limits and vehicle performance; advantages of using Electronic engine controls – open and closed loop fuel control; Block diagram of Electronic ignition system and Architecture of a EMS with multi point fuel injection system, Direct injection; programmed ignition- actuators interface to the ECU; starter motors and circuits - sensors interface to the ECU; Actuators and their characteristics – exhaust gas recirculation.

UNIT II FUEL CELL FOR AUTOMOTIVE POWER 9

Fuel cell-Introduction-Proton exchange membrane FC (PEM), Solid oxide fuel cell (SOFC)-properties of fuel cells for vehicles-power system of an automobile with fuel cell based drive, and their characteristics

UNIT III VEHICLE MANAGEMENT SYSTEMS 9

Electronic Engine Control-engine mapping,air/fuel ratio spark timing control strategy, fuel control, electronic ignition-Vehicle cruise control- speed control-anti-locking braking system-electronic suspension - electronic steering , wiper control ; Vehicle system schematic for interfacing with EMS, ECU. Energy Management system for electric vehicles- for sensors, accelerators, brake-Battery management, Electric Vehicles-Electrical loads, power management system-electrically assisted power steering system.

UNIT IV AUTOMOTIVE TELEMATICS 9

Role of Bluetooth, CAN, LIN and flex ray communication protocols in automotive applications; Multiplexed vehicle system architecture for signal and data / parameter exchange between EMS, ECUs with other vehicle system components and other control systems; Realizing bus interfaces for diagnostics, dashboard display ,multimedia electronics-Introduction to Society of Automotive Engineers(SAE). J1850 message with(IFR) in frame response in protocol-Local Interconnect n/w [LI N], Bluetooth.

UNIT V ELECTRONIC DIAGNOSTICS FOR VEHICLES 9

System diagnostic standards and regulation requirements –On board diagnosis of vehicles electronic units &electric units-Speedometer, oil and temperature gauges, and audio system.
Note: Class room discussions and tutorials can include the following guidelines for improved teaching /learning process : Discussions//Practice on Workbench/Exercise/ AUTOSAR/ Vehicle simulators :on the basics of interfacing sensors, actuators to special automobile-microcontrollers, role of Instrumentation software packages / special automobile-microcontrollers for i/o port communication applicable to vehicles

TOTAL: 45 PERIODS

COURSE OUTCOMES:

After completion of this course, the student will be able to:
CO1: Interpret basic working of electronic engine control and fuel cell based systems
CO2: Analyse vehicle management systems
CO3: Analyse various embedded products used in automotive industry.
CO4: Understand recent trends in embedded systems design.
CO5: Design and develop automotive embedded systems.
CO6: Evaluate the opportunities involving technology, a product or a service required for developing a start-up idea used for automotive applications

REFERENCES

1. William B. Ribbens ,"Understanding Automotive Electronics", Elseiver,2015
2. Ali Emedi, Mehrdedehsani, John M Miller , "Vehicular Electric power system- land, Sea, Air and Space Vehicles" Marcel Decker, 2010.
3. L.Vlacic, M.Parent, F.Harahima,"Intelligent Vehicle Technologies",SAE International, 2001.
4. Jack Erjavec,Jeff Arias," Alternate Fuel Technology-Electric, Hybrid& Fuel Cell Vehicles",Cengage,2012.
5. Electronic Engine Control technology – Ronald K Jurgen Chilton's guide to Fuel Injection – Ford, 1998.

6. Automotive Electricals and Electronics System, Tom Denton, 5th Edition, Routledge, 2017.
7. Uwe Kiencke, Lars Nielsen, "Automotive Control Systems: For Engine, Driveline, and Vehicle", Springer; 1 edition, March 30, 2007.
8. Automotive Electricals Electronics System and Components, Robert Bosch Gmbh, 5th Edition, Springer, 2013.
9. Automotive Hand Book, Robert Bosch, Wiley,2018.
10. Jurgen, R., Automotive Electronics Hand Book, McGraw Hill Inc, 1994.

20EE984	ENERGY EFFICIENT BUILDINGS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the different climate zones and modelling methods
- To understand about the principle of energy conscious building design.
- To understand about the concept of passive solar heating and efficient technologies in electrical system.
- To provide knowledge about the energy conservation techniques in buildings.
- To provide knowledge about energy efficient technologies.

