B.Tech

CURRICULUM and SYLLABUS-2021

Department of
Electrical and Electronics Engineering

Kalasalingam Academy of Research and Education
(Deemed to be University)
Under sec.3 of UGC Ac, 1956. Accredited by NAAC with 'A' Grade
Anand Nagar, Krishnankoil-626126,
Srivilliputtur (via), Virudhunagar (Dt), Tamilnadu, India.
www.kalasalingam.ac.in

Kalasalingam Academy of Research and Education

VISION

To be a Center of Excellence of International Repute in Education and Research.

MISSION

To Produce Technically Competent, Socially Committed Technocrats and Administrators through Quality Education and Research.

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

VISION

To become a centre of excellence in teaching and research in the field of Electrical and Electronics Engineering.

MISSION

To produce technically competent Electrical and Electronics Engineering graduates who are able to offer viable solutions to meet the energy security of the nation.

To provide opportunities and resources to carry out cutting edge research on energy systems.

Program Educational Objectives (PEOs):

PEO1: The Graduates will excel in engineering industries and other research organizations that focus on design and development of Electrical & Electronics products and systems.

PEO2: The Graduates will excel in professional career, entrepreneurship and by earning advanced degree in Electrical Engineering and related discipline.

PEO3: The Graduates will address the societal issues through their core expertise with good human values and professional ethics.

Program Outcomes (POs):

Engineering Graduates will be able to:

PO1: **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2: **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3: **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4: **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5: **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6: **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7: **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8: **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9: **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10: **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend

and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11: **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12: **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes (PSOs):

PSO1: Analysis & Solution of complex problems in Electrical & Electronics Engineering using modern tools.

PSO2: Design and Development of Electrical & Electronics products /systems that meets specified needs.

PSO3: Understand and demonstrate the importance of sustainable energy development.

CURRICULUM STRUCTURE

<table>
<tr><th colspan="3">Category</th><th>Credits</th></tr>
<tr><td rowspan="6">Environment/Indian constitution/</td><td rowspan="6">Foundation Core</td><td>Mathematics and sciences</td><td rowspan="6">44</td></tr>
<tr><td>Engineering Science</td></tr>
<tr><td>Computing</td></tr>
<tr><td>Sustainable Product Development</td></tr>
<tr><td>Human Values and Communication</td></tr>
<tr><td>Entrepreneurship and Innovation</td></tr>
<tr><td rowspan="4">Complimentary skills</td><td rowspan="2">University Elective</td><td>Engineering (outside school)</td><td rowspan="2">16</td></tr>
<tr><td>Liberal arts (Or) Mathematics and Sciences</td></tr>
<tr><td colspan="2">Program Core</td><td>52</td></tr>
<tr><td colspan="2">Program Elective</td><td>24</td></tr>
<tr><td rowspan="2">Audit Courses</td><td rowspan="2">Experiential Core</td><td>Design Project</td><td rowspan="2">16</td></tr>
<tr><td>Capstone</td></tr>
<tr><td>Experiential Elective</td><td>CSP/Internship/UG Research /Competitions</td><td>8</td></tr>
<tr><td colspan="3">Total Credits</td><td>160</td></tr>
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Foundation Core

Course code	Course Name	Course Type	Prerequisite	Co requisite	L	T	P	X	C
211EEE1301	Basic Electrical and Electronics Engineering	ICT			3	0	2	0	4

Program Core

Course code	Course Name	Course Type	Prerequisite	Co requisite	L	T	P	X	C
212EEE1101	Electric Circuit Theory	T			2	1	0	3	3
212EEE1102	Electromagnetic Fields	T			3	1	0	3	3.5
212EEE1303	DC Machines and Transformers	ICT			2	1	2	-	4
212EEE1304	Analog Electronics	ICT			3	0	2	3	4
212EEE2305	Control System	ICT			2	1	1	-	3.5
212EEE2106	AC Machines	T	212EEE1303		2	1	0	-	3
212EEE2307	Measurement and Instrumentation Systems	ICT			2	1	1	-	3.5
212EEE2308	Digital System Design	ICT			3	0	1	-	3.5
212EEE2309	Power Electronics	ICT	212EEE1304		2	1	2	-	4
212EEE2110	Power Generation, Transmission and Distribution	T			2	1	0	-	3
212EEE2311	Microcontrollers and its Applications	ICT	212EEE2308		3	0	2	3	4
212EEE2312	Signals and Systems	ICT			3	0	2	-	4
212EEE2313	Power System Analysis	ICT	212EEE2110		2	1	2	-	4
212EEE2114	Power System Protection	T			2	1	0	3	3
212EEE2215	AC Machines Laboratory	P		212EEE2106	0	0	3	-	2
Total									**52**

Program Elective

Course code	Course Name	Course Type	Prerequisite	L	T	P	X	C
Stream 1: Energy Systems								
213EEE3116	Energy Conservation Practices	T		3	0	0	-	3
213EEE3117	Utilization of Electrical Energy	T		3	0	0	-	3
213EEE3118	Digital Protection	T		3	0	0	-	3
213EEE3119	Power Quality	T		3	0	0	-	3
213EEE3120	HVDC Transmission System	T	212EEE2309	3	0	0	-	3
213EEE3121	Flexible AC Transmission System	T	212EEE2309	3	0	0	-	3
213EEE3122	Soft Computing Techniques	T		3	0	0	-	3
Stream 2: Embedded Systems and IOT								
213EEE2123	IOT and its Applications	T		3	0	0	3	3
213EEE3124	Intelligent Building Energy Management Systems	T		3	0	0	-	3
213EEE3125	Embedded Computing System Design	T		3	0	0	-	3
213EEE3126	Sensing Techniques and Sensor Systems	T		3	0	0	-	3
213EEE3127	Embedded Linux	T		3	0	0	-	3
213EEE3128	Real Time Operating System	T		3	0	0	-	3
213EEE3129	Advanced Embedded Computing	T		3	0	0	-	3
213EEE3130	Automotive Embedded System	T		3	0	0	-	3
213EEE3131	PLC and Industrial Automation	T		3	0	0	-	3

Stream 3: Renewable Energy & Smart Grid								
213EEE3132	Solar Photovoltaic Systems	T		3	0	0	-	3
213EEE3133	Wind Power Generation	T		3	0	0	-	3
213EEE3134	Biomass Energy System	T		3	0	0	-	3
213EEE3135	Geothermal and Ocean Energy Conversion	T		3	0	0	-	3
213EEE3136	Industrial & Commercial Aspects of Renewable Energy Sources	T		3	0	0	-	3
213EEE2137	Renewable Energy Sources	T		3	0	0	-	3
213EEE3138	Fuel Cell Technology	T		3	0	0	-	3
213EEE3139	Smart Grid	T	212EEE2110	3	0	0	-	3
Stream 4: Electrical Machines & Drives								
213EEE3140	Electrical Machine Design	T	212EEE2106	3	0	0	-	3
213EEE3141	Electrical Drives and Control	T	212EEE2309	3	0	0	-	3
213EEE3142	Special Electrical Machines	T	212EEE2106	3	0	0	3	3
213EEE3143	Auto Electrical and Electronics System	T		3	0	0	-	3
213EEE3144	Electrical and Hybrid Vehicle Technology	T		3	0	0	3	3
213EEE3145	Testing & Certification of Automotive Systems	T		3	0	0	-	3

University Elective Courses (Engineering)

Course code	Course Name	Course Type	Prerequisite	L	T	P	C
Stream 1: Power & Energy Systems							
213EEE2146	Principles of Power System	T	-	3	0	0	3
213EEE2147	Power Generation Systems	T	-	3	0	0	3
213EEE2148	Electrical Machines	T	-	3	0	0	3
213EEE2149	Hydro power generation	T	-	3	0	0	3
213EEE2150	Solar and Wind Energy Conversion	T	-	3	0	0	3
213EEE2151	Electrical wiring Estimation and costing	T	-	3	0	0	3
213EEE2152	Electrical Safety	T	-	3	0	0	3
213EEE2153	Energy Conservation and Management	T	-	3	0	0	3
213EEE3154	Evolutionary Computation Techniques	T	-	3	0	0	3
213EEE3155	Soft Computing Techniques	T	-	3	0	0	3
213EEE3156	Smart Grid Technology	T	-	3	0	0	3
Stream 2: Power Electronics & Automation Systems							
213EEE2157	Principles of Power Electronics	T	-	3	0	0	3
213EEE3158	Digital Controllers in Power Electronics Applications						
213EEE2159	Automotive Electronics Engineering	T		3	0	0	3
213EEE2160	Building Management System	T	-	3	0	0	3
213EEE2161	Instrumentation Systems	T	-	3	0	0	3
213EEE3162	Embedded System Design	T	-	3	0	0	3

One Credit Courses

Course code	Course Name	Course Type	L	T	P	C
21XEEEXXXX	Indian Electrical Standards	T	1	0	0	1
21XEEEXXXX	Design of Power Supplies	T	1	0	0	1
21XEEEXXXX	Battery Technology & Super Capacitors	T	1	0	0	1
21XEEEXXXX	Electrical and Electronics Applications in Missile Technology	T	1	0	0	1

Minor Electives

Course code	Course Name	Course Type	L	T	P	X	C
212EEE1101	Electric Circuit Theory	T	2	1	0	3	3
212EEE1102	Electromagnetic Fields	T	3	1	0	3	3.5
212EEE1304	Analog Electronics	ICT	3	0	2	3	4
212EEE2308	Digital System Design	ICT	3	0	1	-	3.5
212EEE2110	Power Generation, Transmission and Distribution	T	2	1	0	-	3

Experiential Core

Course Code	Course Name	Course Type	Credits
215EEE5176	Capstone	P	16

Experiential Electives

Course Code	Course Name	Course Type	Credits
215EEE4163	Energy Storage System	T	3
215EEE4164	Advanced control Theory	T	3
215EEE4165	Distributed Generation and Microgrid	T	3
215EEE4166	Power Electronics for Renewable Energy System	T	3
215EEE4167	Power System Stability and Control	T	3
215EEE4168	Power System Restructuring	T	3
215EEE4169	Digital Relaying and Phasor Measurement Unit	T	3
215EEE4170	Power System Optimization	T	3
215EEE4171	Industrial Electronics	T	3
215EEE4172	PWM Converters and Application	T	3
215EEE4173	Power Switching Devices	T	3
215EEE4174	Digital Signal Processing	T	3
215EEE5175	Community Service Project	P	8

FOUNDATION CORE

211EEE1301 BASIC ELECTRICAL AND ELECTRONICS ENGINEERING

211EEE1301 BASIC ELECTRICAL AND ELECTRONICS ENGINEERING	L	T	P	X	C
	3	0	2	0	4
Pre-requisite: NIL	**Course Category:** Foundation Core – ICT				

Course Outcomes (CO)

On successful completion of the course, the students would be able to;

CO1	Apply the basic laws of electricity in DC and AC circuits
CO2	Understand the construction and operation of static and rotating electrical machines
CO3	Understand the constructional features and operation of fundamental electronic devices and circuits
CO4	Understand the characteristics of digital electronics
CO5	Understand the functioning of digital measuring instruments, sensors and transducers

Mapping of Course Outcomes with Program Outcomes (PO)/ Program Specific Outcomes (PSO)

CO / PO	PO / PSO														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
CO1	M	M		M	M	L		L	M	L			M		
CO2	M	M		M	M	L		M	L	M			M		
CO3	M			M	M	L		L	M	L			S		
CO4	S	M											M		
CO5	S	S	L	M	M	L	M	M	L	M			M		

Course Topics:

Unit 1: Electric Circuits

Circuit elements – resistor, inductor, capacitor - Ohm's Law - Kirchhoff's Laws - series and parallel circuits - analysis of DC circuits - mesh, nodal analysis – simple problems. Alternating voltage - RMS and Average values - form and peak factors - Single phase AC circuits - power, energy calculation and power factor - Concept of three phase system.

Unit 2: Electrical Machines

Construction and operation of DC machines – DC generator – DC motor. Single phase transformer – Construction and operation. Alternator, Three phase induction motor – Construction and operation – Types. Single phase induction motor – Construction – Working – Capacitor start and capacitor run motor.

Unit 3: Electronic Devices and Circuits

PN junction diode, BJT, FET, MOSFET – Working & Characteristics, Diode based Half wave and full wave rectifier – Transistor as switch. Applications of Electronic Circuits.

Unit 4: Digital Electronics

Boolean Algebra - Simplification of Boolean Expressions - Logic Gates - Implementation Of Combinational Logic Circuits – Half Adder, Full Adder, Parallel Adder, Encoders, Decoders – Multiplexers, De-Multiplexers. Applications of Digital Electronic Circuits.

Unit 5: Transducers and Digital Instruments

Sensors & Transducers - selection criteria – LVDT, Tachogenerator, Passive Infrared (PIR), LM35, LDR – Working principle, Applications – Transmission of transducer signal outputs (V, I, F) – Concept of Digital Instruments.

LIST OF EXPERIEMENTS:

1. Choice of method of connection, type and range of meters
2. Analysis of Electrical Circuits
3. Design of Diode Based Full Wave Bridge Rectifier with filter
4. Transistor as a Switch
5. Load Test on Single Phase Induction Motor
6. Determination of Power Savings using Energy Efficient Electrical equipment
7. Verification of Truth Tables of Logic Gates
8. Characteristics of Resistance Temperature Detector
9. Load Test on Single Phase Transformer
10. Half Adder and Full Adder

**Project may be assigned to the students for Project Based Learning*

Text Book(s):

1. V.K. Mehta, “Principles of Electrical Engineering and Electronics”, S. Chand & Company Ltd, 2012
2. S. K. Bhattacharya, Basic Electrical and Electronics Engineering, Pearson, 2016.
3. Albert Malvino, David J. Bates, “Electronic Principles”, 7th Edition, McGraw Hill Education; 2017.
4. Electronic devices and circuit theory / Robert L. Boylestad, Louis Nashelsky.—11th edition, Pearson Education Inc.

Reference(s):

1. R. Muthususbramanian and S. Salivahanan, "Basic Electrical, Electronics and Engineering" McGraw Hill Education (India) Private Limited, 2013.
2. T. Thyagarajan, “Fundamentals of Electrical and Electronics engineering”, SciTech publications (Ind.) Pvt. Ltd., 3rd Edition, 2015.

PROGRAM CORE

212EEE1101 ELECTRIC CIRCUIT THEORY

212EEE1101 ELECTRIC CIRCUIT THEORY	L	T	P	X	C
	2	1	0	-	3
Pre-requisite: NIL	**Course Category:** Programme Core – Theory. With Tutorial				

Course Objective(s):

To acquire knowledge about the basics of circuit analysis, network theorems, concepts of AC circuits, coupled circuits, three phase circuits and transient analysis.

Course Outcome(s):

After completing this course, the student will be able to:

CO1: Describe the various types of Sources and Network and apply Mesh, Nodal analysis to solve electrical circuits.

CO2: Analyze the electrical circuits using various network theorems.

CO3: Solve AC Circuits with Series/parallel combinations.

CO4: Discuss the basic concepts of Resonance and three phase circuits.

CO5: Analyze the steady state and transient behaviour of electric circuits.

Mapping of Course Outcome(s):

CO / PO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	M	M	S												
CO2	S	S	S	S								M			
CO3	S	S	S	S								M			
CO4	S	S	S	M								M			
CO5	S	S	S	S											

Course Topics:

Unit 1: DC Circuit Analysis

Ideal sources - source transformation - voltage division - current division - network reduction - star and delta transformation - concept of duality - dual networks - formation of matrix equations and analysis of complex circuits using mesh-current and nodal-voltage methods.

Unit 2: Network Theorems

Thevenin's theorem, Norton's theorem, superposition theorem, maximum power transfer theorem, substitution theorem, reciprocity theorem, Millman's theorem, Tellegen's theorem - statement, application to AC and DC circuits.

Unit 3: Steady State Analysis of Ac Circuits

Concept of phasor and complex Impedance/Admittance – Analysis of series and parallel circuits- Solution of RLC circuits, power, and power factor - series resonance, parallel resonance - Q factor – bandwidth- locus diagram - Applications of steady state analysis in AC circuits

Unit 4: Coupled Circuits and Three Phase Circuits

Self-inductance - mutual Inductance - coefficient of coupling - dot rule - ideal transformer - effective inductance of coupled coils in series and in parallel - analysis of coupled circuits - single tuned and double tuned circuits. Three phase star delta connections - phasor diagram - solution of three phase balanced circuits and unbalanced circuits - three phase power measurement using watt meters.

Unit 5: Transient Analysis

Concept of complex frequency - representation of network elements in time domain and frequency domain –Source free and forced responses of RL - RC - RLC circuits with DC and sinusoidal excitation- Time constant and natural frequency of oscillation – Laplace transform application to the solution of RL, RC and RLC circuits - Applications of transient analysis

Text Book(s):

1. A Sudhakar and Shyam Mohan SP, “Circuits and Networks: Analysis and Synthesis”, TMH, 5th Edition, New Delhi, 2015.

2. William H. Hayt, Jack E. Kemmerly and Steven M. Durbin, “Engineering Circuit Analysis”, TMH, 8th Edition, 2012.

Reference(s):

1. Paranjothi S.R., 'Electric Circuit Analysis', New Age International Publisher, 2011

2. Mahmood Nahvi, Joseph A. Edminister, Schaum’s outline of Electric Circuits', McGraw Hill Book Company, 6th Edition,2014.

3. Dorf R.C., Introduction to Electric Circuits, John Wiley & Sons Inc, New York, Nineth Edition, 2013.

4. Charles K.Alexander, Mathew N.O. Sadiku., Fundamentals of Electric Circuits, Mcgraw Hill Education 5th Edition, 2013.

212EEE1102 ELECTROMAGNETIC FIELDS

212EEE1102 ELECTROMAGNETIC FIELDS	*L*	*T*	*P*	*X*	*C*
	3	*1*	*0*	*-*	*3.5*
Pre-requisite: NIL	**Course Category:** Programme Core – Theory. With Tutorial				

Course Objective(s):

To provide the students with a solid foundation in engineering fundamentals required to solve problems and also to pursue higher studies.

To acquire the knowledge of Electromagnetic field theory that allows the student to have a solid theoretical foundation to be able in the future to design emission, propagation and reception of Electro -magnetic wave systems.

Course Outcome(s):

After completing this course, the student will be able to:

CO1: Understand the concept of co-ordinate system and solve the electrostatic problems using coulombs law and gauss's law

CO2: Understand the concept of conductors, dielectrics and capacitance

CO3: Apply the boundary conditions and numerical methods to solve the electromagnetic problems

CO4: Solve the magnetic field problems using the laws of magnetism and vector calculus

CO5: Apply the Maxwell's equations to understand the electromagnetic wave propagation

Mapping of Course Outcome(s):

CO / PSO	PSO														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
CO1	S	S	M	M	M							M	S	S	
CO2	S	S	S	S	M							M	S	S	
CO3	S	S	S	S	M							M	S	S	
CO4	S	S	S	S	S							M	S	S	
CO5	S	S	S	S	S							M	S	S	

Course Topics:

Unit 1: ELECTROSTATICS

Review of vector algebra - co-ordinate system - rectangular, cylindrical and spherical - Coulomb's law - electric field intensity - field due to different types of charges - electric flux density - Gauss's law and application - divergence and divergence theorem -electric potential - potential field due to different types of charges - potential gradient.

Unit 2: ELECTROSTATICS APPLICATIONS

Current and current density - continuity of current - conductor properties and boundary conditions - the nature of dielectric materials - boundary conditions for perfect dielectric materials - capacitance - different types of capacitances - energy density in electric field - Poisson's and Laplace's equations.

Unit 3: FIELD MODELLING AND COMPUTATION

Problem formulation - boundary condition - solutions Analytical methods - variables separable methods - conformal transformation - method of images - numerical methods - finite difference method - finite element method - charge simulation method.

Unit 4: MAGNETOSTATICS

Magnetic field - magnetic flux - magnetic flux density –curl- Stoke's theorem - Biot-savart law and application - Ampere's circuital law and application - scalar and vector magnetic potentials - force on a moving charge, differential current element, torque on a closed circuit - inductance - nature of magnetic materials - magnetization and permeability - magnetic boundary conditions – Simulation of Electric Fields using FEM packages.

Unit 5: MAXWELLS EQUATIONS AND ELECTROMAGNETIC WAVES

Faraday's laws- Faraday's law - Lenz's law - Maxwell's equations in differential and integral forms - displacement current - Electromagnetic wave equations - wave parameters - velocity, intrinsic impedance, propagation constant - waves in free space, lossy and lossless dielectric, conductors - skin depth - Poynting theorem.

Text Book(s):

1. Mathew N. O. Sadiku, 'Principles of Electromagnetics', 4thEdition, Oxford University Press Inc. First India edition, 2009.

Reference(s):

1. William H. Hayt and John A. Buck, 'Engineering Electromagnetics', Tata McGraw Hill 8th Revised edition, 2011.
2. Kraus and Fleish, 'Electromagnetics with Applications', McGraw Hill International Editions, Fifth Edition, 2010.
3. Joseph. A.Edminister, 'Schaum's Outline of Electromagnetics, Third Edition (Schaum's Outline Series), Tata McGraw Hill, 2010

212EEE1303 DC MACHINES AND TRANSFORMERS

212EEE1303 DC MACHINES AND TRANSFORMERS	***L***	***T***	***P***	***X***	***C***
	2	***1***	***2***	***0***	***4***
Pre-requisite: Nil	**Course Category:** Programme Core – Integrated Course. With Tutorial				

Course Objective(s):

To give the students a fair knowledge on transformers & various types of DC machines function and its applications.

To expose the students for testing methodologies of DC machines and transformers.

Course Outcome(s):

After completing this course, the student will be able to:

CO1: Develop the equivalent circuit of the given transformer and able to find the vector groupings.

CO2: acquire the knowledge of rotating machines torque production and MMF of distributed winding

CO3: Analyze the performance characteristics of self and separately excited DC generators.

CO4: Analyze the operation, starting methods and speed control of DC Motors.

CO5: Apply the testing procedures of electrical machines as per the standard practice.

Mapping of Course Outcome(s):

CO / PSO	PSO														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
CO1	S	S			S								S	M	
CO2	S			S									S	S	
CO3	S	M		S	S								S	S	
CO4	S			S	S								S	S	
CO5	S	S		M								S	S	M	

Course Topics:

Unit 1: TRANSFORMERS

Construction - working principle - EMF equation - Elementary theory of ideal transformer - Transformation ratio - Transformer with losses but no magnetic leakage - Transformer on no load and on load - Equivalent circuit – Regulation - Efficiency - All day efficiency - Auto transformer - Condition for maximum efficiency - Parallel operation of single phase transformer - Three phase transformer connections (delta-delta, star-star, delta-star, star-delta) – Vector groupings Yy0, Dd0, Yd1, Yd11, Dy1, Dy11 - Scott connection- tertiary winding - Tap changing transformers – No load and on-load tap changing of transformers

Unit 2: BASIC CONCEPTS OF ROTATING MACHINES

Principles of electromechanical energy conversion - Single and multiple excited systems – Physical concept of torque production: Electromagnetic torque and Reluctance torque Generated EMF in full pitched coil – Generated EMF in a short pitched coil MMF produced by distributed windings – MMF of a coil – MMF of single phase distributed winding - MMF of commutator machines

Unit 3: DC GENERATORS

Construction - Principle and operation - EMF equation – Types - Armature windings - Single, double layer windings - Losses in a DC generator – Characteristics (no load & load) - Condition for maximum efficiency - Armature reaction - Demagnetizing and cross magnetizing conductors - Commutation – Methods of improve commutation - Parallel operation of generators - Load sharing – Applications of DC Generators

Unit 4: DC MOTORS

Working principle – Types - EMF equation – Torque equation - Characteristics - Significance of the back EMF - Losses and efficiency - Power stages- Speed control of DC motor - Necessity of starter - three point and four point starters – Applications of DC motors

Unit 5: TESTING OF DC MACHINES AND TRANSFORMERS

DC machines: Brake test - Swinburne's test - Hopkinson's test – Separation of losses - Retardation test - Field test

Transformer: Open and short circuit tests - Load test - Polarity test - Sumpner's test.

List of Experiments:

1. Load test on single-phase transformer
2. Open circuit and short circuit tests on single phase transformer
3. Sumpner's test on transformers
4. Separation of no-load losses in single phase transformer
5. Parallel operation of single phase transformers.
6. Open circuit and load characteristics of separately excited DC generator
7. Open circuit and load characteristics of self-excited DC generator
8. Load characteristics of differential DC compound generator
9. Load characteristics of DC shunt motor
10. Load characteristics of DC series motor
11. Speed control of DC shunt motor
12. Swinburne's test
13. Performance characteristics of DC motors using MATLAB/SIMULINK.

Text Book(s):

1. Prithwiraj Purkait, Indrayudh Bandyopadhyay, "Electrical Machines", Oxford Publications, 2017
2. D. P. Kothari and I. J. Nagrath, Electric Machines, McGraw Hill Education Pvt. Ltd., New Delhi, 5th Edition, 2017.

Reference(s):

1. P. C. Sen, Principles of Electric Machines and Power Electronics, Wiley, 3rd Edition, 2013.
2. Dieter Gerling, "Electrical Machines", Springer, 2014
3. UA Bakshi, MV Godse, "Electrical Machines", Technical Publications, 2010.

212EEE1304 ANALOG ELECTRONICS

212EEE1304 ANALOG ELECTRONICS	*L*	*T*	*P*	*X*	*C*
	3	*0*	*2*	*3*	*4*
Pre-requisite: NIL	**Course Category:** Programme Core – Integrated Course				

Course Objective(s):

The course intends to provide an overview of the principles, operation and application of the Analog building blocks like diodes, BJT, FET etc. for performing various functions. This course relies on elementary treatment and qualitative analysis and makes use of simple models and equation to illustrate the concepts involved. To provide an overview of amplifiers, feedback amplifiers and oscillators. To gain the knowledge on existing on future Analog circuits.

