Francis Xavier Engineering College

(An Autonomous Institution)
Tirunelveli 627 003
Tamil Nadu India

Department of EEE

M. E - Power Electronics & Drives

2021 CURRICULUM AND SYLLABI

CHOICE BASED CREDIT SYSTEM

Regulations 2019

Vision of the Department

"To be a Centre of Excellence for Technology transformation in the field of Electrical and Electronics Engineering"

Mission of the Department

1. **To empower the vibrant young leaders with technical skills and knowledge in the field of technology**
2. **To facilitate the industries to adopt effective solutions in the field of Electrical and Electronics Engineering through consultancy**
3. **To transform technology for rural needs.**

Table of Content

Programme Educational Outcomes (PEOs)

PEO1: Graduates of this program will have technical knowledge, skills and ability to design, develop and test power electronic converters and drives using advanced tools.

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

PEO3: Graduates of this program will show involvement and willingness in assuming responsibility in the domain of power electronics , electric drives and renewable energy systems for societal and environmental causes

Programme Specific Objectives (PSOs)

PSO 1: Integrate the knowledge of, power electronics and Drive systems for the controllability, reliability and sustainability of electrical systems.

PSO2: Contribute for the development of power grid and integrating green energy on it to meet the increasing demand of the society.

Programme Outcomes (POs)

Engineering Graduates will be able to:

1. Graduates will be able to demonstrate the principles and practices of the electrical power industry regarding generation, transmission, distribution and electrical machines and their controls.
2. Graduates will be able to apply their knowledge of electrical power principles, as well as mathematics and scientific principles, to new applications in electrical power.
3. Graduates will be able to perform, analyze, and apply the results of experiments to electrical power application improvements.
4. Graduates will be able to look at all options in design and development projects and creativity and choose the most appropriate option for the current project.
5. Graduates will function effectively as a member of a project team.
6. Graduates will be able to identify problems in electrical power systems, analyze the problems, and solve them using all of the required and available resources.
7. Graduates will be able to effectively communicate technical project information in writing or in personal presentation and conversation.
8. Graduates will be engaged in continuously learning the new practices, principles, and techniques of the electrical power industry.
9. Graduates will work on application software packages for power system analysis and design.
10. Graduates will develop indigenous software packages for power system planning and operational problems of utilities.

Mapping with PO Vs PEO, PSO

PO	PEO1	PEO2	PEO3	PSO1	PSO2
1	X	X	X	X	
2	X			X	X
3				X	X
4	X	X	X		
5	X	X	X	X	
6	X			X	X
7				X	X
8	X	X	X		
9	X	X	X	X	
10	X			X	X

FRANCIS XAVIER ENGINEERING COLLEGE

M.E. – POWER ELECTRONICS & DRIVES REGULATIONS 2019

Choice Based Credit System and Outcome Based Education

SUMMARY OF CREDIT DISTRIBUTION

S.No	Category	Credit Distribution				Total Credits	Credits in %
		I	II	III	IV		
1	HSSM						
2	BS	4				4	5.4
3	EC						
4	PC	19	12			31	42.4
5	PE		9	9		18	24.6
6	OE						
7	EEC		2	6	12	20	27.3

Minimum Number of Credits to be Acquired: 73

HSS - Humanities and Social Sciences including Management

BS - Basic Science

ES - Engineering Sciences

PC - Professional Core

PE - Professional Elective

OE – Open Elective/Programme Specific Elective for Expandable Scope

EEC - Employability Enhancement Course

FRANCIS XAVIER ENGINEERING COLLEGE

M.E. – POWER ELECTRONICS & DRIVES REGULATIONS 2021

Choice Based Credit System and Outcome Based Education

I-IV Semester Curricula and Syllabi

SEMESTER I

S.No	Course Code	Course Name	Category	Contact Periods	L	T	P	C
Theory Courses								
1	21MA1253	Advanced Engineering Mathematics	BS	4	3	1	0	4
2	21PE1601	Analysis and Design of Power Electronic Converters	PC	3	3	0	0	3
3	21PE1602	Computer Aided Design of Power Electronics Circuits	PC	4	3	1	0	4
4	21PE1603	Solid State DC Drives	PC	3	3	0	0	3
5	21PE1604	Power Quality Analysis and Mitigation Techniques	PC	4	3	1	0	4
6	21PE1605	Special Machines and Controllers	PC	3	3	0	0	3
Practical Courses								
1	21PE1611	Design of Power Electronics circuit Laboratory	PC	4	0	0	4	2
			Total	25	18	3	4	**23**

SEMESTER II

S.No	Course Code	Course Name	Category	Contact Periods	L	T	P	C
Theory Courses								
1	21PE2601	Generalized Machine Theory	PC	3	3	0	0	3
2	21PE2602	Solid State AC Drives	PC	4	3	1	0	4
3	21PE2603	Modern Control Theory	PC	3	3	0	0	3
4		Professional Elective –I	PE	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
Practical Courses								
1	21PE2611	Solid state Drives and Control Laboratory	PC	4	0	0	4	2
2	21PE2911	Innovative Project	EEC	4	0	0	4	2
			Total	27	18	1	8	**23**

SEMESTER III

S.No	Course Code	Course Name	Category	Contact Periods	L	T	P	C
Theory Courses								
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
Practical Courses								
1	21PE3911	Project Work Phase I	EEC	12	0	0	12	6
			Total	**21**	09	0	12	**15**

SEMESTER IV

S.No	Course Code	Course Name	Category	Contact Periods	L	T	P	C
Practical Courses								
1	21PE4911	Project Work Phase II	EEC	24	0	0	24	12
			Total	**24**	0	0	24	**12**

Minimum Number of Credits to be Acquired:73

List of Professional Electives Courses

S.No	Course Code	Course Name	Semester	L	T	P	C	Stream/ Domain
Professional Elective I								
1	21PE2701	Solar Photo Voltaic Systems	II	3	0	0	3	Renewable Energy
2	21PE2702	Electromagnetic Field Computation and Modelling	II	3	0	0	3	Field Theory
3	21PE2703	Control System Design for Power Electronics	II	3	0	0	3	Control Engineering
4	21PE2704	Intelligent Control Techniques	II	3	0	0	3	Embedded System
Professional Elective II								
1	21PS2702	Flexible AC Transmission Systems	II	3	0	0	3	Power System
2	21PE2705	Modern Rectifiers and Resonant Converters	II	3	0	0	3	Power Electronics
3	21PE2706	Electromagnetic Interference and Compatibility	II	3	0	0	3	Field Theory
4	21PE2707	Robotics and Control	II	3	0	0	3	Control Engineering
Professional Elective III								
1	21PS2703	Distributed Generation and Micro-grid	II	3	0	0	3	Power System
2	21PE2708	Nano Electronic devices and Nano sensors	II	3	0	0	3	Power Electronics
3	21PS2701	Principles of Smart Grid	II	3	0	0	3	Power System
4	21PE2709	Embedded System Design	II	3	0	0	3	Embedded System
Professional Elective IV								
1	21PS3701	High Voltage Direct Current Transmission	III	3	0	0	3	Power System
2	21PE3701	Non Linear Control	III	3	0	0	3	Control Engineering
3	21PE3702	Wind Energy Technologies	III	3	0	0	3	Renewable Energy
4	21PE3703	Industrial Automation And Control	III	3	0	0	3	Control Engineering
Professional Elective V								
1	21PE3704	Hybrid Electric Vehicles	III	3	0	0	3	Power Electronics
2	21PE3705	Advanced Power Electronic Devices	III	3	0	0	3	Power Electronics

3	21PE3706	Integrated Circuits for Power Conversion	III	3	0	0	3	Power Electronics
4	21PE3707	MEMS Technology	III	3	0	0	3	Power Electronics
Professional Elective VI								
1	21PE3708	Power Electronics for Renewable Energy Systems	III	3	0	0	3	Renewable Energy
2	21PE3709	Modelling and Simulation of Power Electronics Systems	III	3	0	0	3	Power Electronics
3	21PE3710	Intelligent Control of Electric Drives	III	3	0	0	3	Embedded System
4	21PE3711	Energy Storage Systems	III	3	0	0	3	Power Electronics

Semester I

21MA1253	ADVANCED MATHEMATICS FOR ELECTRICAL ENGINEERS	L	T	P	C
		3	1	0	4

Preamble

An engineering PG student needs to have some basic mathematical tools and techniques to apply in diverse applications in Engineering. This emphasizes the development of rigorous logical thinking and analytical skills of the student and appraises him the complete procedure for solving different kinds of problems that occur in engineering. Based on this, the course aims at giving adequate exposure in Linear Algebra to find the singular value decomposition and Pseudo inverse of the matrix, Random Process to deal the Random Experiments with the state space S and parameter set T, stationary Functions, Gaussian Process…, Calculus of Variations to find the maximum or minimum value of a definite integral involving certain functions.

Prerequisites for the course

1. Students should have basic knowledge in Engineering Mathematics

Objectives

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

UNIT I	MATRIX THEORY	9+3

Cholesky decomposition – Generalized Eigen values and Generalized Eigen vectors - Canonical basis - QR Factorization - Least squares method - Singular value decomposition

UNIT II	CALCULUS OF VARIATIONS	9+3

Concept of variation and its properties – Euler's equation – Functional dependant on first and higher order derivatives – Variational problems with moving boundaries–Isoperimetric problems-Direct methods: Ritz and Kantorovich methods.

UNIT III	PROBABILITY AND RANDOM VARIABLES	9+3

Probability – Axioms of probability – Conditional probability - Random variables - Probability function – Moments – Moment generating functions and their properties – Binomial, Poisson, Uniform and Normal distributions

UNIT IV	LINEAR PROGRAMMING	9+3

Formulation of Linear Programming Problem – Graphical solution of LPP – Transportation Models – Degeneracy and Non-Degeneracy Transportation Problems - Assignment models – Balanced and Unbalanced Assignment Problems

UNIT V	**FOURIER SERIES**	**9+3**

Fourier trigonometric series: Periodic function as power signals–Convergence of series– Even and odd function: Cosine and sine series – Parseval's theorem and power spectrum – Eigen value problems and orthogonal functions–Generalized Fourier series.

Total Periods	**45+15**

Suggestive Assessment Methods

Continuous Assessment Test (40 Marks)	**Formative Assessment Test (10 Marks)**	**End Semester Exams (50 Marks)**
WRITTEN TEST	**1.ASSIGNMENT** **2. ONLINE QUIZZES** **3.PROBLEM-SOLVING ACTIVITIES**	**WRITTEN TEST**

Outcomes

Upon completion of the course, the students will be able to:

1	Apply various methods in matrix theory to solve system of linear equations
2	Maximizing and minimizing the functional that occur in electrical engineering discipline
3	Computation of probability and moments, standard distributions of discrete and continuous random variables and functions of a random variable.
4	Develop a linear programming model from problem description
5	Fourier series analysis and its uses in representing the power signals

Reference Books

1. Andrews L.C. and Phillips R.L., "Mathematical Techniques for Engineers and Scientists", Prentice Hall of India Pvt. Ltd., New Delhi, 2016.
2. Bronson, R. "Matrix Operation", Schaum's outline series, 2ndEdition, McGraw Hill, 2016.
3. Elsgolc, L. D. "Calculus of Variations", Dover Publications, New York, 2017.
4. Johnson, R.A., Miller, I and Freund J., "Miller and Freund's Probability and Statistics forEngineers", Pearson Education, Asia, 8thEdition, 2015.
5. O'Neil, P.V., "Advanced Engineering Mathematics", Thomson Asia Pvt. Ltd., Singapore, 2016.
6. Taha, H.A., "Operations Research, An Introduction", 9thEdition, Pearson education, New Delhi, 2016.

Web Recourses

1.https://nptel.ac.in/courses/111102012/

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2
1	3	2										
2	3	2										
3	3	2										
4	3	2										
5	3	2										

BLOOMS LEVEL ASSESSMENT PATTERN

BLOOMS CATEGORY	CAT 1	CAT 2	FAT 1	FAT 2	END SEM EXAM
REMEMBER	10	10	5	5	10
UNDETSTAND	30	30	10	10	30
APPLY	60	60	10	10	60
ANALYZE	0	0	0	0	0
EVALUATE	0	0	0	0	0
CREATE	0	0	0	0	0
	100	100	25	25	100

1-Low , 2- Medium, 3- High

21PE1601	ANALYSIS AND DESIGN OF POWER ELECTRONIC CONVERTERS	L	T	P	C
		3	0	0	3

Preamble

This course provides an introduction about the Power Converters and its Components. In this course, students will learn the important concepts needed to design proper power electronic hardware. By the end of course students should be able to design and test any power electronic converter on their own.

Prerequisites for the course

1. Power Electronics
2. Solid State Drives
3. Power Electronics for Renewable Energy Sources.

Objectives

1. To determine the operation and characteristics of Power converters.
2. To introduce the design of power converter components.
3. To comprehend the concepts of resonant converters and AC-AC power converters.
4. To analyse and comprehend the various types of inverters.
5. To impart knowledge on multilevel inverters and Boost inverters.

UNIT I	POWER CONVERTERS	9

Single-phase and Three phase full converter and semi converter (RL, RLE load) - Dual converter – PWM rectifiers. Operation and analysis of Buck, Boost, Buck-Boost, Cuk& SEPIC – under continuous and discontinuous operation – Isolated converters: basic operation of Fly back, forward and Push-pull topologies.

UNIT II	DESIGN OF POWER CONVERTER COMPONENTS	9

Introduction to magnetic materials- hard and soft magnetic materials –types of cores , copper windings – Design of transformer –Inductor design equations –Examples of inductor design for buck/flyback converter-selection of output filter capacitors – selection of ratings for devices – input filter design.

UNIT III	RESONANT DC-DC CONVERTERS& AC-AC CONVERTERS	9

Resonant switch converters – operation and analysis of ZVS, ZCS converters comparison of ZCS/ZVS Introduction to ZVT/ZCT PWM converters. Single phase ac voltage controller – analysis with R & RL load – Three phase ac voltage controller – principle of operation of cycloconverters – single phase and three phase cycloconverters – Introduction to matrix converters.

UNIT IV	**VOLTAGE SOURCE AND CURRENT SOURCE INVERTERS**	**9**

Principle of operation of single phase full bridge inverters, Three phase Inverter: 180 degree and 120 degree conduction mode inverters – voltage control of inverters: Space vector modulation techniques .Operation of six-step thyristor inverter load – commutated inverters – Auto sequential current source inverter (ASCI), PWM techniques for current source inverters.

UNIT V	**MULTILEVEL INVERTERS, BOOST & RESONANT INVERTERS**	**9**

Multilevel concept – diode clamped – flying capacitor – cascade type multilevel inverters - Comparison of multilevel inverters .Series and parallel resonant inverters - voltage control of resonant inverters – Class E resonant inverter – resonant DC - link inverters.

Total Periods	**45**

Suggestive Assessment Methods

Continuous Assessment Test (30 Marks)	**Formative Assessment Test (10 Marks)**	**End Semester Exams (60 Marks)**
WRITTEN TEST	**1.ASSIGNMENT** **2. ONLINE QUIZZES** **3.PROBLEM-SOLVING ACTIVITIES**	**WRITTEN TEST**

Outcomes

Upon completion of the course, the students will be able to:

1	Understand and analyze various power converters working
2	Design the power converter components.
3	Understand and analyse the resonant converter and ac-ac converters.
4	Understand and analyse the resonant converter and ac-ac converters of inverter.
5	Develop and analyse Multilevel Inverters and boost inverters

Text Books

1. Ned Mohan,T.MUndeland and W.P Robbin, "Power Electronics: converters, Application and design" John Wiley and sons.Wiley India edition, 2006.
2. Rashid M.H., "Power Electronics Circuits, Devices and Applications ", Prentice Hall India, Third Edition, New Delhi, 2004.

Reference Books

1. P.C. Sen, "Modern Power Electronics", Wheeler Publishing Co, First Edition, New Delhi, 1998.
2. P.S.Bimbra, "Power Electronics", Khanna Publishers, Eleventh Edition, 2003.
3. BimalK.Bose "Modern Power Electronics and AC Drives", Pearson Education, Second Edition, 2003.

Web Resources

1. https://nptel.ac.in/courses/108108035
2. https://nptel.ac.in/courses/108105066

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2
1	3	2									3	
2	3	2									3	
3	3	2									3	
4	3	2									3	
5	3	2									3	

BLOOMS LEVEL ASSESSMENT PATTERN

BLOOMS CATEGORY	CAT 1	CAT 2	FAT 1	FAT 2	END SEM EXAM
REMEMBER	10	10	05	05	10
UNDETSTAND	20	20	05	05	20

APPLY	30	30	15	15	30
ANALYZE	30	30	20	20	30
EVALUATE	10	10	05	05	10
CREATE	0	0	0	0	0
	100	100	50	50	100

1-Low , 2- Medium, 3- High

21PE1602	**COMPUTER AIDED DESIGN OF POWER ELECTRONICS CIRCUITS**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Preamble

The objective of the course is to review of power electronic devices and circuits. Apply time domain Analysis and Fourier Series analysis to model and analysis of various Power Electronic Devices.