UNIT I CLIMATE AND SHELTER 9

Historic buildings – Modern architecture – Examples from different climate zones –Thermal comfort – Solar geometry and shading – Energy modeling techniques– Integrative Modeling methods and building simulation.

UNIT II PRINCIPLES OF ENERGY CONSCIOUS BUILDING DESIGN 9

Energy conservation in buildings – Day lighting – Solar based Water heating - Advances in thermal insulation – Heat gain/loss through building components - Solar architecture.

UNIT III PASSIVE SOLAR HEATING 9

Basics of Passive solar – Mechanical Systems – South Facing Glass – Thermal mass – Orientation – site planning for solar access - Direct gain – thermal storage wall – Sunspace – Passive cooling – Ventilation - Radiation – Evaporation and Dehumidification – Design guidelines and natural cooling guidelines.

UNIT IV ENERGY CONSERVATION IN BUILDING 9

Air conditioning – HVAC equipment – Computer packages for thermal design of buildings and performance prediction – Monitoring and instrumentation of passive buildings – Control systems for energy efficient buildings – Illustrative passive buildings – Integration of emerging technologies –Intelligent building design principles – ECBC applicability – Building Envelope – Comfort system and controls – Lighting – Electrical Power and Renewable Energy.

UNIT V EFFICIENT TECHNOLOGIES IN ELECTRICAL SYSTEMS 9

Maximum demand controllers, automatic power factor controllers, energy efficient motors, and soft starters – Energy efficient Lighting and Transformers.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

After completion of this course, the student will be able to:
CO1: Understand the different climate zones and modelling methods
CO2: Design energy conscious building design.
CO3: Understand about the concept of passive solar heating and efficienttechnologies in electrical system.
CO4: Understand the control systems of energy efficient buildings
CO5: Understand about the energy conservation techniques in buildings.
CO6: Understand about different energy efficient technologies.

REFERENCES

1. Joseph Clarke, 'Energy Simulation in Building Design', II Edition, Butterworth, 2015.
2. J. K. Nayak and J. A. Prajapati, 'Handbook on Energy Conscious Buildings', Solar Energy Centre, MNES, May 2006.
3. 'Energy conservation Building Codes – 2017', Bureau of Energy Efficiency, 2017.
4. 'Passive Solar Building - Design Strategies', Guidelines for home passive solar industries council, National Renewable Energy Laboratory and Charles Elay Associates.
5. J. Douglas Batcomb, 'Passive Solar Building',The MIT Press, 1992.
6. Thomas H.Kuehn, James W. Ramsey and J. L. Threlkeld, 'Thermal Environmental Engineering', 3rd Edition Prentice Hall, 1970.

20EE985	**UNMANNED AERIAL VEHICLE**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To make the students to understand the basic concepts and components of UAV systems.
- To teach the UAV design concepts
- To provide an insight about the hardware structure for UAVs
- To emphasis the communication protocol requirements and control strategy for UAVs.
- To highlight the need and the role of UAVs for real time applications and development of real time UAVs

UNIT I INTRODUCTION TO UAV 9

Overview and background - History of UAV –classification – societal impact and future outlook Unmanned Aerial System (UAS) components --models and prototypes – System Composition applications

UNIT II THE DESIGN OF UAV SYSTEMS 9

Introduction to Design and Selection of the System- Aerodynamics and Airframe

Configurations- Characteristics of Aircraft Types- Design Standards-Regulatories and regulations - Design for Stealth--control surfaces-specifications.

UNIT III HARDWAREs for UAVs 9

Real time Embedded processors for UAVs - sensors-servos-accelerometer –gyros-actuators power supply- integration, installation, configuration, and testing –MEMS/NEMS sensors and actuators for UAVs- Autopilot – AGL.

UNIT IV COMMUNICATION PAYLOADS AND CONTROLS 9

Payloads-Telemetry-tracking-Aerial photography-controls-PID feedback-radio control frequency range –modems-memory system-simulation-ground test-analysis-trouble shooting

UNIT V THE DEVELOPMENT OF UAV SYSTEMS 9

Waypoints navigation-ground control software- System Ground Testing- System In-flight Testing- Mini, Micro and Nano UAVs- Case study: Agriculture- Health- Surveying- Disaster Management and Defense.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Ability to identify different hardware for UAV

CO2: Prepare preliminary design requirements for an unmanned aerial vehicle.

CO3: Ability to design UAV system

CO4: Integrate various systems of unmanned aerial vehicle.