Course Outcome(s):

After completing this course, the student will be able to:

CO1: Understand the characteristics and applications of basic semiconductor devices.
CO2: Analyze the characteristics and various configurations of BJT
CO3: Analyze the characteristics and various configurations of FET
CO4: Understand the functioning & characteristics of OP-AMP
CO5: Design of OP-AMP based amplifiers and oscillators

Mapping of Course Outcome(s):

CO / PSO	PSO														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
CO1	S												S		
CO2	S	S											S		
CO3	S	S											S		
CO4	S	S	S	S				M					S	S	M
CO5	S	S	S	M				S				M	S	M	S

Course Topics:

UNIT 1: SEMICONDUCTOR DEVICE CIRCUITS & APPLICATIONS

Characteristics of semiconductor devices & its applications - L, C, LC filters- Regulated Power Supply – Switch Mode Power supply - Problems

UNIT 2: BI-POLAR JUNCTION TRANSISTOR CIRCUITS & APPLICATIONS

Configurations of a BJT - small-signal model, biasing circuits, current mirror; common-emitter, common-base and common collector amplifiers; Small signal equivalent circuits, high-frequency equivalent circuits - BJT as a switch - BJT as an amplifier - problems

UNIT 3: MOSFET CIRCUITS

MOSFET structure and I-V characteristics. MOSFET as a switch. MOSFET as an amplifier: small-signal model and biasing circuits, common-source, common-gate and common-drain amplifiers; small signal equivalent circuits - gain, input and output impedances, trans conductance, high frequency equivalent circuit - problems

UNIT 4: DIFFERENTIAL, MULTI-STAGE AND OPERATIONAL AMPLIFIERS

Differential amplifier; power amplifier; direct coupled multi-stage amplifier; internal structure of

an operational amplifier, ideal op-amp, non-idealities in an op-amp (Output offset voltage, input bias current, input offset current, slew rate, gain bandwidth product)- Idealized analysis of op-amp circuits - problems

UNIT 5: LINEAR AND NONLINEAR APPLICATIONS OF OP-AMP

Inverting and non-inverting amplifier, differential amplifier, instrumentation amplifier, integrator, active filter, P, PI and PID controllers and lead/lag compensator using an op-amp, voltage regulator, oscillators (Wein bridge and phase shift). Analog to Digital Conversion, Zero Crossing Detector, Square-wave and triangular-wave generators - problems

List of Experiments:

1. L, C, LC filters
2. Transistor biasing Methods.
3. Input and Output characteristics of Transistor
4. Transistor as amplifier.
5. FET characteristics and evaluation of its parameters.
6. MOSFET characteristics.
7. BJT and FET as a switch.
8. Class B complementary symmetry power amplifier
9. Phase shift oscillator using BJT/FET.
10. Op Amp applications as Inverting and Non Inverting amplifiers
11. Summing amplifier, Differentiator, Integrator
12. Zero Crossing Detector
13. Op Amp based Instrumentation amplifier
14. Square Wave and Triangle Wave generators
15. Mini project

Text Book(s):

1. Giovanni Saggio, "Principles of Analog Electronics", CRC Press, Taylor & Francis Group, 2014
2. Jacob. Millman, Christos C.Halkias and Sathyabrata Jit, "Electronic Devices and Circuits", Tata McGraw Hill Publishing Limited, New Delhi, 2010.
3. David A. Bell., "Electronic Devices and Circuits" Oxford University Press., 5th Edition, 2008

Reference Books:

1. Robert Boylestad and Luis Nashelaky"Electronic Devices and Circuit Theory" 11th Edision, Pearson publishers.
2. P. R. Gray, R. G. Meyer and S. Lewis, "Analysis and Design of Analog Integrated Circuits", John Wiley & Sons, 2001.

212EEE2305 CONTROL SYSTEM

212EEE2305 CONTROL SYSTEM	***L***	***T***	***P***	***X***	***C***
	2	***1***	***1***	**-**	***3.5***
Pre-requisite: NIL	**Course Category:** Programme Core – Integrated Course. With Tutorial				

Course Objective(s):

1. To present a clear exposition of the classical methods of control engineering, physical system modelling, and basic principles of frequency and time domain design techniques.
2. To teach the practical control system design with realistic system specifications

Course Outcome(s):

After completing this course, the student will be able to:

CO1: Understand the basic concepts of mathematical transformations
CO2: Formulate mathematical model and transfer function of the physical systems
CO3: Analyse the system performance by applying various input signals and analyse the stability of linear systems in time domain
CO4: analysis the system using bode and polar plot and Analyse the stability of linear system in the frequency domain
CO5: Design compensators and controllers for the given specifications
CO6: Solve the state equation by transformation methods.

Mapping of Course Outcome(s):

CO / PO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	S	S	M	S								M	S	M	
CO2	S	S	S	S					S			M	S	S	
CO3	S	S	S	S					S			M	S	S	M
CO4	S	S	S	S					S				S	S	S
CO5	S	S	S	M									S		

Course Topics:

UNIT 1: OVERVIEW OF LAPLACE TRANSFORM

Transforms of elementary functions – Transform of unit step function and unit impulse function – Basic properties – Shifting theorems -Transforms of derivatives and integrals – Initial and final value theorems – Inverse transforms – Convolution theorem – Transform of periodic functions – Application to solution of linear second order ordinary differential equations with constant coefficients.

Practical: Analysis of ODE and PDE by Laplace transform

UNIT 2: SYSTEM REPRESENTATION

Basic elements in control systems - open loop & closed loop - Transfer functions of mechanical, electrical and analogous systems. Block diagram reduction - signal flow graphs.

Practical: Transfer function & Block Diagram Reduction

UNIT 3: TIME RESPONSE AND STABILITY ANALYSIS

Standard test signals, Time response of first and second order system, Time domain specifications, Steady state error, error constants, generalized error coefficient.

Stability - concept and definition, Characteristic equation – Location of poles – Routh Hurwitz criterion - Root locus techniques: construction, properties and applications**.**

Practical: Determination of Time Domain Specifications (Simulink)

Time domain analysis of the second order system (experimental study)

Unit 4: FREQUENCY RESPONSE AND STABILTY ANALYSIS

Bode plot - Polar plot - Correlation between frequency domain and time domain specifications. Relative stability, Gain margin, Phase margin, stability analysis using frequency response methods, Nyquist stability criterion.

Practical: Stability analysis of linear systems

Unit 5: COMPENSATOR AND CONTROLLER

Realization of basic compensators, cascade compensation in time domain and frequency domain, feedback compensation - Design of lag, lead, lag-lead series compensator (using Bode plot), P, PI and PID controllers in frequency domain: Contemporary issues:

Basics of digital control system

Practical: Compensator Design in Frequency and Time Domains & PID Controller Design using Bode Plot

Text Book(s)

1. Norman S. Nise, “Control System Engineering”, John Wiley & Sons, 8th Edition, 2019.
2. Benjamin C Kuo “Automatic Control System” John Wiley & Sons, 8th Edition, 2007

Reference(s):

1. P. Kandasamy, K. Thilagavathy, K. Gunavathi, Numerical Methods, S. Chand & Company, 2nd Edition, Reprint 2012.
2. K. Ogata, “Modern Control Engineering”, Pearson, 5th Edition, 2010.
3. R.C. Dorf & R.H. Bishop, “Modern Control Systems”, Pearson Education, 11th Edition, 2008.
4. M. Gopal, “Control Systems-Principles And Design”, Tata McGraw Hill –4 th Edition, 2012.
5. Graham C. Goodwin, Stefan F. Graebe, Mario E. Sagado, “Control System Design”, Prentice Hall, 2003’
6. J.Nagrath and M.Gopal,” Control System Engineering”, New Age International Publishers, 4 th Edition, 2006.

212EEE2106 AC MACHINES

212EEE2106 AC MACHINES	***L***	***T***	***P***	***X***	***C***
	2	***1***	***0***	***-***	***3***
Pre-requisite: 212EEE1303	**Course Category:** Programme Core – Theory. With Tutorial				

Course Objective(s):

To learn the operation of synchronous machines and their characteristics.
To learn the use of equivalent circuit and circle diagram for Induction motor.
To learn the performance of special machines and their applications.

Course Outcome(s):

After completing this course, the student will be able to:

CO1: Analyze the performance of alternator based on voltage regulation methodologies and describe the parallel operation of alternators through capability curves.

CO2: Describe the performance of synchronous motor based on effect of increased load and changing excitation.

CO3: Analyze the starting and running conditions of three phase induction motor & determine the induction motor parameters through equivalent circuit and circle diagram.

CO4: Apply the knowledge of three phase induction motor, analyze the selection of starters & speed control techniques for the practical applications.

CO5: Describe the operation & performance characteristics of single phase induction motor and special machines.

Mapping of Course Outcome(s):

CO / PO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	S	S		S	M								**S**	**S**	
CO2	S	S		S									**S**	**M**	
CO3	S	S	M	S	S	M							**S**	**S**	
CO4	S	M		M									**S**	**M**	
CO5	S					M							**S**	**M**	

Course Topics:

Unit 1: SYNCHRONOUS GENERATOR

Construction - Working principle - EMF equation - Armature windings - Synchronous reactance - Armature reaction – Voltage regulation - EMF, MMF, ZPF, ASA methods - Synchronizing to infinite bus bars - Operating characteristics - Capability curves - Two reaction theory - Parallel operation of synchronous generators - Applications

Unit 2: SYNCHRONOUS MOTOR

Principle of operation - Methods of starting - Power developed by a synchronous motor - Synchronous motor with different excitations - Effect of increased load with constant excitation -

Effect of changing excitation constant load - Torque equation - V curve and inverted V curve - Hunting – Synchronous phase modifier - PF correction – Case studies

Unit 3: THREE PHASE INDUCTION MOTOR

Constructional details - Principle of operation - Torque-slip characteristics - Starting torque - Condition for maximum starting torque - Rotor EMF & reactance under running conditions - Torque under running condition - Condition for maximum torque under running condition - Relation between torque and slip - Losses and efficiency - Power stages in an induction motor - No load and blocked rotor test - Equivalent circuit - Circle diagram - Power balance equation - Maximum power output - Induction generator

Unit 4: STARTING AND SPEED CONTROL OF INDUCTION MOTOR

Need for starter - Types of starters - Starting methods of three phase induction motor - Cogging & crawling - Speed control of three phase induction motor - Double cage rotor – case studies

Unit 5: SINGLE PHASE INDUCTION MOTORS AND SPECIAL MACHINES

Single phase induction motor: Construction - Double field revolving theory - Split phase induction motor - Capacitor start induction run motor - Capacitor start capacitor run motor - Equivalent circuit (without and with core loss) - Shaded pole induction motor-Special machines: Universal motor - Stepper motor - Linear induction motor - Reluctance motor - Repulsion motor - hysteresis motor - AC series motor- BLDC motor

Text Book(s):

1. D. P. Kothari And I. J. Nagrath, Electric Machines, Tata McGraw Hill Education Pvt. Ltd., New Delhi,: 4thEdition, 2010.
2. Bernard Adkins, Ronald G. Harley, “The General Theory of Alternating Current Machines”, Springer-science Business Media, B.V. 2013

Reference(s):

1. Fitzgerald, A.E., et.al, “Electric Machinery”, Tata McGraw Hill publishing Company Ltd, 2005.
2. Gupta, J.B., “Theory and Performance of Electrical Machines”, S.K.Kataria and Sons, 2005.
3. Theraja,B.L., Theraja,A.K., “A text book on Electrical technology”, Volume-II, S. Chand company & Ltd. 2009.

212EEE2307 MEASUREMENTS AND INSTRUMENTATION SYSTEMS

212EEE2307 MEASUREMENTS AND INSTRUMENTATION SYSTEMS	*L*	*T*	*P*	*C*
	2	*1*	*1*	*3.5*
Pre-requisite: NIL	**Course Category:** Programme Core – Integrated Course. With tutorial			

Course Objective(s):

To introduce the basic concepts related to the operation of Electrical and Electronic Measuring Instruments to measure various electrical quantities and to study about the transducers.

Course Outcome(s):

After completing this course, the student will be able to:

CO1: Understand the fundamental Characteristics of an instrument.

CO2: Analyze instruments adopted for measurement of current, voltage, power and energy

CO3: To study different methods available for measurement of active, passive elements and various signal conditioning devices.

CO4: Analyze the problems in various electrical parameter measurements.

CO5: Study and analyze the storage of digital signal and analyzers.

Mapping of Course Outcome(s):

CO / PO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	S												S		
CO2	S	S	S										S		
CO3	S	M		S									S	S	
CO4	S	S	M										S		
CO5	M	M										L	M		

Course Topics:

Unit 1: FUNDAMENTALS AND CHARACTERISTICS OF INSTRUMENTS

Functional elements of an instrument - static and dynamic characteristics - analog indicating instruments, hall effect instruments - rms, average and peak reading instruments- errors - systematic and random errors, error analysis, errors in measurement - statistical evaluation of measurement data - standards and calibration

Unit 2: MEASURING INSTRUMENTS

Permanent Magnet Moving Coil instrument (PMMC) - Moving Iron instruments – electrodynamic instruments - instrument transformer - current transformer, potential transformer - measurement of power – electrodynamic, ferrodynamic - measurement of energy - induction type - watt-hour meters - maximum demand indicators - polyphase energy meters - power factor meters - frequency meters - synchroscopes - electronic voltmeters - differential voltmeters - electronic multimeter

Unit 3: BRIDGES AND SIGNAL CONDITIONING DEVICES

Measurement of resistance - Wheatstone bridge, Kelvin's bridge, measurement of self-inductance - Hay's, Anderson's, Owen's bridges- measurement of capacitance - Schering bridge - components

of signal conditioning devices - current to voltage and voltage to current converter - buffer amplifier - differential amplifier - instrumentation amplifier - Digital to Analog converters - Analog to digital converters - components of data acquisition systems.

Unit 4: TRANSDUCERS AND SENSORS

Classification of transducers - selection of transducers - resistive, capacitive and inductive transducers - piezoelectric, optical and digital transducers - pH electrodes - transducers for measurements – measurement of displacement, temperature, level flows, pressure, velocity, acceleration, torque, speed, viscosity and moisture , Acoustic Sensors – flow and level measurement, Radiation Sensors - Smart Sensors - Film sensor

Unit 5: DIGITAL MEASURING INSTRUMENTS

Digital Voltmeters and Multi meters – Microprocessor based DMM with auto ranging and self-diagnostic features- Digital Energy meter –Frequency, Period, time interval and Pulse Width measurement.

LIST OF EXPERIMENTS

1. Overview of Instruments
2. Potentiometer Error Detector
3. Calibration of single–phase and three - phase energy meter.
4. Measurement of three phase real, reactive and apparent power and power factor using electronic tri-vector meter.
5. Measurement of power factor of an inductive load and its improvement by static capacitor.
6. DC bridges- Wheatstone and Kelvin double bridge using LABVIEW
7. AC bridges – Anderson and Schering bridge using LABVIEW
8. Instrumentation amplifiers.
9. Characteristics of Strain Gauge
10. Measurement of displacement using LVDT
11. Study of temperature transducers
12. Measurement of pressure
13. Torque measurement trainer
14. Study of speed measurement using Electromagnetic transducer

Text Book(s):

1. Alan S. Morris, Reza Langari, “Measurement and Instrumentation – Theory and Application”, Second Edition, Elsevier, 2016.
2. Francis S. TSE, Ivan E. Morse, “Measurement and Instrumentation in Engineering – Principles and Basic Laboratory Experiments”, Marcel Dekker, INC. 2018.
3. Sawhney, A.K., A Course in Electrical & Electronic Measurements & Instrumentation, DhanpatRai and Co, 2004.
4. Albert D.Helfrick., William D.Cooper, Modern Electronic Instrumentation & measurement techniques, Prentice Hall of India 2003.

References(s):

1. Bouwens, J., Digital Instrumentation, Tata McGraw Hill, 2002.
2. Kalsi, H.S., Electronic Instrumentation, Tata McGraw Hill, 2004.
3. Doebelin, E.O., Measurement Systems - Application and Design, Tata McGraw Hill publishing company, 2005.
4. David.A.Bell, "Electronic Instrumentation and Measurements", 2nd edition, Oxford University Press, 2007.

212EEE2308 DIGITAL SYSTEM DESIGN

212EEE2308 DIGITAL SYSTEM DESIGN	***L***	***T***	***P***	***C***
	3	***0***	***1***	***3.5***
Pre-requisite: NIL	**Course Category:** Programme Core – Integrated Course			

Course Objective(s):

Introduce the concept of digital and binary systems
Be able to design and analyze combinational logic circuits.
Be able to design and analyze sequential logic circuits.
Understand the basic software tools for the design and implementation of digital circuits and systems.
Reinforce theory and techniques taught in the classroom through experiments and projects in the laboratory.

Course Outcome(s):

After completing this course, the student will be able to:

CO1: Understand the philosophy of number systems and codes.
CO2: Solve the logic functions using different simplification techniques
CO3: Design combinational logic circuits using logic gates.
CO4: Design Sequential circuits using Flip Flop
CO5: Summarize the function, characteristics and structure of different memory systems and programmable logic devices

Mapping of Course Outcome(s):

CO / PO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	S												**S**		
CO2	S	S		S									**S**	**S**	
CO3	S	M	S	S	M				M				**S**	**S**	**M**
CO4	S	S	S	S	S				S				**S**	**S**	**S**
CO5	S												**S**		

Course Topics:

Unit 1: NUMBER SYSTEMS & BOOLEAN ALGEBRA

Review of binary, octal, hexadecimal number systems - representation of signed numbers - floating point number representation - BCD -ASCII-EBCDIC - excess 3 codes - gray code -error detecting, correcting codes - Boolean Algebra- postulates and theorems of Boolean Algebra - canonical forms - simplification of logic functions using karnaugh map and Quine Mcclausky method.

Unit 2: COMBINATIONAL LOGIC DESIGN

Digital Logic families - Logic gates - implementation of combinational logic functions - binary adder - parity generator/checker -implementation of logical functions using multiplexers.

Unit 3: SEQUENTIAL CIRCUITS

Flip flops - SR, D, JK and T - analysis and design of synchronous sequential circuits - state diagram, state reduction and state assignment - counters - modulus counters, shift register, Johnson counter , ring counter – Design of Asynchronous sequential circuits.

Unit 4: MEMORIES & PROGRAMMABLE LOGIC DEVICE

ROM, PROM, EPROM, Semi custom design - introduction to PLD‟s - PAL - PLA - architecture of PLD‟s - PAL 22V10, PLS 100/101 - implementation of digital functions- FPGA

Unit 5: VHSIC HARDWARE DESCRIPTION LANGUAGE (VHDL)

RTL Design - combinational logic - Types - Operators - Packages - Sequential Circuit - Sub programs - Test Benches. (Examples: adders, counters, flip flops, FSM, multiplexers / Demultiplexers)

LIST OF EXPERIMENTS

1. Operation of OR gate according to the OR's truth table, using the IC 74LS32
2. Operation of AND gate according to the AND's truth table, using the IC 74LS08
3. Operation of NOT gate according to the NOT's truth table, using the IC 74LS04
4. Operation of NOR gate according to the NOR's truth table, using the IC 74LS02
5. Operation of NAND gate according to the NAND's truth table, using the IC 74LS00
6. Operation of XOR gate according to the XOR's truth table, using the IC 74LS86
7. Design the BCD-to-seven-segment decoder circuit.
8. Design the multiplexer using IC74LS04, 08 32
9. Design and verify the shift register using a flip flop.
10. Operation of two stage binary ripple up counter
11. Instruction of VHDL
12. To perform the operation of Half adder circuit using VHDL
13. To perform the operation of Full adder circuit using VHDL
14. To perform the operation of multiplexers and full adder circuit using VHDL
15. To perform the operation of Demultiplexers and full adder circuit using VHDL

Text Book(s):

1. Morris Mano, M., Digital Design, Prentice Hall of India (P) Ltd., New Delhi, 2016.

Reference(s):

1. Tocci, R.J., Digital Systems - Principles & Applications, Prentice Hall of India, 2002.
2. Floyd, Digital Fundamentals, Prentice Hall of India, 2003.

212EEE2309 POWER ELECTRONICS

212EEE2309 POWER ELECTRONICS	*L*	*T*	*P*	*C*
	2	*1*	*2*	*4*
Pre-requisite: 212EEE1304	**Course Category:** Programme Core – Integrated Course. With Tutorial			

Course Objective(s):

The main objective of the course is to provide an understanding of the operation and characteristics of the power electronic converters. On completion of the course the students will be able to design and analyse the power electronic circuits like rectifier, chopper, inverter and AC-AC converter for various applications.

Course Outcome(s):

After completing this course, the student will be able to:

CO1: Analyze the performance characteristics of various types of phase controlled converter.
CO2: Design and analyze the DC-DC converter.
CO3: Describe the operation of the inverter and analyze its performance.
CO4: Design and analyze the performance of AC/ AC converters.
CO5: Understand the power quality issues and its mitigation.

Mapping of Course Outcome(s):

CO / PO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	S												S		
CO2	S	M	S										S		
CO3	S	S	S	S									S	S	
CO4	S	S	L	S									S	S	
CO5	S	M	S									M	S		

Course Topics:

Unit 1: PHASE–CONTROLLED CONVERTERS

IGBT – Firing circuit for Thyristor- Voltage and Current commutation of Thyristor – Gate Drive Circuit for MOSFET and IGBT - 2-pulse, 3-pulse, 6-pulse and dual converters- inverter operation of fully controlled converter – effect of source inductance – distortion and displacement factor, Power factor – ripple factor - Problems

Unit 2: CHOPPERS

Step-down and step-up choppers – time ratio and current limit control – switching mode regulators – buck and boost converter – multiphase choppers – chopper control of DC motors - Problems

Unit 3: INVERTERS

Classification of inverters – single phase, three phase (both 120 and 180 degree mode) inverters– series inverter – parallel inverter –voltage control of single phase, three phase inverters – current source inverters, harmonic reduction in inverters, Multilevel inverter, Inverter fed induction motor drive - Problems

Unit 4: AC TO AC CONVERTERS

Single phase AC regulators – sequence control of AC regulators –three phase AC regulators – single phase to single phase cycloconverter – three phase cycloconverter – control circuit output voltage equation - Problems

Unit 5: POWER QUALITY ISSUES

Sources of pollution and regulations - Power quality problems - Rapid voltage fluctuations, voltage unbalance, Voltage dips and voltage swells, Short duration outages. Harmonic analysis - Harmonic sources-the static converters, Total harmonic distortion - rms and average value calculations, Effects of harmonic distortion - Locating sources of harmonics - Passive and active filters, Harmonic filter design - Problems

Text Book(s):

1. Muhammad H. Rashid., Power Electronics: Circuits, Devices and Applications, Prentice Hall of India, Pearson education, 4th edition, 2013
2. P.S.Bimbhra, Power Electronics, Khanna Publishers, 5th edition, 2012.

Reference(s):

1. Singh, M.D., Power Electronics, Tata McGraw Hill publications, 2nd Edition, 2008.
2. Ned Mohan.,et.al., Power Electronics: Converters, Applications and Design, John Wiley and sons.

List of Experiments:

1. Characteristics of IGBT
2. Single phase half controlled converters
3. Single phase fully controlled converters
4. Three phase half controlled converters
5. Three phase fully controlled converter
6. Design of MOSFET Based Step Up Chopper
7. Design of MOSFET Based Step Down Chopper
8. Simulation of DC-DC Converter in MATLAB/Simulink
9. Single phase IGBT based PWM inverter
10. Simulation of single phase inverter in MATLAB/Simulink
11. Generation of Pulse Width Modulation and Calculation of Modulation Index

12. Single and three phase AC voltage Controllers
13. Step up and step down cycloconverters
14. Study the effect of voltage sag on Electrical equipment using MATLAB/Simulink
15. Effect of Nonlinear loads on Power Quality using MATLAB/Simulink

212EEE2110 POWER GENERATION, TRANSMISSION AND DISTRIBUTION

212EEE2110 POWER GENERATION, TRANSMISSION AND DISTRIBUTION	***L***	***T***	***P***	***X***	***C***
	2	***1***	***0***	***-***	***3***
Pre-requisite: NIL	**Course Category:** Programme Core – Theory. With Tutorial				

Course Objective(s):

To develop basic knowledge in Electrical Transmission and Distribution

To learn the substation operation and maintenance of Substations

Course Outcome(s):

After completing this course, the student will be able to:

CO1: To understand the various types of distribution systems.

CO2: To develop the mathematical model for transmission line parameters

CO3: To determine the performance of different types of transmission lines

CO4: To understand the mechanical design and characteristics of insulators and cables.

CO5: To understand the functioning of substations and to evaluate the performance of distribution systems

Mapping of Course Outcome(s):

CO / PSO	**PSO**														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
CO1	S					M							S	M	
CO2	S	S	S	M									S	M	
CO3	S	S		S		M						S	S	S	
CO4	S	S		M		S	M						S	M	M
CO5	S	M		S		S	M						S	S	M

Course Topics:

Unit 1 BASICS OF POWER GENERATION SYSTEMS

Sources of Energy—Comparison of Energy Sources—Generating Stations—Steam Power Station—Schematic Arrangement of Steam Power Station—Choice of Site for Steam Power Stations—Efficiency of Steam Power Station—Equipment of Steam Power Station—Hydroelectric Power Station - Schematic Arrangement of Hydroelectric Power Station— Choice of Site for Hydroelectric Power Stations —Constituents of Hydroelectric Plant—Diesel Power Station— Schematic Arrangement of Diesel Power Station—Nuclear Power Station— Schematic Arrangement of Nuclear Power Station—Selection of Site for Nuclear Power Station—Gas Turbine Power Plant—Schematic Arrangement of Gas Turbine Power Plant—Comparison of the Various Power Plants.-Overview of renewable energy sources-Structure of electric power system

Unit 2 TRANSMISSION SYSTEMS AND LINE PARAMETERS

Types of Transmission systems-Parameters of single and three phase transmission lines with single and double circuits – resistance, inductance and capacitance of solid, stranded and bundled conductors – symmetrical and unsymmetrical spacing and transposition – application of self and mutual GMD – skin and proximity effect – interference with neighbouring communication circuits

Unit 3 MODELLING AND PERFORMANCE OF TRANSMISSION LINES

Classification of lines – short line, medium line and long line – equivalent circuits, attenuation constant, phase constant, surge impedance transmission efficiency and voltage regulation – real and reactive power flow in lines – power angle diagram –surge impedance loading, load ability limits based on thermal loading, angle and voltage stability considerations – compensation in transmission lines, Ferranti effect, formation of corona and corona loss – Stress and Sag Calculation – Effects of Wind and Ice loading.

Unit 4 INSULATORS AND CABLES

Properties of an insulator – insulator materials – types of insulators – insulator string – voltage distribution, string efficiency, methods of increasing string efficiency –testing of insulators – cables – comparison of underground and overhead cables– construction, types, insulating materials, dielectric stress, grading, thermal characteristics.