Prerequisites for the course

1. Fourier Analysis
2. Power semiconductor devices
3. Transients and time domain analysis

Objectives

1. To discuss about the implementation of high efficiency power electronics circuits.
2. To impart knowledge on advance techniques and computing steady state solution.
3. To perform time domain analysis and harmonic components of power electronic circuits.
4. To Study the Fourier analysis of power electronic circuits.
5. To learn the computation of performance parameters using Simulation

UNIT I	**INTRODUCTION**	**9**

Importance of simulation–General purpose circuit analysis–Methods of analysis of power electronic systems– Review of power electronic devices and circuits.

UNIT II	**ADVANCED TECHNIQUES IN SIMULATION**	**9**

Analysis of power electronic systems in sequential manner–coupled and decoupled systems – Various algorithms for computing steady state solution in power electronic systems–Future trends in computer simulation.

UNIT III	**MODELING OF POWER ELCTRONIC DEVICES**	**9**

Introduction–AC sweep and DC sweep analysis–Transients and the time domain analysis – Fourier series and harmonic components–BJT, FET, and MOSFET and its model-Amplifiers and

Oscillator–Non-linear devices.

UNIT IV	SIMULATION OF CIRCUITS	9

Introduction– Schematic capture and libraries–Time domain analysis–System level integration and analysis–Monte Carlo analysis–Sensitivity/stress analysis–Fourier analysis.

UNIT V	CASE STUDIES	9

Simulation of Converters, Choppers, Inverters, AC voltage controllers, and Cyclo- converters feeding R, R-L, and R-L-E loads–computation of performance parameters: Harmonics, power factor, angle of overlap.

Total Periods	**45**

Suggestive Assessment Methods

Continuous Assessment Test (30 Marks)	**Formative Assessment Test (10 Marks)**	**End Semester Exams (60 Marks)**
WRITTEN TEST	**1.ASSIGNMENT** **2. ONLINE QUIZZES** **3.PROBLEM-SOLVING ACTIVITIES**	**WRITTEN TEST**

Outcomes

Upon completion of the course, the students will be able to:

1	Introduce the design oriented analysis and implementation of high efficiency power electronics circuits.
2	Identify the advance techniques and computing steady state solution in simulation.
3	Determine the time domain analysis and harmonic components of power electronic circuits.
4	Perform the Fourier analysis of power electronic circuits.
5	Simulate the Power Electronic Circuits and to determine the performance parameters using Simulation

Text Books

1. Rashid,M.,"SimulationofPowerElectronicCircuitsusingpSPICE",PHI,2006.
2. Rajagopalan, V. "Computer Aided Analysis of Power Electronic systems"-Marcell – Dekker Inc., 1987

Reference Books

1. John Keown "Microsim, Pspice and circuit analysis"-Prentice Hall Inc., 1998.

Web Resources

1. https://onlinecourses.nptel.ac.in/noc22_ee33/preview
2. https://archive.nptel.ac.in/courses/108/107/108107127/
3. https://onlinecourses.nptel.ac.in/noc20_ee97/preview

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2
1	3	2									3	
2	3	2									3	
3	3	2									3	
4	3	2									3	
5	3	2									3	

BLOOMS LEVEL ASSESSMENT PATTERN

BLOOMS CATEGORY	CAT 1	CAT 2	FAT 1	FAT 2	END SEM EXAM
REMEMBER	10	10	05	05	10
UNDETSTAND	20	20	05	05	20
APPLY	30	30	15	15	30
ANALYZE	30	30	20	20	30

EVALUATE	10	10	05	05	10
CREATE	0	0	0	0	0
	100	100	50	50	100

1-Low , 2- Medium, 3- High

21PE1603	**SOLID STATE DC DRIVES**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Preamble

This course provides an introduction to the operation of electric drives controlled from a power electronic converter, design concepts of controllers and also provides the digital control of DC drive.

Prerequisites for the course

- Power Electronics
- DC Machines and Transformers
- AC Machines

Objectives

1. To discuss the steady state operation and transient dynamics of a motor load system
2. To study and analyze the operation of the converter both qualitatively and quantitatively.
3. To Learn the operation of the chopper fed DC drive both qualitatively and quantitatively.
4. To analyze and design the current and speed controllers for a closed loop solid state DC motor drive.
5. To understand the implementation of control algorithms using microcontrollers and phase locked loop.

UNIT I	**DC MOTORS FUNDAMENTALS AND MECHANICAL SYSTEMS**	**9**

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

UNIT II	**CONVERTER CONTROL**	**9**

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

UNIT III	**CHOPPER CONTROL**	**9**

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

UNIT IV	**CLOSED LOOP CONTROL**	**9**

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

UNIT V	**DIGITAL CONTROL OF D.C DRIVE**	**9**

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

	Total Periods	**45**

Suggestive Assessment Methods

Continuous Assessment Test (30 Marks)	**Formative Assessment Test (10 Marks)**	**End Semester Exams (60 Marks)**
WRITTEN TEST	**1.ASSIGNMENT** **2. ONLINE QUIZZES** **3.PROBLEM-SOLVING ACTIVITIES**	**WRITTEN TEST**

Outcomes

Upon completion of the course, the students will be able to:	
1	Understand the basic concept of fundamentals and mechanism of drives.
2	Acquire knowledge about the operation of the converter fed DC drive.
3	Understand the concepts of chopper fed DC drive.
4	Expertise in design the current and speed controllers for a closed loop solid state DC motor drive.
5	Implement of control algorithms using microcontrollers and phase locked loop.

Text Books

1. Gopal K Dubey, "Power Semiconductor controlled Drives", Prentice Hall Inc., New Yersy, 1989.
2. Vedam Subramanyam, "Electric Drives – Concepts and Applications", Tata McGraw-Hill publishing company Ltd., New Delhi, 2002.

Reference Books

1. R.Krishnan, "Electric Motor Drives – Modeling, Analysis and Control", Prentice-Hall of India Pvt. Ltd., New Delhi, 2010.
2. GobalK.Dubey, "Fundamentals of Electrical Drives", Narosal Publishing House, New Delhi, Second Edition ,2009
3. P.C Sen "Thyristor DC Drives", John wiely and sons, New York, 1981.

Web Resources

1. https://nptel.ac.in/courses/108104140
2. https://nptel.ac.in/courses/108106184

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PSO 1	PSO 2
1	3	2									3	
2	3	2									3	
3	3	2									3	
4	3	2									3	
5	3	2									3	

BLOOMS LEVEL ASSESSMENT PATTERN

BLOOMS CATEGORY	CAT 1	CAT 2	FAT 1	FAT 2	END SEM EXAM

REMEMBER	10	10	05	05	10
UNDETSTAND	20	20	05	05	20
APPLY	30	30	15	15	30
ANALYZE	30	30	20	20	30
EVALUATE	10	10	05	05	10
CREATE	0	0	0	0	0
	100	100	50	50	100

1-Low , 2- Medium, 3- High

21PE1604	**POWER QUALITY ANALYSIS AND MITIGATION TECHNIQUES**	**L**	**T**	**P**	**C**
		3	**1**	**0**	**4**

Preamble

It is needless to mention that how much we are dependent on electricity in our day to day life. A reasonable understanding on the basics of different problems and their solutions to applied electricity is therefore important for an electrical engineer. This course will help the students know different power quality problems occurring in power system and provide brief idea about their solutions with comparative study.

Prerequisites for the course

1. Advanced Engineering Mathematics
2. FACTS

Objectives

1. Analysis on the Electrical power quality issues and power quality standards
2. Investigation on the Analysis of various PQ issues
3. Exploration on the power quality improvement
4. Understand the conventional compensation techniques used for power factor correction and load voltage regulation.
5. Recognize the active compensation techniques used for load voltage regulation.

UNIT I	**POWER QUALITYAN OVERVIEW**	**12**

Introduction – Characterization of Electric Power Quality: Transients, short duration and long duration voltage variations, Voltage imbalance, waveform distortion, Voltage fluctuations, Power frequency variation, Power acceptability curves – power quality problems: poor load power factor, Non-linear and unbalanced loads, DC offset in loads, Notching in load voltage, Disturbance in supply voltage – Power quality as per IEEE standard		
UNIT II	**ANALYSIS OF PQ ISSUES**	**12**
Analysis of Harmonics distortion: Fourier series and Fourier Transform, Harmonic indices, Analysis of power outages, Analysis of voltage sag: Detroit Edison sag score, Voltage sag energy, Voltage Sag Lost Energy Index (VSLEI), Analysis of voltage flicker		
UNIT III	**POWER QUALITY IMPROVEMENT**	**12**
Passive and active harmonic filters, phase multiplication, power conditioners, UPS, Constant voltage transformers, Introduction to custom power devices.		
UNIT IV	**DSTATCOM**	**12**
Compensating single phase loads – Ideal three phase shunt compensator structure –Generating reference currents using instantaneous PQ theory – Instantaneous symmetrical components theory – Generating reference currents when the source is unbalanced – Realization and control of DSTATCOM – DSTATCOM in Voltage control mode		
UNIT V	**DVR**	**12**
Rectifier supported DVR – DC Capacitor supported DVR – DVR Structure – voltage Restoration – Series Active Filter. UPQC: Configurations and characteristics.		
	Total Periods	**60**

Suggestive Assessment Methods

Continuous Assessment Test (30 Marks)	Formative Assessment Test (10 Marks)	End Semester Exams (60 Marks)
WRITTEN TEST	**1.ASSIGNMENT 2. ONLINE QUIZZES 3.PROBLEM-SOLVING ACTIVITIES**	**WRITTEN TEST**

Outcomes

Upon completion of the course, the students will be able to:

1	To understand various sources, causes and effects of power quality issues,electrical Systems and their measures and mitigation.
2	To Analyse the various PQ problems
3	Explain the conventional mitigation methods for PQ issues
4	To understand and design load compensation methods useful for mitigating power Quality problems.

5	To acquire knowledge on DVR

Text Books

1. ArindamGhosh "Power Quality Enhancement Using Custom Power Devices", Kluwer Academic Publishers, 2002
2. R.C. Duggan, Mark.F.McGranaghan,SuryaSantoas and H.WayneBeaty, Electrical Power System Quality", McGraw-Hill, 2017.

Reference Books

1. Jos Arrillaga and Neville R. Watson ," Power system harmonics",Wiley,2015
2. Derek A. Paice , "Power Electronics Converter Harmonics :Multipulse Methods for Clean Power",Wiley,1999

Web Resources

1. https://testguy.net/content/361-Power-Quality-Analysis-Basic-Theory-and-Applications-Explained
2. https://nptel.ac.in/courses/108102179/

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2
1	2	2	2		2	1				2	2	
2	2	2	2		1	2				1	2	
3	2	2	2		2	1				2	2	
4	2		2		2	3				3		2
5	2	2	2		1	2				1		2

BLOOMS LEVEL ASSESSMENT PATTERN

BLOOMS CATEGORY	CAT 1	CAT 2	FAT 1	FAT 2	END SEM EXAM
REMEMBER	20	20	10	10	20
UNDETSTAND	30	30	10	10	30
APPLY	20	20	10	10	20
ANALYZE	15	15	10	10	15

EVALUATE	15	15	10	10	15
CREATE	0	0	0	0	0
	100	100	50	50	100

1-Low, 2- Medium, 3- High

21PE1605	**SPECIAL MACHINES AND CONTROLLERS**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Preamble

Special electrical machines are finding ever-increasing applications, typically in position control systems, robotics and mechatronics, electric vehicles, and high speed transportation. A particular feature of this course is that it does not stop at the basic principles of these complex machines but goes on to cover recent developments and current research, making it useful for senior graduate students and research scholars in the field of electrical machines and drives.

Prerequisites for the course

1.Electrical Machines-I

2.Electrical Machines -II

Objectives

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

UNIT I	**PERMANENT MAGNET BRUSHLESS DC MOTORS**	**9**

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

UNIT II	**PERMANENT MAGNET SYNCHROUNOUS MOTORS**	**9**

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

UNIT III	**SWITCHED RELUCTANCE MOTORS**	**9**

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

UNIT IV	**STEPPER MOTORS**	**9**

Constructional features –Principle of operation –Types – Torque predictions – Linear and Nonlinear 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 Periods	**45**

Suggestive Assessment Methods

Continuous Assessment Test (30 Marks)	**Formative Assessment Test (10 Marks)**	**End Semester Exams (60 Marks)**
WRITTEN TEST	**1.ASSIGNMENT 2. ONLINE QUIZZES 3.PROBLEM-SOLVING ACTIVITIES**	**WRITTEN TEST**

Outcomes

Upon completion of the course, the students will be able to:

1	Understand the Characteristics of Permanent magnet Brushless DC motors.
2	Recognize the concept of Permanent magnet Synchronous DC motors.
3	Realize the Concept of Switched Reluctance motors.
4	Develop the Concept of Stepper motors.
5	Interpret the various types of special motor for a certain job Conditions.

Text Books

1. T.J.E. Miller, 'Brushless magnet and Reluctance motor drives', Clare don press, London,1989.
2. R. Krishnan, 'Switched Reluctance motor drives', CRC press, 2001.

Reference Books

1. T.Kenjo, 'Stepping motors and their microprocessor controls', Oxford University press, New Delhi, 2000.
2. T.Kenjo and S.Nagamori, 'Permanent magnet and Brushless DC motors', Clarendon press, London, 1988.
3. R.Krishnan, 'Electric motor drives',prentice hall of India, 2002.
4. D.P.Kothari and I.J.Nagrath, ' Electric machines', Tata Mc Graw hill publishing company, New Delhi, Third Edition, 2004.

Web Resources

3. https://www.brainkart.com/subject/Special-Electrical-Machines_185/
4. https://nptel.ac.in/courses/108105131/

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2
1	3	2			2			2		1		2
2	3	2			2			2		1		2
3	3	2	1		2			2		1		2
4	3	2	1		2			2		1		2
5	3	2			2			2		1		2

BLOOMS LEVEL ASSESSMENT PATTERN

BLOOMS CATEGORY	CAT 1	CAT 2	FAT 1	FAT 2	END SEM EXAM
REMEMBER	20	20	10	10	20
UNDETSTAND	30	30	10	10	30
APPLY	20	20	10	10	20
ANALYZE	15	15	10	10	15
EVALUATE	15	15	10	10	15
CREATE	0	0	0	0	0
	100	100	50	50	100

1-Low, 2- Medium, 3- High

21PE2601	Generalized Machine Theory	L	T	P	C
		3	0	0	3
Preamble					

The aim of the subject is to develop an understanding of the basic concepts of synchronous machine, Magnetic circuits, permanent magnet, stored magnetic energy, Transfer function for DC machine, Transient Power Angle characteristics, Phases diagram for cylindrical rotor and salient pole machine. Apply this knowledge to develop modelling of major machine components

Prerequisites for the course

1. Fundamentals of Applied Electromagnetics
2. DC Machines and Transformers

Objectives

1. To discuss the fundamentals of magnetic circuits, energy, force and torque of multi-excited systems
2. To impart the general equations for voltages of all type of rotating machines
3. To impose the general equations for torque of all type of DC machines
4. To acquire the simulation model of Synchronous machines
5. To provide adequate knowledge the simulation model of three-phase AC machines

UNIT I	PRINCIPLES OF ELECTROMAGNETIC ENERGY CONVERSION	9

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

UNIT II	REFERENCE FRAME THEORY	9

Reference frame theory, 3-Φ→2-Φ transformation, Physical concept of park's transformation, Volt-ampere and torque equations, Space vector concept.

UNIT III	MODELLING OF DC MACHINE	9

Transfer function for DC machine, (Shunt, Series and compound), Linearization technique, Analysis under motoring and generating mode, Dynamic analysis.

UNIT IV	MODELLING OF SYNCHRONOUS MACHINE	9

General machine equation in different frame, Dynamic analysis, Transient Power Angle characteristics, Phases diagram for cylindrical rotor and salient pole machine, Electromagnetic and reluctance torque, Electric braking of synchronous machine.

UNIT V	MODELLING OF THREE PHASE INDUCTION MACHINE	9

Performance equations in different rotating frames, Equivalent circuit, Different inductance, Effect of voltage and frequency on the performance, Braking, Unbalance operations.

	Total Periods	**45**

Suggestive Assessment Methods

Continuous Assessment Test (30 Marks)	**Formative Assessment Test (10 Marks)**	**End Semester Exams (60 Marks)**

WRITTEN TEST	**1.ASSIGNMENT** **2. ONLINE QUIZZES** **3.PROBLEM-SOLVING ACTIVITIES**	**WRITTEN TEST**

Outcomes

Upon completion of the course, the students will be able to:

1	Derive the various electrical parameters of electromagnetic conversion in mathematical form
2	Formulate the parameters in different reference frame of Electrical Machines.
3	Investigate the transient performance of different DC machines.
4	Assess the special purpose small machines for different applications.
5	Develop mathematical model of three-phase AC machines

Text Books

1. Bimbhra, P.S., Generalized Theory of Electric Machines, Khanna Publishers (2010).
2. Kraus, P.C., Analysis of Electric Machine, McGraw–Hill (2000).