CO5: Understand the communication controls and payloads

CO5: Design micro aerial vehicle systems by considering practical limitations.

REFERENCES:

1. Reg Austin "Unmanned Aircraft Systems UAV design, development and deployment", Wiley, 2017.

2. Paul G Fahlstrom, Thomas J Gleason, "Introduction to UAV Systems", UAV Systems, Inc, 2016

3. Dr. Armand J. Chaput, "Design of Unmanned Air Vehicle Systems", Lockheed Martin Aeronautics Company, 2001

4. Kimon P. Valavanis, "Advances in Unmanned Aerial Vehicles: State of the Art and the Road to Autonomy", Springer, 2010.

5. Robert C. Nelson, Flight Stability and Automatic Control, McGraw-Hill, Inc, 2017.

20EE331	PROJECT WORK PHASE I	L	T	P	C
		0	0	12	6

COURSE OBJECTIVES:

- To develop the ability to solve a specific problem right from its identification and literature review till the successful solution of the same.

- To train the students in preparing project reports and to face reviews and viva voce examination.

COURSE DESCRIPTION:

- Project work consists of Phase–I and Phase–II.
- Phase–I is to be undertaken during III semester and Phase–II, which is a continuation of Phase–I is to be undertaken during IV semester.
- Students can enroll for Phase-II, only after successful completion of Phase-I.
- Evaluation of Project Work for Phase-I and Phase-II shall be done independently in the respective semesters
- There shall be three assessments (each 100 marks) during the Semester by a review committee.
- The Student shall make presentation on the progress made before the Committee.
- The Head of the Institution shall constitute the review committee.
- The total marks obtained in the three assessments shall be reduced to 40 marks and rounded to the nearest integer (as per the Table given below).
- There will be a viva-voce Examination during End Semester Examinations conducted by a Committee consisting of the supervisor, one internal examiner and one external examiner.
- The internal examiner and the external examiner shall be appointed by the Controller of Examinations.
- The distribution of marks for the internal assessment and End semester examinations is given below:

Internal Assessment (40 Marks)			**End Semester Examination (60 Marks)**			
Review – I	**Review – II**	**Review - III**	**Thesis Evaluation**	**Viva – Voce**		
			External Examiner	Internal Examiner	External Examiner	Supervisor
10	15	15	20	15	15	10

TOTAL: 180 PERIODS

COURSE OUTCOMES:

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

CO1: Interpret literature with the purpose of formulating a project proposal.

CO2: Solve the challenging practical problems with the required modern technology.

CO3: Identify solution by formulating proper methodology.

CO4: Identify the key stages in development of the project.

CO5: Improve and refine technical aspects for engineering projects.

CO6: Discuss and report effectively project related activities and findings.

SEMESTER IV

		L	T	P	C
20EE431	**PROJECT WORK PHASE II**	**0**	**0**	**24**	**12**

COURSE OBJECTIVES:

- To develop the ability to solve a specific problem right from its identification and literature review till the successful solution of the same.
- To train the students in preparing project reports and to face reviews and viva voce examination.

COURSE DESCRIPTION:

- Students can enroll for Phase-II, only after successful completion of Phase-I.
- There shall be three assessments (each 100 marks) during the Semester by a review committee.
- The Student shall make presentation on the progress made before the Committee.
- The Head of the Institution shall constitute the review committee.
- The total marks obtained in the three assessments shall be reduced to 40 marks and rounded to the nearest integer (as per the Table given below).
- There will be a viva-voce Examination during End Semester Examinations conducted by a Committee consisting of the supervisor, one internal examiner and one external examiner.
- The internal examiner and the external examiner shall be appointed by the Controller of Examinations.
- The distribution of marks for the internal assessment and End semester examinations is given below:

Internal Assessment (40 Marks)			**End Semester Examination (60 Marks)**			
Review – I	**Review – II**	**Review - III**	**Thesis Evaluation**	**Viva – Voce**		
			External Examiner	Internal Examiner	External Examiner	Supervisor
10	15	15	20	15	15	10

TOTAL: 360 PERIODS

COURSE OUTCOMES:

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

CO1: Interpret literature with the purpose of formulating a project proposal.

CO2: Solve the challenging practical problems with the required modern technology.

CO3: Identify solution by formulating proper methodology.

CO4: Identify the key stages in development of the project.

CO5: Improve and refine technical aspects for engineering projects.

CO6: Discuss and report effectively project related activities and findings.