Unit 5 SUBSTATION, GROUNDING SYSTEM AND DISTRIBUTION SYSTEM

Types of substations – bus-bar arrangements – substation bus schemes – single bus scheme, double bus with double breaker, double bus with single breaker, main and transfer bus, ring bus, double bus-bar with bypass isolators, resistance of grounding systems – resistance of driven rods, resistance of grounding point electrode, grounding grids – design principles of substation grounding system – neutral grounding. Radial and ring-main distributors – interconnectors – AC distribution –AC distributor with concentrated load – three-phase, four-wire distribution system – sub-mains – stepped and tapered mains, Distribution Automation

Text Book(s)

1. Singh, S.N., Electric Power Generation, Transmission and Distribution, Prentice Hall of India (P) Ltd, New Delhi, 2006.
2. Gupta, B.R., Power System Analysis and Design, S.Chand Publications, New Delhi, 2005.

Reference Book(s)

1. Hadi Saadat., Power System Analysis, Tata McGraw Hill Publishing Company, 2005.
2. Luces M.Fualkenberry., Walter Coffer., Electrical Power Distribution and Transmission, Pearson education, 1996.
3. V.K. Mehta, Principles of Power System, Chand(S.) & Co Ltd, India, 2005

212EEE2311 MICROCONTROLLER AND ITS APPLICATIONS

212EEE2311 MICROCONTROLLER AND ITS APPLICATIONS	*L*	*T*	*P*	*X*	*C*
	3	*0*	*2*	*3*	*4*
Pre-requisite: 212EEE2308	**Course Category:** Programme Core – Integrated Course				

Course Objective(s):

To develop an in-depth understanding of the operation of microcontrollers, machine language programming & interfacing techniques.

Developing of assembly level programs and providing the basics of the processors

Course Outcome(s):

After completing this course, the student will be able to:

CO1: Describe the concept of microcontroller architectures.

CO2: Understand the architectural features of MCS-51 variants and select a suitable microcontroller to suit the application.

CO3: Study the architecture of AVR microcontroller

CO4: Design the AVR microcontroller based control circuit for electrical and electronics applications.

CO5: Understand the architecture of ARM based microcontroller

Mapping of Course Outcome(s):

CO / PSO	PSO														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
CO1			S	S					-			S	S	S	
CO2			S	S	S				S			M	S	S	S
CO3			S	S					S				S	S	S
CO4			S	S	S								S	S	
CO5			S	S	S					L			S	S	

Course Topics:

Unit 1: FUNDAMENTALS OF MICROCONTROLLER

Introduction to 8 bit microcontrollers- Basic differences and similarities between Microprocessor and Microcontroller-Types of various architectures; Harvard and Von-Neumann, RSIC and CSIC-Concept of pipelining- Selection of microcontrollers, variants of MCS-51 family and their features. Applications of microcontrollers

UNIT 2: ARCHITECTURE AND ASSEMBLY LANGUAGE OF 8051

8051 microcontroller hardware: Oscillator and Clock, Role of PC and DPTR, Flags and PSW, CPU registers, Internal RAM and RAM organization, Internal Memory, Special Function Registers, I/O pins, ports and circuits, External memory, Counter and Timers, Serial Transmission, Interrupts, 8051 Addressing modes, Instruction set: Classification, syntax and function of instructions, example programs.

UNIT 3: AVR Microcontroller and its programming

AVR Microcontroller History and Features – AVR Architecture, Introduction to Arduino-Pin configuration and architecture-Arduino IDE-Programming in C- data types, Variables and constants ,Operators, Logic Operations, Data Conversion, Control Statements, Arrays, Functions, I/O Port Programming- Basic features and comparison of ARM, PIC, AVR, Arduino, Raspberry Pie Microcontrollers

Unit 4: AVR Micrcontroller application

ATMEGA32 connection to RS232 – LCD Interfacing – Keyboard Interfacing – ATMEGA32 ADC features – Interfacing temperature sensor to AVR – DAC Interfacing – AVR connection to relay – AVR connection to solid state relay – DC motor interfacing – DC motor control using PWM – Seven Segment Decoder interfacing

Unit 5: ARM Based Microcontroller

Introduction to ARM processors and its versions. ARM7, ARM9 & ARM11 comparison, advantages & suitability in embedded application- 7L ARM7 Based Microcontroller LPC2148: Features, Architecture (Block Diagram and Its Description), and -System Control Block (PLL and VPB divider) Memory Map-GPIO- Pin Connect Block- timer- interfacing with LED, LCD, and KEYPAD.

LIST OF EXPERIMENTS

8051 Experiments:

1. Simple arithmetic operations
2. ADC and DAC interfacing
3. Stepper motor control
4. Seven segment display

AVR Programs

Using Arduino IDE

1. Scroll a text on a 16x2 LCD screen
2. Spin a DC (Toy) motor in either direction using H-bridge (Texas Instruments L293NE or Texas Instruments SN754410). Change motor direction based on comparing light intensity received by photocell (LDR) with a threshold value
3. Control a servo with LED movement indication and LCD position display
4. Display temperature using TMP36 on first row of 16x2 LCD; Display Maximum, Minimum Temperatures on second row of 16x2 LCD; Log the values in a text file on an SD card
5. Interface an electret condenser microphone (or) Turn a pencil drawing into a capacitive sensor
6. Interface a keypad and LCD screen to design a simple calculator

Text Book(s):

1. M. A.Mazidi, J. G. Mazidi and R. D. McKinlay, “The 8051 Microcontroller and Embedded Systems: Using Assembly and C”,Pearson Education, 2007.

2. Muhammad Ali Mazidi, SarmadNaimi, SepehrNaimi, AVR Microcontroller and Embedded Systems: Using Assembly and C, Pearson India, 2014.
3. Simon Monk, "Programming Arduino Next Steps: Going Further with Sketches', McGraw-Hill, 2014.
4. ARM System Developer's guide –Andrew N. SLOSS, ELSEVIER Publications,ISBN 978-81-8147-646-3, 2016

Reference(s):

1. The 8051 Microcontroller & Embedded systems using assembly and C (2nd Edition) – M.A.Mazidi , J.C. Mazidi &R.D.McKinlay ISBN: 81-317-1026-2
2. Microcontrollers & applications, Ramani Kalpathi, & Ganesh Raja , ISBN: 81-888-4918-9
3. Dhananjay Gadre, Programming and Customizing the AVR Microcontroller, TMH, 1st Edition, 2009
4. Richard H. Barnett, Larry D. O'Cull, Sarah Alison Cox, Embedded C Programming and the ATMEL AVR, Cengage International, 2010
5. Steve Furber, ARM System on Chip Architecture, Second Edition, Pearson Education Limited, 2000.
6. LPC214x User Manual – http://www.keil.com/dd/docs/datashts/philips/ (LPC2148, GPIO, Registers, Embedded components selected)

212EEE2312 SIGNALS AND SYSTEMS

212EEE2312 SIGNALS AND SYSTEMS		*Credits*			
		L	***T***	***P***	***Total***
		3	***0***	***2***	***4***
Pre-requisite: NIL	**Course Category:** Programme Core - Integrated Course				

Course Objective(s):

1. Students can understand continuous-time and discrete-time linear systems
2. Students can apply Fourier analysis to important problems in communication and signal processing

Course Outcome(s):

After completing this course, the student will be able to:
CO1: Explain the functional concepts of signals and systems
CO2: Analyse the concepts of continuous time signals
CO3: Analyse the concepts of linear time invariant continuous time systems
CO4: Analyse the concepts of discrete time signals
CO5: Analyse the concepts of linear time invariant discrete systems

Mapping of Course Outcome(s):

CO / PO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	S	S											S		

CO2	S	S											S	M	
CO3	S	S		M										M	
CO4	S	S		M											
CO5	S	S													

Course Topics:

Unit 1: CLASSIFICATION OF SIGNALS AND SYSTEMS

Standard signals- Step, Ramp, Pulse, Impulse, Real and complex exponentials and Sinusoids_ Classification of signals – Continuous time (CT) and Discrete Time (DT) signals, Periodic & Aperiodic signals, Deterministic & Random signals, Energy & Power signals – Classification of systems- CT systems and DT systems – Linear & Nonlinear, Time-variant & Time-invariant, Causal & Non-causal, Stable & Unstable.

Unit 2: ANALYSIS OF CONTINUOUS TIME SIGNALS

Fourier series for periodic signals – Fourier Transform – properties- Laplace transforms and properties

Unit 3: LINEAR TIME INVARIANT CONTINUOUS TIME SYSTEMS

Impulse response – convolution integrals- Differential Equation- Fourier and Laplace transforms in Analysis of CT systems – Systems connected in series / parallel.

Unit 4: ANALYSIS OF DISCRETE TIME SIGNALS

Baseband signal Sampling – Fourier Transform of discrete time signals (DTFT) – Properties of DTFT – Z Transform & Properties

Unit 5: LINEAR TIME INVARIANT-DISCRETE TIME SYSTEMS

Impulse response – Difference equations-Convolution sum- Discrete Fourier Transform and Z Transform Analysis of Recursive & Non-Recursive systems-DT systems connected in series and parallel.

Text Books

1. A. V. Oppenheim, A. S. Willsky and S. H. Nawab, “Signals and systems”, Prentice Hall India, 1997, 2nd edition.
2. J. G. Proakis and D. G. Manolakis, “Digital Signal Processing: Principles, Algorithms, and Applications”, Pearson, 2006.
3. H. P. Hsu, “Signals and systems”, Schaum’s series, McGraw Hill Education, 2010.
4. S. Haykin and B. V. Veen, “Signals and Systems”, John Wiley and Sons, 2007.

Reference Books

1. A. V. Oppenheim and R. W. Schafer, “Discrete-Time Signal Processing”, Prentice Hall, 2009.
2. M. J. Robert “Fundamentals of Signals and Systems”, McGraw Hill Education, 2007.
3. B. P. Lathi, “Linear Systems and Signals”, Oxford University Press, 2009, 2nd edition.

212EEE2313 POWER SYSTEM ANALYSIS

212EEE2313 POWER SYSTEM ANALYSIS	*L*	*T*	*P*	*X*	*C*
	2	*1*	*2*	*-*	*4*
Pre-requisite: 212EEE2110	**Course Category:** Programme Core – Integrated Course. With Tutorial				

Course Objective(s):

To have an overview of the power system.

To model power-frequency dynamics and to design power-frequency controllers.

To model reactive power-voltage interaction and the control actions to be implemented for maintaining the voltage profile against varying system load.

To study the economic operation of the power system.

To teach about application for real time operation and control of power systems**.**

Course Outcome(s):

After completing this course, the student will be able to:

CO1: To form Y_{bus} and Z_{bus} matrices for power system networks and to solve the power flow problem using numerical methods.

CO2: To analyze the fault using Z_{bus} matrix and To apply symmetrical component techniques for unsymmetrical fault analysis

CO3: To develop the swing equation and analyze the stability of a synchronous machine.

CO4: To understand the methods to control voltage, frequency and power flow.

CO5: To solve the economic dispatch problem using mathematical programming techniques.

Mapping of Course Outcome(s):

CO / PSO	**PSO**														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
CO1	S												S		
CO2	S	S			S								S	S	
CO3	S	S	M	M		M							S	M	
CO4	S	M	S	S									S	S	
CO5	S				S	S						S	S	S	

Course Topics:

Unit 1: Load Flow Analysis

Overview of power system analysis- single line diagram, per unit representation-Bus Admittance and impedance matrix formation-Importance of power flow analysis– power flow problem – classification of buses – development of power flow model in Gauss-seidel power flow – numerical problems – computation of transmission line flows, losses and slack bus power – Newton-Raphson (N-R) method (polar form)– flowchart – numerical problems – development of Fast Decoupled Power Flow (FDPF) model, flowchart, numerical problems – comparison of the three methods of load flow.

Unit 2 Fault Analysis

Need for fault analysis – common approximations made in fault analysis – symmetrical short circuits – Thevenin's equivalent circuit and its applications – short circuit capacity – circuit breaker

selections – fault analysis using Z bus matrix- Unsymmetrical short circuits – short circuit analysis – symmetrical components method – derivation of fault current – LG, LL, LLG short circuits – Phase shift due to star- delta transformers - Current limiting reactors.

Unit 3 Stability Analysis

Importance of stability analysis – classification of power system stability – single Machine Infinite Bus (SMIB) system – development of swing equation – synchronous machine representation by classical model – power – angle equation– equal area criterion – determination of critical clearing angle and time – algorithm for numerical solution of swing equation using modified Euler method – plotting of swing curves.

Unit 4 Economic Dispatch and Unit Commitment

Incremental cost curve – co-ordination equations – without loss and with loss – solution by direct method and λ-iteration method – hydrothermal coordination, Unit commitment Solution methods: Priority-List methods.

Unit 5 Real and Reactive Power Control

Fundamentals of speed governing mechanism and modelling – speed-load characteristics – load sharing between two synchronous machines in parallel – concept of control area – LFC control of a single-area system – static and dynamic analysis of uncontrolled and controlled cases- multi-area systems – modelling of two-area system, static analysis and dynamic analysis of two area system- Excitation system – modelling, static and dynamic analysis – stability compensation; generation and absorption of reactive power

List of Experiments:

1. Introduction to MATLAB and ETAP
2. Ybus Formation Using Singular Transformation Method
3. Load flow solution using Gauss – Seidal method
4. Load flow solution using Newton – Raphson method
5. Load flow solution using Fast Decoupled load flow method
6. Z_{BUS} formation using bus building algorithm
7. Gaussian Elimination method
8. Solution of economic dispatch control
9. Symmetrical fault analysis
10. Transient stability analysis using step by step algorithm
11. Simulation of Automatic Generation control using MATLAB Simulink
12. Simulation of AVR using MATLAB Simulink

Text Book(s):

1. Olle. I. Elgerd., Electric Energy Systems Theory – An Introduction, Tata McGraw Hill Publishing Company Ltd, New Delhi, Revised edition, 2006.
2. Allen.J.Wood and Bruce F.Wollenberg., Power Generation, Operation and Control, John Wiley and Sons, Inc., 2004.
3. D. P. Kothari and I. J. Nagrath, "Modern Power System Analysis", McGraw Hill Education, 2003.

4. B. M. Weedy, B. J. Cory, N. Jenkins, J. Ekanayake and G. Strbac, "Electric Power Systems", Wiley, 2012.

Reference(s):

1. Kothari ,D.P., and Nagrath., I.J., Modern Power System Analysis, Tata McGraw Hill Pulishing Company Limited, New Delhi, 3rd edition, 2005.

212EEE2114 POWER SYSTEM PROTECTION

212EEE2114 POWER SYSTEM PROTECTION	*L*	*T*	*P*	*X*	*C*
	2	*1*	*0*	*-*	*3*
Pre-requisite: NIL	**Course Category:** Programme Core – Theory. With Tutorial				

Course Objective(s):

To learn various faults in power systems

To learn about various protection schemes of electrical power Systems.

Course Outcome(s):

After completing this course, the student will be able to:

CO1: To understand the requirement of protective relays and circuit breakers in power systems.

CO2: To explain the working of different type of circuit breakers.

CO3: To analyze the functioning of various protective systems.

CO4: To design the protective system for the given power system components.

CO5: To explain the working of static relays.

Mapping of Course Outcome(s):

CO / PSO	PSO														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CO1	S												S		
CO2	S												S		
CO3	S	M	S	S									S		
CO4	S	S	S	S									S	M	
CO5	S												S		

Course Topics:

Unit 1: PROTECTIVE RELAYS

Principles and need for protective schemes – nature and causes of faults – types of faults – essential qualities of protection – zones of protection – primary and back up protection – relay classification – principle types of electromagnetic relays – theory of induction disc relay – relay design – relay construction – general equation for electromagnetic relays – over current relays – directional relays – distance relays – differential relays

Unit 2: CIRCUIT BREAKERS

Physics of arc phenomena – maintenance of the arc – losses – arc interruption theories – circuit breaker rating – characteristics of restriking voltage – current chopping – types of circuit breakers – air break CB, Air blast CB, Oil CB, Vacuum CB,SF6 CB – basic steps for design of circuit breaker

Unit 3: POWER SYSTEM APPARATUS PROTECTION

Over current, distance, pilot feeder, protection schemes – transformer protection – generator protection – motor protection – bus zone protection, Frame Leakage Protection. – auto reclosing –methods of testing protective gear – Protection of Ring Mains, Earth Fault and Phase Fault Protection, Combined Earth Fault and Phase Fault Protective Scheme, Phase Fault Protective Scheme, Directional Earth Fault Relay

Unit 4: OVER VOLTAGE PROTECTION

Causes of over voltages – lightning – Klydonograph and Magnetic Link, switching – insulation failure and arcing grounds – methods of protection – ground wires, Peterson coils, surge absorbers and diverters – location of protective apparatus – insulation coordination – Basic Impulse Insulation Level (BIL) -neutral earthing

Unit 5: STATIC RELAYS

Basis for static relay development – classification – components of static relays – elements of a static relay – over current relay – differential protection – static distance relay – microprocessor based relays – concepts of digital relaying. Comparison of digital relays with previous generation relays.

Text Book(s):

1. Sunil S.Rao., Switchgear Protection and Power system, Khanna Publishers, New Delhi, 13th Edition, 1999.
2. Ravindranath B., Chander, N., Power Systems Protection and Switch Gear, Wiley Eastern (P) Ltd., Second Edition, 2011.

Reference(s):

1. Badri Ram., Vishwakarma, D.N., Power system protection and switchgear, Tata Mc Graw Hill publishing company Ltd., Second Edition , 2011.
2. Uppal, S.L., Electrical Power, Khanna Publishers, New Delhi, 2004.
3. V.K. Metha, Principles of power system, chand (s) & Co. Hd Ltd. Revised Edition

212EEE2215AC MACHINES LABORATORY

212EEE2215 AC MACHINES LABORATORY	***L***	***T***	***P***	***X***	***C***
	0	***0***	***3***	***-***	***2***
Co-requisite: 212EEE2106	**Course Category:** Programme Core – Laboratory				

Course Objective(s):

To expose the students to the operation of synchronous machines and induction motors and give them experimental skills.

Course Outcome(s):

After completing this course, the student will be able to:

CO1: Acquire the knowledge, experimental procedure in synchronous and induction machines.

CO2: Improve the ability of observation and mathematical manipulation of experiments in AC dynamic machines.

CO3: Analyze the performance & characteristics of rotating AC machines based on conduction of experiments and apply the knowledge of experiment skills of AC machines for solving the electrical problems in industries.

Mapping of Course Outcome(s):

CO / PO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	M			S	S				S				**M**	**S**	**S**
CO2				S	S	M			S	S	S			**S**	**S**
CO3				S	S	S		M	S		S	S		**S**	**M**

Course Topics:

1. Regulation of three phase alternator using EMF method.
2. Regulation of three phase alternator using MMF method.
3. Regulation of three phase alternator using ZPF method.
4. Regulation of three phase alternator using ASA method.
5. Load test on alternator.
6. Parallel operation of two alternators.
7. V and inverted V curves of three phase synchronous motor.
8. Load test on three-phase squirrel cage induction motor.
9. Equivalent circuit for three phase induction motor.
10. Circle diagram for three phase induction motor.
11. Load test on three phase slip ring induction motor
12. V / f control of three phase induction motor.
13. Speed control of three phase squirrel cage induction motor by voltage control and frequency control methods
14. Speed control of three phase slip ring induction motor using rotor resistance method.
15. Load test on single-phase induction motor.
16. Load test on three phase induction generators

PROGRAM ELECTIVE

Stream-1: Energy Systems

213EEE3116 ENERGY CONSERVATION PRACTICES

213EEE3116 ENERGY CONSERVATION PRACTICES	Credits			
	L	*T*	*P*	*Total*
	3	*0*	*0*	*3*
Pre-requisite: NIL	**Course Category:** Programme Elective			

Course Objective(s):

To acquire knowledge about the basics of energy conservation practices in major electric utilities.

Course Outcome(s):

After completing this course, the student will be able to:

CO1: To have knowledge of energy conservation practices.

CO2: To appreciate conservation measures in electrical supply and lighting systems.

CO3: To realize energy consumption and energy saving potentials by energy management and auditing.

CO4: To have knowledge on electrical conservation in major thermal utilities.

CO5: To understand the techniques of conservation methods in electrical utilities.

Mapping of Course Outcome(s):

CO / PO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	S			S									S	S	
CO2	S												S		
CO3	S		S	S									S	S	
CO4	S		S	M									S		
CO5	S		S	S									S	S	S

Course Topics:

Unit 1: INTRODUCTION **9 Hours**

Energy Conservation: Introduction, Indian Energy Conservation Act, Rules for Efficient Energy Conservation, Identification of Energy Conservation opportunities, Energy Conservation Schemes and Measures, Energy flow networks, Critical assessment of energy use, Optimizing Energy Inputs and Energy Balance.

Unit 2: ELECTRICAL SUPPLY AND LIGHTING SYSTEMS FOR ENERGY CONSERVATION **9 Hours**

Components of electrical systems, Transformers, Cable Sizing, Concept of Capacitors, Power Factor Improvement, Harmonics, Energy efficient lighting - Terminology - Cosine law of luminance - Types of lamps - Characteristics - Design of illumination systems, Steps for lighting energy conservation

Unit 3: ENERGY MANAGEMENT AND AUDITING FOR ENERGY CONSERVATION **9 Hours**

Energy scenario - Energy savings- Roles and responsibilities of energy managers in industries. Environmental aspects associated with energy utilization –Energy Auditing: Need, Types, Methodology and Barriers. Instruments for energy auditing - Standards and Labelling

Unit 4: ENERGY CONSERVATION IN THERMAL UTILITIES 9 Hours

Pumps, Fans, Blowers, Compressed Air Systems, Refrigeration and Air Conditioning Systems – Cooling Towers

Unit 5: ENERGY CONSERVATION IN ELECTRICAL UTILITIES 9 Hours

Potential areas for electrical energy conservation in various industries - Conservation methods - Energy management opportunities in electrical heating, lighting system - Cable selection - Energy efficient motors - Factors involved in determination of motor efficiency -, Adjustable AC drives - Variable speed drives - Energy efficiency in electrical system.

Text Book(s):

1. Energy Manager Training Manual (4 Volumes) available at www.energymanager training.com, a website administered by Bureau of Energy Efficiency (BEE), a statutory body under Ministry of Power, Government of India, 2004.
2. Dr. Clive Beggs, "Energy: Management, Supply and Conservation", Butterworth-Heinemann, 2012.
3. Energy Management Conservation and Audits Anil Kumar, Om Prakash, Prashant Singh Chauhan, Samsher Gautam, Published, 2020 by CRC Press
4. Practical Guide to Energy Conservation & Management, Notion press, Ashok Sethuraman
5. Energy Conservation and Management, technical Publications, SUBHASH GADHAVE, Vishal Shitole, Pramod Mane

213EEE3117 UTILISATION OF ELECTRICAL ENERGY

213EEE3117 UTILISATION OF ELECTRICAL ENERGY	***L***	***T***	***P***	***C***
	3	***0***	***0***	***3***
Pre-requisite: Nil	**Course Category:** Programme Elective			

Course Objective(s):

To introduce the basic concepts of utilization and conservation of electrical energy.

Course Outcome(s):

After completing this course, the student will be able to:

CO1: Describe the basic principles & technologies of various renewable and non-renewable energy resource based power Utilization.

CO2: Apply the energy management and energy audit techniques for a given system and measure the cost analysis.

CO3: Design the lighting, heating, and welding system for domestic, commercial and industrial application standards.

CO4: Analyze the behavior & control of the electric traction system.

CO5: . Analyze the behavior of domestic utilization of electrical energy

Mapping of Course Outcome(s):

CO / PSO	**PSO**														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**

CO1	S	M											S		
CO2	S	S					S					L	S		S
CO3	S	S	S			S		S				S	S	S	S
CO4	S	S	S	S			M						S	S	M
CO5	S	M	S	S		S		S					S	S	S

Course Topics:

Unit 1: ELECTROLYSIS PROCESS

Introduction, electrolysis and the hydrogen economy, Faradays Laws of Electrolysis, Hydrogen generation, storage and use - storage of hydrogen, Generation of hydrogen, Fossil Fuel-based hydrogen production, Hydrogen *via* electrolysis, electrolysis using organic fuels, Photo-electrolysis, Biological and biomass processes, Thermal-electrochemical generation of hydrogen from water, Hydrogen as a By-product from Electrolysis. Application of Electrolysis

Unit 2: DESIGN OF POWER AND ENERGY CONSERVATION

Economics of generation – definitions – load curves – number and size of UNITs – cost of electrical energy – tariff – need for electrical energy conservation – methods – energy efficient equipment – energy management – energy auditing – economics of power factor improvement – design for improvement of power factor using power capacitors – power quality – effect on conservation.

Unit3: ILLUMINATION, HEATING AND WELDING

Nature of radiation – definition – laws of photometry – lighting calculations – design of illumination systems – residential, industrial, commercial, health care, sports and administrative complexes, street lighting – types of lamps – energy efficient lamps – Methods of heating, requirement of heating material – design of heating element – furnaces – welding generator – welding transformer and its characteristics

Unit 4: ELECTRIC TRACTION

Requirements of an ideal traction system – supply systems – mechanics of train movement – traction motors and control – multiple UNITs – braking – current collection systems – recent trends in electric traction. Hybrid Electric Vehicles, Conventional Vehicles. Hybrid Electric Drive-trains and Electric Drive trains.

Unit 5: DOMESTIC UTILIZATION OF ELECTRICAL ENERGY

Domestic utilization of electrical energy – House wiring. Induction based appliances, Online and OFF line UPS, Batteries – Power quality aspects – nonlinear and domestic loads – Earthing - Domestic, Industrial and Substation.

Text Book(s):

1. Wadhwa, C.L., Generation, Distribution and Utilization of Electrical Energy, New Academic Science, 2011

2. Openshaw Taylor, E., Utilization of Electrical Energy, Orient Longman (P) Ltd, 2003.
3. Energy Efficiency in Electric Utilities, BEE Guide Book, 2010

Reference(s):

1. Partab, H., Art and Science of Utilization of Electrical Energy, Dhanpat Rai and Co, New Delhi, 2004.
2. Gupta, B.R., Generation of Electrical Energy, Eurasia Publishing House (P) Ltd, New Delhi, 2003.
3. Gupta, J.B., Utilization of Electric Power and Electric Traction, S.K.Kataria and Sons, 2002.
4. Cleaner Production – Energy Efficiency Manual for GERIAP, UNEP, Bangkok prepared by National Productivity Council.

213EEE3118 DIGITAL PROTECTION

213EEE3118 DIGITAL PROTECTION	***L***	***T***	***P***	***C***
	3	***0***	***0***	***3***
Pre-requisite: NIL	**Course Category:** Programme Elective			

Course Objective(s):

- Introduction to static relay, static over current relay.
- Brief description of static differential relay schemes single phase and three phase schemes.
- Introduction to static differential protection of generator and transformer.
- Different types of Circuit Breaker and their applications.
- Introduction to digital over current, transformer differential and transmission line distance protection.