Reference Books

1. Charles V. Johnes, "Unified Theory of Electrical Machines". New York, Plenum Press, 2008
2. Charles Concordia," Synchronous Machines- Theory and Performance", John Wiley and Sons Incorporate, Newyork.2009.

Web Resources

1. https://www.academia.edu/4644500/GENERALIZED_THEORY_OF_ELECTRICAL_MACHINES
2. https://easyengineering.net/generalized-theory-of-electrical-machines-by-bimbhra/
3. https://www.youtube.com/watch?v=iDBeDHGSaPE

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2
1	3	3										3
2	3	3										3

3	3	3	1									3
4	3	3										3
5	3	3	1									3

BLOOMS LEVEL ASSESSMENT PATTERN

BLOOMS CATEGORY	**CAT 1**	**CAT 2**	**FAT 1**	**FAT 2**	**END SEM EXAM**
REMEMBER	10	10	10	10	10
UNDETSTAND	30	30	10	10	30
APPLY	30	30	10	10	30
ANALYZE	20	20	10	10	15
EVALUATE	10	10	10	10	15
CREATE	0	0	0	0	0
	100	100	50	50	100

1-Low , 2- Medium, 3- High

21PE2602	**SOLID STATE AC DRIVES**	**L**	**T**	**P**	**C**
		3	**1**	**0**	**4**

Preamble

The aim of the subject is to develop an understanding of the basic concepts Induction motor steady state performance equations, rotating magnetic field, CSI fed IM variable frequency drives comparison, static scherbius drives – power factor considerations – modified Kramer drives introduction to the operation of electric drives controlled from a power electronic converter and also provides the design concepts of controllers

Prerequisites for the course

1. Power Electronics
2. AC Machines

Objectives

1. To review various operating regions of the induction motor drives.
2. To study and analyze the operation of VSI & CSI fed induction motor control.

3. To acquire the speed control techniques of induction motor drive from the rotor side.		
4. To impart knowledge on field oriented control of induction machine.		
5. To enlighten the control of synchronous motor drives		
UNIT I	**INTRODUCTION TO INDUCTION MOTORS**	**12**
Steady state performance equations – Rotating magnetic field – torque production, Equivalent circuit– Variable voltage, constant frequency operation – Variable frequency operation, constant Volt/Hz operation. Drive operating regions, variable stator current operation, different braking methods.		
UNIT II	**VSI AND CSI FED INDUCTION MOTOR CONTROL**	**12**
AC voltage controller circuit – six step inverter voltage control-closed loop variable frequency PWM inverter with dynamic braking-CSI fed IM variable frequency drives comparison		
UNIT III	**ROTOR CONTROLLED INDUCTION MOTOR DRIVES**	**12**
Static rotor resistance control – injection of voltage in the rotor circuit – static scherbius drives – power factor considerations – modified Kramer drives		
UNIT IV	**FIELD ORIENTED CONTROL**	**12**
Field oriented control of induction machines – Theory – DC drive analogy – Direct and Indirect methods – Flux vector estimation – Direct torque control of Induction Machines – Torque expression with stator and rotor fluxes, DTC control strategy.		
UNIT V	**SYNCHRONOUS MOTOR DRIVES**	**12**
Wound field cylindrical rotor motor – Equivalent circuits – performance equations of operation from a voltage source – Power factor control and V curves – starting and braking, self-control – Load commutated Synchronous motor drives – Brush and Brushless excitation		
	Total Periods	**60**

Suggestive Assessment Methods

Continuous Assessment Test (30 Marks)	**Formative Assessment Test (10 Marks)**	**End Semester Exams (60 Marks)**
WRITTEN TEST	**1.ASSIGNMENT** **2. ONLINE QUIZZES** **3.PROBLEM-SOLVING**	**WRITTEN TEST**

	ACTIVITIES	

Outcomes

Upon completion of the course, the students will be able to:

1	Apply the basic concept of induction motors
2	Analyze about the operation of VSI & CSI fed induction motor drive.
3	Interpret the concepts of rotor controlled drive.
4	Articulate the field oriented control of induction machine
5	Examine the concepts of synchronous motor from the mathematical equation

Text Books

1. Bimal K Bose, "Modern Power Electronics and AC Drives", Pearson Education Asia 2002.
2. Vedam Subramanyam, "Electric Drives – Concepts and Applications", Tata McGraw Hill, 1994.

Reference Books

1. Gopal K Dubey, "Power Semiconductor controlled Drives", Prentice Hall Inc., New Yersy,1989
2. R.Krishnan, "Electric Motor Drives – Modeling, Analysis and Control", Prentice-Hall of India Pvt. Ltd., New Delhi, 2003.
3. W.Leonhard, "Control of Electrical Drives", Narosa Publishing House, 1992

Web Resources

1. https://www.vssut.ac.in/lecture_notes/lecture1424084684.pdf
2. https://www.scribd.com/document/253784176/Solid-State-Dc-Drives-Part1-PDF

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2
1	3	3									3	3
2	3	3	1								3	3
3	3	3									3	3
4	3	3	1								3	3

5	3	3									3	3

BLOOMS LEVEL ASSESSMENT PATTERN

BLOOMS CATEGORY	CAT 1	CAT 2	FAT 1	FAT 2	END SEM EXAM
REMEMBER	10	10	10	10	10
UNDETSTAND	30	30	10	10	30
APPLY	30	30	10	10	30
ANALYZE	20	20	10	10	15
EVALUATE	10	10	10	10	15
CREATE	0	0	0	0	0
	100	100	50	50	100

1-Low , 2- Medium, 3- High

21PE2603	Modern Control Theory	L	T	P	C
		3	0	0	3

Preamble

This course is to impart in students a good understanding of fundamental principles in Modern Control Theory. The course includes: Nonlinear systems and their properties, Common Non-linearities, Optimal control problems, Mathematical procedures for optimal control design, sampling and data hold, Reconstructing original signal from sampled signals, Stability analysis of closed-loop systems in the z-plane, Lyapunov stability analysis, Controllability and Observability, Design via pole placement, State observer design.

Prerequisites for the course

1. Control systems
2. Digital Signal Processing

Objectives

1. To study the fundamentals of physical systems in terms of its modern control system for the real time analysis and design of control systems
2. To educate on representing optimal control to any system.
3. To impart knowledge on Z-Plane Analysis of Discrete-Time Control Systems
4. To apply the comprehensive knowledge of optimal theory for Control Systems.
5. To enlighten the concept on stability analysis of systems using Lyapunov‟s theory.

UNIT I	**Nonlinear Control System**	**9**
Introduction to Nonlinear systems and their properties, Common Non-linearities, Describing functions, Phase plane method, Lyapounov's method for stability study, concept of Limit Cycle.		
UNIT II	**Optimal Control Theory**	**9**
Introduction, Optimal control problems, Mathematical procedures for optimal control design: Calculus of variations, Pontryagin's optimum policy, Bang-Bang Control, Hamilton-Jacobi Principle.		
UNIT III	**Z-Plane Analysis of Discrete-Time Control Systems**	**9**
Introduction, Impulse sampling and data hold, Reconstructing original signal from sampled signals, concept of pulse transfer function, Realization of digital controllers.		
UNIT IV	**Design of Discrete-time Control Systems**	**9**
Introduction, Stability analysis of closed-loop systems in the z-plane, Transient and steady state response analysis, Design based on the rootlocus method, Design based on the frequency-response method.		
UNIT V	**State-Space Analysis**	**9**
Introduction, State-space representations of discrete-time systems, Solving discrete-time state-space equations, Pulse transfer function matrix, Discretization of continuous time state space equations, Lyapunov stability analysis, Controllability and Observability, Design via pole placement, State observer design.		
	Total Periods	**45**

Suggestive Assessment Methods

Continuous Assessment Test (30 Marks)	**Formative Assessment Test (10 Marks)**	**End Semester Exams (60 Marks)**
WRITTEN TEST	**1.ASSIGNMENT** **2. ONLINE QUIZZES** **3.PROBLEM-SOLVING ACTIVITIES**	**WRITTEN TEST**

Outcomes

Upon completion of the course, the students will be able to:

1	Demonstrate non-linear system behavior by phase plane and describing function methods.
2	Perform the stability analysis nonlinear systems by lyapunov method develop design skills in optimal control problems.
3	Derive discrete-time mathematical models in both time domain (difference equations, state equations) and z-domain (transfer function using z-transform).
4	Predict and analyze transient and steady-state responses and stability and sensitivity of both open-loop and closed-loop linear, time-invariant, discrete-time control systems.
5	apply the knowledge of state space and state feedback in modern control systems, pole

	placement, design of state observers and output feedback controllers.

Text Books

1. Slotine & Li, Applied Non-Linear Control, Englewood Cliffs, NJ: Prentice-Hall, (1991).
2. Bandyopadhyay, M.N., Control Engineering: Theory and Practice, Prentice-Hall of India Private Limited (2003)

Reference Books

1. Ogata, K., Discrete-time Control Systems, Pearson Education (2005).

Web Resources

1. **https://nptel.ac.in/courses/108/101/108101037/**
2. **https://freevideolectures.com/course/2337/control-engineering/5**

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2
1	3	3									3	
2	3	3									3	
3	3	3	2								3	
4	3	3	2								3	
5	3	3	2								3	

BLOOMS LEVEL ASSESSMENT PATTERN

BLOOMS CATEGORY	CAT 1	CAT 2	FAT 1	FAT 2	END SEM EXAM
REMEMBER	10	10	10	10	10
UNDETSTAND	30	30	10	10	30
APPLY	30	30	10	10	30
ANALYZE	20	20	10	10	15

EVALUATE	10	10	10	10	15
CREATE	0	0	0	0	0
	100	100	50	50	100

1-Low , 2- Medium, 3- High

21PE2611	**SOLID STATE DRIVES AND CONTROL LABORATORY**	**L**	**T**	**P**	**C**
		0	**0**	**4**	**2**

Preamble

To get exposure about the DC and AC drives and their speed control techniques.

Prerequisites for the course

- Power electronics
- Solid state drives
- Power electronics laboratory

Objectives

1. To design and analyse the various DC and AC drives.
2. To Study the performance of Induction motor drives.
3. To discuss the hardware and software simulation of Special Machines.
4. To design the multi level inverter and three-phase Synchronous Generator.
5. To learn the basic concepts of Power Quality Anayzer.

S.No	**List of Experiments**	**CO**
1	Speed control of Converter fed DC motor.	**1**
2	Speed control of Chopper fed DC motor.	**1**
3	V/f control of three-phase induction motor.	**2**
4	Micro controller based speed control of Stepper motor.	**3**
5	Speed control of BLDC motor.	**3**
6	DSP based speed control of SRM motor.	**3**
7	Voltage Regulation of three-phase Synchronous Generator.	**4**
8	Cyclo-converter fed Induction motor drives.	**2**
9	Single phase Multi Level Inverter based induction motor drive.	**4**

10	Study of power quality analyzer.	**5**

Suggestive Assessment Methods

Lab Components Assessments (60 Marks)	**End Semester Exams (40 Marks)**
Observation **Record** **Viva-voce**	**End semester Examination** **Viva-voce**

Outcomes

Upon completion of the course, the students will be able to:

CO1	Ability to simulate different types of machines, converters in a system.
CO2	Analyze the performance of Induction motor drives.
CO3	Ability to perform both hardware and software simulation of Special Machines.
CO4	Ability to simulate the multi level inverter and three-phase Synchronous Generator.
CO5	To understand the basic concepts of Power Quality Anayzer.

Laboratory Requirements

Converter fed DC motor drive-1
Chopper fed DC motor drive-1
V/f control based Induction motor devices-1
Cyclo converter fed induction motor drive-1
Three phase synchronous generator-1
SRM Drive with DSP controller-1
PMBLDC Drive-1
Stepper motor drive with microprocessor based control-1
Single phase multilevel inverter fed with motor drive-1
Power Quality Analyser-1
Tachometers-10
Ammeters-10
Voltmeters-10
Digital storage oscilloscope-5

Reference Books

1. Ned Mohan,T.M Undeland and W.P Robbin, "Power Electronics: converters, Application and design" John Wiley and sons.Wiley India edition, 2006.
2. Rashid M.H., "Power Electronics Circuits, Devices and Applications ", Prentice Hall India, Third Edition, New Delhi, 2004.
3. Vedam Subramanyam, "Electric Drives – Concepts and Applications", Tata McGraw-Hill publishing company Ltd., New Delhi, 2002.

Web Resources

1. https://www.youtube.com/playlist?list=PLUSE6w0Kh7fI86nz-q35hwG8NCHRvvKEY
2. https://nptel.ac.in/courses

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2
1	3	2							2		3	
2	3	2							2		3	
3	3	2							2		3	
4	3	2							2		3	
5	3	2							2		3	

1-Low , 2- Medium, 3- High

21PE2911	INNOVATIVE PROJECT	L	T	P	C
		0	0	4	2

Preamble

Innovative Project has been proven to be the most effective method of delivering products within cost, schedule, and resource constraints. It provides the skills to ensure that the projects are completed on time and on budget while giving the user the product, they expect.

Prerequisites for the course

NIL

Objectives

1. To develop the ability to solve a specific problem right from its identification and literature review till the successful solution of the same.
2. To explain the organizational structure for projects to develop a product with a given specification.
3. To discuss the cost required to complete a given project
4. To Introduce about the work breakdown structure for a given Solutions.
5. 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.

Rectifiers, DC-DC Converters, Inverters, cyclo-converters, 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.

Speed control of Converter fed DC motor.

PROFESSIONAL ELECTIVES

21PE2701	SOLAR PHOTOVOLTAIC SYSTEMS	L	T	P	C
		3	0	0	3

Preamble

This course focuses on solar photovoltaic (PV) systems, which convert solar energy into a convenient electrical energy form. We will mainly study the types of electrical components and schemes used in such PV systems. The course will cover the characteristics of solar radiation, PV cells, modules and arrays, stand-alone PV schemes with battery energy storage and grid-connected PV schemes.

Prerequisites for the course

- Advanced Engineering Mathematics
- Physics For Engineers

Objectives

1. To understand the Basics of solar photovoltaic systems.
2. To study components of standalone PV systems.
3. To learn the Necessity of grid connected PV systems.
4. To analyze the Need and type of Hybrid systems.
5. To discuss the designing of the System Components for different PV Applications.

UNIT I	PHOTOVOLTAIC BASICS	9

Structure and working of Solar Cells - Types, Electrical properties and Behaviour of Solar Cells - Cell properties and design - PV Cell Interconnection and Module Fabrication - PV Modules and arrays - Basics of Load Estimation.

UNIT II	STAND ALONE PV SYSTEMS	9

Schematics, Components, Batteries, Charge Conditioners - Balance of system components for DC and/or AC Applications - Typical applications for lighting, water pumping etc.

UNIT III	GRID CONNECTED PV SYSTEMS	9

Schematics, Components, Charge Conditioners, Interface Components - Balance of system Components - PV System in Buildings.

UNIT IV	HYBRID SYSTEMS	9

Solar, Biomass, Wind, Diesel Hybrid systems - Comparison and selection criteria for a given applications.

UNIT V	**DESIGN OF PV SYSTEMS**	**9**

Radiation and load data - Design of System Components for different PV Applications - Sizing and Reliability - Simple Case Studies.

Total Periods	**45**

Suggestive Assessment Methods

Continuous Assessment Test (30 Marks)	**Formative Assessment Test (10 Marks)**	**End Semester Exams (60 Marks)**
WRITTEN TEST	**1.ASSIGNMENT** **2. ONLINE QUIZZES** **3.PROBLEM-SOLVING ACTIVITIES**	**WRITTEN TEST**

Outcomes

Upon completion of the course, the students will be able to:

1	Explain the basics of Photovoltaic systems.
2	Provide accurate schematic of stand-alone PV systems.
3	Provide accurate schematic of grid-connected PV systems.
4	Select appropriate hybrid system for different applications.
5	Design and simulate the stand-alone and grid connected system.

Text Books

1. CS Solanki: Solar Photovoltaics – Fundamentals, Technologies and Applications, PHI Learning Pvt. Ltd., 2013.
2. Stuart R. Wenham, Martin A. Green, Muriel E. Watt, Richard Corkish (Editors), Applied Photovoltaics, Earthscan, 2011.

Reference Books

1. Michael Boxwell, The Solar Electricity Handbook, Code Green Publishing, UK, 2012.
2. RikDeGunther, Solar Power Your Home for Dummies, Wiley Publishing Inc, 2010.
3. Photovoltaics: Design and Installation Manual, Published by Solar Energy International,2004.

Web Resources

1. **https://nptel.ac.in/courses/117/108/117108141/**

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PSO 1	PSO 2
1	3	2									3	
2	3	2									3	
3	3	2									3	
4	3	2									3	
5	3	2									3	

BLOOMS LEVEL ASSESSMENT PATTERN

BLOOMS CATEGORY	CAT 1	CAT 2	FAT 1	FAT 2	END SEM EXAM
REMEMBER	10	10	05	05	10
UNDETSTAND	20	20	05	05	20
APPLY	30	30	15	15	30
ANALYZE	30	30	20	20	30
EVALUATE	10	10	05	05	10
CREATE	0	0	0	0	0
	100	100	50	50	100

1-Low , 2- Medium, 3- High

21PE2702	ELECTROMAGNETIC FIELD COMPUTATION AND MODELLING	L	T	P	C
		3	0	0	3
Preamble					

The Course is designed to impart knowledge of fundamentals of vector calculus, concept of electric and magnetic fields (both static and time varying) applicable to electrical engineering. The course exposes the students to the concept of resistance, capacitance, and Inductance.

Prerequisites for the course

- Control System Design
- Electromagnetic Fields

Objectives

1. To refresh the fundamentals of Electromagnetic Field Theory
2. To impart foundation in formulation
3. To Evaluate Electromagnetic Fields using analytical and numerical methods.
4. To impart in-depth knowledge on Finite Element Method in solving Electromagnetic field problems
5. 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 ELEMENT METHOD (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 USING FEM PACKAGES	9

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

UNIT V	DESIGN APPLICATIONS	9

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

Total Periods	**45**

Suggestive Assessment Methods

Continuous Assessment Test (30 Marks)	**Formative Assessment Test (10 Marks)**	**End Semester Exams (60 Marks)**
WRITTEN TEST	**1.ASSIGNMENT** **2. ONLINE QUIZZES** **3.PROBLEM-SOLVING ACTIVITIES**	**WRITTEN TEST**

Outcomes

Upon completion of the course, the students will be able to:

1	Demonstrate the concepts of electromagnetic Field
2	Ability to formulate the FEM method and use of the package
3	Build the concepts in the design of rotating machines
4	Ability to acquire in-depth knowledge on Finite Element Method in solving Electromagnetic field problems
5	To construct the concept of mathematical modelling of electrical apparatus

Text Books

1. Matthew. N.O. Sadiku, "Elements of Electromagnetics", Fourth Edition, Oxford University Press, First Indian Edition 2007
2. Nicola Biyanchi , "Electrical Machine analysis using Finite Elements", Taylor and Francis Group, CRC Publishers, 2005.

Reference Books

1. K.J.Binns, P.J.Lawrenson, C.W Trowbridge, "The analytical and numerical solution of Electric and magnetic fields", John Wiley & Sons, 1993.
2. Nathan Ida, Joao P.A.Bastos , "Electromagnetics and calculation of fields", SpringerVerlage, 1992.
3. S.J Salon, "Finite Element Analysis of Electrical Machines" Kluwer Academic Publishers, London, 1995, distributed by TBH Publishers & Distributors, Chennai, India.

Web Resources

1. https://nptel.ac.in/courses/108106023/

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PSO 1	PSO 2
1	3		3		2			2			3	
2	3		3		2			2			3	
3	3		3		2			2			3	
4	3		3		2			2			3	
5	3		3		2			2			3	

BLOOMS LEVEL ASSESSMENT PATTERN

BLOOMS CATEGORY	CAT 1	CAT 2	FAT 1	FAT 2	END SEM EXAM
REMEMBER	20	20	10	10	20
UNDERSTAND	40	40	20	20	40
APPLY	20	20	10	10	20
ANALYZE	20	20	10	10	20
	100	100	50	50	100

1-Low , 2- Medium, 3- High

21PE2703	CONTROL SYSTEM DESIGN FOR POWER ELECTRONICS	L	T	P	C
		3	0	0	3

Preamble

This course is to impart in students a good understanding of fundamental principles in control system. The course includes Mathematical Modelling of Linear Continuous and Analysis and Design of Closed Loop Control Systems. Power electronics involves the study of electronic circuits intended to control the flow of electrical energy. It deals with the processing and control of 'raw' electrical

power from an electrical source such as an AC mains supply, a battery bank,

Prerequisites for the course

1. Control Systems
2. Power Electronics

Objectives

1. To learn the model DC-DC Converter
2. To study the conceptual design of Sliding Mode controller
3. To learn the linear controller design in converter
4. Tostudy the techniques relevant to the design of feedback controllers in Power Electronics
5. To design appropriate controllers for power converters

UNIT I	MODELLING OF DC-TO-DC POWER CONVERTERS	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 MODE CONTROLLER DESIGN	9

Variable Structure Systems. Single Switch Regulated Systems Sliding Surfaces, Accessibility of the Sliding Surface Sliding 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 LINEARIZATION CONTROLLER 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 OF POWER 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 Periods	**45**

Suggestive Assessment Methods

Continuous Assessment Test (30 Marks)	**Formative Assessment Test (10 Marks)**	**End Semester Exams (60 Marks)**
WRITTEN TEST	**1.ASSIGNMENT** **2. ONLINE QUIZZES** **3.PROBLEM-SOLVING ACTIVITIES**	**WRITTEN TEST**

Outcomes

Upon completion of the course, the students will be able to:

1	Improve the model DC-DC Converter
2	Enhance the design of Sliding Mode controller
3	To understand an overview on modern linear and nonlinear control strategies for power electronics devices.
4	Gain acknowledgeson overview of the techniques relevant to the design of feedback controllers in Power Electronics
5	To learn the design of appropriate controllers for power converters

Text Books

1. Patil, PankajRodey, "Control Systems for Power Electronics: A Practical Guide", Springer India, 2015. Mahesh
2. Blaabjerg José Rodríguez, "Advanced and Intelligent Control in Power Electronics and Drives" , Springer,

Reference Books

1. HeberttSira-Ramírez PhD, Ramón Silva-Ortigoza, "Control Design Techniques in Power Electronics Devices", Springer 2012
2. Enrique Acha, VassiliosAgelidis, Olimpo Anaya, TJE Miller, "Power Electronic Control in Electrical Systems", Newnes, 2002
3. Marija D. Aranya Chakrabortty, Marija , "Control and Optimization Methods for Electric

Smart Grids", Springer, 2012

WEB RESOURCES

1.https://www.digimat.in/nptel/courses/video/108101002/L01.html

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2
1	3		3		2			2						3
2	3		3		2			2						3
3	3		3		2			2						3
4	3		3		2			2						3
5	3		3		2			2						

BLOOMS LEVEL ASSESSMENT PATTERN

BLOOMS CATEGORY	CAT 1	CAT 2	FAT 1	FAT 2	END SEM EXAM
REMEMBER	25	25	15	15	25
UNDERSTAND	40	40	15	15	35
APPLY	20	20	10	10	20
ANALYZE	15	15	10	10	20
EVALUATE					
CREATE					

	100	100	50	50	100

1-Low , 2- Medium, 3- High

21PE2704	INTELLIGENT CONTROL TECHNIQUES	L	T	P	C
		3	0	0	3

Preamble

This course is to impart in students a good understanding of fundamental principles in control engineering. The course includes: Mathematical modelling of Linear Continuous Time Invariant Single Input - Single Output Dynamical Systems, Transfer Functions and State Space Models, Performance Specifications, Analysis and Design of Closed Loop Control Systems

Prerequisites for the course

1.Power Quality Analysis and Mitigation Techniques
2.Modern Control Theory

Objectives

1. To uncover the concepts and Design of ANN and fuzzy set theory.
2. To impart adequate knowledge on Analysis and implementation ofANN for modeling and control of Non-linear system and to get familiarized with the Matlab toolbox.
3. To teach about the concept of on Analysis and implementation of Fuzzy logic for modeling and control of Non-linear system and to get familiarized with the Matlab toolbox.
4. To uncover the ideas about genetic algorithm
5. 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 non linear system using ANN- Direct and Indirect neuro control schemes- Adaptive neuro controller –Case study - Familiarization of Neural Network Control Tool Box.

UNIT III	FUZZY LOGIC FOR MODELLING AND CONTROL	9

Modeling of 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 Periods	**45**

Suggestive Assessment Methods

Continuous Assessment Test (30 Marks)	**Formative Assessment Test (10 Marks)**	**End Semester Exams (60 Marks)**
WRITTEN TEST	**1.ASSIGNMENT** **2. ONLINE QUIZZES** **3.PROBLEM-SOLVING ACTIVITIES**	**WRITTEN TEST**

Outcomes

Upon completion of the course, the students will be able to:

1	Derive the basic architectures of Neural Network and Fuzzy sets.
2	Construct and implement ANN architectures, algorithms and know their limitations.
3	Examine and work with different operations on the fuzzy sets.
4	Create ANN and fuzzy logic based models and control schemes for non-linear systems.
5	Classify and explore hybrid control schemes and Particle Swarm Optimization.

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.

Reference Books

1. Zimmermann H.J. "Fuzzy set theory and its Applications" Springer international edition, 2011.
2. David E.Goldberg, “Genetic Algorithms in Search, Optimization, and Machine Learning”, Pearson Education, 2009.

3. W.T.Miller, R.S.Sutton and P.J.Webrose, "Neural Networks for Control" MIT Press", 1996.

Web Resources

1. https://nptel.ac.in/courses/106/105/106105173/
2. https://nptel.ac.in/content/storage2/nptel_data3/html/mhrd/ict/text/106105173/lec1.pdf

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PSO 1	PO1 2	PSO 1	PSO 2
1	3	2			2			1	2	3	2			
2	3	2			2			1	2	3	2			
3	3	2			2			1	2	3	2			
4	3	2			2			1	2	3	2			
5	3	2			2			1	2	3	2			

BLOOMS LEVEL ASSESSMENT PATTERN

BLOOMS CATEGORY	CAT 1	CAT 2	FAT 1	FAT 2	END SEM EXAM
REMEMBER	30	30	10	10	30
UNDETSTAND	35	35	20	20	35
APPLY	20	20	10	10	20

ANALYZE	15	15	10	10	15
EVALUATE	0	0	0	0	0
CREATE	0	0	0	0	0
	100	100	50	50	100

1-Low , 2- Medium, 3- High

21PS2702	**FLEXIBLE AC TRANSMISSION SYSTEMS**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Preamble

This course will describe about basic concepts, different types, scope and applications of FACTS controllers in power transmission system

Prerequisites for the course

1. High Voltage Engineering.
2. High Voltage Direct Current Engineering

Objectives

1. To know the importance of compensation in transmission lines and the concepts of FACTS devices.
2. To illustrate the design, modeling and applications of SVC
3. To learn the operation, modes, modeling and applications of TCSC.
4. To study the principle, characteristics, modeling and applications of STATCOM and SSSC.
5. To summarize about the importance in coordination of FACTS controllers.

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 ofa 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- modelling 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 Periods	**45**

Suggestive Assessment Methods

Continuous Assessment Test (30 Marks)	Formative Assessment Test (10 Marks)	End Semester Exams (60 Marks)
WRITTEN TEST	1.ASSIGNMENT 2. ONLINE QUIZZES 3.PROBLEM-SOLVING ACTIVITIES	WRITTEN TEST

Outcomes

Upon completion of the course, the students will be able to:

1	Explain the basic fundamental of FACTS controllers
2	Summarize about Static VAR Compensators
3	Understand about Modeling, Operation and control strategies of Static series compensation-SVC
4	Explain the voltage source based FACTS controllers

5	Analyse the modeling and design of Coordinating multiple FACTS controllers using control techniques

Text Books

1. Bjarne R. Andersen Stig L. Nilsson Flexible AC Transmission Systems: FACTS (CIGRE Green Books) July 2020
2. Sheikh M. Nawaz "Flexible AC Transmission System " January 2016

Reference Books

1. K.R.Padiyar," FACTS Controllers in Power Transmission and Distribution", New Age International(P) Ltd., Publishers New Delhi, Reprint 2008.
2. V. K.Sood, "HVDC and FACTS controllers- Applications of Static Converters in Power System", 2004, Kluwer Academic Publishers.

Web Resources

1. https://nptel.ac.in/courses/108107114
2. https://onlinecourses-archive.nptel.ac.in/noc18_ee44/preview

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PSO 1	PSO 2
1	2	2	1	2				2				3
2	2	2	1	2				2			2	
3	2	2	1	2				2			3	
4	2	2	1	2				2				2
5	2	2	1	2				2				3

BLOOMS LEVEL ASSESSMENT PATTERN

BLOOMS CATEGORY	CAT 1	CAT 2	FAT 1	FAT 2	END SEM EXAM
REMEMBER	20	20	10	10	20
UNDETSTAND	30	30	10	10	30
APPLY	20	20	10	10	20

ANALYZE	15	15	10	10	15
EVALUATE	15	15	10	10	15
CREATE	0	0	0	0	0
	100	100	50	50	100

1-Low , 2- Medium, 3- High

21PE2705	**Modern Rectifiers and Resonant Converters**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Preamble

It is an introductory course which emphasize the fundamental concepts of harmonics standards and operation of rectifiers and overview of Rectifiers along with series resonant converter

Prerequisites for the course

1. Power electronics

Objectives

1. To gain knowledge about the harmonics standards and operation of rectifiers in CCM &DCM.
2. To study the operation of pulse width modulated rectifiers.
3. To impart knowledge on operation of resonant converters for SMPS applications.
4. To carry out dynamic analysis of DC- DC Converters.
5. 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 offull 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	**RESONANT CONVERTERS**	**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.

UNIT V	**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 Periods	**45**

Suggestive Assessment Methods

Continuous Assessment Test (30 Marks)	**Formative Assessment Test (10 Marks)**	**End Semester Exams (60 Marks)**
WRITTEN TEST	**1.ASSIGNMENT** **2. ONLINE QUIZZES** **3.PROBLEM-SOLVING ACTIVITIES**	**WRITTEN TEST**

Outcomes

Upon completion of the course, the students will be able to:

1	Analyse the Harmonic analysis in various types of rectifiers.
2	Compare the different types of PWM rectifiers.
3	Identify the importance resonant converter
4	Design the various DC-DC converter techniques.
5	Demonstrate the source current shaping for rectifiers.

Text Books

1. Andrzej M. Trzynadlowski, " Introduction To Modern Power Electronics", John Wiley &Sons, 2016.
2. Marian.K.Kazimierczuk and DariuszCzarkowski, “Resonant Power Converters”, John Wiley & Sons limited, 2011.

Reference Books

1. Abraham I.Pressman, Keith Billings and Taylor Morey, " Switching Power Supply Design" McGraw-Hill ,2009.

2. Simon Ang and Alejandro Oliva, "Power Switching Converters", Taylor & Francis Group, 2010.

Web Resources

1. https://nptel.ac.in/courses/108108036

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2
1	3		2		3			2	3				2	
2	3		2		2			2	3				2	
3	3		2		3			2	3				2	
4	3		2		2			2	3				2	
5	3		2		3			2	3				2	

BLOOMS LEVEL ASSESSMENT PATTERN

BLOOMS CATEGORY	CAT 1	CAT 2	FAT 1	FAT 2	END SEM EXAM
REMEMBER	20	20	10	10	20
UNDETSTAND	30	30	10	10	30

APPLY	20	20	10	10	20
ANALYZE	15	15	10	10	15
EVALUATE	15	15	10	10	15
CREATE	0	0	0	0	0
	100	100	50	50	100

1-Low , 2- Medium, 3- High

21PE2706	**Electromagnetic Interference and Compatibility**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Preamble

It is an introductory course which emphasize the fundamental concepts of electromagnetic interference and EMC design components.

Prerequisites for the course

- Electromagnetic Theory
- Transmission and Distribution
- Power System Analysis

Objectives

1. To provide fundamental knowledge on electromagnetic interference
2. To provide fundamental knowledge on electromagnetic compatibility.
3. To study the important techniques to control EMI
4. To study the important techniques to control EMC.
5. 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 modelling, Cross talk - Methods of eliminating interferences.

UNIT II	**GROUNDING AND 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 Periods	**45**

Suggestive Assessment Methods

Continuous Assessment Test (30 Marks)	**Formative Assessment Test (10 Marks)**	**End Semester Exams (60 Marks)**
WRITTEN TEST	**1.ASSIGNMENT** **2. ONLINE QUIZZES** **3.PROBLEM-SOLVING ACTIVITIES**	**WRITTEN TEST**

Outcomes

Upon completion of the course, the students will be able to:

1	Recognize the sources of Conducted and radiated EMI in Power Electronic Converters and consumer appliances and suggest remedial measures to mitigate the problems.
2	Assess the insertion loss and design EMI filters to reduce the loss.
3	Design EMI filters, common-mode chokes and RC-snubber circuits measures to keep the interference within tolerable limits.
4	Analyze the parameters of grounding and cables.
5	Assess the different standards and testing techniques in electrostatic discharge

Text Books

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

Reference Books

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

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

Web Resources

https://archive.nptel.ac.in/courses/108/106/108106138

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PSO 1	PSO 2
1	3									2	2	
2	3		2		2					2	2	
3	3		3							2	2	
4	3	3								2	2	
5	3				3					2	2	

BLOOMS LEVEL ASSESSMENT PATTERN

BLOOMS CATEGORY	CAT 1	CAT 2	FAT 1	FAT 2	END SEM EXAM
REMEMBER	20	20	10	10	20

UNDETSTAND	30	30	10	10	30
APPLY	20	20	10	10	20
ANALYZE	15	15	10	10	15
EVALUATE	15	15	10	10	15
CREATE	0	0	0	0	0
	100	100	50	50	100

1-Low , 2- Medium, 3- High

21PE2707	**ROBOTICS AND CONTROL**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Preamble

The purpose of this course is to introduce the student to the basics of robotics and control. This course will enable learners to understand an overview of robotics in practice and research with topics including sensors, actuators, Robot path planning, transformation and its control techniques.