Course Outcome(s):

After completing this course, the student will be able to:

CO1: To explain the working of numerical relay.
CO2: To discuss the different types of protection methods for transmission lines.
CO3: To explain the different types of faults and protection methods for synchronous generators.
CO4: To discuss the different types of faults and protective schemes for power transformers.
CO5: To understand the concept of relay coordination for distance and overcurrent relay

Mapping of Course Outcome(s):

CO / PSO	**PSO**														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
CO1	M	M	S										M		
CO2	S				S								S	S	
CO3															
CO4					S									S	
CO5	S			S	S								S	S	

Course Topics:

Unit 1: NUMERICAL PROTECTION

Introduction – block diagram of numerical relay– sampling theorem, correlation with a reference wave–least error squared (LES) technique–digital filtering, numerical over current protection.

Unit 2: ALGORITHMS FOR RELAY OPERATIONS

Sinusoidal wave based algorithms, ample and first derivative (Mann and Morrison) algorithm. Fourier and Walsh based algorithms, Fourier Algorithm: Full cycle window algorithm, fractional cycle window algorithm, Walsh function based algorithm, least Squares based algorithms. Differential equation based algorithms, Traveling Wave based Techniques

Unit 3: DIGITAL PROTECTION OF TRANSMISSION LINE

Introduction–protection scheme of transmission line–distance relays, traveling wave relays–digital protection scheme based upon fundamental signal, hardware design, software design–digital protection of EHV/UHV transmission line based upon travelling wave phenomenon, new relaying scheme using amplitude comparison.

Unit 4: DIGITAL PROTECTION OF SYNCHRONOUS GENERATOR AND POWER TRANSFORMER

Introduction–faults in synchronous generator, protection schemes for synchronous generator, digital protection of synchronous generator. – Faults in a transformer, schemes used for transformer protection–digital protection of transformer.

Unit 5: DIGITAL PROTECTION FOR SHORT CIRCUIT STUDIES

Types of faults– assumptions, development of algorithm for S.C. studies–PC based integrated software for S.C. studies, transformation to component quantities, S.C. studies of multiphase systems. Ultra high speed protective relays for high voltage long transmission line.

Text Book(s):

1. Digital Protection, L. P. Singh, New Age International Pvt Limited Publishers, New Delhi, 2nd Edition.
2. Digital Relay / Numerical relays – T.S.M. Rao, Tata Mc Graw Hill, New Delhi. 2005
3. A.G. Phadke and J. S. Thorp, “Computer Relaying for Power Systems”, Wiley/Research studies Press, 2009

Reference(s):

1. Fundamentals of Power System Protection, Paithankar & Bhide Prentice Hall of India Pvt. Ltd., New Delhi. 2004
2. Protective Relaying for Power System II, Stanley Horowitz IEEE press, New York Transmission Network Protection, Paithankar (Marcel & Dekker, New York).
3. A.T. Johns and S. K. Salman, “Digital Protection of Power Systems”, IEEE Press,1999

213EEE3119 POWER QUALITY

213EEE3119 POWER QUALITY	*L*	*T*	*P*	*C*
	3	*0*	*0*	*3*
Pre-requisite: Nil	**Course Category:** Programme Elective			

Course Objective(s):

To study the production of voltages sags, over voltages and harmonics and methods of control. To study the various methods of power quality monitoring

Course Outcome(s):

After completing this course, the student will be able to:

CO1: To understand the concepts of voltage imbalance, transients and variation.
CO2: To understand the concepts of sags and interruptions
CO3: To know the concepts of harmonics
CO4: To understand the sources, mitigation and effects of harmonics
CO5: To know the concepts of power quality issues

Mapping of Course Outcome(s):

CO / PSO	PSO														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
CO1	S		M				M						S		M
CO2	S						M						S		M
CO3	S		S										S		
CO4	S			S		M	S						M	S	S
CO5							S								S

Course Topics:

UNIT 1: 9 Hours

Overview and definition of power quality (PQ): Sources of pollution and regulations, Power quality problems, Rapid voltage fluctuations, voltage unbalance, Voltage dips and voltage swells, Short duration outages.

UNIT II: 9 Hours

Voltage sag analysis and mitigation: Sag caused by motor starting, Sag caused by utility fault clearing, Sag mitigation, Sag magnitude and duration calculations, RMS voltage, Calculation in 1-phase systems, Equipment performance in presence of sag, Computers, AC and DC drives.

UNIT III 9 Hours

Harmonics and Harmonic distortion: Effects-within the power system, Interference with communication harmonic measurements, Harmonic elimination. Power Overview system harmonics, Harmonic analysis, Harmonic sources-the static converters, Transformer magnetization and non-linearities, Rotating machines, Arc furnaces, Fluorescent lighting, Total harmonic distortion, rms and average value calculations, Effects of harmonic distortion. Locating sources of harmonics, Passive and active filters, Harmonic filter design.

UNIT IV **9 Hours**

Monitoring power quality & Power Conditioning: Monitoring essentials, Power quality measuring equipment, Current industry trends. Electric power conditioning, Active and passive filters IEEE, IEC, ANSI standards, Power acceptability curves, Various standards.

UNIT V CUSTOM POWER DEVICES

Principle& Working of DSTATCOM – DSTATCOM in Voltage control mode, current control mode, DVR Structure – Rectifier supported DVR – DC Capacitor supported DVR -Unified power quality conditioner**.**

Text Book(s):

1. Kennedy, B., Power Quality Primer, McGrawHill (2000).
2. Beaty, H. and Santoso,S., Electrical Power System Quality, McGrawHill (2002).
3. Roger.C.Dugan, Mark.F.Mc Granagham, Surya Santoso, H.WayneBeaty, "Electrical Power Systems Quality", McGraw Hill Publishing Company Ltd, New Delhi, Third Edition, 2013.

Reference(s):

1. C.Sankaran, "Power Quality", CRC press, 2002.
2. J.Arrilaga, N.R.Watson, S.Chen, " Power System Quality Assessment", John Wiley & Sons, 2000

213EEE3120 HVDC TRANSMISSION SYSTEM

213EEE3120 HVDC TRANSMISSION SYSTEM	***L***	***T***	***P***	***C***
	3	***0***	***0***	***3***
Pre-requisite: 212EEE2309	**Course Category:** Programme Elective			

Course Objective(s):

To understand the concept, planning of DC power transmission and comparison with AC power transmission. To analyze HVDC converters, harmonics and design of filters. To study about compounding and regulation. To learn about HVDC cables and simulation tools

Course Outcome(s):

After completing this course, the student will be able to:

CO1: To know the concepts of high voltage dc power transmission
CO2: To analyze the characteristics of HVDC converters
CO3: To understand the control characteristics of HVDC system
CO4: To understand the concepts of harmonics and filters
CO5: To apply the modelling and simulation in HVDC system

Mapping of Course Outcome(s):

CO / PSO	**PSO**														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
CO1	S												M		
CO2	M	S		S									S	S	
CO3															
CO4	S	S	S	M				M					S	L	M
CO5	S	M	S	S				M					S	S	M

Course Topics:

Unit 1: DC POWER TRANSMISSION TECHNOLOGY 9 Hours

Introduction of DC Power transmission technology – Comparison of AC and DC transmission – Application of DC transmission – Description of DC transmission system –Ground Electrodes for HVDC systems-Planning for HVDC transmission – Modern trends in DC transmission.

Unit 2: ANALYSIS OF HVDC CONVERTERS 9 Hours

Pulse number, Choice of converter configuration, Simplified analysis of Graetz circuit, Converter bridge characteristics, Characteristics of a twelve-pulse converter, detailed analysis of converters with and without overlap.

Unit 3: HVDC SYSTEM CONTROL 9 Hours

General, Principles of DC link control, Converter control characteristics, System control hierarchy, Firing angle control, Current and extinction angle control, Starting and stopping of DC link, Power control, higher level controllers.

UNIT 4: CONVERTER FAULTS AND PROTECTION: Converter faults, Protection against over-currents, over voltages in a converter station, Surge arresters, Protection against over-voltages. **SMOOTHING REACTOR AND DC LINE:** Introduction, Smoothing reactors, DC line, Transient over voltages in DC line, Protection of DC line, DC breakers, Monopolar operation, Effects of proximity of AC and DC transmission lines.

UNIT 5: REACTIVE POWER CONTROL & COMPONENT MODELS FOR THE ANALYSIS OF AC/DC SYSTEMS:

Reactive power requirements in steady state, Sources of reactive power, Static VAR systems, Reactive power control during transients, Harmonics and filters, Generation of harmonics, Design of AC filters, DC filters.

General, Converter model, Converter control, Modelling of DC network, Modelling of AC networks. Power flow analysis in AC/DC systems: General, Modelling of DC links, Solution of DC load flow, Discussion, Per unit system for DC quantities

Textbook(s):

1. Kundur P., “Power System Stability and Control”, McGraw-Hill, 1993.
2. Arrillaga, J., HVDC Transmission, IEE Press (2007).
3. Edwart, K., Direct Current Transmission (Vol. 1), John Wiley and Sons (2008).
4. Padiyar, K.R., HVDC Power Transmission System, New Age International (P) Limited, Publishers (2008).
5. Arrillaga, J. and Smith, B.C., AC to DC Power System Analysis, IEE Press (2008)

213EEE3121 FLEXIBLE AC TRANSMISSION SYSTEM

213EEE3121 FLEXIBLE AC TRANSMISSION SYSTEM	*L*	*T*	*P*	*C*
	3	*0*	*0*	*3*
Pre-requisite: 212EEE2309	**Course Category:** Programme Elective			

Course Objective(s):

To understand the concept of flexible AC transmission and the associated problems.
To review the static devices for series and shunt control.
To study the operation of controllers for enhancing the transmission capability.
To provide knowledge on FACTS controllers

Course Outcome(s):

After completing this course, the student will be able to:

CO1: To know the basic concepts of FACTS controllers
CO2: To analyze the various compensation of static shunt compensators
CO3: To analyze the various static power converters
CO4: To understand the various series and shunt compensation
CO5: To analyze the various flow controllers

Mapping of Course Outcome(s):

CO / PSO	PSO														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
CO1	S												M		
CO2	M	S		S									S	S	
CO3															
CO4	S	S	S	M				M					S	L	M
CO5	S	M	S	S				M					S	S	M

Course Topics:

9 Hours

Unit 1: Power Transmission control: Fundamentals of AC power transmission, Transmission problems and needs, Overview of stability, the emergence of FACTS, FACTS controller and consideration. Application of FACTS devices to improve steady state voltage stability

9 Hours

Unit 2: Static power converter: Review of Power Electronics fundamentals: Static power converter structures, AC controller-based structure, DC link converter topologies, Converter output and harmonic control. Analysis and Design of Power Converter Topologies for Application in Electric Aircraft. **9 Hours**

Unit 3: Shunt and Series Compensation: Shunt SVC principles, Configuration and control, STATCOM, Configuration applications. Fundamental of series compensation, Principle of operation, Application of TCSC for different problems of power system, TCSC lay out, SSSC principle of operation. TVA's Sullivan Static Synchronous Compensator (STATCOM)

9 Hours

Unit 4: Phase Shifter: Principle of operation, Steady state model of static phase shifter, operating characteristics of SPS, Power current configuration of SPS application. BPA's Slatt Thyristor-Controlled Series Capacitor (TCSC)

9 Hours

Unit 5: Unified Power Flow Controllers (UPFC): Basic operating principles and characteristics, Control UPFC installation applications, UPFC model for power flow studies.
AEP's Inez Unified Power Flow Controller (UPFC)

Textbook(s):

1. N.G. Hingorani & L. Gyugyi, "Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems" IEEE Press, 2005.
2. R. Mohan Mathur, Rajiv K. Varma, "Thyristor-Based FACTS Controllers for Electrical Transmission Systems", IEEE press and John Wiley & Sons, 2002

Reference(s):

1. Sang, Y.H. and John, A.T., Flexible AC Transmission Systems, IEEE Press (2006).
2. Ghosh,A. and Ledwich,G., Power Quality Enhancement Using Custom Power Devices, Kluwer Academic Publishers (2005).

213EEE3122 SOFT COMPUTING TECHNIQUES

213EEE3122 SOFT COMPUTING TECHNIQUES	***Credits***			
	L	***T***	***P***	***Total***
	3	***0***	***0***	***3***
Pre-requisite:MAT21R101	**Course Category:** Programme Elective			

Course Objective(s):

To expose the concepts of feed forward neural networks.

To provide adequate knowledge about feedback neural networks.

To teach about the concept of fuzziness involved in various systems.

To expose the ideas about genetic algorithm

To provide adequate knowledge about of FLC and NN toolbox.

Course Outcome(s):

After completing this course, the student will be able to:

CO1: To understand the basic concepts of soft computing techniques
CO2: To solve real world problems using neural network
CO3: To analyse the functioning of recurrent neural network

CO4: To apply genetic algorithm to solve the optimization problem
CO5: To develop fuzzy logic controller and ANN for the given system

Mapping of Course Outcome(s):

CO / PSO	PSO														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
CO1	M			M	S								M	M	
CO2		S	M	S	S				S				S	S	S
CO3	S	S		S	S								S	S	
CO4	S		S	S	S				S			M	S	S	M
CO5	S		S	S	S				S			M	S	S	S

Course Topics:

Unit 1: INTRODUCTION AND FEEDFORWARD NEURAL NETWORK 9 Hours

Introduction to soft computing -soft computing vs. hard computing-various types of soft computing techniques-applications of soft computing-Neuron-Nerve structure and synapse-Artificial Neuron and its model-activation functions-Neural network architecture-single layer and multilayer feed forward networks-McCulloch Pitts neuron model-perceptron model -Adaline and Madaline-multilayer perception model-back propagation learning algorithm- Implement back propagation learning algorithm using Matlab Toolbox.

Unit 2: RECURRENT NEURAL NETWORKS 9 Hours

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

Unit 3: FUZZY LOGIC SYSTEM 9 Hours

Fuzzy set theory, Fuzzy set versus crisp set, Crisp relation & fuzzy relations, introduction & features of membership functions, Extension Principle, Fuzzy If-Then Rules, Fuzzy Inference Systems, Sugeno Fuzzy Models, Fuzzification, Defuzzification, Development of fuzzy Control system using MATLAB tool box.

Unit 4: GENETIC ALGORITHM 9Hours

Genetic Algorithm(GA): Basic concepts, working principle, procedures of GA, flow chart of GA, Genetic representations, (encoding) Initialization and selection, Genetic operators, Mutation, Generational Cycle. Types of GA

Unit 5: Applications of Soft Computing. 9 Hours

Applications of ANN in smart grid and energy forecasting. Applications of Fuzzy Logic for Home appliances and smart homes. GA application for Power Plant Scheduling using MATLAB Toolbox.

Text Book(s):

1. S.N. Sivanandam, S.N. Deepa, “Principles of Soft Computing” 2nd Edition, Wiley, 2011.

2. Fakhreddine O. Karray and Clarence De Silva, "Soft Computing & Intelligent System: Theory, Tools and Applications", First edition, Pearson Education, 2009.

Reference(s):

1. Laurene V. Fausett, Fundamentals of Neural Networks: Architectures, Algorithms and Applications, Pearson Education. 2004
2. Timothy J. Ross, "Fuzzy Logic with Engineering Applications" Wiley India. 2010.

Stream-2: Embedded Systems and IoT

213EEE2123 IoT AND ITS APPLICATIONS

213EEE2123 IoT AND ITS APPLICATIONS	Credits				
	L	*T*	*P*	*X*	*Total*
	3	*0*	*0*	*3*	*3*
Pre-requisite: Nil	**Course Category:** Programme Elective				

Course Objective(s):

The topics of the course impart knowledge on the concept of IoT, outline the global context of M2M and IoT, to provide an overview of IoT architecture, to learn to program Arduino microcontroller for IoT, to cover real-world implementation examples of IoT.

Course Outcome(s):

After completing this course, the student will be able to:

- Develop more understanding on the concepts of IOT and its present developments.
- Study about different IOT technologies.
- Acquire knowledge about different platforms and Infrastructure for IOT
- Learn the art of implementing IOT for smart applications and control

Mapping of Course Outcome(s):

CO / PSO	PSO														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
CO1	M			M	S								M	M	
CO2		S	M	S	S				S				S	S	S
CO3	S	S		S	S								S	S	
CO4	S		S	S	S				S			M	S	S	M
CO5	S		S	S	S				S			M	S	S	S

Course Topics:

UNIT I INTRODUCTION TO INTERNET OF THINGS

Overview, Technology drivers, Business drivers - Components of Internet of Thing devices: Control UNITs – Sensors – Communication modules – Power Sources. Communication Technologies: RFID – Bluetooth – ZigBee – Wi-Fi – RFlinks – Mobile Internet – Wired Communication. Safety – privacy – trust - security model Typical IoT applications, Trends and implications

UNIT II IOT ARCHITECTURE:

Node Structure - Sensing, Processing, Communication, Powering, Networking - Topologies, Layer/Stack architecture, IoT standards,Cloud computing for IoT,Bluetooth, Bluetooth Low Energy, beacons.

UNIT III PROTOCOLS AND WIRELESS TECHNOLOGY FOR IOT

Protocols: NFC, RFID, Zigbee MIPI, M-PHY, UniPro, SPMI, SPI, M-PCIe Wired vs. Wireless communication,GSM, CDMA, LTE, GPRS, small cell. Wireless technologies for IoT: WiFi (IEEE 802.11), Bluetooth/Bluetooth Smart, ZigBee/ZigBee Smart, UWB (IEEE 802.15.4), 6LoWPAN, Proprietary systems.

UNIT IV DATA ANALYSTICS FOR IOT

Services/Attributes: Big-Data Analytics and Visualization, Dependability, Security, Maintainability.

Data analytics for IoT: A framework for data-driven decision making , Descriptive, Predictive and Prescriptive Analytics , Business Intelligence and Artificial Intelligence Importance of impact and open innovation in data-driven decision making.

UNIT V CASE STUDIES

Home Automation, smart cities, Smart Grid, Electric vehicle charging, Environment, Agriculture, Productivity Applications

Reference Book(s):

1. Arshdeep Bahga and Vijai Madisetti: A Hands-on Approach "Internet of Things",Universities Press 2015.
2. Oliver Hersent, David Boswarthick and Omar Elloumi "The Internet of Things", Wiley, 2016.
3. Samuel Greengard, " The Internet of Things", The MIT press, 2015
4. Adrian McEwen and Hakim Cassimally "Designing the Internet of Things "Wiley, 2014.
5. Jean- Philippe Vasseur, Adam Dunkels, "Interconnecting Smart Objects with IP: The Next Internet" Morgan Kuffmann Publishers, 2010.
6. Adrian McEwen and Hakim Cassimally, "Designing the Internet of Things", John Wiley and sons, 2014
7. Lingyang Song/Dusit Niyato/ Zhu Han/ Ekram Hossain," Wireless Device-to-Device Communications and Networks, CAMBRIDGE UNIVERSITY PRESS,2015
8. OvidiuVermesan and Peter Friess (Editors), "Internet of Things: Converging Technologies for Smart Environments and Integrated Ecosystems", River Publishers Series in Communication, 2013
9. Vijay Madisetti , Arshdeep Bahga, "Internet of Things (A Hands on-Approach)", 2014

213EEE3124 INTELLIGENT BUILDING ENERGY MANAGEMENT SYSTEMS

213EEE3124 INTELLIGENT BUILDING ENERGY MANAGEMENT SYSTEMS	*L*	*T*	*P*	*C*
	3	*0*	*0*	*3*
Pre-requisite: Nil	**Course Category:** Programme Elective			

Course Objective(s):

1. To manage the sub-systems within a building to ensure pleasant, controlled and saf environment
2. To control all or some of the following in a building: HVAC, CCTV, Access Control, Fire and Intruder Alarms, Lighting and Power Consumption

Course Outcome(s):

After completing this course, the student will be able to:

CO1: Understand the basics of building automation and its design concepts

CO2: Analyse electronics and electrical components and systems, and get familiarized with different tools of building automation

CO3: Achieve networking in automation with necessary security systems

CO4: Operate and program the PLC, SCADA and HMI for automation of buildings

CO5: Understand the working concepts of alarms, panels & controls pertaining to building control and management

Course Topics:

UNIT: BUILDING AUTOMATION SYSTEMS AND CONTROL

Building automation systems & controls: Philosophy, system configuration, system modules, distributed systems, communication protocol and on-line measurements. Fire protection, security and energy management. Control objectives. Sensors, controllers and actuators. Control system schematics system design. Microprocessor based controllers & digital controls. Examples

UNIT 2: BUILDING ENERGY MANAGEMENT SYSTEM

Basic criteria of designing – BMS – components, Design concepts – Energy management systems - MEP fundamentals - Components of building automation system - HVAC, electrical, lighting, security, fire-fighting, communication - Integrated approach in design, maintenance and management system - Current trend and innovation in building automation systems.

UNIT III: SUPERVISORY AND CONTROL FUNCTIONS:

Data acquisitions, status indications, measured values, energy values, monitoring alarm and event application processing. Regulatory functions: set points and feed-back loops, time tagged data, disturbance data collection and analysis, calculation and report preparation, PLC used as RTU, DCS versus SCADA terminology.

UNIT IV DATA BASES – SCADA, EMS and NETWORK DATA BASE

SCADA system structure - local system, communication system and central system, Configuration- non-redundant single processor, redundant dual processor, multi control centers, system configuration. Performance considerations: real time operation system requirements, modularization of software programming languages.

Unit V. ENERGY MANAGEMENT CENTER

Functions performed at a centralized management center, production control and load management, economic dispatch, distributed centers and power pool management.

Text Book(s):

1. G. J. Levermore, "Building Energy Management Systems: Applications to Low-energy HVAC and Natural Ventilation Control", Taylor & Francis, 2000
2. Shengwei Wang, "Intelligent Buildings and Building Automation", Routledge, Technology & Engineering, 2009
3. Doug Oughton, Steve Hodkinson, "Faber & Kell's Heating & Air-conditioning of Buildings", Routledge, Technology & Engineering, 2008

Reference(s):

1. Stuart A. Boyer, SCADA: Supervisory Control and Data Acquisition, The Instrumentation, Systems and Automation Society, 4th edition, 2009.
2. Krishna Kant, Computer-Based Industrial Control, PHI Learning, 2nd edition, 2013.

213EEE3125 EMBEDDED COMPUTING SYSTEM DESIGN

213EEE3125 EMBEDDED COMPUTING SYSTEM DESIGN	***Credits***			
	L	***T***	***P***	***Total***
	3	***0***	***0***	***3***
Pre-requisite:Nil	**Course Category:** Programme Elective			

COURSE OBJECTIVES

To provide a clear understanding on the basic concepts, Building Blocks of Embedded System

To teach the fundamentals of Embedded processor Modelling, Bus Communication in processors, Input/output interfacing

To introduce on processor scheduling algorithms, Basics of Real time operating system

To discuss on aspects required in developing a new embedded processor, different Phases & Modelling of embedded system

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

Course Outcome(s):

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

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

UNIT I INTRODUCTION TO EMBEDDED SYSTEMS 9 Hr

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

UNIT II EMBEDDED NETWORKING AND INTERRUPTS SERVICE MECHANISM 9 Hr

Embedded Networking: Introduction, I/O Device Ports & Buses– Serial Bus communication protocols - RS232 standard – RS485 –USB – Inter Integrated Circuits (I2C) – interrupt sources , Programmed-I/O busy-wait approach without interrupt service mechanism- ISR concept-– multiple interrupts – context and periods for context switching, interrupt latency and deadline - Introduction to Basic Concept Device Drivers.

UNIT III RTOS BASED EMBEDDED SYSTEM DESIGN 9 Hr

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

UNIT IV SOFTWARE DEVELOPMENT TOOLS 9 Hr

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

UNIT V EMBEDDED SYSTEM APPLICATION DEVELOPMENT 9 Hr

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

REFERENCES

1. Rajkamal, ‘Embedded system-Architecture, Programming, Design’, TMH, 2011.
2. Peckol, “Embedded system Design”,JohnWiley&Sons,2010
3. Shibu.K.V, “Introduction to Embedded Systems”, TataMcgraw Hill,2009
4. Lyla B Das,” Embedded Systems-An Integrated Approach”,Pearson2013
5. Elicia White,”Making Embedded Systems”,O’Reilly Series,SPD,2011
6. Bruce Powel Douglass,”Real-Time UML Workshop for Embedded Systems,Elsevier,2011
7. Simon Monk, “Make: Action, Movement, Light and Sound with Arduino and Raspberry Pi”, O’Reilly Series, SPD, 2016.

8. Tammy Noergaard, ”Embedded System Architecture, A comprehensive Guide for Engineers and Programmers”, Elsevier, 2006
9. Jonathan W.Valvano,”Embedded Microcomputer Systems, Real Time Interfacing”, Cengage Learning,3rd edition,2012
10. Michael Margolis,” Arduino Cookbook, O’Reilly Series, SPD, 2013.

213EEE3126 SENSING TECHNIQUES AND SENSOR SYSTEMS

213EEE3126 SENSING TECHNIQUES AND SENSOR SYSTEMS	***L***	***T***	***P***	***C***
	3	***0***	***0***	***3***
Pre-requisite: Nil	**Course Category:** Programme Elective			

Course Objective(s):

To expose the students to know about various sensing technologies using physical parameters which were used in Industries.

Course Outcome(s):

After completing this course, the student will be able to:

CO1: Describe the Concepts behind the working of measurement systems and different types of sensors.

CO2: To understand the Working principle of resistive, inductive and capacitive transducers and their applications know the operational features of PMBLDC.

CO3: Understanding of thermocouples, piezoelectric and pyro-electric transducers and their applications

CO4: Understanding of acoustic, optical sensors and other sensors and their applications

CO5: Describe the concepts of sensors and sensor less control

Mapping of Course Outcome(s):

CO / PSO	**PSO**														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
CO1	S	S											S		
CO2	S	S		S							S		S	S	
CO3	S	S		M									S	M	
CO4	S	S									S		S		
CO5	S	S											S		

Course Topics:

Unit1: INTRODUCTION TO SENSOR- BASED MEASUREMENT SYSTEMS

General Concepts And Terminology, Sensor Classification, General Input-Output Configuration, Static Characteristics Of Measurement Systems, Dynamic Characteristics, Other Sensor Characteristics, Primary Sensors, Materials For Sensors, Micro sensor Technology

Unit2: RESISTIVE, REACTANCE VARIATION, ELECTROMAGNETIC SENSORS

Potentiometers, Strain Gages, Resistive Temperature Detectors (RTDs), Thermistors, Magnetoresistors, Light-Dependent Resistors (LDRs), Resistive Hygrometers, Resistive Gas Sensors, Liquid Conductivity Sensors, SignaF Conditioning for Resistive Sensors: Resistance Measurement, Voltage Dividers, Dynamic Measurements, Capacitive Sensors, Inductive Sensors, Electromagnetic Sensors..