Prerequisites for the course

1. Mathematics
2. Engineering Mechanics
3. Control systems

Objectives

1. To introduce robot terminologies and robotic sensors.
2. To educate direct and inverse kinematic relations.
3. To educate on formulation of manipulator Jacobian's and introduce path planning techniques.
4. To educate on robot dynamics.
5. 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 Periods	**45**

Suggestive Assessment Methods

Continuous Assessment Test (30 Marks)	**Formative Assessment Test (10 Marks)**	**End Semester Exams (60 Marks)**
1. WRITTEN TEST	**1.ASSIGNMENT** **2. ONLINE QUIZZES**	**1. WRITTEN TEST**

Outcomes

Upon completion of the course, the students will be able to:

1	Understand the components and basic terminology of Robotics.
2	Model the motion of Robots and analyze the workspace and trajectory panning of robots.
3	Develop application based Robots.
4	Create dynamic modelling.
5	Formulate models for the control of mobile robots in various industrial applications.

Reference Books

1. R.K. Mittal and I J Nagrath, " Robotics and Control", Tata MacGraw Hill, 2017.
2. Saeed B. Niku ,''Introduction to Robotics analysis and control'', Pearson Education, 2011.
3. R.D. Klafter, TA Chmielewski and Michael Negin, "Robotic Engineering, An Integrated

approach",Prentice Hall of India, 2003.

4. A.J. Koivo, "Fundamentals for Control of Robotic Manipulation", John Wiley Inc. New York, 2001.

Web Resources

1. https://nptel.ac.in/courses/112107289/
2. https://nptel.ac.in/courses/112101099/
3. https://swayam.gov.in/nd1_noc20_me03/preview

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PSO 1	PSO 2
1	2	2	2	2		2	2	2			3	
2	2	3					2				3	
3	2	2	2			2	2	2			3	
4	2	2	2	2		2	2	2			3	
5	2	2	2	2	2	2	2	2			3	

BLOOMS LEVEL ASSESSMENT PATTERN

BLOOMS CATEGORY	CAT 1	CAT 2	FAT 1	FAT 2	END SEM EXAM
REMEMBER	20	20	10	10	20
UNDETSTAND	30	30	10	10	30
APPLY	20	20	10	10	20
ANALYZE	15	15	10	10	15
EVALUATE	0	0	0	0	0

CREATE	0	0	0	0	0
	100	100	50	50	100

1-Low , 2- Medium, 3- High

21PS2703	**DISTRIBUTED GENERATION AND MICROGRID**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Preamble

This course emphasizes the platform for the use of renewable sources which are the key to a sustainable energy supply infrastructure since they are both inexhaustible and non-polluting. The concepts discussed herein are intended to provide clarification on basic integration, control and operation of micro grid for electrical engineering graduates.

Prerequisites for the course

1. Power Electronics
2. Power Generation Systems
3. Solid state drives
4. Power system operation and control

Objectives

1. To illustrate the concept of distributed generation
2. To impart knowledge on Distributed Generation
3. To analyse the impact of grid integration.
4. To study concept of Micro grid and its configuration
5. To impart knowledge on Microgrid

UNIT I	**INTRODUCTION**	**9**

Conventional power generation: advantages and disadvantages, Energy crises, Nonconventional 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 micro grid, 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 Periods	**45**

Suggestive Assessment Methods

Continuous Assessment Test (30 Marks)	**Formative Assessment Test (10 Marks)**	**End Semester Exams (60 Marks)**
1 WRITTEN TEST	**1.ASSIGNMENT** **2. ONLINE QUIZZES** **3.PROBLEM-SOLVING ACTIVITIES**	**1. WRITTEN TEST**

Outcomes

Upon completion of the course, the students will be able to:

1	Make use of various schemes of conventional and nonconventional power generation.
2	Identify topologies and energy sources of distributed generation.
3	Discover about the requirements for grid interconnection and its impact with NCE sources.
4	Intereference the fundamental concept of Microgrid.
5	Inspect control and operation of Microgrid.

Reference Books

1. AmirnaserYezdani, 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, 2013.

3. Chetan Singh Solanki, "Solar Photo Voltaics", PHI learning Pvt. Ltd., New Delhi,2009.
4. J.F. Manwell, J.G. McGowan "Wind Energy Explained, theory design and applications", Wiley publication 2010.
5. Gevork B. Gharehpetian, S. Mohammad Mousavi Agah, Distributed Generation Systems: Design, Operation and Grid Integration, Butterworth Heinemann, 2017

Web Resources

1. https://nptel.ac.in/courses/108/108/108108034/
2. https://nptel.ac.in/courses/108107143/

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PSO 1	PSO 2
1	2	2				2		2				3
2	2	3	2				2	2				3
3	2	2						3				3
4	2							2				3
5	2	2	2					3				3

BLOOMS LEVEL ASSESSMENT PATTERN

BLOOMS CATEGORY	CAT 1	CAT 2	FAT 1	FAT 2	END SEM EXAM
REMEMBER	20	20	10	10	20
UNDETSTAND	50	50	10	10	50
APPLY	30	30	05	05	30
ANALYZE	0	0	0	0	0

EVALUATE	0	0	0	0	0
CREATE	0	0	0	0	0
	100	100	25	25	100

1-Low , 2- Medium, 3- High

21PE2708	**NANO ELECTRONIC DEVICES AND NANO SENSORS**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Preamble

This course have the concept of Nano materials, Which are playing a critical role in the development of novel devices. Nano materials have unique characteristics which differ greatly from those of their bulk counterparts. These unique characteristics provide the basis for novel nanoelectronics, nanosensors and nanodevices which are able to overcome the limitations of current devices.

Prerequisites for the course

1. Electronic Devices and Circuits
2. Power Semiconductor Devices

Objectives

1. The students earn the basic understanding of nano electronics and followed the advanced understanding of the nano-photonics.

2. To understand the theory of nano devices.

3. To understand and familiarize the manufacturing process of nano devices.

4. To provide the recent advancement of nano transistors.

5. To find various application in the field of sensors technology, optoelectronics, communication and nano technology etc.

UNIT I	**TUNNEL JUNCTION**	**9**

Tunnel junction and applications of tunneling, Tunneling Through a Potential Barrier, Metal—Insulator, Metal-Semiconductor, and Metal-Insulator-Metal Junctions, Coulomb Blockade, Tunnel Junctions, Tunnel Junction Excited by a Current Source. Spintronics and Foundations of nano-photonics.

UNIT II	**INTRODUCTION TO NANO DEVICES**	**9**

Field Emission, Gate—Oxide Tunneling and Hot Electron Effects in nano MOSFETs, Theory of Scanning Tunneling Microscope, Double Barrier Tunneling and the Resonant Tunneling Diode.

UNIT III	**MANUFACTURING OF NANO DEVICES**	**9**

Introduction to lithography- Contact, proximity printing and Projection Printing, Resolution Enhancement techniques, overlay-accuracies, Mask-Error enhancement factor (MEEF), Positive and negative photoresists, Electron Lithography, Projection Printing, Direct writing, Electron resists. Lithography based on Surface Instabilities: Wetting, De-wetting, Adhesion, Limitations, Resolution and Achievable / line widths etc. Lift off process, Bulk Micro machining.

UNIT IV	**NANO TRANSISTORS**	**9**

Introduction – Scaling of physical systems – Geometric scaling & Electrical system scaling. The Single-Electron Transistor: The Single- Electron Transistor Single-Electron Transistor Logic, Other SET and FET Structures, Carbon Nanotube Transistors (FETs and SETs), Semiconductor Nanowire FETs and SETs,Coulomb Blockade in a Nanocapacitor, Molecular SETs and Molecular Electronics.

UNIT V	**MEMORY DEVICES AND SENSORS**	**9**

Memory devices and sensors – Nano ferroelectrics – Ferroelectric random access memory –Fe-RAM circuit design –ferroelectric thin film properties and integration – calorimetric -sensors – electrochemical cells – surface and bulk acoustic devices– resistive semiconductor gas sensors – electronic noses – identification of hazardous solvents and gases – semiconductor sensor array.

Total Periods	**45**

Suggestive Assessment Methods

Continuous Assessment Test (30 Marks)	**Formative Assessment Test (10 Marks)**	**End Semester Exams (60 Marks)**
1 WRITTEN TEST	**1.ASSIGNMENT** **2. ONLINE QUIZZES** **3.PROBLEM-SOLVING ACTIVITIES**	**1. WRITTEN TEST**

Outcomes

Upon completion of the course, the students will be able to:

1	Identify the nano electronics.
2	Make use of the technical knowledge in the theory of nano devices.
3	Identify the concepts of manufacturing process in nano devices
4	Interact with the advancement of nano transistors.
5	Analyse various application in the field of sensors technology, optoelectronics, communication and nanotechnology etc.

Reference Books

1.Marc Madou, Fundamentals of microfabrication & Nanofabrication, 2011

2.Evgeni Gusev, Eric Garfunkel, Advanced Materials and Technologies for Micro/Nano-Devices, Sensors and Actuators,.2010

3. Julian W.Gardnes, Vijay K. Varda, Micro sensors MEMS & Smart Devices, 20.

Web Resources

1. https://www.youtube.com/watch?v=wdNFCWLuC10
2. https://www.coursera.org/learn/nanotechnology1
3. https://nptel.ac.in/courses/117/108/117108047/

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2
1	2										2	
2	2	3					2				2	
3	2	2	2	2		2	2	2			2	
4	2		2	2		2	2				2	
5	2	2	2	2	2		2				2	

BLOOMS LEVEL ASSESSMENT PATTERN

BLOOMS CATEGORY	CAT 1	CAT 2	FAT 1	FAT 2	END SEM EXAM
REMEMBER	20	20	10	10	20
UNDETSTAND	50	50	10	10	50

APPLY	30	30	05	05	30
ANALYZE	0	0	0	0	0
EVALUATE	0	0	0	0	0
CREATE	0	0	0	0	0
	100	100	25	25	100

1-Low , 2- Medium, 3- High

21PS2701	**PRINCIPLES OF SMART GRID**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Preamble

This course imparts the conceptual knowledge on new smart grid technologies in power system. This knowledge is significant to construct and expand a Micro-grid and Nano-grid technologies in future.

Prerequisites for the course

- Transmission & Distribution
- Power System Analysis
- Power System Operation and Control

Objectives

1. To study about Smart Grid technologies, different smart meters and advanced metering infrastructure.
2. To understand about new smart grid technologies and power control
3. To acquire the knowledge on sensors and transducers in smart grid technologies
4. To learn about the energy management system and Smart energy integration
5. To categorize the power quality issues in Smart Grid.

UNIT I	**INTRODUCTION**	**9**

Evolution of Electric Grid - Definitions, Architecture and Concept of Smart Grid - Need of Smart Grid - Functions of Smart Grid - Opportunities & Barriers of Smart Grid - Difference between conventional & smart grid - Difference between smart grid and Micro-grid - Present development & International policies in Smart Grid - Smart grid economic and environmental benefits - Case study of 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	**SENSORS AND MEASUREMENT**	**9**

Sensors for Smart Grid, Monitoring and Measurement Technologies, PMU, Smart meters, Smart Appliances, Multi Agent Systems (MAS) Technology, Micro grid and Smart grid comparison, Wide Area Measurement.

UNIT IV	**ENERGY MANAGEMENT SYSTEM(EMS)**	**9**

Energy Management System (EMS) - Smart substations - Substation Automation - Feeder Automation, SCADA – Remote Terminal Unit – Intelligent Electronic Devices – Protocols, Phasor Measurement Unit – Wide area monitoring protection and control, Smart integration of energy resources – Renewable, intermittent power sources – Energy Storage.

UNIT V	FACTS AND ENERGY STORAGE IN THE SMART GRID	**9**

Introduction – Renewable energy generation – Fault current limiting – Shunt compensation – Series compensation – FACTS devices – HVDC-Energy storage-applications and technologies.

	Total Periods	**45**

Suggestive Assessment Methods

Continuous Assessment Test (30 Marks)	**Formative Assessment Test (10 Marks)**	**End Semester Exams (60 Marks)**
1. DESCRIPTIVE QUESTIONS ***2. FORMATIVE MULTIPLE CHOICE QUESTIONS***	*1.**ASSIGNMENT*** ***2. ONLINE QUIZZES*** ***3.PROBLEM-SOLVING ACTIVITIES***	***1. DESCRIPTIVE QUESTIONS*** ***2. FORMATIVE MULTIPLE CHOICE QUESTIONS***

Outcomes

Upon completion of the course, the students will be able to:

1	Understand the concept of Smart Grid and its present developments.
2	Categorize the different Smart Grid technologies of EMS, DMS, FACTS, HVDC and PHEV
3	Interpret the smart meters and advanced metering infrastructure in smart grid
4	Understand the knowledge on power quality management in Smart Grids.
5	Determine the Fault current and power quality issues in Smart Grid operation.

Text Books

1. Stuart Borlase “Smart Grids: Advanced Technologies and Solutions”, CRC Press 2017 second edition.

2. JanakaEkanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama, "Smart Grid: Technology and Applications", Wiley 2017.

Reference Books

1. Mini S Thomas & John D Mcdonald, "Power System SCADA and Smart Grids" CRC Press 2017.
2. SawanSen ,SamarjitSengupta, AbhijitChakrabarti , "Electricity pricing- regulated, deregulated and smart grid systems", CRC press, 2014

Web Resources

1. https://nptel.ac.in/courses/108/107/108107113/
2. https://onlinecourses.nptel.ac.in/noc21_ee68/preview

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2
1	3	3		2		3		3				2
2	3	3		2		3	3	3				3
3	3	2	2	2		3		3				3
4	3	3	2			3		3				3
5	3	3				3		3				2

1-Low , 2- Medium, 3- High

BLOOMS LEVEL ASSESSMENT PATTERN

BLOOMS CATEGORY	CAT 1	CAT 2	FAT 1	FAT 2	END SEM EXAM
REMEMBER	10	10	2	3	10
UNDETSTAND	10	10	3	2	10
APPLY	30	30	10	10	30
ANALYZE	50	50	10	10	50
EVALUATE	0	0	0	0	0
CREATE	0	0	0	0	0
	100	100	25	25	100

21PE2709	EMBEDDED SYSTEM DESIGN	L	T	P	C
		3	0	0	3

Preamble

This advanced course embraces the microcontroller and computer programming to design &operate large, medium and small scale electronic devices. This embedded platform deals with system design and real time operating systems.

Prerequisites for the course

- Microprocessor &Microcontroller concepts andapplications
- Assembly languageconcepts
- Operating systemconcepts
- Computer organization and architectureconcepts
- Basics of all electronicscomponents

Objectives

1. To impart knowledge on basic functions, structure, concepts and applicationsof embedded systems.
2. To develop familiarity with 8051 Microcontrollers and their applications in an embeddedenvironment.
3. To learn the method of designing and program an Embedded Systems for real timeapplications.
4. To understand the concept of operating system, types and choosing RTOS.
5. To determine the Issues in the TaskCommunication and Synchronization

UNIT I	INTRODUCTION TO EMBEDDED SYSTEMS	9

Definition of Embedded System, Embedded Systems VsGeneral Computing Systems, Historyof Embedded Systems,Classification, Major Application Areas, Purpose of Embedded Systems, Characteristics and Quality Attributes of EmbeddedSystems.

UNIT II	TYPICAL EMBEDDED SYSTEM	9

Core of the Embedded System: General Purpose and Domain Specific Processors, ASICs, PLDs, Commercial Off-The-Shelf Components (COTS), Memory: ROM, RAM, Memory according to the type of Interface, Memory Shadowing, Memory selection for Embedded Systems, Sensors and Actuators, Communication Interface: On-board and External Communication Interfaces.

UNIT III	EMBEDDED FIRMWARE	9

Reset Circuit, Brown-out Protection Circuit, Oscillator Unit, Real Time Clock, Watchdog Timer, Embedded Firmware Design Approaches and Development Languages.

UNIT IV	**RTOS BASED EMBEDDED SYSTEM DESIGN**	**9**

Operating System Basics, Types of Operating Systems, Tasks, Process and Threads, Multi processing and Multi-tasking, Task Scheduling.

UNIT V	**TASK COMMUNICATION**	**9**

Shared Memory, Message Passing, Remote Procedure Call and Sockets, Task Synchronization: Task Communication/Synchronization Issues, Task Synchronization Techniques, Device Drivers, How to Choose an RTOS.

Total Periods	**45**

Suggestive Assessment Methods

Continuous Assessment Test (30 Marks)	**Formative Assessment Test (10 Marks)**	**End Semester Exams (60 Marks)**
1. DESCRIPTIVE QUESTIONS ***2. FORMATIVE MULTIPLE CHOICE QUESTIONS*** ***CO205-4.1***	**1.ASSIGNMENT** **2. ONLINE QUIZZES** **3.PROBLEM-SOLVING ACTIVITIES**	***1. DESCRIPTIVE QUESTIONS*** ***2. FORMATIVE MULTIPLE CHOICE QUESTIONS***

Outcomes

Upon completion of the course, the students will be able to:

1	Understand the conceptual knowledge on embedded systems functions, structure and applications
2	Analyze the concept of Memory Shadowing, Memory selection for Embedded Systems, External Communication Interfaces, On-board Communication Interfaces, Sensors and Actuators
3	Develop the embedded hardware and software cycles and tools.
4	Understand the concept of real-time operating systems, types, issues and remedial actions
5	To identify the issues in the Task Communication, Task Synchronization, Memory sharing and Message Passing

Text Books

1. K. V Shibu, "Introduction To Embedded Systems", McGraw Hill India, 2016.
2. Raj Kamal, "Embedded Systems Architecture Programming and Design", The McGraw Hill Companies, 2nd Edition, 2017.

Reference Books

1. Frank Vahid, Tony Givargis, "Embedded System Design", Wiley, 2001
2. Lyla B Das, "Embedded Systems", Pearson Education, 2013

Web Resources

- http://nptel.ac.in/courses/10810205/

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2
1	3	3				2	2	3				3
2	3	3	3			3	3	3		2		2
3	3	3				3	2	3		3		3
4	3	3				3		3				2
5	3	3				3		3		3		3

BLOOMS LEVEL ASSESSMENT PATTERN

BLOOMS CATEGORY	CAT 1	CAT 2	FAT 1	FAT 2	END SEM EXAM
REMEMBER	10	10	2	3	10
UNDETSTAND	10	10	3	2	10
APPLY	30	30	10	10	30
ANALYZE	50	50	10	10	50
EVALUATE	0	0	0	0	0
CREATE	0	0	0	0	0
	100	100	25	25	100

21PS3701	HIGH VOLTAGE DIRECT CURRENT TRANSMISSION	L	T	P	C
		3	0	0	3

Prerequisites for the course

- Power Electronics and Drives
- Power Systems Analysis
- Power system operation and control

Objectives

1. To impart knowledge on DC Power Transmission Technology
2. To apply the knowledge of converter bridge operation, modelling and control in HVDC transmission system.
3. To understand the knowledge on Multi-Terminal system of Direct Current
4. To perform steady state analysis of AC/DC system.
5. To design the different HVDC links using 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 - Modeling 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 OFF line simulators –– Dynamic interactions between DC and AC systems.

Total Periods	**45**

Suggestive Assessment Methods

Continuous Assessment Test (30 Marks)	**Formative Assessment Test (10 Marks)**	**End Semester Exams (60 Marks)**
1. DESCRIPTION QUESTIONS 2. FORMATIVE MULTIPLE CHOICE QUESTIONS	***1.ASSIGNMENT 2. ONLINE QUIZZES 3.PROBLEM-SOLVING ACTIVITIES***	***1. DESCRIPTION QUESTIONS 2. FORMATIVE MULTIPLE CHOICE QUESTIONS***

Outcomes

Upon completion of the course, the students will be able to:

1	Understand knowledge on operation, modeling and control of HVDC link
2	Understand knowledge on thyristor based HVDC converters
3	Understand knowledge on multi terminal DC systems
4	Understand knowledge on power flow analysis in AC/DC systems
5	Expose various HVDC simulators.

Text Books

1. P. Kundur, "Power System Stability and Control", McGraw-Hill, 1994
2. K.R.Padiyar, , "HVDC Power Transmission Systems", New Age International (P) Ltd., New Delhi, 2010

Reference Books

1. J.Arrillaga, , "High Voltage Direct Current Transmission", Institution of Engineering and Technology, London, 2008
2. Ahmed, Khaled, Jovcic, Dragan, "High voltage direct current transmission : converters, systems and DfC grids", Wiley, 2015.

Web Resources

- https://nptel.ac.in/courses/108104013

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2
1	3	3				2	2	3				3
2	3	3	3			3	3	3		2		2
3	3	3				3	2	3		3		3
4	3	3				3		3				2
5	3	3				3		3		3		3

1-Low, 2- Medium, 3- High

BLOOMS LEVEL ASSESSMENT PATTERN

BLOOMS CATEGORY	CAT 1	CAT 2	FAT 1	FAT 2	END SEM EXAM
REMEMBER	10	10	2	3	10
UNDETSTAND	10	10	3	2	10
APPLY	30	30	10	10	30
ANALYZE	50	50	10	10	50
EVALUATE	0	0	0	0	0
CREATE	0	0	0	0	0
	100	100	25	25	100

21PE3701	NON LINEAR CONTROL	L	T	P	C
		3	0	0	3

Preamble

Most systems are nonlinear, and therefore, it is of general interest to investi-gate possible behaviours of nonlinear systems, investigate their stability, and to design control schemes. This course will be a core requirement for all postgraduate students in Control. This will probably be a highly useful acquirement for postgraduate students in Power Systems, in Robotics, and in Differential equations.

Prerequisites for the course

1. Control System

Objectives

1. To analyse the Linear and Non linear systems in phase plane.
2. To compute the Describing functions of the system.
3. To analyse the system based on Lyapunov's Theory
4. To linearization of SISO and MIMO by feedback linearization.
5. To apply sliding mode control in different control application.

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

SlidingSurfaces- Continuous approximations of Switching Control laws - The Modelling/ Performance Trade-Offs- MIMO Systems. simulation of sliding mode controller in MATLAB

Total Periods	**45**

Suggestive Assessment Methods

Continuous Assessment Test (30 Marks)	**Formative Assessment Test (10 Marks)**	**End Semester Exams (60 Marks)**
WRITTEN TEST	**1.ASSIGNMENT** **2. ONLINE QUIZZES**	**WRITTEN TEST**

Outcomes

Upon completion of the course, the students will be able to:

1	Construct, Analyse and Simulate the Phase portraits in MATLAB.
2	Apply theDescribingfunction-based approach to non-linear systems.
3	Apply the Lyapunov's theoryon stability analysis of systems.
4	Implement the feedback linearization of SISO and MIMO systems.
5	Simulate the sliding mode controller in MATLAB.

Text Books

1. Nonlinear Systems, H. Khalil, 3rd edition, 2014, Pearson

Reference Books

1. Torkel Glad and Lennart Ljung, "Control Theory – Multivariable and NonlinearMethods",Taylor& Francis, 2002.
2. K. P. Mohandas, Modern Control Engineering, Sanguine, India, 2006

Web Resources

1. https://nptel.ac.in/courses/108106024
2. https://nptel.ac.in/courses/108102113

CO Vs PO Mapping and CO Vs PSO Mapping

CO	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO1 0**	**PO1 1**	**PO1 2**	**PSO 1**	**PSO 2**
1	1	2	2											3
2	1	2	3											3
3	1	2	3											3
4	1	2	3											3

5	1	2	2											3

BLOOMS LEVEL ASSESSMENT PATTERN

BLOOMS CATEGORY	CAT 1	CAT 2	FAT 1	FAT 2	END SEM EXAM
REMEMBER	10	10	10	10	20
UNDETSTAND	20	20	10	10	20
APPLY	40	30	10	10	30
ANALYZE	30	40	10	10	30
EVALUATE	0	0	0	0	0
CREATE	0	0	0	0	0
	100	100	50	50	100

1-Low , 2- Medium, 3- High

21PE3702	**WIND ENERGY TECHNOLOGIES**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Preamble

Wind energy is the fast-growing renewable source for electricity generation. This course presents a broad overview of wind energy technology

Prerequisites for the course

1. Power Electronics for Renewable Energy Systems

Objectives

1. To learn about power extraction from wind energy.
2. To Introduce the concepts of mathematical modelling and control of the Wind turbine.
3. To Acquire knowledge on design of Fixed speed system.
4. To impart knowledge on Variable speed system and its modelling.
5. To learn about Grid integration issues and current practices of wind interconnections with power system.

UNIT I	**INTRODUCTION**	**9**

Components of WECS-WECS schemes-Power obtained from wind-simple momentum theory-Power coefficient-Sabinin'stheory-Aerodynamic Principles – Design – Betz limit.

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-Electrical braking – mechanical braking-MPPT Schemes.

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- Wind Converter Configurations-DFIG- PMSG -Variable speed generators modeling- Variable speed variable frequency schemes-- Real Power Control.

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 Periods	**45**

Suggestive Assessment Methods

Continuous Assessment Test (30 Marks)	**Formative Assessment Test (10 Marks)**	**End Semester Exams (60 Marks)**
WRITTEN TEST	**1.ASSIGNMENT** **2. ONLINE QUIZZES**	**WRITTEN TEST**

Outcomes

Upon completion of the course, the students will be able to:

1	Acquire knowledge on the basic concepts of Wind energy conversion system.
2	Understand the mathematical modelling and control of the Wind turbine.
3	Develop more understanding on the design of Fixed speed system.

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

Text Books

1. S.N.Bhadra, D.Kastha ,S.Banerjee, "Wind Electrical Systems", Oxford UniversityPress,2010.
2. N. Jenkins," Wind Energy Technology" John Wiley & Sons,1997

Reference Books

1. S.Heir "Grid Integration of WECS", Wiley 1998.
2. Ion Boldea, "Variable speed generators", Taylor & Francis group, 2006

Web Resources

1. https://nptel.ac.in/courses/108/105/108105058/

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2
1	3	2	1	3		1							3	
2	2	2	1	3		2							3	
3	2	2	1	3		2							3	
4	1	2	3	3		2							3	
5	1	2	2	3		2							3	

BLOOMS LEVEL ASSESSMENT PATTERN

BLOOMS CATEGORY	CAT 1	CAT 2	FAT 1	FAT 2	END SEM EXAM
REMEMBER	20	20	10	10	20
UNDETSTAND	40	35	10	10	30

APPLY	30	30	10	10	35
ANALYZE	10	15	20	20	15
EVALUATE	0	0	0	0	0
CREATE	0	0	0	0	0
	100	100	50	50	100

1-Low , 2- Medium, 3- High

21PE3703	**INDUSTRIAL AUTOMATION AND CONTROL**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Preamble

The purpose of this course is provide the knowledge of PLC, DCs and SCADA and computer aided measurement and control system.

Prerequisites for the course

- Modern control systems
- Instrumentation and control

Objectives

1. To introduce the need of automation and concept of PLC
2. To impart knowledge on different types of transmitters, Final Control elements and actuators
3. To know about the role of computers in Process Industries
4. To familiarize students on Programming of PLC with typical case studies
5. To expose students about the various sub-systems of DCS and role of SCADA in industrial automation

UNIT I	**INTRODUCTION**	**9**

Need and benefits of automation – PLC system: Introduction to PLC - PLC modules - I/O module - Communication module - PID module - Input analog and digital devices - Output analog and digital devices - Introduction to Industrial Data Networks - Foundation Field Bus and Profibus

UNIT II	**FIELD DEVICES**	**9**

Conventional/Smart Process Transmitters - Temperature – Pressure – Flow - Level and pH Measurement - Final Control Elements – Actuators - Pneumatic and electric actuators - Control Valves - Thyristor Power Controller - Introduction to DC and AC Servo Drives for motion control – Interfacing Field devices with I/O Sub Systems

UNIT III	**COMPUTER AIDED MEASUREMENT AND CONTROL SYSTEMS**	**9**

Role of computers in measurement and control - Elements of computer aided measurement and control:- Man-Machine interface - Computer aided process control hardware and software – Industrial Internet of things (I^2oT) – Cyber Security for Industrial automation

UNIT IV	**PROGRAMMABLE LOGIC CONTROLLERS (PLC)**	**9**

Programmable Logic Controllers:- Hardware of PLC - PLC programming - Ladder diagram with examples - PLC Communication and networking - Case studies - Bottle filling application and Elevator control

UNIT V	**DISTRIBUTED CONTROL SYSTEMS (DCS) AND SCADA**	**9**

Introduction – Concept of DCS – LCU - Shared communication facility - Display Hierarchy - High Level and Low Level interfaces - Case studies - DCS in cement plant and thermal power plant - Introduction to supervisory Control and Data Acquisition system (SCADA) - SCADA Architecture - Interfacing SCADA with PLC

Total Periods	**45**

Suggestive Assessment Methods

Continuous Assessment Test (30 Marks)	**Formative Assessment Test (10 Marks)**	**End Semester Exams (60 Marks)**
WRITTEN TEST	**1.ASSIGNMENT** **2. ONLINE QUIZZES** **3.PROBLEM-SOLVING ACTIVITIES**	**WRITTEN TEST**

Outcomes

Upon completion of the course, the students will be able to:

1	Understand the need of automation and concept of PLC in practical applications
2	Understand the different types of transmitters, Final Control elements and actuators
3	Understand the role of Computers in Process Industries and analyse its performance
4	Develop the Programming of PLC with typical case studies

5	Analyze about the various sub-systems of DCS and role of SCADA in industrial automation

Text Books

1. Webb John W. and Reis A. Ronald, "Programmable Logic Controllers Principles and applications" PHI , New Delhi, 2016.
2. Popovic &Bhatkar, "Distributed Computer Control for Industrial Automation", CRC Press, New Delhi, Latest edition.

Reference Books

1. S.K.Singh, "Industrial Instrumentation", Tata Mcgraw Hill, 2nd edition, 2003.
2. Gary Dunning, Thomson Delmar, "Programmable Logic Controller", Cengage Learning, 3rd Edition, 2005.
3. E.A.Parr, Newnes, "Industrial Control Handbook", 3rd Edition, 2000

Web Resources

1. https://nptel.ac.in/courses/108/105/108105088/
2. https://www.automation.com/en-us/automation-control-resources

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2
1	3	2	2	1		1			1	1	2	
2	3	3	2	1		1			1	1	2	
3	3	3	2	2		2			3	3	2	
4	3	2	3	2		1			3	3	2	
5	3	3	3	2		1			3	3	2	

BLOOMS LEVEL ASSESSMENT PATTERN

BLOOMS CATEGORY	CAT 1	CAT 2	FAT 1	FAT 2	END SEM EXAM
REMEMBER	20	20	10	10	20

UNDETSTAND	30	30	10	10	30
APPLY	35	35	20	20	35
ANALYZE	15	15	10	10	15
EVALUATE	0	0	0	0	0
CREATE	0	0	0	0	0
	100	100	50	50	100

1-Low , 2- Medium, 3- High

21PE3704	**HYBRID ELECTRIC VEHICLES**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Preamble

This course introduces the fundamental concepts, principles, analysis and design of hybrid, electric and fuel cell vehicles. It is an introductory course which emphasize the fundamental concepts and overview of Electric and Hybrid vehicles. The concepts discussed herein are intended to provide clarification on basic of Electric and Hybrid vehicles.

Prerequisites for the course

1. Basic Electrical and Electronics Engineering

Objectives

1. Elucidate electric, hybrid electric and plug-in hybrid electric vehicle (PHEV), their architecture, technologies and fundamentals
2. Validate different energy storage technologies used for hybrid electric vehicles and their control and energy balancing techniques
3. Demonstrate different configurations of electric vehicles and charging techniques
4. Explicate the design, component sizing of the power electronics converters
5. Develop various electric drives suitable for hybrid electric vehicles

UNIT I	**HEV FUNDAMENTALS AND HYBRIDIZATION OF THE AUTOMOBILE**	**9**

HEV Fundamentals: Vehicle Basics, vehicle model, Vehicle Resistance: Rolling Resistance, Aerodynamic Drag, Grading Resistance, Dynamic Equation Tire–Ground Adhesion and Maximum Tractive Effort, Power Train Tractive Effort and Vehicle Speed, EV Powertrain Component Sizing.

Hybridization of the Automobile: Basics of the EV, Basics of the HEV, Basics of Plug-In Hybrid Electric Vehicle (PHEV) and vehicle architectures: Series Hybrid Vehicle, Parallel Hybrid Vehicle, Basics of Fuel Cell Vehicles (FCVs).

UNIT II	**POWER ELECTRONICS IN HEVs**	**9**

Power Electronics in HEVs: Power electronics circuits used for control and distribution of electric power in DC-DC, AC-DC, DC-AC converters used for HEV. Electric Machines and Drives in HEVs: Fundamental of Drives and Control of EV Using DC motor, Induction Motor, Permanent Magnet Motor, Switched Reluctance Motor, BLDC motor, Design and Sizing of Traction Motors.

UNIT III	**BATTERY**	**9**

Batteries, Ultra capacitor, Fuel Cells, and Controls: Introduction, Different batteries for EV, Battery Characterization, Comparison of Different Energy Storage Technologies for HEVs, Battery Charging Control, Charge Management of Storage Devices, Flywheel Energy Storage System, Fuel Cells and Hybrid Fuel Cell Energy Storage System and Battery Management System.

UNIT IV	**EV CHARGING TECHNOLOGIES**	**9**

EV Charging Technologies: Classification of different charging technology for EV charging station, introduction to Grid-to-Vehicle, Vehicle to Grid (V2G) or Vehicle to Buildings (V2B) or Vehicle to Home (V2H) operations, bi-directional EV charging systems, energy management strategies used in hybrid and electric vehicle, Wireless power transfer (WPT) technique for EV charging.