Unit 3: SELF-GENERATING TEMPERATURE SENSORS

Thermoelectric Sensors: Thermocouples, Piezoelectric Sensors, Pyroelectric Sensors, Electrochemical Sensors, Acoustic Temperature Sensors, Nuclear Thermometer, Magnetic Thermometer, Semiconductor Types, Thermal Radiation, Quartz Crystal, NQR, Spectroscopic Noise Thermometry, Heat Flux Sensors

Unit 4: DIGITAL AND SEMICONDUCTOR SENSORS

Position Encoders, Resonant Sensors, SAW Sensors, Sensors Based On Semiconductor Junctions, Sensors Based On MOSFET Transistors, Charge-Coupled And CMOS Image Sensors, Fiber-Optic Sensors, Ultrasonic-Based Sensors, Biosensors.

Unit 5: SENSORS FOR ROBOTICS

Construction - Principle of operation – EMF and torque equations – Phasor diagram – Vector Control – Self-control – Sensor less control – Microprocessor based control - Applications.

Text Book(s)

1. Patranabis D., "Sensors and Transducers", Prentice-Hall India, 2nd Ed., 2004.
2. Ramon Pallas & John G. Webster, "Sensors and Signal Conditioning", John Wiley & Sons, 2nd Ed., 2001.
3. Webster John G., "Instrumentation and Sensors Handbook", CRC Press, 1st Ed., 1999.

Reference(s):

1. Jacob Fraden, "Handbook of Modern Sensors: Physics, Designs and Applications", Springer, 3rd Ed., 2004.

213EEE3127EMBEDDED LINUX

213EEE3127 EMBEDDED LINUX	***Credits***			
	L	***T***	***P***	***C***
	3	***0***	***0***	***3***
Prerequisite: Nil	**Course Category:** Programme Elective			

Course Objectives:

- To impart knowledge about Linux Operating System
- To expose the students to the fundamentals of Linux Operating system and its basic commands.

- To Teach about the various Linux distributions and running them on a typical Embedded Board.
- To demystify the details of various Embedded Boards and programming them.
- To give an introduction to Linux Device Drivers.

Course Outcomes:

At the end of this course, students will have the following knowledge and skills

CO1: Thorough understanding of Linux and its commands

CO2: Differentiate Embedded Linux from its Desktop counterpart and its internals

CO3: Successfully run Linux on an Embedded Board, Use Eclipse IDE for Cross- compilation

CO4: Able to write a simple device driver in Linux

CO5: Improved Employability and entrepreneurship capacity due to knowledge upgradation on recent trends in embedded linux skills.

Mapping of Course Outcome(s):

CO / PO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	S			S	S										
CO2		S		S	S							M			
CO3	S		S	S	S	S						M			
CO4				S	S							M			
CO5	S		S		S	S		S	S						

UNIT I LINUX FUNDAMENTALS

Introduction to Linux: A brief History - Features and Advantages of Linux - System and Software Features - Linux's Copyright - The Design Philosophy of Linux - Differences between Linux and Other Operating Systems - Hardware Requirements - Source of Linux Information - Obtaining and Installing Linux: Distributions of Linux - Installing Linux. Working with Linux: Logging in and Logging Out - Linux File System - Directory and File Commands - Other Useful Linux Commands - File Access Permissions - Pipes and Filters - Text Editors - Working with GNOME.

UNIT II CROSS-DEVELOPMENT TOOLCHAIN

History of Embedded Linux - Embedded Linux Vs Desktop Linux - Types of Hosts - Types of Host/Target Development Setups - Types of Host/Target Debug Setups - Types of Boot Configurations - System Memory Layout. User space - Architecture of Embedded Linux - Linux Kernel Architecture - Linux Start-Up Sequence. GNU Cross Platform Toolchain.

UNIT III RUNNING LINUX ON EMBEDDED BOARDS

12 Embedded Boards and their Features - Exploring Embedded Linux System: Different Raspberry Pi Boards and their comparison - Embedded Linux Introduction - Managing Linux Systems - Using Git for Version Control - Using Desktop Virtualization. Programming on the Raspberry Pi: Scripting Languages - Dynamically Compiled Languages - C and C++ on the RPi - Overview of Object- Oriented Programming - Interfacing to the Linux OS - Improving the Performance of Python.

UNIT IV CROSS-COMPILATION AND INTERFACING TO THE RASPBERRY PI BUSSES

Cross-Compilation and the Eclipse IDE: Setting Up a Cross-Compilation Toolchain - Cross-Compilation Using Eclipse - Building Linux. Interfacing to the Raspberry Pi Busses: Introduction to Bus Communication - I2C - SPI - UART - Logic-Level Translation

UNIT V INTRODUCTION TO LINUX DEVICE DRIVERS

Device Driver Basics: User Space and Kernel Space - Driver Skeletons - Errors and Message Printing - Module Parameters - Building First Module. Character Device Drivers: Concept behind Major and Minor - Introduction to Device File Operations - Allocating and Registering a Character Device - Writing File Operations.

TEXTBOOKS:

1. Karim Yaghmour, Jon Masters, Gilad Ben-Yossef, and Philippe Gerum, "Building Embedded Linux Systems", O'Reilly Media Inc., 2008.

2. P. Raghavan, Amol Lad and Sriram Neelakandan, "Embedded Linux System Design and Development", Auerbach Publications, Taylor & Francis Group, 2006.

3. Derek Molloy, "Exploring Raspberry Pi: Interfacing to the Real World with Embedded Linux", John Wiley & Sons, Inc., 2016.

4. John Madieu, "Linux Device Drivers Development: Develop customized drivers for embedded Linux", Packt Publishing, 2017.

213EEE3128 REAL TIME OPERATING SYSTEM

213EEE3128 REAL TIME OPERATING SYSTEM	***Credits***			
	L	***T***	***P***	***C***
	3	***0***	***0***	***3***
Prerequisite: Nil	**Course Category:** Programme Elective			

Course Objectives:

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

Course Outcomes:

CO1: Understanding Operating System structures and types.

CO2: Insight into scheduling, disciplining of various processes execution.

CO3: Provide knowledge on various RTOS support modelling

CO4: Understanding commercial RTOS Suite features to work on real time processes design.

CO5: Improved Employability and entrepreneurship capacity due to knowledge upgradation on recent trends in RTOS and embedded automation design.

Mapping of Course Outcome(s):

CO / PO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1				S				S							
CO2	S	S	S									M			
CO3			S		S			S				M			
CO4		S	S	S								M			
CO5	S	S						S	S						

UNIT I REVIEW OF OPERATING SYSTEMS

Basic Principles - Operating System structures – System Calls – Files – Processes – Design and Implementation of processes – Communication between processes – Introduction to Distributed operating system – Embedded operating systems

UNIT II OVERVIEW OF RTOS

RTOS Task and Task state –Multithreaded Pre-emptive scheduler- Process Synchronization- Message queues– Mailboxes -pipes – Critical section – Semaphores – Classical synchronization problem – Deadlocks

UNIT III REALTIME MODELS AND LANGUAGES

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

UNIT IV REALTIME KERNEL

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

UNIT V APPLICATION DEVELOPMENT

Discussions on Basics of Linux supportive RTOS – uCOS-C Executive for development of RTOS Application – Case study

REFERENCES:

1. Silberschatz,Galvin,Gagne" Operating System Concepts,6th ed,John Wiley,2003

2. Charles Crowley, "Operating Systems-A Design Oriented approach" McGraw Hill, 1997

3. Raj Kamal, "Embedded Systems- Architecture, Programming and Design" Tata McGraw Hill, 2006.

4. Karim Yaghmour,Building Embedded Linux System",O'reilly Pub,2003

5. Mukesh Sighal and N G Shi "Advanced Concepts in Operating System", McGraw Hill, 2000

213EEE3129 ADVANCED EMBEDDED COMPUTING

213EEE3129 ADVANCED EMBEDDED COMPUTING	***Credits***			
	L	***T***	***P***	***C***
	3	***0***	***0***	***3***
Prerequisite: Nil	**Course Category:** Programme Elective			

Course Objectives:

- To expose the students to the fundamentals of Network communication technologies.
- To teach the fundamentals of Java Internet and Java card
- To develop distributed embedded system with Java
- To teach the smart card and Apps development

- To involve Discussions/ Practice in familiarizing the concepts acquired over the 5 Units of the subject for improved employability skills

Course Outcomes:

CO1: The learning process delivers insight into involving JAVA concepts & internet-based Communication to establish decentralized control mechanism of system
CO2: Understanding the software and hardware architecture for distributed computing
CO3: Able to develop solution for smart card
CO4: Able to develop Apps based on android SDK.
CO5: Improved Employability and entrepreneurship capacity due to knowledge upgradation on recent trends in embedded system computing environment.

Mapping of Course Outcome(s):

CO / PO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1		S	S	S		S									
CO2				S	S							M			
CO3			S	S	S			S	S			M			
CO4			S		S			S	S			M			
CO5			S	S											

UNIT I NETWORK INFRASTRUCTURE

BroadBand Transmission facilities –Open Interconnection standards – networking devices Network diagram –Network management – Network Security – Cluster computers

UNIT II JAVA TECHNOLOGY FOR EMBEDDED SYSTEMS

Basic concepts of Java - IO streaming – Object serialization – Networking – Threading – RMI – distributed databases — Advantages and limitations of Internet – Web architecture for embedded systems – security model for embedded systems.

UNIT III SMART CARD TECHNIQUES

Smart Card basics – Java card technology overview – Java card Types - Card components SMART CARD MICROCONTROLLERS - Contactless Cards - Smart Card Operating Systems– smart card Security Techniques

UNIT IV ANDROID FRAMEWORK

Android SDK – Access to Hardware - Framework development - Peer-to-Peer communication- Android security design and architecture – Case study

UNIT V DEVELOPING DISTRIBUTED REAL-TIME SYSTEM APPLICATIONS

Developing MATLAB Real-Time Targets - Using the xPC Target - Building various Distributed Real Time Applications

REFERENCES:

1. Amitava Gupta , Anil Kumar Chandra and Peter Luksch " Real-Time and Distributed Real- Time Systems Theory and Applications " CRC Press 2016 International Standard Book Number-13: 978-1-4665-9849-2 (eBook - PDF)
2. Joshua "Android hacker's Handbook" John Wiley & sons, 2014.
3. Mohamed Khalgui, Olfa Mosbahi, Antonio Valentini, "Embedded Computing Systems: Applications, Optimization, and Advanced Design", IGI Global (701 E. Chocolate Avenue, Hershey, Pennsylvania, 17033,USA), 2013.
4. Bashir I. Morshed, "Embedded Systesm – A Hardware-Software Co-Design Approach, Springer, 2021

213EEE3130 AUTOMOTIVE EMBEDDED SYSTEM

213EEE3130 AUTOMOTIVE EMBEDDED SYSTEM	***Credits***			
	L	***T***	***P***	***C***
	3	***0***	***0***	***3***
Prerequisite: Nil	**Course Category:** Programme Elective			

Course Objectives:

To support the automotive parts industry by focusing on the electronics control system and relevant software. To constantly strengthen our human resources.

Course Outcomes:

CO1: To understand the basic concepts of electronics in automobile system.
CO2: To understand the challenges and opportunities of drive by wire
CO3: To understand the functions of types of sensors and hardware modules
CO4: To understand the basic concepts of electronic ignition systems
CO5: To understand the concepts of various types of communication systems

Mapping of Course Outcome(s):

CO / PO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	S	S	S		S										
CO2	S	S		S	S							M			
CO3	S	S	S	S	S							M			
CO4		S	S									M			
CO5	S	S	S			S		S	S						

UNIT I ELECTRONICS IN THE AUTOMOBILE

Introduction- Body and convenience electronics - vehicle power supply controllers and lighting modules - door control modules -Safety electronics: active safety systems: ABS, ASR, ESP - passive safety systems: Restraint systems and their associated sensors in an automobile. - Powertrain Electronics: Gasoline engine management, - Infotainment electronics: Dashboard/instrument cluster, - car audio, - telematic systems - navigation systems - multimedia systems - cross application technologies - 42V vehicle power supply system

UNIT II Drive by wire

Challenges and opportunities of X-by-wire: - system & design requirements, - steer-by-wire, brake-by-wire - suspension-by-wire - gas-by-wire - power-by-wire, - shift by wire – Future of automotive electronics

UNIT III Hardware Modules

Basic sensor arrangement - types of sensors such as- oxygen sensors - crank angle position sensors- Fuel metering - vehicle speed sensors and destination sensors, - Attitude sensor, - Flow sensor - exhaust temperature - air mass flow sensors - Throttle position sensor – solenoids - stepper motors -relays

UNIT IV Electronic Ignition Systems

Electronic ignition systems - Types of solid state ignition systems and their principle of operation - Digital engine control system - Open loop and closed loop control system - Engine cranking and warm up control - Acceleration enrichment - Deceleration learning and ideal speed control - Distributor less ignition – Integrated engine control system - Exhaust emission control engineering

UNIT V Communication systems

PIC, Freescale microcontroller based system. - Recent advances like GLS, GPSS, GMS - Multiprocessor communication using CAN bus - Case study- cruise control of car - Artificial Intelligence and engine management.

REFERENCES:

1. William B. Ribbens, “Understanding Automotive Electronics”, Elseiver,2012
2. Jack Erjavec,Jeff Arias,”Alternate Fuel Technology-Electric ,Hybrid& Fuel Cell Vehicles",Cengage ,2012 5. Electronic Engine Control technology – Ronald K Jurgen Chilton’s guide to Fuel Injection – Ford.
3. “Embedded System Design: A unified Hardware / Software Introduction” – Frank Vahid and Tony Givargis, Wiley India Publishers.
4. “A Practical Introduction to Hardware/Software Co-Design”- Patrick R. Schaumont, Springer Publishers.

213EEE3131 PLC AND INDUSTRIAL AUTOMATION

213EEE3131 PLC AND INDUSTRIAL AUTOMATION	Credits			
	L	*T*	*P*	*C*
	3	*0*	*0*	*3*
Pre-requisite:Nil	**Course Category:** Programme Elective			

Course Objective(s):

The topics of the course impart knowledge on simple logic circuits used in industrial applications, various programming methods of PLC and applications in automation industries.

Course Outcome(s):

After completing this course, the student will be able to:

CO1: To understand the fundamentals of PLC and its logics
CO2: To understand the concepts PLC programming
CO3: To analyze and Develop Fundamental PLC Wiring Diagrams and Ladder Logic Programs
CO4: To understand the local variables and functional blocks
CO5: To apply and design the various application for industry

Mapping of Course Outcome(s):

CO / PSO	PSO														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
CO1															
CO2	S		S		S	S				S	S		S	S	
CO3	S		S		S		M			S		S	S	S	M
CO4			S		S	S								S	
CO5	S		L		S		S				S		S	S	S

Course Topics:

Unit1: Programmable Logic Controllers (PLCs): An Overview 9 Hours

Programmable Logic Controllers -Parts of a PLC -Principles of Operation - Modifying the Operation - PLCs versus Computers - PLC Size and Application- fundamentals of logic-The Binary Concept - AND, OR, and NOT Functions- The AND Function -The OR Function- The NOT Function -The Exclusive-OR (XOR) Function- Boolean Algebra - Developing Logic Gate Circuits from Boolean Expressions - Producing the Boolean Equation for a Given Logic Gate Circuit

Unit 2: Basics of PLC Programming 9 Hours

Processor Memory Organization - Program Files - Data Files - Program Scan - PLC Programming Languages - Relay-Type Instructions - Instruction Addressing - Branch Instructions- Internal Relay Instructions - Programming Examine If Closed and Examine If Open Instructions- Entering the Ladder Diagram - Modes of Operation

Unit 3: Developing Fundamental PLC Wiring Diagrams and Ladder Logic Programs 9 Hours

Electromagnetic Control Relays - Contactors - Motor Starters - Manually Operated Switches - Mechanically Operated Switches - Sensors - Proximity Sensor- Magnetic Reed Switch- Light Sensors- Ultrasonic Sensors - 106 Strain/Weight Sensors- Temperature Sensors- Flow Measurement - Velocity and Position Sensors - Output Control Devices - Seal-In Circuits - Latching Relays -Converting Relay Schematics into PLC Ladder Programs-Writing a Ladder Logic Program Directly from a Narrative Description

Unit 4: Ladder logic programs 9 Hours

Ladder Logic Basics - Symbolic Name - Local Variables – Function and Function Blocks, Instance Data block, Shared Data Block– Basic Ladder Logic Rung Analysis - System Function and System Function Blocks.

Unit 5: Industrial Applications 9 Hours

Development of control logic for Planner machine-Skip hoist control-Automatic control of water pump-Air compressor-Conveyor system-Battery operated truck-bottle filling system

Text Book(s)

1. Frank Petruzella, "Programmable Logic Controllers"McGraw-Hill Education – Fourth Edition, 2010.

Reference(s):

1. W. Bolton, "Programmable Logic Controllers" Newnes, Sixth edition 2015.
2. BISWANATH PAUL, "Industrial Electronics and Control Including Programmable Logic Controller" Prentice-Hall of India Private Limited – Third Edition, 2014.
3. John W. Webb, Ronald A. Reis, "Programmable Logic Controllers: Principles and Applications" Prentice Hall, 2003.
4. Jon Stenerson, "Programmable Logic Controllers with ControlLogics, DELMAR Cengage Learning.
5. Simatic S7 – 1200 Programming Manual 6. Simatic St – 300 Programming Manual

Stream-3 Renewable Energy & Smart Grid

213EEE3132 SOLAR PHOTOVOLTAIC SYSTEMS

213EEE3132 SOLAR PHOTOVOLTAIC SYSTEMS	*Credits*			
	L	***T***	***P***	***Total***
	3	**0**	**0**	**3**
Course Category: Programme Elective				

COURSE OUTCOMES:

After successful completion of course, the students will be able to,

CO1: Understand the fundamental concepts of solar cells.

CO2: Analyze the performance of PV module

CO3: Design the PV systems based on the applications

CO4: Understand the operation and performance of PV systems and its components

CO5: Study the applications of PV systems in practical cases.

CO/PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	S		S		S					S	
CO2	S	S		S							S
CO3	S		M		L					M	
CO4	S	S									
CO5	S		S	S	S					M	S

UNIT I - SOLAR CELL FUNDAMENTALS

Photovoltaic effect - Principle of direct solar energy conversion into electricity in a solar cell. Semiconductor properties, energy levels, basic equations. Solar cell, p-n junction, structure.

UNIT II - PV MODULE PERFORMANCE

I-V characteristics of a PV module, maximum power point, cell efficiency, fill factor, effect of irradiation and temperature.

UNIT III - MANUFACTURING OF PV CELLS & DESIGN OF PV SYSTEMS

Commercial solar cells - Production process of single crystalline silicon cells, multi crystalline silicon cells, amorphous silicon, cadmium telluride, copper indium gallium diselenide cells. Design of solar PV systems and cost estimation. Case study of design of solar PV lantern, stand alone PV system - Home lighting and other appliances, solar water pumping systems.

UNIT IV - CLASSIFICATION OF PV SYSTEMS AND COMPONENTS

Classification - Central Power Station System, Distributed PV System, Stand alone PV system, Grid Interactive PV System, small system for consumer applications, Hybrid solar PV system, Concentrator solar photovoltaic. System components - PV arrays, inverters, batteries, charge controls, net power meters. PV array installation, operation, costs, reliability.

UNIT V - PV SYSTEM APPLICATIONS

Building-integrated photovoltaic units, grid-interacting central power stations, standalone devices for distributed power supply in remote and rural areas, solar cars, aircraft, space solar power satellites. Socio-economic and environmental merits of photovoltaic systems.

Text Books

1. Chetan Singh Solanki., Solar Photovoltaic: "Fundamentals, Technologies and Application", PHI Learning Pvt., Ltd., 2009.
2. Jha .A.R, "Solar Cell Technology and Applications", CRC Press, 2010.
3. John R. Balfour, Michael L. Shaw, Sharlave Jarosek., "Introduction to Photovoltaics", Jones & Bartlett Publishers, Burlington, 2011.

REFERENCE BOOKS

1. Luque .A. L and Andreev .V.M, "Concentrate or Photovoltaic", Springer, 2007.
2. Partain .L.D, Fraas L.M., "Solar Cells and Their Applications", 2nd ed., Wiley, 2010.
3. Sukhatme .S.P, Nayak .J.K, "Solar Energy", Tata McGraw Hill Education Private Limited, New Delhi, 2010.

213EEE3133 WIND POWER GENERATION

213EEE3133 WIND POWER GENERATION	***Credits***			
	L	***T***	***P***	***Total***
	3	**0**	**0**	**3**
Course Category: Programme Elective				

COURSE OUTCOMES:

After successful completion of course, the students will be able to,

CO1: Understand the principle of wind energy conversion and aerodynamics and its types

CO2: Analyze the variable of direct rotor coupled generator

CO3: Understand the working principle of PMSG / DFIG.

CO4: Understand the construction and operation of offshore wind turbine.

CO5: Design the monitoring system and control system for modern wind turbine.

CO/PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	S										
CO2			S				S				S
CO3	S		S	S	M	S	S				S
CO4	M	S				S	M				
CO5	S		M	M	S	S	S				M

Unit 1 WIND ENERGY FUNDAMENTALS AND MEASUREMENTS

Wind energy basics - Wind speed and scales - Terrain-Roughness-Wind mechanics - Power content – Class of wind turbine- Atmospheric boundary layers-Turbulence. Instrumentation for wind measurements - Wind data analysis - tabulation. Wind resource estimation - Betz's limit-Turbulence analysis. Wind Turbine Areodynamics And Types:Airfoil terminology - Blade element theory - Blade design - Rotor performance and dynamics- Balancing technique (Rotor &Blade)-Types of loads - Source of loads-Vertical axis type -Horizontal axis - Constant speed Constant frequency - Variable speed variable frequency - Up wind-Down wind - Stall control-Pitch control - Gear coupled generator type - Direct generator drive/PMG/Rotor excited sync generator.

Unit 2 GEAR COUPLED GENERATOR WIND TURBINE COMPONENTS AND THEIR CONSTRUCTION

Electronics sensors /Encode /Resolvers - Wind measurement: anemometer & wind vane - Grid synchronization system - Soft starter - Switchgear [ACB/VCB]-Transformer - Cables and assembly - Compensation panel - Programmable logic control – UPS - Yaw & pitch system: AC drives - Safety chain circuits - Generator rotor resistor controller(Flexi slip) - Differential protection relay for generator - Battery/Super capacitor charger & Batteries/Super capacitor for pitch system-Transient Suppressor/Lightning arrestors - Oscillation & Vibration sensing.

Unit 3 WIND POWER GENERATOR

PMSG generator - Control rectifier-Capacitor banks - Step up/Boost converter (DC-DC Step Up) - Grid tied inverter - Power management - Grid monitoring unit (Voltage and current) - Transformer - Safety chain circuits-Doubly Fed Induction Generator – Power Control

Unit 4 OFFSHORE WIND ENERGY

Offshore Wind Energy Resources – Basic structure for offshore wind energy – Factors - Comparison of offshore with conventional wind energy - Commercial Offshore Wind Energy Generation - Transport of Wind-Generated Energy

Unit 5 MODERN WIND TURBINE CONTROL & MONITORING SYSTEM

Details of pitch system &Control algorithms-Protections used & Safety consideration in wind turbine-Wind turbine monitoring with error codes - SCADA & Databases: remote monitoring and generation reports - Operation & Maintenance for product lifecycle - Balancing technique (Rotor & Blade) - FACTS control & LVRT & New trends for new grid codes.

TEXT BOOKS

1. Kaldellis J.K, Stand – alone and Hybrid Wind Energy Systems, CRC Press, 2010
2. Mario Garcia –Sanz, Constantine H. Houpis, Wind Energy Systems,CRC Press 2012
3. John D Sorensen and Jens N Sorensen, Wind Energy Systems, Woodhead Publishing Ltd, 2011
4. Sathyajith Mathew: Wind Energy: fundamentals, resource analysis and economics 5. Prepared by WISE: Wind Power in India, 5000MW BY 2015
5. B.H.Khan: Non Conventional Energy Sources, Tata McGraw-Hill Education, 2006.

REFERENCES

1. Godfrey Boyle., Renewable Energy: Power for a Sustainable Future, Second Edition, Oxford University Press, 2004.
2. L. L. Freris, Wind Energy Conversion systems, Prentice Hall, UK, 1990.

213EEE3134 BIOMASS ENERGY SYSTEM

213EEE3134 BIOMASS ENERGY SYSTEM	***Credits***			
	L	***T***	***P***	***Total***
	3	**0**	**0**	**3**
Course Category: Programme Elective				

COURSE OUTCOMES:

After successful completion of course, the students will be able to,

CO1: Understand the energy conservation mechanism from biomass and waste characteristics.

CO2: Apply the different biomass conversion techniques for power generation.

CO3: Design biogas plant for bio-chemical conversion.

CO4: Understand the various liquid bio fuels and its production.

CO5: Design biogas plant for the given specification.

CO/PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	S	M				S	S				S
CO2	S			S							
CO3	S	S				S	M				
CO4	S	S	M		M	S					M
CO5	S			M	S	S	S				

Unit 1 BIOMASS RESOURCES AND WASTES CHARACTERISTICS

Biomass potential - terrestrial, aquatic and marine. Production and availability of biomass-biopolymers - lignin - cellulose - hemi cellulose contents of biomass. Potentials of solid and liquid wastes - agriculture - industrial - human origin (municipal and kitchen wastes) - quantities and characteristics.

Unit 2 THERMO-CHEMICAL CONVERSION

Thermo-chemical conversion of biomass, biomass processing, briquetting, pelletisation, biomass stoves, biomass carbonization, pyrolysis of biomass, biomass gasification, gasifiers: [updraft (forced draft & Natural draft), downdraft (Open core, throat type & modular)], Gasifier stoves, gasifier thermal applications, gasifier engine applications: dual fuel and 100% gas mode operation, power generation systems: (decentralized, grid interactive).