UNIT V	**ENERGY STORAGE**	**9**

Introduction to energy storage requirements in hybrid and Electric vehicles, Battery based energy Storage and its analysis, fuel cell based and super capacitor based energy storage and its analysis. Hybridization of different energy storage devices.

	Total Periods	**45**

Suggestive Assessment Methods

Continuous Assessment Test (30 Marks)	**Formative Assessment Test (10 Marks)**	**End Semester Exams (60 Marks)**
WRITTEN TEST	**1.ASSIGNMENT 2. ONLINE QUIZZES 3.PROBLEM-SOLVING ACTIVITIES**	**WRITTEN TEST**

Outcomes

Upon completion of the course, the students will be able to:

1	Explain the basics of electric and hybrid electric vehicles, their architecture, technologies and fundamentals.

2	Analyse the use of different power electronics converters and electrical machines in hybrid electric vehicles.
3	Able to interpret the working of different configurations of electric vehicles and its components, hybrid vehicle configurations
4	Explain the use of different energy storage systems used for hybrid electric vehicles, their control techniques, and select appropriate energy balancing technology
5	Ability to understand the control and configurations of HEV charging stations.

Text Books

1. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press , 2004
2. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press , 2003

Reference Books

1. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley , 2003
2. Chris Mi, M. Abul Masrur, David Wenzhong Gao, Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives, John Wiley & Sons Ltd. , 2011

Web Resources

1. https://nptel.ac.in/courses/108103009
2. https://nptel.ac.in/courses/108102121
3. https://nptel.ac.in/courses/108106170

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2
1	2	2					1	2						2
2	2	3					2							2
3	2	2					1	2						2
4	2		3				1	1					2	
5	1		3				3	1					1	

BLOOMS LEVEL ASSESSMENT PATTERN

BLOOMS CATEGORY	CAT 1	CAT 2	FAT 1	FAT 2	END SEM EXAM

REMEMBER	20	20	10	10	20
UNDETSTAND	30	30	10	10	30
APPLY	20	20	10	10	20
ANALYZE	15	15	10	10	15
EVALUATE	15	15	10	10	15
CREATE	0	0	0	0	0
	100	100	50	50	100

1-Low, 2- Medium, 3- High

21PE3705	**ADVANCED POWER ELECTRONIC DEVICES**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Preamble

Upon completion of this program, the students are expected to acquire both analytical and practical knowledge in Power Electronics and Drives (PED). The program structure is planned in an application oriented manner through specialized core-courses with a significant hands-on practicum component, research and development (R&D) oriented advanced-level courses and project work.

Prerequisites for the course

1. Power Electronic Devices
2. Linear and Integrated Circuits

Objectives

1. Select and design power electronic converter topologies for a broad range of energy conversion applications.
2. Analyse and simulate the performance of power electronic conversion systems.
3. Ability to model and design controllers for the closed loop operation of power converters.
4. Apply the basic concepts of power electronics to design the circuits in the fields of AC and DC drives, power generation and energy conversion, industrial applications, extraction of energy from renewable sources.
5. Build and troubleshoot power electronics circuits.

UNIT I	**SWITCHING VOLTAGE REGULATORS**	**9**

Introduction; Linear power supply (voltage regulators); Switching voltage regulators; Review of basic dc-dc voltage regulator configurations -Buck, Boost, Buck-Boost converters and their analysis for continuous and discontinuous mode; Other converter configurations like Flyback converter, Forward converter, Half bridge, Full bridge configurations, Push-pull converter, C'uk converter, SEPIC Converter; Design criteria for SMPS; Multi-output switch mode regulator

UNIT II	**RESONANT AND MULTI-LEVEL CONVERTERS**	**9**

Resonant Converters: Introduction, Need of resonant converters, Classification of resonant converters, Load resonant converters, Resonant switch converters, zero-voltage switching dc-dc converters, zero current switching dc-dc converters, clamped voltage topologies

Multi-level Converters: Need for multi-level inverters, Concept of multi-level, Topologies for multi-level: Diode Clamped, Flying capacitor and Cascaded H-bridge multilevel Converters configurations; Features and relative comparison of these configurations applications, Introduction to carrier based PWM technique for multi-level converters

UNIT III	**MULTIPULSE CONVERTERS**	**9**

Concept of multi-pulse, Configurations for m-pulse (m=12,18,24 ….) converters, Different phase shifting transformer (Y-?1, Y-?2, Y-Z1 and Y-Z2) configurations for multi-pulse converters, Applications

UNIT IV	**HVDC TRANSMISSION**	**9**

Introduction, Operation of 12-pulse converter as receiving and sending terminals of HVDC system, Equipment required for HVDC System and their significance, Comparison of AC and DC transmission, Control of HVDC transmission

UNIT V	**FACTS DEVICES**	**9**

Importance of reactive power compensation, Flow of power in AC system and conventional control mechanisms, Definition of Flexible ac Transmission Systems (FACTS) and brief description, possible benefits from FACTS, Thyristor- Controlled Reactor (TCR), Fixed Capacitor-Thyristor-Controlled Reactor (FC-TCR), Thyristor-Switched capacitor and Reactor, Thyristor-Switched capacitor-Thyristor-Controlled Reactor (TSCTCR), STATCOM configuration and operating principle, Static characteristics of SVC and STATCOM Comparison of SVC and STATCOM, Principle of series compensation, Introduction to Static Synchronous Series Compensator, Advantages and limitation of SSSC, Introduction to UPFC and operating principle

	Total Periods	**45**

Suggestive Assessment Methods

Continuous Assessment Test (30 Marks)	**Formative Assessment Test (10 Marks)**	**End Semester Exams (60 Marks)**
WRITTEN TEST	**1.ASSIGNMENT 2. ONLINE QUIZZES 3.PROBLEM-SOLVING ACTIVITIES**	**WRITTEN TEST**

Outcomes

Upon completion of the course, the students will be able to:	
1	Evaluate different DC-DC voltage regulators
2	Simulate and analyse resonant converters
3	Illuminate the cause and effect of appropriate phase shifting converter for a multi-pulse converter
4	Evaluate various multi-level inverter configurations
5	Compare various FACTS devices for VAR compensation

Text Books

1. High-Power Converters and AC Drives (IEEE Press Series on Power and Energy Systems), by Bin Wu, 2017
2. Power Electronics: Converters Applications and Design, Media Enhanced, Third Edition, Robbins Mohan 2007

Reference Books

1. Power electronics handbook by Rashid, 2017
2. L. Umanand, "Power Electronics Essentials and Applications", Wiley India Ltd., 2009
3. P.C.Sen, "Modern Power Electronics", S. Chand and Co. Ltd., New Delhi, 2000.

Web Resources

1. https://nptel.ac.in/courses/108107128
2. Free Online Course: Advance power electronics and Control from YouTube | Class Central

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2
1	3	2	2										2	
2	3	2	2										2	
3	3	2	1										3	
4	3	2		2										2
5	3	2		3										2

BLOOMS LEVEL ASSESSMENT PATTERN

BLOOMS CATEGORY	CAT 1	CAT 2	FAT 1	FAT 2	END SEM EXAM
REMEMBER	20	20	10	10	20
UNDETSTAND	30	30	10	10	30
APPLY	20	20	10	10	20
ANALYZE	15	15	10	10	15
EVALUATE	15	15	10	10	15
CREATE	0	0	0	0	0
	100	100	50	50	100

1-Low, 2- Medium, 3- High

21PE3706	INTEGRATED CIRCUITS FOR POWER CONVERSION	L	T	P	C
		3	0	0	3

Preamble

By the end of this course, students would understand the concept behind power management circuits and be able to design a dc-dc converter for a specific system using behavioural and circuit level simulators such as MATALB/Simulink, LTSpice and Cadence. One would be able to select various parameters such as switching frequency, inductor and capacitor values for best performance and efficiency.

Prerequisites for the course

1. Analog Electronics
2. Power Electronics

Objectives

1. Review of modern power management converters and circuits;
2. Elucidate the Modeling and control of converters;
3. Feature discussion of voltage and current mode controllers;
4. Understand the power converter losses and optimization method, as well as management of power
5. Interpret the IC implementation of power management chip

UNIT I	INTRODUCTION TO POWER MANAGEMENT AND VOLTAGE REGULATORS	9

Need of power management, power management applications, classification of power management, power delivery of a VLSI system, power conversion, discrete vs. integrated power management, types of voltage regulators (switching vs linear regulators) and applications, converter's performance parameters (voltage accuracy, power conversion efficiency, load

regulation, line regulation, line and load transient response, settling time, voltage tracking), local Vs remote feedback, kelvin sensing, Point-of-Load (POL) regulators.

UNIT II	**LINEAR REGULATORS**	**9**

Bandgap Voltage Reference, Low Drop-Out Regulator (LDO), Source and sink regulators, shunt regulator, pass transistor, error amplifier, small signal model and stability analysis, compensation techniques, current limiting, power supply rejection ratio (PSRR), NMOS vs. PMOS regulator, current regulator.

UNIT III	**SWITCHING DC - DC CONVERTERS**	**9**

Types (Buck, boost, buck-boost), power FETs, choosing L and C, PWM modulation, leading, trailing and dual edge modulation, Losses in switching converters, output ripple, voltage Vs current mode control, CCM and DCM modes, hysteretic control, switched capacitor DC-DC converters.

UNIT IV	**SIGNAL MODEL OF DC-DC CONVERTER**	**9**

Small signal model of DC-DC converter, loop gain analysis of un-compensated DC-DC converter, type-I, type-II and type-III compensation, compensation of a voltage mode DC-DC converter, compensation of a current mode DC-DC converter, Selecting topology, selecting switching frequency and external components, sizing power FETs, segmented power FET, designing gate driver, PWM modulator, error amplifier, oscillator, ramp generator, feedback resistors, current sensing, PFM/PSM mode for light load, effect of parasitic on reliability and performance, current limit and short circuit protection, soft start control, chip level layout and placement guidelines, board level layout guidelines, EMI considerations.

UNIT V	**INTRODUCTION TO ADVANCED TOPICS IN POWER MANAGEMENT**	**9**

Digitally controlled DC-DC converters, digitally controlled LDOs, time-based control for voltage regulators, adaptive compensation, dynamic voltage scaling (DVS), Single-Inductor Multiple-Outputs (SIMO) Converters, dc-dc converters for LED lighting, Li-ion battery charger.

	Total Periods	**45**

Suggestive Assessment Methods

Continuous Assessment Test (30 Marks)	**Formative Assessment Test (10 Marks)**	**End Semester Exams (60 Marks)**
WRITTEN TEST	**1.ASSIGNMENT 2. ONLINE QUIZZES 3.PROBLEM-SOLVING ACTIVITIES**	**WRITTEN TEST**

Outcomes

Upon completion of the course, the students will be able to:

1	Demonstrate a power management voltage and current mode controller circuit
2	Develop an integrated power stage

3	Interpret the supervisory circuitry – under voltage lockout, bandgap references
4	Analyse and Explain a complete power management integrated circuit
5	Formulate the Integrated circuits without any Flaws

Text Books

1. Power Management Techniques for Integrated Circuit Design, Author: Ke-Horng Chen, Publisher: Wiley-Blackwell (29 July 2016)
2. Erickson, "Fundamentals of Power Electronics", 2001.

Reference Books

1. Behazad Razavi," Design of Analog CMOS Integrated Circuits", 2003.
2. David A. Johns and Ken Martin," Analog Integrated Circuit Design", 2005.
3. Gray and Meyer," Analog Integrated Circuits", 3rd or 4th editions, 1996.

Web Resources:

1. https://archive.nptel.ac.in/courses/108/106/108106159/
2. Power Management Integrated Circuits - Course (nptel.ac.in)

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2
1	2	2					1	2						2
2	2	3					2							2
3	2	2					1	2						2
4	2		3				1	1					2	
5	1		3				3	1					1	

BLOOMS LEVEL ASSESSMENT PATTERN

BLOOMS CATEGORY	CAT 1	CAT 2	FAT 1	FAT 2	END SEM EXAM

REMEMBER	20	20	10	10	20
UNDETSTAND	30	30	10	10	30
APPLY	20	20	10	10	20
ANALYZE	15	15	10	10	15
EVALUATE	15	15	10	10	15
CREATE	0	0	0	0	0
	100	100	50	50	100

1-Low, 2- Medium, 3- High

21PE3707	**MEMS TECHNOLOGY**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Preamble

The rapid development of the integrated circuit (IC) industry has led to the emergence of micro electronics process engineering as a new advanced discipline. The combination of MEMS and integrated intelligence has been put forward as a disruptive technology. This provides an advanced level, vast understanding to the device electronics for integrated circuits, a foundation for the device fabrication and various applications in the field of sensors, actuators, optoelectronics, biomedical, communication and nanotechnology

Prerequisites for the course

1.Engineering Physics

2.Measurements and Instrumentation

Objectives

1. To define properties of materials ,microstructure and fabrication methods..
2. To design and modeling of Electrostatic sensors and actuators.
3. To Build thermal sensors and actuators through design and modelling.
4. To familiarise the fundamentals of piezoelectric sensors and actuators through exposure to different MEMS and NEMS devices.
5. To Revise the concept acquired over the 5 Units of the subject for improved employability skills.

UNIT I	**MICRO-FABRICATION, MATERIALS AND ELECTROMECHANICAL CONCEPTS**	**9**

Overview of micro fabrication – Silicon and other material based fabrication processes – Concepts: Conductivity of semiconductors-Crystal planes and orientation-stress and strain-flexural beam

bending analysis-torsional deflections-Intrinsic stress- resonant frequency and quality factor

UNIT II	ELECTROSTATIC SENSORS AND ACTUATION	9

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

UNIT III	THERMAL SENSING AND ACTUATION	9

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

UNIT IV	PIEZOELECTRIC SENSING AND ACTUATION	9

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

UNIT V	CASE STUDIES	9

Piezoresistive sensors, Magnetic actuation, Micro fluidics applications, Medical applications, Optical MEMS.-NEMS Devices Note: Class room discussions and tutorials can include the following guidelines for improved teaching /learning process: Discussions/Exercise/Practice on Workbench: on the basics /device model design aspects of thermal/peizo/resistive sensors etc.

	Total Periods	**45**

Suggestive Assessment Methods

Continuous Assessment Test (30 Marks)	**Formative Assessment Test (10 Marks)**	**End Semester Exams (60 Marks)**
WRITTEN TEST	**1.ASSIGNMENT** **2. ONLINE QUIZZES** **3.PROBLEM-SOLVING ACTIVITIES**	**WRITTEN TEST**

Outcomes

Upon completion of the course, the students will be able to:

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

5	Improved Employability and entrepreneurship capacity due to knowledge up gradation on recent trends in embedded systems design.

Text Books

1. Tai Ran Hsu,"MEMS and Microsystems design and manufacture", Tata McGraw Hill Publishing Company, New Delhi, 2016.
2. 2. Chang Liu, "Foundations of MEMS," Pearson Prentice Hall, 2019.

Reference Books

1. Chang Liu, "Foundations of MEMS", Pearson International Edition, 2019.
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

Web Resources

1. https://www.mems-exchange.org/MEMS/what-is.html
2. https://nptel.ac.in/courses/108108113/

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
1			3	1	2			2		2				3
2			3	1	2			2		2				3
3			3	1	2			2		2				3
4			3	1				2		2				3
5			3		2			2		2				3

BLOOMS LEVEL ASSESSMENT PATTERN

BLOOMS CATEGORY	CAT 1	CAT 2	FAT 1	FAT 2	END SEM EXAM
REMEMBER	20	20	0	0	20
UNDETSTAND	30	30	10	10	30
APPLY	20	20	10	10	20
ANALYZE	30	30	5	5	30
EVALUATE	0	0	0	0	0
CREATE	0	0	0	0	0
	100	100	25	25	100

1-Low , 2- Medium, 3- High

21PE3708	**POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Preamble

The PE plays crucial role of conversion and control electrical power. Therefore, PE based power converters are also widely used in renewable energy systems. This papers deals only with the wind and solar-PV systems as they are the most promising renewable energy sources for generation of electricity.

Prerequisites for the course

1.Engineering Mathematics
2.Engineering Physics

Objectives:

To impart knowledge on

1.	Illustrate the basics of solar photovoltaic systems.
2	Design of various PV-interconnected systems.
3	Identify the necessity of grid connected PV
4	Explain the need and type of Hybrid systems
5	Develop the System Components for different PV Applications

UNIT I	**GLOBAL AND NATIONAL ENERGY SCENARIO**	**9**

Over view of conventional & renewable energy sources, need, potential &development of renewable energy sources, types of renewable energy systems, Future of Energy Use, Global and Indian Energy scenario, Energy for sustainable development, renewable electricity and key elements, Global climate change, CO2 reduction potential of renewable energy- concept of Hybrid systems.