Unit 3 BIO-CHEMICAL CONVERSION

Aerobic, and anaerobic processes, activated sludge process, plug flow reactors, anaerobic fixed film reactor, UASB reactor, anaerobic fluidized bed reactor, estimation of methane yield, anaerobic digestion system for MSW, Vermi-composting, different designs of biogas plants for animal waste, Biogas engine applications.

Unit 4 LIQUID BIO FUELS

Liquid biofuels, non-edible oilseeds, oil extraction, preprocessing, transesterification, biodiesel, characterization of liquid fuels, production of syngas from biomass, production of methanol from syngas, production of ethanol from ligno-cellulosic biomass, Liquid bio-fuel applications.

Unit 5 BIO GAS PLANT AND ITS APPLICATIONS

Commissioning and management of biogas plant, community plant - Biogas appliances - manurial aspects. Socio-economic aspects - cost- benefit analysis. Composting - pathway - utilisation. Solid state - fermentation - recycling of industrial and municipal wastes - activated sludge system - trickling filters - lagooning - oxidation ponds.

TEXT BOOKS

1. Nijaguna, B.T., Biogas Technology, New Age International publishers (P) Ltd., 2002
2. VVN Kishore, Renewable energy engineering and Technology, Principles and Practices, TERI, 2009

REFERENCES

1. Rezaiyan. J and N. P. Cheremisinoff, "Gasification Technologies, A Primer for Engineers and Scientists", Taylor & Francis, 2005
2. Bioenergy and Biofuel from Biowastes and Biomass edited by Samir Kumar Khana, ASCE Publications, 2010

213EEE3135 GEOTHERMAL & OCEAN ENERGY CONVERSION

213EEE3135 GEOTHERMAL & OCEAN ENERGY CONVERSION	***Credits***			
	L	***T***	***P***	***Total***
	3	**0**	**0**	**3**
Course Category: Programme Elective				

COURSE OUTCOMES:

After successful completion of course, the students will be able to,

CO1: Understand the development of magneto static energy conversion.

CO2: Understand the principles of ocean thermal energy conversion.

CO3: Understand the construction and operation of tidal energy.

CO4: Analyze different types of wave-energy converters.

CO5: Apply the knowledge of geothermal power plant for power generation.

CO / PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	S	M				S					
CO2	S		S				S	S			
CO3	S		S		S						
CO4	S	S	S		S						
CO5	S	M	S			S	M	S			

Unit 1 MAGNETO STATIC ENERGY CONVERSION

MHD generation – principle – Faraday and Hall effect generators –choice of generation parameters – magnetic field requirements –conductivity and ionization – MHD design problems and developments – Voltage and power output of MHD generator. Recent developments in MHD power systems.

Unit 2 OTEC POWER PLANTS

Ocean energy resources, ocean energy routes, Principles of ocean thermal energy conversion systems, ocean thermal power plants, Operational problem, Ecological & environmental impacts.

Unit 3 TIDAL ENERGY

Tide generating forces, Analysis and prediction of tides and tidal currents, Structure of the tidal currents, Tidal dynamics and tidal energy generation.

Unit 4 WAVE POWER

Introduction to wave energy, resources and potential, Different types of wave-energy converters.

Unit 5 GEOTHERMAL POWER

Description of how geothermal heat is produced from the earth and its electrical potential, geothermal areas. Topographical challenges, calculating estimated yield, environmental challenges and concerns, etc. Measuring yield, connecting to the grid, storing and distributing power, etc. States and countries that already purchase Geothermal power for public and/or commercial structures.

TEXT BOOKS

1. Geothermal Energy and Technology Status: A Review. Barbier, E.

2. Rai, G.D., Non–conventional Energy Sources, Khanna Publishers, New Delhi, 2003.

3. Dr. B. mazumdar., A Text Book of Energy Technology - Both Conventional and Renewable Source of Energy, S.B. Nangia, A.P.H. Publishing Corporation.

REFERENCES

1. Enhanced Geothermal Systems Wellfield Construction Workshop," Summary Report, 2007.

2. Mann, K. H. and J. R. N. Lazier, 1991. Dynamics of Marine Ecosystems. Blackwell Scientific Pub.

213EEE3136 INDUSTRIAL & COMMERCIAL ASPECTS OF RENEWABLE ENERGY SOURCES

213EEE3136 INDUSTRIAL & COMMERCIAL ASPECTS OF RENEWABLE ENERGY SOURCES	***Credits***			
	L	***T***	***P***	***Total***
	3	**0**	**0**	**3**
Course Category: Program Electives– Theory				

COURSE OUTCOMES:

After successful completion of course, student will be able to,

CO1: Understand the basics of Commercial and industrial energy demand.

CO2: Develop renewable energy system for industrial applications.

CO3: Analyze the renewable energy generation to meet the needs.

CO4: Apply the renewable energy generation for different kinds of loads.

CO5: Analyze renewable energy installations both commercial and industrial installations.

CO / PO Mapping:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**
CO1	S		S	S			M		S		
CO2	S	S			M	S		S	S		S
CO3		S	S				S	S	S		
CO4	S	S	S	S	M	S		M			
CO5	S		S	S					M		S

Unit 1 COMMERCIAL AND INDUSTRIAL ENERGY DEMAND

Commercial and industrial energy demand; Qualitative and quantitative features and characteristics.

Unit 2 RENEWABLE HEATING SYSTEMS

Renewable & electricity for a growing economy. Water heating, process heating and drying applications; Solar, Biomass and geothermal energy based systems, Combined space and building service hot water systems.

Unit 3 RENEWABLE ENERGY SYSTEMS

Electricity generation from renewable to meet commercial and industrial power requirement. Stand alone and grid connected systems.

Unit 4 FORMS OF RENEWABLE ENERGY

Ethanol and methanol from cellulosic biomass, Use of renewable in commercial and industrial buildings for load leveling, lighting and space heating and cooling.

Unit 5 RENEWABLE ENERGY ECONOMICS

Economics of renewable energy based commercial and industrial installations case studies.

TEXT BOOKS

1. Godfrey Boyle., Renewable Energy: Power for a Sustainable Future, Second Edition, Oxford University Press, 2004.
2. Sunggyu Lee, James G. Speight, Sudarshan K. Loyalka, Handbook of Alternative Fuel Technologies, CRC Press,Taylor and Franics Group, 2007.

REFERENCE BOOKS

1. 1. Renewable Energy Engineering and Technology – A Knowledge Compendium, ed. VVN Kishore, TERI Press, 2008.

213EEE2137 RENEWABLE ENERGY SOURCES

213EEE2137 RENEWABLE ENERGY SOURCES	*L*	*T*	*P*	*C*
	3	*0*	*0*	*3*
Pre-requisite: Nil	**Course Category:** Programme Elective			

Course Objective(s):

To understand the basic principle of solar PV system and WECS characteristics.
To understand the concept of hybrid Renewable energy system for standalone power system and grid connected system.

Course Outcome(s):

After completing this course, the student will be able to:

CO1: To gain the knowledge about the renewable energy scenario in India and its features
CO2: To understand the concept of Photovoltaic cell and its performance characteristics
CO3: To understand the concept of Photovoltaic system design for standalone and grid connected systems.
CO4: To understand the concept of WECS and its types and performance characteristics.
CO5: To understand the concept of fuel cell and hybrid renewable energy systems.

Mapping of Course Outcome(s):

CO / PSO	PSO														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
CO1	S						S						S		S
CO2	S	S	M	S		S			S	M		M	S	S	M
CO3	S	M		M		M						S	M	M	
CO4	S	S			S								S	S	
CO5	M		S	S		S	S	M					S	S	S

Course Topics:

Unit1: RENEWABLE ENERGY (RE) SOURCES

Classification of energy sources-Features of Renewable energy- Renewable energy scenario in India–Solar Energy: Sun and Earth-Basic Characteristics of solar radiation- angle of sunrays on solar collector-Estimating Solar Radiation Empirically

Unit2: WIND ENERGY

Origin of Winds: Global and Local Winds- Aerodynamics of Wind turbine-Derivation of Betz's limit- Power available in wind-Classification of wind turbine: Horizontal Axis wind turbine and Vertical axis wind turbine- Aerodynamic Efficiency-Tip Speed- Tip Speed Ratio-Solidity-Blade Count-Power curve of wind turbine – Configurations of wind energy conversion systems: Type A, Type B, Type C and Type D Configurations- Grid Integration.

Unit3: PHOTOVOLTAIC SYSTEM DESIGN

PV systems classification- Stand-alone PV system configurations-Design of PV-powered DC pump-Design of stand-alone system with battery and AC or DC load-Hybrid PV systems – Grid connected solar photovoltaic system – Grid integration issues.

Unit4: BIOMASS ENERGY

Biomass resources –Energy from Biomass: conversion processes-Biomass Cogeneration-Environmental Benefits. Geothermal Energy: Basics, Direct Use, Geothermal Electricity. Mini/micro hydro power: Classification of hydropower schemes, Classification of water turbine, Turbine theory, Essential components of hydroelectric system,

Unit5: OTHER ENERGY SOURCES

Tidal Energy: Energy from the tides, Barrage and Non Barrage Tidal power systems. Wave Energy: Energy from waves, wave power devices. Ocean Thermal Energy Conversion (OTEC)-Hydrogen Production and Storage- Fuel cell : Principle of working- various types - construction and applications. Energy Storage System- Hybrid Energy Systems

Text Book(s):

1. Chetan Singh Solanki, "Solar Photovoltaics: Fundamentals, Technologies and Applications", PHI Learning Private Limited, 2012.
2. D.P.Kothari, K.C Singal, Rakesh Ranjan "Renewable Energy Sources and Emerging Technologies", PHI Learning Pvt.Ltd, New Delhi, 2013.
3. Scott Grinnell, "Renewable Energy & Sustainable Design", CENGAGE Learning, USA, 2016.

Reference(s):

1. Tasneem Abbasi & Abbasi Sa, "Renewable Energy Sources", PHI Learning Private Limited, New Delhi, 2013.
2. Richard A. Dunlap," Sustainable Energy" Cengage Learning India Private Limited, Delhi, 2015.
3. Bradley A. Striebig,Adebayo A.Ogundipe and Maria Papadakis," Engineering Applications in Sustainable Design and Development", Cengage Learning India Private Limited, Delhi, 2016.
4. Shobh Nath Singh, 'Non-conventional Energy resources' Pearson Education, 2015.

213EEE3138 FUEL CELL TECHNOLOGY

213EEE3138 FUEL CELL TECHNOLOGY	***Credits***			
	L	***T***	***P***	***Total***
	3	**0**	**0**	**3**
Course Category: Programme Elective				

COURSE OUTCOMES:

After successful completion of course, the students will be able to,

CO1: Understand the concepts of storage and utilization of hydrogen products

CO2: Gain the basic knowledge of technology for fuel cells

CO3: Analyze the fuel cell modes of operation and its performance

CO4: Apply the knowledge of fuel cells in practical applications

CO5: Understand the international policy and standards of fuel cells

CO/PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	S	S		M		L							S		
CO2	S		M		S						S		S		
CO3	S	S		S						S			S	S	
CO4	S	S	M	S	S	M							S		
CO5	S	S		S						M			S		

UNIT I - HYDROGEN PRODUCTION STORAGE AND UTILIZATION

Hydrogen production methods. Hydrogen storage - Onboard hydrogen storage - chemical storage - physical storage - in metal and alloy hydrides, carbon nanotubes. Glass capillary arrays - pipeline storage and hydrogen utilization.

UNIT II - FUEL CELL TECHNOLOGY

Fuel cell electrochemistry - Reaction rate - Butler Volmer equation-implications and use of fuel cell polarization curve - Conversion of chemical energy in electricity in a fuel cell.

UNIT III - FUEL CELL AND MODES OF OPERATION

Type of fuel cells, fuel cell working principle – Design - Proton exchange membrane fuel cells - Design issues - High temperature fuel cells - SOFC-MCFC - Comparison of fuel cell - Performance characteristics - Efficiency of leading fuel cell types.

UNIT IV - APPLICATION OF FUEL CELLS IN POWER COGENERATION

Cogeneration - Fuel cell electric vehicles - Fuel cell vehicles - Motor cycles and bicycles-airplanes - Fueling stations - Fuel cell power plant structure - Fuel processor and fuel cell stack.

UNIT V – POLICY AND STANDARDS OF FUEL CELLS

Power conditioner - Advantages and disadvantages. Problems with fuel cells. Research related to fuel cell development in the world and in India. Energy economy - International agreements on codes, standards and regulations – Policy.

REFERENCE BOOKS

1. Kingshuk Dutta, "Direct Methanol Fuel Cell Technology" Elsevier, 2020.
2. Noriko Hikosaka Behling, "Fuel Cells – Current Technology Challenges and Future Research Needs", Elsevier, 2013.
3. Detlef Stolten, "Hydrogen and Fuel Cells: Fundamentals, Technologies and Applications", 2010.

213EEE3139 SMART GRID

213EEE3139 SMART GRID	***Credits***			
	L	***T***	***P***	***Total***
	3	***0***	***0***	***3***
Pre-requisite: 212EEE2110	**Course Category:** Programme Elective			

COURSE OUTCOMES:

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

Mapping of Course Outcome(s):

CO / PSO	**PSO**														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
CO6	M		S										M		
CO7	S	S			S								S		
CO8				S											
CO9													S	S	
CO10	S			S	S								S	S	

UNIT I INTRODUCTION TO SMART GRID

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

UNIT II TECHNOLOGIES OF SMART GRID SYSTEM

Distributed Generation resources: Introduction to Renewable Energy Technologies –Micro grids –Storage Technologies –Electric Vehicles and plug –in hybrids –Environmental impact and Climate Change –Economic Issues.

UNIT III SMART METERING

Introduction to Advanced Metering infrastructure (AMI) - drivers and benefits, - Structure of the AMI System , AMI protocols, standards and initiatives, Communication technologies for AMI,

Need of AMI in the smart grid, Real time management and control, Challenges to be addressed, Case Study

UNIT IV PHASOR MEASUREMENT TECHNIQUES

Historical overview- Phasor representation of sinusoids- Fourier series and Fourier transform- Sampled data and aliasing-DFT and Fourier series- DFT and phasor representation-Leakage phenomena, a generic PMU –introduction- The global positioning system- Hierarchy for phasor measurement systems- Communication options for PMUs, Functional requirements of PMUs and PDCs - The evolution of "Synchro-phasor" standard, File structure of "Synchro-phasor" standard, PDC files, Transient Response of Phasor Measurement Units, Wide Area measurement system (WAMS), communication technologies for WAMS, Case Study

UNIT V APPLICATIONS OF WAMS AND ISSUES

WAMS Applications in Smart Grid, WAMS Based Protection Concepts, Adaptive Relaying, State estimation, Power system security issues and challenges in smart grid

Text Book(s):

1. James Momoh, "Smart Grid: Fundamentals of design and analysis", John Wiley & sons Inc, IEEE press 2012.
2. Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihi kookoyam "Smart Grid: Technology and Applications", John Wiley sons inc, 2012.
3. Smart Grids Advanced Technologies and Solutions, Second Edition, Edited by Stuart Borlase, CRC, 2018

Reference(s):

1. Fereidoon P.Sioshansi, "Smart Grid: Integrating Renewable, Distributed & Efficient Energy", Academic Press, 2012
2. Ahmed F. Zobaa, Trevor J. Bihl, Big data analytics in future power systems, 1st Edition, CRC press 2018.
3. C. Gungor et al., "Smart Grid Technologies: Communication Technologies and Standards," in IEEE Transactions on Industrial Informatics, vol. 7, no. 4, pp. 529-539, Nov. 2011.doi: 10.1109/TII.2011.2166794.

Stream 4: Electrical Machines & Drives

213EEE3140 ELECTRICAL MACHINE DESIGN

213EEE3140 ELECTRICAL MACHINE DESIGN	*L*	*T*	*P*	*C*
	3	*0*	*0*	*3*
Pre-requisite: 212EEE2106	**Course Category:** Programme Elective			

Course Objective(s):

To develop knowledge on principles of design of static and rotating electrical machines. Also students must be able to understand the concept of magnetic circuits and fundamental concepts of design of main dimensions & cooling systems of static and rotating machines.

Course Outcome(s):

After completing this course, the student will be able to:

CO1: Describe the concepts of magnetic circuit in static and rotating electrical machines

CO2: Design the field poles, field winding, armature core and armature windings of DC machines

CO3: Design the transformer core, windings and cooling tubes for core and shell type transformers.

CO4: Design the stator core, squirrel cage rotor and slip ring rotor of three phase induction motor.

CO5: Design the main dimensions of three phase salient pole and turbo alternators.

Mapping of Course Outcome(s):

CO / PSO	PSO														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
CO1	S	S											S		
CO2	S	S	S										S		
CO3	S	S	S			S		M					S	S	M
CO4	S	S	S			S							S	S	
CO5	S	S	S			M							S	M	

Course Topics:

DESIGN OF FIELD SYSTEM AND ARMATURE

Concept of magnetic circuit – MMF calculation for various types of electrical machines – real and apparent flux density of rotating machines – leakage reactance calculation for rotating machines – thermal rating –continuous, short time and intermittent short time rating of electrical machines.

DESIGN OF DC MACHINES

Constructional details, output equation, main dimensions, choice of specific loadings, choice of number of poles – armature design – armature winding design- design of field poles and field coil, design of commutator and brushes.

DESIGN OF TRANSFORMERS

Constructional details of core and shell type transformers – output rating of single phase and three phase transformers – design of core, yoke and windings for core and shell type transformers– design of tank and cooling tubes of transformers.

DESIGN OF THREE PHASE INDUCTION MOTORS

Stator core and winding design, squirrel cage rotor design- design of rotor bar and end ring and slip ring rotor design-rotor winding design. Construction - Output equation of Induction motor – Main dimensions – choice of specific loadings – Design of squirrel cage rotor and wound rotor –

Magnetic leakage calculations – Operating characteristics : Magnetizing current - Short circuit current – Circle diagram - Computer program: Design of slip-ring rotor

DESIGN OF SYNCHRONOUS MACHINES

Alternators – constructional details of cylindrical pole and salient pole alternators, output equation, choice of specific loadings, main dimensions, short circuit ratio –design of stator and rotor of cylindrical pole and salient pole machines, design of field coil. Design of damper winding – Determination of full load field MMF – Design of field winding – Design of turbo alternators - Computer program: Design of Stator main dimensions-Brushless DC Machines

Text Book(s):

1. Sawhney, A.K., A Course in Electrical Machine Design, DhanpatRai and Sons, New Delhi, 2006.
2. Sen,S.K., Principles of Electrical Machine Design with Computer Programmes, Oxford and IBH Publishing Co.(P) Ltd., New Delhi, 2004.
3. M V Deshpande 'Design and Testing of Electrical Machines' PHI learning Pvt Lt, 2011.
4. Sen, S.K., 'Principles of Electrical Machine Designs with Computer Programmes', Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, Second Edition, 2009.

Reference(s):

1. Agarwal, R.K., Principles of Electrical Machine Design, S.K.Kataria and Sons, Delhi, 2002.
2. Mittle, V.N., and Mittle, A., Design of Electrical Machines, Standard Publications and Distributors, Delhi, 2002.
3. Balbir Singh, Electrical Machine Design, Brite Students Publications.
4. A.Shanmugasundaram, G.Gangadharan, R.Palani 'Electrical Machine Design Data Book', New Age International Pvt. Ltd., Reprint 2007.
5. V Rajini, V.S Nagarajan, 'Electrical Machine Design', Pearson, 2017.
6. K.M.Vishnumurthy 'Computer aided design of electrical machines' B S Publications,2008

213EEE3141 ELECTRICAL DRIVES AND CONTROL

213EEE3141 ELECTRICAL DRIVES AND CONTROL	*L*	*T*	*P*	*C*
	3	*0*	*0*	*3*
Pre-requisite: 212EEE2309	**Course Category:** Programme Elective			

Course Objective(s):

To describe the characteristics of Electric Drive systems and their role in various applications and also learn solid state speed control methods of DC and AC motor drives using power electronics.

Course Outcome(s):

After completing this course, the student will be able to:

CO1: To understand steady state operation and transient dynamics of a motor load system.

CO2: To study and analyze the operation of the converter/chopper fed dc drive, both qualitatively and quantitatively.

CO3: To study and understand the operation and performance of AC motor drives.

CO4: To analyze and design the current controllers for a closed loop solid state DC motor drive

CO5: To analyze and design the speed controllers for a closed loop solid state DC motor drive

Mapping of Course Outcome(s):

CO / PSO	PSO														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CO1	S												S		
CO2	S	S	L										S		
CO3	S	S	S										S		
CO4	S	S	S										S		
CO5	S	M		M									S	M	

Course Topics:

Unit 1: DRIVE CHARACTERISTICS

Electric drive – Equations governing motor load dynamics – steady state stability – multi quadrant Dynamics: acceleration, deceleration, starting & stopping – typical load torque characteristics Selection of motor. Layout of an Electric Vehicle, Performance of Electric Vehicles a) Traction Motor Characteristics b) Tractive Effort and Transmission Requirements c) Vehicle Performance, Consumption

Unit 2: CONVERTER / CHOPPER FED DC MOTOR DRIVE

Steady state analysis of the single and three phase converter fed separately excited DC motor drive–continuous and discontinuous conduction– Time ratio and current limit control – 4 quadrant operation of converter / chopper fed drive.

Unit 3: INDUCTION MOTOR DRIVES

Stator voltage control–energy efficient drive–v/f control–constant air gap flux–field weakening mode– voltage / current fed inverter – closed loop control. Static control of rotor resistance - Vector control of induction motor- Speed Estimation methods – Slip calculation – Direct Synthesis from state equations – Direct Vector control without Speed signal.

Unit 4: SYNCHRONOUS MOTOR DRIVES

V/f control and self-control of synchronous motor: Margin angle control and power factor control –Permanent magnet synchronous motor. Speed control - Inverter fed synchronous motors – Vector control of Synchronous motor – Sensorless control – Trapezoidal SPM machine – Sinusoidal PM Machine.

Unit 5: DESIGN OF CONTROLLERS FOR DRIVES

Transfer function for DC motor / load and converter – closed loop control with Current and speed feedback–armature voltage control and field weakening mode – Design of controllers; current controller and speed controller. Simulation Of Electrical Drive Systems: DC motor drive-Induction motor drive, Design of controller for AC drive and IM.

Text Book(s):

1. Dubey G.K., "Fundamentals of Electrical Drives", Narosa Publishing House, Second Edition ,2016
2. Krishnan R., " Electric Motor & Drives: Modelling, Analysis and Control", Pearson Education, 2015

Reference(s):

1. ShaahinFelizadeh, "Electric Machines and Drives", CRC Press (Taylor and Francis

Group), 2013.
2. S.K.Pillai, A First course on Electrical Drives, New Age International Publishers, Third Edition, 2013.

213EEE3142 SPECIAL ELECTRICAL MACHINES

213EEE3142 SPECIAL ELECTRICAL MACHINES	*L*	*T*	*P*	*X*	*C*
	3	*0*	*0*	*3*	*3*
Pre-requisite: 212EEE2106	**Course Category:** Programme Elective				

Course Objective(s):

To expose the students to the construction, principle of operation and performance of special electrical machines.

Course Outcome(s):

After completing this course, the student will be able to:

CO1: Understand the features of synchronous reluctance motor.
CO2: Know the operational features of stepping motor.
CO3: Know the control strategy of switched reluctance motor.
CO4: Know the operational features of PMBLDC.
CO5: Know the operational features of Permanent magnet synchronous machine.

Mapping of Course Outcome(s):

CO / PSO	PSO														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
CO1	S	S											S		
CO2	S	S		S							S		S	S	
CO3	S	S		M									S	M	
CO4	S	S									S		S		
CO5	S	S											S		

Course Topics:

Unit1: SYNCHRONOUS RELUCTANCE MOTORS and SWITCHED RELUCTANCE MOTORS 9 Hours

Syncrel: Construction – Types – Axial and radial air gap motors – Operating principle – Phasor diagram – Characteristics – Vernier motor – Applications.

SRM: Construction – Principle of operation – Torque equation – Power semiconductor switching circuits – characteristics - Applications

Unit2: STEPPING MOTORS 9 Hours

Construction – Principle of operation – Variable reluctance stepper motor – Permanent magnet stepper motor - Hybrid motor – Single and multi-stack configurations – Theory of torque predictions – Linear and non-linear analysis – Characteristics – Driver circuits – Open and closed loop controls of stepper motor - Applications.

Unit 3: PERMANENT MAGNET BRUSHLESS DC MOTORS 9 Hours

Construction - Principle of operation – Mechanical and Electronic commutations – Square wave and sine wave PMBLDC motors – Types of PMBLDC motor – Control of PMBLDC motor – Microprocessor based control – Applications.

Unit 4: PERMANENT MAGNET SYNCHRONOUS MOTORS 9 Hours

Construction - Principle of operation – EMF and torque equations – Phasor diagram – Vector Control – Self-control – Sensor less control – Microprocessor based control - Applications.

Unit 5: HYSTERESIS AND REPULSION MOTORS

Hysteresis motor: Constructional features – Principle of operation and Characteristics of Hysteresis motor - Applications –Case studies - Linear Induction motor

Repulsion motor- Construction – Operation – Characteristics – Applications – Case studies

Text Book(s):

1. E.G. Janardanan, Special Electrical Machines, PHI, 2014.
2. J.Gnanavadivel, Dr.S.Muralidharan,. J.Karthikeyan, Principles of Special Electrical Machines, Anuradha Publications.
3. K. Venkataratnam, Special Electrical Machines, CRC Press, 2008.

Reference(s):

1. D. P. Kothari And I. J. Nagrath, Electric Machines, Tata McGraw Hill Education Pvt. Ltd., New Delhi, 4thEdition, 2010.
2. Theodore Wildi, Electrical Machines Drives, Pearson Education, 2013.
3. Kenjo, T., Stepping Motors and Their Microprocessor Controls, Clarendon Press London, 1984.
4. Kenjo,T., Nagamori,S., Permanent Magnet and Brushless DC Motors, Clarendon Press, London, 1988.
5. Miller, T.J.E., Brushless Permanent Magnet and Reluctance Motor Drives, Clarendon Press, Oxford, 1989.
6. Aearnley P., Stepping Motors – A Guide to Motor Theory and Practice, Peter Perengrinus, London, 1982.

213EEE3143 AUTO ELECTRICAL & ELECTRONICS SYSTEM

213EEE3143 AUTO ELECTRICAL & ELECTRONICS SYSTEM	*L*	*T*	*P*	*C*
	3	*0*	*0*	*3*
Co-requisite:- Nil	**Course Category:** Programme Elective			

Course objectives:-

This course makes the students to know the functions, working principles of various automotive electrical & electronics components.

Course Outcome(s):

After completing this course, the student will be able to:

CO1 : Enumerate the construction, characteristics and maintenance of battery, lighting system and different accessories in a typical automobile after careful inspection.

CO2 : Understand the construction, characteristics and maintenance of starting and ignition system and diagnose the ignition system fault of any vehicle.

CO3 : Understand the principles and characteristics of charging system components and demonstrate their working with suitable tools.

CO4 : Analyze the principles and architecture of electronics systems and its components present in an automobile related to instrumentation, control, security and warning systems.

CO5 : Enumerate the principles, application, construction and specification of different sensors and actuators usable in typical automobile by suitable testing

Mapping of Course Outcome(s):

CO / PSO	PSO														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
CO6	S	S			S								S	S	
CO7	S												S	S	
CO8	S				M									M	
CO9	S		S										M	S	
CO10	S	S	M										S		

Course Topics:

UNIT-I: Electrical Systems

Principle and Construction of Lead Acid and Lithium-Ion Battery- Characteristics of BatteryRating Capacity and Efficiency of Batteries- Various Tests on Batteries- Maintenance and Charging. Lighting System and Photometry: insulated and Earth Return System- Details of Head Light and Side Light- LED Lighting System- Head Light Dazzling and Preventive Methods Horns- Wiper System and Trafficator.

UNIT-II: Starting and Ignition System

Condition at Starting- Behavior of Starter During Starting- Series Motor and Its Characteristics- Principle and Construction of Starter Motor- Over Running Clutch Working of Different Starter Drive Units- Care and Maintenances of Starter Motor- Starter Switches. Spark Plugs. Advance Mechanisms. Different Types of Ignition Systems.

UNIT-III: Charging System

Generation of Direct Current- Shunt Generator Characteristics- Armature Reaction- Third Brush Regulation- Cutout. Voltage and Current Regulators- Compensated Voltage Regulator Alternators Principle and Constructional Aspects and Bridge Rectifiers- New Developments.

UNIT-IV: Sensors and Actuators

Types of Sensors: Sensor for Speed- Throttle Position- Exhaust Oxygen Level- Manifold Pressure- Crankshaft Position- Coolant Temperature- Exhaust Temperature- Air Mass Flow for Engine Application. Solenoids- Stepper Motors- Relay.

UNIT-V: Electronics Systems

Current Trends in Automotive Electronic Engine Management System- Types of EMS Electromagnetic interference Suppression- Electromagnetic Compatibility- Electronic Dashboard Instruments- On board Diagnostic System- Security - Warning System infotainment and Telematics.

Reference(s) :

1. Mehrdad Ehsani, Yimin Gao, Stefano Longo, Kambiz Ebrahimi, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles", Third Edition, CRC Press, Taylor & Francis Group, 2018.
2. Julian Edgar, "Car Electrical & Electronic Systems", Veloce Publishing Limited, 2020.

213EEE3144 ELECTRICAL AND HYBRID VEHICLE TECHNOLOGY

213EEE3144 ELECTRICAL AND HYBRID VEHICLE TECHNOLOGY	*L*	*T*	*P*	*X*	*C*
	3	*0*	*0*	*3*	*3*
Pre-requisite: Nil	**Course Category:** Programme Elective				

Course Objective(s):

To expose the students to the construction, principle of operation and performance of special electrical machines.

Course Outcome(s):

After completing this course, the student will be able to:

CO1: Understand the functional concepts of vehicles.
CO2: Describe the performance of hybrid electric vehicles.
CO3: Study of Electric trains.
CO4: Understand the different possible ways of energy storage.
CO5: Understand the various strategies in energy storage system.

Mapping of Course Outcome(s):

CO / PSO	PSO														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CO1	S	S											S		
CO2	S	S													
CO3	S	S													
CO4	S	S													
CO5	S	S											S		

Unit 1 INTRODUCTION

Conventional Vehicles: Basics of vehicle performance, vehicle power source characterization, transmission characteristics, and mathematical models to describe vehicle performance. Dynamic equation of vehicle motion, Tire-Ground Adhesion, Maximum tractive effort, Power train tractive effort

Unit 2 HYBRID ELECTRIC VEHICLES

Introduction to Hybrid Electric Vehicles: History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies.

Unit 3 ELECTRIC TRAINS

Electric Drive-trains: Basic concept of electric traction, introduction to various electric drive train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis. Electric Propulsion unit: Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives, configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance Motor drives, drive system efficiency.

Unit 4 ENERGY STORAGE

Introduction to energy storage for power systems: Role of energy storage systems, applications. Overview of energy storage technologies: Thermal, Mechanical, Chemical, Electrochemical, Electrical. Efficiency of energy storage systems. Electrical energy storage: Batteries, Super capacitors, Superconducting Magnetic Energy Storage (SMES), charging methodologies, SoC, SoH estimation techniques. Hydrogen production and storage, fuel cells. Mobile storage system: electric vehicle, G2V, V2G.Hybrid Energy storage systems: configurations and applications. Storage for renewable energy systems: Solar energy, Wind energy, pumped hydro energy, fuel cells. Energy storage in Microgrid and Smart grid. Energy Management with storage systems, Battery SCADA, Increase of energy conversion efficiencies by introducing energy storage.

Unit 5 DESIGN SPECIFICATION OF ENERGY MANAGEMENT STRATEGIES

Design specifications – Selection of motor and sizing – Selection of power electronics components and sizing – Inverter technology – Design of battery pack and auxiliary energy storage system – Design of ancillary systems – EV recharging and refuelling system design. Case Studies: Design of a Hybrid Electric Vehicle (HEV), Design of a Battery Electric Vehicle (BEV).

Text Books

1. C. Mi, M. A. Masrur and D. W. Gao, “Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives”, John Wiley & Sons, 2011.
2. S. Onori, L. Serrao and G. Rizzoni, “Hybrid Electric Vehicles: Energy Management Strategies”, Springer, 2015.

Reference Books

1. M. Ehsani, Y. Gao, S. E. Gay and A. Emadi, “Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design”, CRC Press, 2004.
2. T. Denton, “Electric and Hybrid Vehicles”, Routledge, 2016.
3. K. T. Chau, ‘Electric vehicle machines and drives: Design, analysis and application’, first edition, John Willey and Sons Singapore pte. ltd., 2015.
4. M. Ehsani, Y. Gao and A. Emadi, ‘Modern electric, hybrid electric and fuel cell vehicles: Fundamentals, Theory and design’, second edition, CRC press, 2011.

J. Larminie and J. Lowry, 'Electric vehicle technology explained', second edition, John Willey and Son ltd., 2012.
5. Husain, 'Electric and hybrid vehicles: Design fundamentals', CRC press, 2003.

213EEE3145 TESTING & CERTIFICATION OF AUTOMOTIVE SYSTEMS

213EEE3145 TESTING & CERTIFICATION OF AUTOMOTIVE SYSTEMS	*L*	*T*	*P*	*C*
	3	*0*	*0*	*3*
Co-requisite:- Nil	**Course Category:** Programme Elective			

Course objectives:-

This course gives an exposure to Indian Test standards and Test methods for automotive Electrical & Electronic components and Test standards & Compliance requirements for EMCs. Also focuses on the test Methods for HIL testing with various environmental requirements.

Course Outcome(s):

After completing this course, the student will be able to:

CO1 : Understand the Indian Test standards for homologation of 2W/3W
CO2 : Understand the Indian Test standards & Test methods for Electrical & Electronic components
CO3 : Understand the Indian Test standards & Compliance requirements for EMC
CO4 : Test the HIL
CO5 : Understand the Indian Test standards for Environmental requirements

Mapping of Course Outcome(s):

CO / PSO	PSO														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
CO11	S	S			S			S					S	S	
CO12	S	S	S										S	S	
CO13	S	M	S		S				S				M	S	
CO14	S		S		S								S	S	
CO15	S	S	M					S				S	S		

Course Topics:

Unit-I: Indian Test standards

Overview of European, Japanese, North American Standards - Overview of Indian Standards - Homologation & Type approval of 2W & 3W, EV & HEV

Unit-II: Test standards & Test methods for Electrical & Electronic components

Test standards & Test methods for Electrical & Electronic components - Starter Motor, Lighting system, battery, Horn, Wiring Harness- Instrument Cluster & ECU

Unit-III: Test standards & Compliance requirements for EMCs

Relevant standard - Classification of standards – Test Standards & compliance requirements - Radiated emission - Conducted emission- Radiated susceptibility - Conducted susceptibility

Unit-IV: HIL testing

HIL Test Objective- Test set-up - Test Methods

Unit-V: Environmental requirements

Indian Test Standards for Environmental requirements - List of major tests & Standards - Test set-up &Test Methods

Reference(s):

1. Tom Denton, "Automobile Electrical and Electronic Systems", Fifth Edition, Routledge Taylor & Francis Group, London and New York, 2018.
2. James D. Halderman, "Automative Electrical and Engine Performance", Pearson Education, 2019.
3. David M. Jones, Kirk VanGelder, "Automotive Electricity and Electronics", CDX Learning Systems, Master Automotive Technician Series, 2018.

University Elective Courses (Engineering)

Stream 1: Power & Energy Systems

213EEE2146 PRINCIPLES OF POWER SYSTEM

213EEE2146 PRINCIPLES OF POWER SYSTEM	*Credits*			
	L	***T***	***P***	***Total***
	3	**0**	**0**	**3**
Pre-requisite:Nil	**Course Category:** Open Elective - Theory			

Course Objective(s):

The course provides the theoretical background required to model and analyze large power systems. This includes basic concepts of transmission lines, corona and interference, mechanical design and grounding.

Course Outcome(s):

After completing this course, the student will be able to:

CO1 : To understand the basic concepts of power system
CO2 : To know the basic concepts of overhead lines
CO3 : To acquire the knowledge about corona and interference
CO4 : To understand the mechanical design of transmission lines
CO5 : To gain knowledge on neutral grounding

Course Topics:

Unit 1: POWER SYSTEM COMPONENTS 9 Hours

Single line Diagram of Power system, Brief description of power system Elements: Synchronous machine, transformer, transmission line, bus bar, circuit breaker and isolator Supply System Different kinds of supply system and their comparison, choice of transmission voltage, Transmission Lines: Configurations, types of conductors, resistance of line, skin effect, Kelvin's law. Proximity effect

Unit 2: OVER HEAD TRANSMISSION LINES 9 Hours

Calculation of inductance and capacitance of single phase, three phase, single circuit and double circuit transmission lines-Representation and performance of short, medium and long transmission lines, Ferranti effect. Surge impedance loading

Unit 3: CORONA AND INTERFERENCE 9 Hours

Phenomenon of corona, corona formation, calculation of potential gradient, corona loss, factors affecting corona, methods of reducing corona and interference. Electrostatic and electromagnetic interference with communication lines. Overhead line Insulators: Type of insulators and their applications, potential distribution over a string of insulators, methods of equalizing the potential, string efficiency

Unit 4: MECHANICAL DESIGN OF TRANSMISSION LINE 9 Hours

Catenary curve, calculation of sag & tension, effects of wind and ice loading, sag template,

vibration dampers. Insulated cables: Type of cables and their construction, dielectric stress, grading of cables, insulation resistance, capacitance of single phase and three phase cables, dielectric loss, heating of cables.

Unit 5: DISTRIBUTION AND NEUTRAL GROUNDING 9 Hours

Distribution Systems – General Aspects – Kelvin's Law – AC and DC distributions – Techniques of Voltage Control and Power factor improvement – Distribution Los –Types of Substations - Methods of Grounding – Trends in Transmission and Distribution: EHVAC, HVDC and FACTS (Qualitative treatment only). Necessity of neutral grounding, various methods of neutral grounding, earthing transformer, grounding practices.

Text Book(s):

1. W. D. Stevenson, "Element of Power System Analysis", McGraw Hill,
2. L. Wadhwa, "Electrical Power Systems" New age international Ltd. Third Edition
3. Asfaq Hussain, "'Power System", CBS Publishers and Distributors,
4. R. Gupta, "Power System Analysis and Design" Third Edition, S. Chand & Co.
5. M. V. Deshpande, "Electrical Power System Design" Tata Mc Graw Hill.

Reference(s):

1. Soni, Gupta & Bhatnagar, "A Course in Electrical Power", Dhanpat Rai & sons,
2. S. L. Uppal, "Electric Power", Khanna Publishers
3. S.N.Singh, "Electric Power Generation, Transmission& distribution." PHI Learning

213EEE2147 POWER GENERATION SYSTEMS

213EEE2147 POWER GENERATION SYSTEMS	***Credits***			
	L	***T***	***P***	***Total***
	3	**0**	**0**	**3**
Pre-requisite: Nil	**Course Category:** Open Elective - Theory			

Course Objective(s):

To understand the working of different types of power generation systems and to realize the necessity of operation of different types of power stations.

Course Outcome(s):

After completing this course, the student will be able to:

CO1 : To understand the various power UNITs and its load

CO2 : Determine the significance of various components of the steam power generation plants

CO3 : To understand the insights of hydro power station

CO4 : Understand the operations on nuclear power station and MHD power generation system.

CO5 : Correlate the importance of operation of the different renewable power generation systems

Course Topics:

UNIT I: INTRODUCTION 9 Hours

Prediction of Load: Definition of connected load, maximum load, maximum demand, demand factor, load factor, diversity factor, plant capacity factor, plant utilization factor, load duration curve, mass curve. Choice of Power station and UNITs: Types of power station, choice of type of generation, choice of size of generator UNITs and number of UNITs.

UNIT II: STEAM POWER STATION 9 Hours

Steam Power station: Main parts and working of a steam station, characteristics off steam turbines, characteristics of turbo alternators, steam station auxiliaries, steam station layout, super pressure steam stations.

UNIT III: HYDRO POWER STATIONS 9 Hours

Hydro power stations: Hydrology, hydrographs, flow duration curve, mass curve, types of dam, principle of working of a hydroelectric plant, tidal power plant, power to be developed, types of turbine and their characteristics, characteristics of generators, power station structure and layout.

UNIT IV: NUCLEAR AND MHD GENERATION 9 Hours

(A) Nuclear power stations: main parts of nuclear power station principle of nuclear energy, main parts of reactor, types of power reactor, location of nuclear power plant, layout of power station, reactor control, nuclear waste disposal.

(B) MHD generation: history of MHD generation, principle of MHD generation, MHD cycles and working fluids, open cycle MHD system, closed cycle MHD system, advantage of MHD generation.

UNIT V: RENEWABLE POWER GENERATION 9 Hours

New Energy Sources: Solar radiation, Solar energy collectors, Conversion of solar energy into electric energy, Solar hydrogen energy cycle, Wind mills, Tidal power generation schemes, Tidal barrage, Environmental aspects of new and old electric energy generation.

Text Book(s):

1. Generation of Electrical Energy by B.R. Gupta, S. Chand & Company Ltd, 2014, 5th Edition.
2. Carr, T.H., Electric Power Stations, Published by Chapman and Hall.

Reference(s):

1. Elements of Electric Power Station Design by M.V. Deshpande, PHI Learning Pvt. Ltd., 2010
2. A Course in Electrical Power by Soni Gupta Bhatnagar, Dhanpat Rai, 2015.
3. A Course in Electrical Power by J.B.Gupta, ‘, S.K.Kataria and sons, reprint 2010-2011
4. Nag. P.K., "Power Plant Engineering", Third Edition, Tata McGraw – Hill Publishing Company Ltd., 2008.

213EEE2148 ELECTRICAL MACHINES

213EEE2148 ELECTRICAL MACHINES	*Credits*			
	L	***T***	***P***	***Total***
	3	**0**	**0**	3
Pre-requisite: Nil	**Course Category:** Open Elective - Theory			

Course Objective(s):

To understand the basic principle of operation of static and rotating electrical machines and also to analyze the performance characteristics of electrical machines.

Course Outcome(s):

After completing this course, the student will be able to:

CO1 : To understand the concepts of electromagnetic induction and electro magnetism

CO2 : To understand the principle of operation of DC machines and to analyze its performance characteristics.

CO3 : To understand the principle of operation of transformer and to analyze its performance characteristics.

CO4 : To understand the principle of operation of synchronous machines and to analyze its performance characteristics.

CO5 : To understand the principle of operation of Induction machines and to analyze its performance characteristics.

Course Topics:

Unit 1: ELECTRO MAGNETIC INDUCTION & BASIC CONCEPTS IN ROTATING MACHINES 9 Hours

Introduction to magnetic circuits –Compare electric and magnetic circuits- Magnetically induced e.m.f and force – AC operation of magnetic circuits – Hysteresis and Eddy current losses. Energy in magnetic systems Field energy & mechanical force

Unit 2:D.C. MACHINES 9 Hours

Construction of D.C. Machines - Principle and theory of operation of D.C. generator - EMF equation- Characteristics of D.C. generators - Armature reaction – Commutation - Principle of operation of D.C.motor - Voltage equation - Torque equation - Types of D.C. motors and their characteristics – Starters -Speed control of D.C. motors - Applications.

Unit 3: TRANSFORMERS 9 Hours

Principle, Theory of ideal transformer - EMF equation - Construction details of shell and core type transformers - Tests on transformers - Equivalent circuit - Phasor diagram - Regulation and efficiency of auto transformer - Introduction to three - phase transformer connections.

Unit 4: INDUCTION MACHINES 9 Hours

Induction motor - Construction and principle of operation, Classification of induction motor, Torque equation, Condition for maximum torque, Equivalent Circuit, Starting methods and Speed control of induction motors.

Unit 5: SYNCHRONOUS MACHINES 9 Hours

Principle of alternators: - Construction details, Equation of induced EMF and Vector diagram – Synchronous motor:- Starting methods, Torque, V curves, Speed control and Hunting.

Text Book(s):

1. Nagrath, I.J., and Kothari, D.P., "Electrical Machines", Tata McGraw - Hill, 1997.
2. Fitzgerald A.E, Kingsley C., Umans, S. and Umans S.D., "Electric Machinery", McGraw-Hill,Singapore, 2000.

Reference(s):

1. Theraja, B.L., "A Text book of Electrical Technology", Vol.II, S.C Chand and Co., New Delhi, 2007.
2. Del Toro, V., "Electrical Engineering Fundamentals", Prentice Hall of India, New Delhi, 1995.

213EEE2149 HYDRO POWER GENERATION

213EEE2149 HYDRO POWER GENERATION	***Credits***			
	L	***T***	***P***	***Total***
	3	**0**	**0**	**3**
Pre-requisite: Nil	**Course Category:** Open Elective - Theory			

Course Objective(s):

To gain the basic knowledge for constructive structure and design of hydropower plant and able to analyze the load factor based on the electric load.

Course Outcome(s):

After completing this course, the student will be able to:

CO1 : Understand the basic knowledge about the hydropower plants.
CO2 : Understand the selection methodology for prime mover based on water level and find out the efficiency of pumped storage plant.
CO3 : Analyze the designing criteria of various types of penstock pipes.
CO4 : Understand the selection criteria for turbines and basic layout of power houses.
CO5 : Solve the capacity and diversity factors of hydro plant based on load.

Course Topics:

UNIT-I INTRODUCTION

Sources of energy - status of hydropower - Environmental aspects for selecting the sites and locations of hydro power stations - advantages of hydropower - place of hydropower in power system - Types of hydropower stations - classification of hydropower stations - run of river plants - general layout of run of river plants - storage and pondage.

UNIT-II PRIME MOVER AND PUMP STORAGE PLANT

Selection of prime mover, speed and pressure regulation, methods of governing, starting and stopping of water turbines, operation of hydro turbines. Machine loading and frequency control, Maintenance of hydropower plants, Basic features of Hydropower plants - advantages of pumps storage plants - storage plants - types of pump storage plants - efficiency of pump storage plants.

UNIT-III WATER CONVEYANCE SYSTEM

Classifications of penstocks - design criteria of penstocks - anchor blocks - types of valves - water hammer - surges in power channels - Types of Surge shafts - surge analysis - design of surge shafts

UNIT-IV TURBINES AND POWER HOUSES

Types of turbines - criteria for selection - specifies speed of turbines - unit power - unit discharge - cavitations in turbines - design of draft tube, Types of power houses - lay out of power houses – ventilations - underground power houses -advantages.

UNIT-V ELECTRICAL LOAD ON HYDRO POWER

Load curves - load factor - capacity factors - utility factors - diversity factors - load on hydropower stations -load duration curves - firm power - secondary power - prediction of loads

Text Book(s):

1. K N Sharma& M M Dandekar, Water Power Engineering,. Vikas Publishing, 2013
2. Mosonyi, Water Power Development Vol-I, New Chand & Bros.,

Reference(s):

1. Hydropower structures Volume III-By R S Varshney
2. Hydro Power Engineering By Dr Darde P N ,Vayu Education, Delhi

213EEE2150 SOLAR AND WIND ENERGYCONVERSION

213EEE2150 SOLAR AND WIND ENERGYCONVERSION	***Credits***			
	L	***T***	***P***	***Total***
	3	**0**	**0**	**3**
Pre-requisite: Nil	**Course Category:** Open Elective - Theory			

Course Objective(s):

1. To understand and analyze the various renewable energy technologies.
2. To understand the nature of the solar and wind as an energy source.
3. To understand and evaluate different uses of solar energy, such as direct conversion to electricity (photovoltaic), different types of wind turbines.
4. To design and perform the financial estimations of a wind power system.

Course Outcome(s):

After completing this course, the student will be able to:

CO1 : Apply the knowledge in solar spectrum and solar radiation.
CO2 : Understand the basic concept of solar photovoltaic energy conversion and different types of solar PV plants.
CO3 : Apply the solar power Conversion techniques in the field of solar cars, air craft and space satellites.
CO4 : Understand the basic concept of wind energy conversion system.
CO5 : Analyze the various aspects related to Wind turbine generators.

Course Topics:

Unit 1: SOLAR SPECTRUM AND SOLAR RADIATION 9 Hours

World energy resources - Indian energy scenario - environmental aspects of energy utilization - renewable energy resources and their importance – global solar resources - solar spectrum – electromagnetic spectrum - basic laws of radiation - physics of the sun - energy balance of the earth - energy flux - solar constant for earth – green-house effect. Solar radiation on the earth surface – extra-terrestrial radiation characteristics - terrestrial radiation - solar isolation - spectral energy distribution of solar radiation- depletion of solar radiation – absorption – scattering - beam

radiation - diffuse and global radiation - measurement of solar radiation

Unit 2: SOLAR ELECTRICAL ENERGY CONVERSION 9 Hours

Solar photovoltaic energy conversion - principles - physics and operation of solar cells - classification of solar PV systems - solar cell energy conversion efficiency - I-V characteristics - effect of variation of solar insulation and temperature – losses - solar PV power plants.

Unit 3: PV SYSTEM APPLICATIONS AND GRID INTEGRATION 9 Hours

Integrated photovoltaic UNITs – grid interacting central power stations – standalone devices for distributed power supply in remote and rural areas - solar cars – aircraft - space solar power satellites - socio-economic and environmental merits of photovoltaic systems – Grid Integration – Issues in Grid Integration – Grid Integration Techniques

Unit 4: INTRODUCTION OF WIND ENERGY 9 Hours

Basics & power analysis - wind resource assessment - power conversion technologies and applications - wind power estimation techniques - principles of aerodynamics of wind turbine blade - various aspects of wind turbine design

Unit 5: WIND TURBINE GENERATORS **9** Hours

Induction machines - synchronous machine - constant V & F and variable V & F generations - reactive power compensation - site selection - concept of wind form & project cycle - cost economics & viability of wind farm.

Text Book(s):

1. Duffy and Buckman, Solar energy thermal process, John wiley and sons, 4th Edition. April 2013.
2. CulpA.W., Principles of Energy Conversion, Tata McGraw Hill Publication, New Delhi.
3. Solar Energy: Principles of Thermal Collection and Storage S. Sukhatme (Author), J Nayak (Author), Mcgraw Hill Education 2008.

Reference(s):

1. Rai, G.D., Non–conventional Energy Sources, Khanna Publishers, New Delhi, 2011.
2. Sathyajith Mathew, Wind energy–Fundamentals, Resource Analysis and Economics, Springer, 2006.
3. S. Sumathi (Author), L. Ashok Kumar (Author), P. Surekha (Author), Solar PV and Wind Energy Conversion Systems, Springer; 2015 edition (14 April 2015).
4. Energy Harvesting: Solar, Wind, and Ocean Energy Conversion Systems (Energy, Power Electronics, and Machines), Alireza Khaligh (Author), Omer C. Onar (Author) CRC Press 2009.

213EEE2151 ELECTRICAL WIRING ESTIMATION AND COSTING

213EEE2151 ELECTRICAL WIRING ESTIMATION AND COSTING	*Credits*			
	L	***T***	***P***	***Total***
	3	***0***	***0***	***3***
Prerequisite: Nil	**Course Category:** Open Elective – Theory			

Course Objective(s):

Knowledge of electrical engineering drawing, IE rules, different types of electrical Installation their design considerations equips the students with the capability to design and prepare working of different Installation projects.

Course Outcome(s):

After completing this course, the student will be able to:

CO1: To understand the basic of wiring accessories and types of wiring systems
CO2: To gain the knowledge about Estimating and Costing of electrical wiring
CO3: To gain the knowledge for estimating and constructing the domestic wiring.
CO4: To understand the cost of equipment and estimation of wiring used in industry
CO5: To do the plan for overhead underground lines.

Course Topics:

Unit 1: WIRING MATERIALS AND ACCESSORIES 9 Hours

Need of electrical symbols - List of symbols for electrical equipment and accessories used in electrical works – IE rules - General specifications and different types of wires – Cables – Switches - Distribution board - Switch board – Boxes - Batten and its accessories - Conduit and its accessories - Lamp holders - Socket out lets - Plug ceiling roses - Fuse and energy meter used in domestic and power wiring installations- Type of wiring diagrams - Wiring diagrams (multiple and single line representation)

Unit 2: PRINCIPLES OF ESTIMATING AND COSTING 9 Hours

Purpose of estimating and costing - Essentials of estimating and costing-market survey - Price list and net prices - Preparation of list of materials - Calculation of material and labour cost – Contingencies - Overhead charges - Profit and total cost.

Unit 3: ESTIMATION OF DOMESTIC WIRING CIRCUITS: 9 Hours

Description of various domestic wiring systems - calculation of No. of points (light, fan, socket outlet) - Calculation of total load including domestic power - Determination of no. of circuits - Size of wires and cables - Switches and main switch - Distribution board and switch board - Batten conduit and other wiring accessories - Need of earthing as per IE rules.