UNIT II	**SOLAR ENERGY**	**9**

Solar energy system, Solar Radiation, Availability, Measurement and Estimation, Solar Thermal Conversion Devices and Storage, Solar-Electrical Power Generation, general Solar Photo Voltaic (SVP) system, Different configurations, SPV system components and their characteristics, Stand-Alone and Grid Connected SPV systems, other Miscellaneous Applications of Solar Energy.

UNIT III	**WIND, HYDEL AND TIDAL POWER SYSTEMS**	**9**

Wind Energy Conversion, Potential, Nature of the wind, Site selection, Types of wind turbines, Wind farms, Wind Generation and Control., classification of wind, characteristics, offshore wind energy .

Hydel- Basic working principle, Classification of Hydel systems: Large, small, micro – measurement of head and flow – Energy equation – Types of turbines – Tidal power – Basics – Kinetic energy equation – Wave power – Basics – Kinetic energy equation.

UNIT IV	**BIOMASS, GEOTHERMAL AND OCEAN ENERGY**	**9**

Principles of Bio-Conversion, Anaerobic/aerobic digestion, types of Bio-gas digesters, gas yield, combustion characteristics of bio-gas, utilization for cooking, I.C. Engine operation and economic aspects. Geothermal Energy: Resources, types of wells, methods of harnessing the energy, potential in India.Ocean Energy: OTEC, Principles utilization, setting of OTEC plants, thermodynamic cycles.

UNIT V	**INTEGRATED ENERGY SYSTEMS**	**9**

Introduction, Integrated Smart infrastructure, Integrated Energy system Modelling, Various Integrated energy schemes, their cost benefit analysis.

	Total Periods	**45**

Suggestive Assessment Methods

Continuous Assessment Test (30 Marks)	**Formative Assessment Test (10 Marks)**	**End Semester Exams (60 Marks)**
WRITTEN TEST	**1.ASSIGNMENT** **2. ONLINE QUIZZES** **3.PROBLEM-SOLVING ACTIVITIES**	**WRITTEN TEST**

Outcomes

Upon completion of the course, the students will be able to:

1	Analyse the impacts of renewable energy generation on environment.
2	Explain the working principle of solar energy system.
3	Understand the importance about wind, tidal and Hydel power systems.
4	Select appropriate renewable energy system for different applications
5	Capable to carry out basic design of renewable energy systems

Text Books

1. Renewable Energy Resources, John Twidell and Tony Weir, Taylor and Francis -second edition, 2013.
2. Integrated energy systems modeling--Karlsson, Kenneth Bernard; Skytte, Klaus Morthorst; Publishedin: DTU International Energy Report 2015.

Reference Books

1. Solar Energy: Principles of Thermal Collection and Storage, S. P. Sukhatme and J. K. Nayak, TMH, New Delhi, 3rd Edition.
2. Non conventional energy source –B.H. Khan- TMH-2nd edition.
3. Renewable energy technologies – A practical guide for beginners – Chetong Singh Solanki, PHI.
4. Renewable Energy- Edited by Godfrey Boyle-oxford university, press, 3rd edition, 2013.

Web Resources

1. https://nptel.ac.in/courses/117/108/117108141/
2. https://nptel.ac.in/courses/108/105/108105058/
3. https://nptel.ac.in/content/storage2/courses/108108078/pdf/chap7/teach_slides07.pdf

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2
1	3		1						2					2
2	3		3	3	3				3					2
3	3		3	2	3				3					2
4	3		2	2	3				3					2
5	3		3		3				2					

BLOOMS LEVEL ASSESSMENT PATTERN

BLOOMS CATEGORY	CAT 1	CAT 2	FAT 1	FAT 2	END SEM EXAM
REMEMBER	10	10	5	5	10
UNDETSTAND	30	30	10	10	30
APPLY	60	60	10	10	60
ANALYZE	0	0	0	0	0
EVALUATE	0	0	0	0	0
CREATE	0	0	0	0	0
	100	100	25	25	100

1-Low , 2- Medium, 3- High

21EE2601	**Modelling and Simulation of Power Electronics Systems**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Preamble

Power electronics simulation should be considered for the following tasks: Designing and validating new topologies and control strategies. Optimizing system behavior using model libraries of energy sources, power semiconductors, passive circuit elements, and machines such as PMSM and induction motors.

Prerequisites for the course

1.Power Electronics lab

2. Analysis of Power Converters

3. Numerical methods

Objectives

1. Develop the mathematical models for the different power electronic converters.
2. Demonstrate the Application of Power Electronic semiconductors using MATLAB SIMULINK
3. Illustrate mathematical modelling and simulation of single and three phase rectifiers with R, R-L and R-L-E load using MATLAB and SIMULINK.
4. Simulate various power converters using simulation software like PSPICE and MATLAB SIMULINK

5. Analyze power electronics circuits for different loads.

UNIT I	INTRODUCTION	9

Need for simulation – Challenges in simulation – Classification of simulation programs – Overview of PSPICE, MATLAB and SIMULINK. Review of numerical methods to solve transients in D.C. Switched R,L,R-L, R-C and R-L-C circuits. Extension to A.C circuits.

UNIT II	MODELING AND SIMULATION OF POWER SEMICONDUCTOR DEVICES	9

Modelling and simulation of diode, SCR, TRIAC, IGBT and power transistors – Application of numerical methods to power electronic switches – Simulation of gate/base drive circuits and snubber circuits (Using MATLAB and PSPICE).

UNIT III	MODELING AND SIMULATION OF RECTIFIERS	9

Mathematical modeling and simulation of single and three phase semi, fully controlled rectifiers with R, R-L and R-L-E load using MATLAB and SIMULINK.

UNIT IV	MODELING AND SIMULATION OF CHOPPERS	9

Mathematical modeling and simulation of buck, boost and buck- boost converters with R, R-L and R-L-E load using MATLAB and SIMULINK.

UNIT V	MODELING AND SIMULATION OF INVERTERS	9

Mathematical modelling and simulation of single and three phase half and full bridge inverter with R, R-L loads using MATLAB and SIMULINK.

	Total Periods	**45**

Suggestive Assessment Methods

Continuous Assessment Test (30 Marks)	**Formative Assessment Test (10 Marks)**	**End Semester Exams (60 Marks)**
WRITTEN TEST	**1.ASSIGNMENT** **2. ONLINE QUIZZES** **3.PROBLEM-SOLVING ACTIVITIES**	**WRITTEN TEST**

Outcomes

Upon completion of the course, the students will be able to:

1	Develop mathematical models for DC and AC circuits**.**
2	Model and simulate various power electronic devices using simulation software.
3	Analyze power electronic uncontrolled rectifiers using MATLAB/SIMULINK.

4	Model and simulate power electronics controlled rectifiers.
5	Analyze power electronic DC-DC converters using simulation software.

Text Books

1. Robert Ericson, "Fundamentals of Power Electronics", Springer Publication 2020
2. Power Electronics | Devices, Circuits and Applications | Fourth Edition | Pearson Paperback – 28 November 2017

Reference Books

1. Simulink reference manual, Math works, USA
2. Joseph Vithayathil, "Power Electronics: Principles and Applications", Delhi, Tata McGraw Hill,2010
3. P.S.Bimbra, "Power Electronics", New Delhi, Khanna Publishers, 2012
4. M.H.Rashid, "SPICE for circuits and Electronics using PSPICE", Prentice Hall, 2011

Web Resources

1. https://nptel.ac.in/courses/103/106/103106118/
2. https://nptel.ac.in/courses/117/105/117105147/
3. https://nptel.ac.in/courses/108/102/108102145/

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
1	2		3	3	1			2		2			3	
2	2		3	3	1			2		2			3	
3	2		3	3	1			2		2			3	
4	2		3	3	1			2		2			3	
5	2		3	3	1			2		2			3	

BLOOMS LEVEL ASSESSMENT PATTERN

BLOOMS CATEGORY	CAT 1	CAT 2	FAT 1	FAT 2	END SEM EXAM
REMEMBER	20	20	10	10	20
UNDETSTAND	30	30	10	10	30
APPLY	40	40	5	5	40
ANALYZE	0	0	0	0	0
EVALUATE	0	0	0	0	0
CREATE	0	0	0	0	0
	100	100	25	25	100

1-Low , 2- Medium, 3- High

21PE3710	**INTELLIGENT CONTROL OF ELECTRIC DRIVES**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Preamble

This course aims to explore new areas of induction motor control based on artificial intelligence (AI) techniques in order to make the controller less sensitive to parameter changes. Selected AI techniques are applied for different induction motor control strategies.

Prerequisites for the course

1. Power Electronics

Objectives

1. To understand the fundamentals of Vector Control of Induction Motor
2. To familiarize on Sensor less Vector Control of Induction Motor.
3. To realize on Control of Synchronous Motor Drives
4. To comprehend on Control of Switched Reluctance Motor Drives
5. To enlighten on Control of BLDC Motor Drives

UNIT I	**INTRODUCTION**	**9**

Introduction: Concepts, and classification of Electric drives. Selection of motors. Dynamics of Electric drives: Types of loads, Multi quadrant operations, motor dynamics steady state stability and transient stability. Rating and Heating of motors: Heating effects, heating and cooling curves, classes of duty, load equalization, environmental factors.

UNIT II	DC MOTOR DRIVES	9
Basic characteristics, Operating modes, Single phase and three phase controlled rectifier fed DC drives, Dual converters drives, Chopper drives, Rheostat and regenerative braking, effects of changes in supply voltage and load torque, closed loop control schemes.		
UNIT III	**AC MOTOR DRIVES**	**9**
Induction motor drives, stator voltage control, stator impedance control, rotor voltage control – Slip power recovery, Concepts of Static Kramer drives and Static Schermie's drive, V/f control, Current control method. Need for harmonic filter, Closed loop control. Introduction to vector control scheme.		
UNIT IV	**SYNCHRONOUS MOTORS**	**9**
Synchronous motors: Speed torque characteristics and torque angle characteristics. Fixed and variable frequency operation modes, Self-control modes.		
UNIT V	**SPECIAL MACHINES**	**9**
Brushless DC motor, Switched Reluctance Motor, Introduction to the relevant converter circuits.		
	Total Periods	**45**

Suggestive Assessment Methods

Continuous Assessment Test (30 Marks)	Formative Assessment Test (10 Marks)	End Semester Exams (60 Marks)
WRITTEN TEST	1.ASSIGNMENT 2. ONLINE QUIZZES 3.PROBLEM-SOLVING ACTIVITIES	WRITTEN TEST

Outcomes

Upon completion of the course, the students will be able to:

1	Apply the Vector Control of Induction Motor
2	Demonstrate the Sensor less Vector Control of Induction Motor.
3	Implement the Control of Synchronous Motor Drives.
4	Execute the Control of Switched Reluctance Motor Drives.
5	Interpret the Control of BLDC Motor Drives.

Text Books

1. Gopal K. Dubey, Fundamentals of Electrical Drives, Narosa Publishing House, 2001.
2. R.Krishnan, "Electric Motor Drives – Modeling, Analysis and Control", Prentice- Hall of India Pvt. Ltd., New Delhi, 2010.

3. VedamSubramanyam, "Electric Drives – Concepts and Applications", Tata McGraw-Hillpublishing company Ltd., New Delhi, 2002.

Reference Books

1. Modern Power Electronics and AC Drives –B. K. Bose-Pearson Publications, 2000
2. Power Electronics control of AC motors – MD Murphy & FG Turn Bull Pergman Press -1st edition-1998.

Web Resources

1. http://www.digimat.in/nptel/courses/video/108104049/L04.html
2. http://www.nptelvideos.in/2012/11/advanced-electric-drives.html

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2
1	2	1	2		2								2	
2	3	2		1	1								2	
3	2	1	2		2								2	
4	3	1	2			1								2
5	3	1	2			1								2

BLOOMS LEVEL ASSESSMENT PATTERN

BLOOMS CATEGORY	CAT 1	CAT 2	FAT 1	FAT 2	END SEM EXAM
REMEMBER	20	20	10	10	20
UNDETSTAND	30	30	10	10	30
APPLY	20	20	10	10	20
ANALYZE	15	15	10	10	15
EVALUATE	15	15	10	10	15

CREATE	0	0	0	0	0
	100	100	50	50	100

1-Low, 2- Medium, 3- High

21PE3711	**ENERGY STORAGE SYSTEMS**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Preamble

This course provide the conceptual knowledge on energy storage system and energy management system in India. It is essential and significant to build sophisticated features in electrical energy storage management

Prerequisites for the course

- Power Electronics and Drives
- Renewable Energy System

Objectives

1. To impart knowledge on Basic concepts of different energy storage systems.
2. To analyse the entire Hydrogen energy systems and its storage techniques
3. To differentiate the different types of Energy storage system using batteries.
4. To determine different Battery Charging techniques, Charge Controllers and its challenges
5. To analyse the Energy storage system using fuel-cell.

UNIT I	**ENERGY STORAGE METHODS**	**9**

Need for Energy storage-Different energy storage Methods- Mechanical energy storage: Pumped storage, Compressed air storage - Electromagnetic storage-Electrostatic storage-Thermal energy storage: Sensible heat storage, Latent heat storage-Different methods of chemical Energy storage-Reversible Chemical Storage.

UNIT II	**DESIGN OF POWER CONVERTER COMPONENTS**	**9**

Block diagram of Hydrogen energy systems - Properties of Hydrogen - Extraction methods of Hydrogen: Thermo chemical methods - Electrolysis of water-Thermolysis of water- Biophotolysis - Hydrogen storage techniques Delivery of Hydrogen-Conversion of Hydrogen - Applications-Safety Issues.

UNIT III	**ENERGY STORAGE USING BATTERIES**	**9**

Batteries - Construction and working - Elements of electrochemical cell-operation of electrochemical cell Theoretical cell voltage and capacity-Losses in a cell-Battery classification-Constructions and working principle of Lead Acid battery-Nickel Cadmium batteries-Lithium-ion batteries-Battery parameters: Battery capacity, Battery Voltage, Depth of discharge-Battery life cycle-Discharge/charge rate, Self discharge-Ragone Plots.

UNIT IV	**BATTERY CHARGING AND CHARGE CONTROLLERS**	**9**

Factors affecting battery performance: Battery voltage level, Battery Discharge current, Battery Temperature during discharge-Factors affecting Choice of a battery-Battery charging and discharging methods-Charge controllers for stand-alone PV system-Types of charge controllers for stand-alone PV system: Shunt type, Series type, DC-DC converter type, MPPT charge controller – Power stage and control scheme for battery charging using DC-DC converter-Flow chart for battery charging.

UNIT V	**FUEL CELL**	**9**

Introduction-Advantages-Applications-Classification of fuel cells- Construction and working of Phosphoric Acid fuel cell-Alkaline Fuel cell-Polymer Electrolyte Membrane Fuel cell-Fuels for Fuel Cells-Efficiency of Fuel cell-VI characteristics of Fuel Cell-Power Electronics controller for fuel cell.

Total Periods	**45**

Suggestive Assessment Methods

Continuous Assessment Test (30 Marks)	**Formative Assessment Test (10 Marks)**	**End Semester Exams (60 Marks)**
1. DESCRIPTIVE TYPE QUESTIONS ***2. FORMATIVE MULTIPLE CHOICE QUESTIONS***	**1.ASSIGNMENT** **2. ONLINE QUIZZES** **3.PROBLEM-SOLVING ACTIVITIES**	***1. DESCRIPTIVE TYPE QUESTIONS*** ***2. FORMATIVE MULTIPLE CHOICE QUESTIONS***

Outcomes

Upon completion of the course, the students will be able to:

1	Understand the various basic concepts ofenergy storage systems and its practical applications
2	Analyse the Hydrogen energy system and its designing of the power converter components
3	Understand and develop the energy storage system using batteries.
4	Ability to construct the Energy storage system, Charging techniques, Charge Controllers and challenges of Battery
5	Analyse the role of fuel cell and its controller for real time applications.

Text Books

1. KonradMertens, "Photovoltaics Fundamentals, Technology, and Practice",Wiley Publication, 2nd Edition, 2018.
2. Khan B.H.,"Non-Conventional Energy Resources", Tata McGraw Hill Publication, 3rd Edition, 2016.

Reference Books

1. Robert A. Huggins, "Energy Storage: Fundamentals, Materials and Applications", Springer, 2015.
2. AmitSoni, DharmendraTripathi, JagratiSahariya, Kamal Narayan Sharma, "Energy Conversion and Green Energy Storage" , CRC Press, 2022

Web Resources

1. https://archive.nptel.ac.in/courses/113/105/113105102/

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2
1	3	3				2	2	2			3	
2	3	3				2		3			3	
3	3	3		2		2	3	3			3	
4	3	3		2		2	3	3			3	
5	3	3		3		2		3			3	

BLOOMS LEVEL ASSESSMENT PATTERN

BLOOMS	CAT 1	CAT 2	FAT 1	FAT 2	END SEM

CATEGORY					EXAM
REMEMBER	10	10	2	3	10
UNDETSTAND	10	10	3	2	10
APPLY	30	30	10	10	30
ANALYZE	50	50	10	10	50
EVALUATE	0	0	0	0	0
CREATE	0	0	0	0	0
	100	100	25	25	100