Unit 4: ESTIMATION OF POWER WIRING 9 Hours

IE rules for power wiring - Calculation of current for single and three phase motors - Determination of sizes of cables, conductors distribution board, main switches and starters for power circuits - Cost of equipments and accessories and schedule of materials - Estimation and cost of material and work for motors upto 20 H.P., pumpsets and small workshops.

Unit 5: ESTIMATION OF OVERHEAD AND UNDERGROUND DISTRIBUTION LINES **9 Hours**

IE rules for overhead and underground lines - Main components of overhead lines-line supports - Cross-arm – Clamps - Conductors and stay sets - Lightening arrestors - Danger plates -Ant climbing devices - Bird guards - Jumpers - Concreting of poles - Earthing of transmission line - Formation of lines - Specification of materials for O.H. lines - Cost of material and work for overhead and underground lines upto 11 KV.

Textbook(s):

1. Uppal S.L, "Electrical Wiring - Estimating and costing", Khanna Publishers, Sixth edition 2011.
2. Giridharan M.K., "Electrical Systems Design", I.K. International Publishing House, New Delhi, 2011.
3. Surjit Singh, "Electrical Estimating and Costing", Dhanpat Rai & Co. LTD., 2016.

Reference(s):

1. Gupta J.B., "A Course in Electrical Installation Estimating and Costing", S. K. Kataria & Sons, Ninth Edition, 2012.
2. Raina K.B., Bhattacharya S.K., "Electrical Design Estimating and Costing" New Age International Pvt. Ltd., 2005.
3. **B.D. Arora, "Electrical Wiring, Estimating and Costing", R.B. Publication, New Delhi**

213EEE2152 ELECTRICAL SAFETY

213EEE2152 ELECTRICAL SAFETY	*Credits*			
	L	***T***	***P***	***Total***
	3	**0**	**0**	**3**
Pre-requisite: Nil	**Course Category:** Open Elective - Theory			

Course Objective(s):

To provide a comprehensive exposure to electrical hazards, various grounding techniques, safety procedures and various electrical maintenance techniques.

Course Outcome(s):

After completing this course, the student will be able to:

CO1 : Describe electrical hazards and safety equipment.
CO2 : Analyze and apply various grounding and bonding techniques.
CO3 : Select appropriate safety method for low, medium and high voltage equipment.
CO4 : Participate in a safety team.
CO5 : Carry out proper maintenance of electrical equipment by understanding various standards.

Course Topics:

UNIT I: ELECTRICAL HAZARDS 9 Hours

Primary and secondary hazards-arc, blast, shocks-causes and effects-safety equipment-flash and thermal protection, head and eye protection-rubber insulating equipment, hot sticks, insulated

tools, barriers and signs, safety tags, locking devices-voltage measuring instruments-proximity and contact testers-safety electrical one line diagram-electrician's safety kit.

UNIT II: GROUNDING 9 Hours

General requirements for grounding and bonding-definitions-grounding of electrical equipment-bonding of electrically conducting materials and other equipment-connection of grounding and bonding equipment-system grounding-purpose of system grounding-grounding electrode system-grounding conductor connection to electrodes-use of grounded circuit conductor for grounding equipment-grounding of low voltage and high voltage systems

UNIT III: PROTECTION SYSTEM 9 Hours

The six step safety methods-pre job briefings -hot-work decision tree-safe switching of power system-lockout-tag out-flash hazard calculation and approach distances-calculating the required level of arc protection-safety equipment , procedure for low, medium and high voltage systems-the one minute safety audit

UNIT IV: SAFETY 9 Hours

Electrical safety programme structure, development-company safety team-safety policy-programme implementation-employee electrical safety teams-safety meetings-safety audit-accident prevention-first aid-rescue techniques-accident investigation

UNIT V: ELECTRICAL MAINTENANCE 9Hours

Safety related case for electrical maintenance-reliability centered maintenance (RCM) -eight step maintenance programme-frequency of maintenance-maintenance requirement for specific equipment and location-regulatory bodies-national electrical safety code-standard for electrical safety in work place-occupational safety and health administration standards, Indian Electricity Acts related to Electrical Safety.

Text Book(s):

1. Rao .S," Electrical Safety Fire Safety Engineering and Safety Management", Khanna Publications, 2nd Edition, 2012.
2. Fordham Cooper, W., "Electrical Safety Engineering" Butterworth and Company, London, 1986.

Reference(s):

1. Indian Electricity Act and Rules, Government of India.
2. Power Engineers – Handbook of TNEB, Chennai, 1989.
3. Martin Glov, 'Electrostatic Hazards in powder handling', Research Studies Pvt. Ltd., England, 1988.
4. MassimA.G.Mitolo, 'Electrical safety of Low voltage systems', Mc Graw Hill, 2009.
5. John Cadick et al., 'Electrical safety Handbook', Third Edition, Mc Graw Hill, 2006.

213EEE2153 ENERGY CONSERVATION AND MANAGEMENT

213EEE2153 ENERGY CONSERVATION AND MANAGEMENT	***Credits***			
	L	***T***	***P***	***Total***
	3	**0**	**0**	**3**
Pre-requisite: Nil	**Course Category:** Open Elective - Theory			

Course Objective(s):

1. To impart basic knowledge to the students about current energy scenario, energy management, auditing and conservation.
2. To inculcate among the students systematic knowledge and skill about assessing the energy efficiency, energy auditing and energy management.

Course Outcome(s):

After completing this course, the student will be able to:

CO1 : To understand and analyze the energy data of industries
CO2 : To carryout energy basics and energy conservation techniques
CO3 : To conduct energy audit and suggest methodologies for energy savings
CO4 : To utilize the available resources in optimal ways and perform the financial estimations of energy performance
CO5 : To Know the energy monitoring and targeting techniques

Course Topics:

UNIT I: INDIAN ENERGY SCENARIO

Commercial and Non-commercial energy, primary energy resources, commercial energy production, final energy consumption, Indian energy scenario, Sectorial energy consumption (domestic, industrial and other sectors), energy needs of growing economy, energy intensity, long term energy scenario, energy pricing, Energy security, energy conservation and its importance, energy strategy for the future, Energy Conservation Act 2001 and its features.

UNIT II: BASICS OF ENERGY ITS VARIOUS FORMS AND CONSERVATION

Electricity basics – Direct Current and Alternative Currents, electricity tariff, Thermal Basics-fuels, thermal energy contents of fuel, temperature and pressure, heat capacity, sensible and latent heat, evaporation, condensation, steam, moist air and humidity and heat transfer, analysis of existing buildings setting up an energy management programme and use management – electricity saving techniques

UNIT III: ENERGY MANAGEMENT & AUDIT

Definition, energy audit, need, types of energy audit. Energy management (audit) approach-understanding energy costs, Bench marking, energy performance, matching energy use to requirement, maximizing system efficiencies, optimizing the input energy requirements, fuel and energy substitution, energy audit instruments and metering

UNIT IV: FINANCIAL MANAGEMENT

Investment-need, appraisal and criteria, financial analysis techniques simple payback period, return on investment, net present value, internal rate of return, cash flows, risk and sensitivity analysis; financing options, energy performance contracts and role of Energy Service Companies (ESCOs)

UNIT V: ENERGY MONITORING AND TARGETING

Defining monitoring & targeting, elements of monitoring & targeting, data and information-analysis, techniques – energy consumption, production, cumulative sum of differences (CUSUM).Energy Management Information Systems (EMIS).

Text Book(s):

1. Energy Engineering and Management Amlan Chakrabarti Prentice hall India 2011
2. Energy Management Principles, CB Smith, Pergamon Press, New York, 2007.
3. Bureau of energy efficiency, "General Aspects of Energy Management & Energy Audit", old edition on2005& new edition on2011.

Reference(s):

1. Energy Management Hand Book. W. C. Turner. John Wiley and sons Handbook on Energy Efficiency, TERI, New Delhi, 2009
2. Energy Auditing and Conservation; Methods, Measurements, Management & Case Study, Hamies, Hemisphere Publishing, Washington, 1980.
3. Industrial Energy Management & Utilization, Write, Larry C Hemisphere Publishers, Washington, 1998.

213EEE3154 EVOLUTIONARY COMPUTATION TECHNIQUES

213EEE3154 EVOLUTIONARY COMPUTATION TECHNIQUES	***Credits***			
	L	***T***	***P***	***Total***
	3	**0**	**0**	**3**
Pre-requisite:- Nil	**Course Category:** Open Elective - Theory			

Course Objective(s):

To provide a broad introduction to the field of Genetic Algorithms and other fields of Evolutionary Computation and global optimization. To teach students how to apply these methods to solve problems in complex domains. The course is appropriate both for students preparing for research in Evolutionary Computation, as well as Science and Engineering students who want to apply Evolutionary Computation techniques to solve problems in their fields of study.

Course Outcome(s):

After completing this course, the student will be able to:

CO1 : To understand the working principle of evolutionary computation.

CO2 : To apply Genetic Algorithm to solve optimization problems.

CO3 : To recognize the powerfulness of EC Techniques and the ability to apply EC algorithms to solve optimization problem.

CO4 : To understand the principle of PSO and to solve optimization problems.

CO5 : To understand the principle of ACO and to solve optimization problems.

Course Topics:

UNIT I: EVOLUTIONARY COMPUTATION (EC): THE BACKGROUND

Outline of Evolutionary Algorithms (EA) – EA Terminologies – Robust adaptation and Machine Intelligence – Principles of Evolutionary Processes – Principles of Genetics – No-free Lunch theorem for EA – Advantages of EA over other approaches.

UNIT II: GENETIC ALGORITHM (GA)

Binary GA – genetic operators – Tournament, Proportionate and Ranking Selection – Single point, two-point and uniform crossover – Elitism – Real Parameter GA – Linear, naïve, blend and Simulated Binary Crossover – Random, Non-uniform, Normally distributed and Polynomial Mutation – Constraint Handling Techniques in GA.

UNIT III: EVOLUTIONARY STRATEGIES (ES) & EVOLUTIONARY PROGRAMMING (EP)

Non-Re combinative ES – Re combinative ES – Self Adaptive ES – Connection between RGA and Self adaptive ES – Evolutionary Programming(EP) – EP and ES: Similarities and Differences – Genetic Programming (GP) – Population size and Dynamics – Convergence and Stopping Criteria – Exploration and Exploitation.

UNIT IV: PARTICLE SWARM OPTIMIZATION (PSO)

Concepts and formulation – Simulating the Social behavior – PSO algorithm – Topology – Parameter Selection and Improvements for Convergence – Maximum Velocity – Acceleration Constants - Constriction factor - Inertia weight – Advantages of PSO.

UNIT V: ANT COLONY OPTIMIZATION (ACO)

Ants' Foraging Behavior – Stigmergy – Double Bridge Experiment – Real Ants to Artificial Ants – Behavioral Differences – Properties of Artificial Ants – ACO Algorithms – Ant System - MAX−MIN Ant System – Ant Colony System (ACS) – Advances of ACO.

Text Book(s):

1. Kalyanmoy Deb, "Multi-Objective Optimization using Evolutionary Algorithms", 3rd Edition, John Wiley & Sons, 2008.
2. D.B.Fogel,"Evolutionary Computation", Prentice HallIndia publications, 2001.
3. Thomas Back, David BFogel and ZbigniewMichalewicz, "Evolutionary Computation 1 &2: Basic/advanced Algorithms and Operators", Institute of Physics Publishing, 2000.
4. Marco Dorigo and Thomas Stutzle, "Ant Colony Optimization", MIT Press, 2004.

5. JurgenBranke, Kalyanmoy Deb, Kaisa Miettinen and Roman Slowinski (Eds.), "MultiObjective Optimization: Interactive and Evolutionary Approaches", Springer-Verlag, 2008.
6. S.N.Sivanandam and S.N.Deepa, "Introduction to Genetic Algorithms", Springer-Verlag, 2008.
7. Thomas Baeck, D.B.Fogel and Z.Michalewicz,"Handbookof Evolutionary Computation"aylor and Francis, 1997.

213EEE3155 SOFT COMPUTING TECHNIQUES

213EEE3155 SOFT COMPUTING TECHNIQUES	*Credits*			
	L	***T***	***P***	***Total***
	3	**0**	**0**	**3**
Pre-requisite:- Nil	**Course Category:** Open Elective - Theory			

Course Objective(s):

1. To expose the concepts of feed forward neural networks.
2. To provide adequate knowledge about feedback neural networks.
3. To teach about the concept of fuzziness involved in various systems.
4. To expose the ideas about genetic algorithm
5. To provide adequate knowledge about of FLC and NN toolbox.

Course Outcome(s):

After completing this course, the student will be able to:

CO1 : To understand the basic concepts of soft computing techniques
CO2 : To solve real world problems using neural network
CO3 : To analyze the functioning of recurrent neural network
CO4 : To apply genetic algorithm to solve the optimization problem
CO5 : To develop fuzzy logic controller for the given system

Course Topics:

Unit 1: **INTRODUCTION AND FEEDFORWARD NEURAL NETWORKS**

Introduction to soft computing -soft computing vs hard computing-various types of soft computing techniques-applications of soft computing-Neuron-Nerve structure and synapse-Artificial Neuron and its model-activation functions-Neural network architecture-single layer and multilayer feed forward networks-McCullochPitts neuron model-perceptron model -Adaline and Madaline-multilayer perception model-back propagation learning algorithm- Implement back propagation learning algorithm using software, Introduction to MATLAB toolbox

Unit 2: **RECURRENT NEURAL NETWORKS**

Counter propagation network-architecture-functioning & characteristics of counter-Propagation network-Hopfield/ Recurrent network-configuration-stability constraints-associative memory-and characteristics-limitations and applications-Hopfield v/s Boltzman machine-Adaptive

Resonance Theory-Architecture-classifications-Implementation and training-Associative Memory- Design of multilayer feed forward network using software.

Unit 3: **FUZZY LOGIC SYSTEM**

Introduction to crisp sets and fuzzy sets-basic fuzzy set operation and approximate reasoning. Introduction to fuzzy logic modeling and control-Fuzzification-inferencing and defuzzification-Fuzzy knowledge and rule bases-Fuzzy modeling and control schemes for nonlinear systems. Self-organizing fuzzy logic control-Fuzzy logic control for nonlinear time delay system- Adaptive Neuro Fuzzy Inference System, Development of Neuro fuzzy system using software.

Unit 4: **GENETIC ALGORITHM**

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 and ant colony search techniques for solving optimization problems-Implementation of optimization problem using software.

Unit 5: **APPLICATIONS**

Case studies: Identification and control of linear and nonlinear dynamic systems using Matlab-Neural Network toolbox. Stability analysis of Neural Network interconnection systems-Implementation of fuzzy logic controller using Matlab fuzzy logic toolbox-Stability analysis of fuzzy control systems, GA application to power system optimization problem.

Text Book(s):

1. S.N. Sivanandam, S.N. Deepa, "Principles of Soft Computing" 2nd Edition, Wiley, 2011.
2. Fakhreddine O. Karray and Clarence De Silva, "Soft Computing & Intelligent System: Theory, Tools and Applications", First edition, Pearson Education, 2009.

Reference(s):

1. Laurene V. Fausett, Fundamentals of Neural Networks: Architectures, Algorithms and Applications, Pearson Education. 2004
2. Timothy J. Ross, "Fuzzy Logic with Engineering Applications" Wiley India. 2010.

213EEE3156 SMART GRID TECHNOLOGY

213EEE3156 SMART GRID TECHNOLOGY	*Credits*			
	L	***T***	***P***	***Total***
	3	**0**	**0**	**3**
Pre-requisite: Nil	**Course Category:** Open Elective - Theory			

Course Objective(s):

The topics of the course focus on various types of smart-grid devices that are used in the power industry. Emphasis is placed on the operation, installation and maintenance of smart-grid devices and systems.

Course Outcome(s):

After completing this course, the student will be able to:

CO1 : To know the importance of smart grid and to design the smart grid architecture.

CO2 : To understand the basic concepts of the power flow model ling through power grid and measurement technologies for wide area monitoring systems.

CO3 : To understand the working principle of smart meter and to design the policy and economic drives of the smart grid

CO4 : To learn and analyze the power quality conditioners for smart grid

CO5 : To understand the concepts of web service and CLOUD computing to make smart grids smarter

Course Topics:

Unit 1: SMART GRID ARCHITECTURA DESIGNS 9 Hours

Introduction–Comparison of Power grid with Smart grid –power system enhancement – communication and standards-General View of the Smart Grid Market Drivers Stakeholder Roles and Function-Measures- Representative Architecture-Functions of Smart Grid Components-Wholesale energy market in smart grid-smart vehicles in smart grid.National and International Initiatives in Smart Grid.

Unit 2: SMART GRID COMMUNICATIONS AND MEASUREMENT TECHNOLOGY 9 Hours

Communication and Measurement - Monitoring, Phasor Measurement UNIT (PMU), Smart Meters, Wide Area Monitoring systems(WAMS)-Elements of the power grid and measurement technologies: generation, transmission, distribution, and end user-Basic concepts of power-load models-load flow analysis -wide area monitoring system (WAMS)-advanced metering infrastructure (AMI)and phasor measurement UNITs (PMU). ISDN–overview–interfaces and functions–layers and services–signalling System–broadband ISDN architecture and protocols

Unit 3: **SMART METERS AND ADVANCED METERING INFRASTRUCTURE** 9 Hours

Introduction to Smart Meters-Advanced Metering Infrastructure(AMI) drivers and benefits-AMI protocols-standards and initiatives-AMI needs in the smart grid-Policy and economic drives of the smart grid; environmental implications; sustainability issues; state of smart grid implementation.

Unit 4: POWER QUALITY MANAGEMENT IN SMART GRID 9 Hours

Power quality & EMC in Smart Grid- power quality issues of grid connected renewable energy sources-power quality conditioners for smart grid-web based power quality monitoring- power quality audit.

Unit 5: SMART GRID DEVICES 9 Hours

Load flow state of the art: classical, extended formulations, and algorithms–load flow for smart grid design- contingencies studies for smart grid-basics of web service and CLOUD computing to make smart grids smarter -cyber security for smart grid.

Text Book(s):

1. James Momoh, "Smart Grid: Fundamentals of design and analysis", John Wiley & sons Inc, IEEE press 2012.
2. Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihi kookoyam "Smart Grid: Technologyand Applications", John Wiley sons inc, 2012.

Reference(s):

1. Fereidoon P.Sioshansi, "Smart Grid: Integrating Renewable, Distributed & Efficient Energy", Academic Press, 2012.
2. Stuart Borlase "Smart Grid: Infrastructure, Technology and Solutions", CRC Press 2012.

Stream 2: Power Electronics & Automation Systems

213EEE2157 PRINCIPLES OF POWER ELECTRONICS

213EEE2157 PRINCIPLES OF POWER ELECTRONICS	*Credits*			
	L	***T***	***P***	***Total***
	3	**0**	**0**	**3**
Pre-requisite: Nil	**Course Category:** Open Elective - Theory			

Course Objective(s):

1. To get an overview of different types of power semi-conductor devices and their switching characteristics and to understand the operation, characteristics and performance parameters of controlled rectifiers.
2. To study the operation, switching techniques and basic topologies of DC-DC switching regulators.
3. To learn the different modulation techniques of pulse width modulated inverters and to understand the harmonic reduction methods.
4. To study the operation of AC voltage controller and Matrix converters.

Course Outcome(s):

After completing this course, the student will be able to:

CO1 : Describe the construction, working and Characteristics of various Power Semiconductor Devices.
CO2 : Analyze the performance characteristics of various types of phase controlled converter.
CO3 : Design and analyze the DC-DC converter.
CO4 : Describe the operation of inverter and analyze its performance.
CO5 : Design and analyze the performance of AC/ AC converter.

Course Topics:

Unit 1: POWER SEMI-CONDUCTOR DEVICES 9 Hours

Structure, operation and characteristics of SCR, TRIAC, Power transistor, MOSFET, IGBT and GTO- turn on and turn off characteristics- Introduction to Driver and Snubber circuits

Unit 2: PHASE–CONTROLLED CONVERTERS 9 Hours

2- pulse, 3-pulse, 6-pulse and dual converters- inverter operation of fully controlled converter – effect of source inductance – distortion and displacement factor – ripple factor – triggering circuits. Applications-light dimmer, solar PV systems

Unit 3: CHOPPERS 9 Hours

Step-down and step-up choppers – time ratio and current limit control – switching mode regulators – buck, boost, buck-boost converter– chopper control of DC motors. Applications-Battery operated vehicles

Unit 4: INVERTERS 9 Hours

Classification of inverters – single phase, three phase (both 120^0 mode and 180^0 mode) inverters– series inverter – parallel inverter –voltage control of single phase, three phase inverters – current source inverters, harmonic reduction in inverters. Applications-Induction heating, UPS

Unit 5: AC TO AC CONVERTERS 9 Hours

Single phase AC regulators – sequence control of AC regulators –three phase AC regulators – single phase to single phase cycloconverter – three phase half wave cycloconverter. Applications –welding.

Text Book(s):

1. Muhammad H. Rashid., Power Electronics: Circuits, Devices and Applications, Prentice Hall of India, Pearson education, 4th edition, 2013
2. Bhimbra.P. S. Power Electronics", Khanna publishers, Fifth edition
3. Sen .P C, "Power Electronics", Tata Mc Graw Hill Education, Twelfth edition
4. Singh. M.D., Power Electronics, Tata McGraw Hill publications, 2nd Edition, 2008.

Reference(s):

1. Ramamoorthy ,M., An Introduction to thyristor and their application, Affiliated East west press (P) Ltd, 2nd Edition, 1991
2. Ned Mohan, Power Electronics: Converters, Applications and Design, John Wiley and sons, 3rd edition, 2003
3. PowerTransmission: The HVDC Options, Wiley-Blackwell,2007
4. Joseph Vithayathil, "Power Electronics", Mc Graw Hill series in Electrical and Computer Engineering, USA, 1995.
5. Dubey.G.K, Doradia.S.R, Joshi, A. and Sinha.R.M, "Thyristorised Power Controllers", Wiley Eastern Limited, 1986.
6. Lander.W, "Power Electronics", McGraw Hill and Company, Third Edition, 1993.
7. LoganathanUmanand, "Power Electronics", Wiley India Pvt. Limited, 2009.

213EEE2159 AUTOMOTIVE ELECTRONICS ENGINEERING

213EEE2159 AUTOMOTIVE ELECTRONICS ENGINEERING	***Credits***			
	L	***T***	***P***	***Total***
	3	**0**	**0**	**3**
Pre-requisite:-	**Course Category:** Open Elective - Theory			

Course Objective(s):

The objective of this course is to prepare students for entry-level employment. By the end of this course the student, should have a thorough grasp of electronics system functions in Automotives. The student should understand and be able to diagnose problems with basic electronic systems and components in Automobiles.

Course Outcome(s):

After completing this course, the student will be able to:

CO1 : To understand the basic need of electronic system in vehicle
CO2 : To know the concepts and working of control systems in Automotives.
CO3 : To gain the concept of ignition system
CO4 : To understand the concepts and importance of electronics ignition system
CO5 : To understand the concepts of electrical equipment and electronics accessories used in Automobiles.

Course Topics:

UNIT I AUTOMOTIVE ELECTRONICS SYSTEM 9

Introduction to Electronic systems in Automotives – Sensors and Actuators for body electronics, power train and chassis systems. Body electronics domain- Automotive alarms, Lighting, Central locking and electric windows, Climatic Control, Driver information, parking, etc.

UNIT II ELECTRONICS CONTROL SYSTEM 9

Power train and chassis control domain – Engine management , Transmission control, ABS, ESP, Traction Control, Active Suspension, passive safety, Adaptive Cruise Control, etc. Hardware

implementation example of simple automotive systems using Sensors, Controller, Actuators etc.

UNIT III IGNITION SYSTEMS 9

Battery Coil and Magneto–Ignition System, Circuit details and Components of Battery Coil and Magneto–Ignition System, Centrifugal and Vacuum Advance Mechanisms, Spark plugs: Function, Requirements, Design, Constructional details and types, Electrode materials, Spark-plug concepts, Electrode gap, Spark position, Spark-plug heat ranges.

UNIT IV ELECTRONIC IGNITION SYSYTEMS 9

Electronically–Assisted and Full Electronic Ignition System, Non–Contact–type Ignition Triggering devices, Capacitive Discharge Ignition Distributor–less Ignition System, Digital Ignition System, Control Strategy of Electronic Ignition System. Electronic fuel Control: Basics of combustion – Engine fuelling and exhaust emissions – Electronic control of carburetion – Petrol fuel injection – Diesel fuel injection.

UNIT V WIRING, LIGHTING AND OTHER INSTRUMENTS 9

Electrical and electronic symbols, Automotive Wiring circuits, Circuit protection, Insulated and Earth Return System, Positive and Negative Earth Systems. External lightings: Fog lights, Tail lights, Turn signals, Daytime running lights, Headlights, Lighting circuits, Anti–Dazzling and Dipper Details, Regulations relating to external lights. Theory and Constructional Details of Dash Board Instruments and their Sensors like Speedometer, Odometer, Fuel Level Indicator, Oil Pressure and Coolant Temperature Indicators and other warning lamps. Auxiliaries – Circuits and working principles of Wiper motors, Headlight wipers and washers, Horns, Cooling fan motors, Electrical and Electronic Fuel Lift Pumps.

TEXT BOOKS

1. Young A.P. & Griffiths. L. “Automotive Electrical Equipment", ELBS & New Press- 1999.
2. William B.Riddens “Understanding Automotive Electronics", 5th edition - Butter worth Heinemann Woburn, 1998.

REFERENCES

1. Bechhold “Understanding Automotive Electronics", SAE, 1998.
2. Crouse, W.H “Automobile Electrical Equipment", McGraw-Hill Book Co., Inc., New York, 3rd edition, 1986.
3. Judge A.W “Modern Electrical Equipment of Automobiles", Chapman & Hall, London, 1992.
4. Kholi.P.L “Automotive Electrical Equipment", Tata McGraw-Hill Co., Ltd., New Delhi, 1975.
5. Robert Bosch “Automotive Hand Book", SAE (5th Edition), 2000.
6. Ganesan.V. “Internal Combustion Engines", Tata McGraw-Hill Publishing Co., New Delhi, 2003.

213EEE2160 BUILDING MANAGEMENT SYSTEM

213EEE2160 BUILDING MANAGEMENT SYSTEM	*Credits*			
	L	***T***	***P***	***Total***
	3	**0**	**0**	**3**
Pre-requisite:- Nil	**Course Category:** Open Elective – Theory			

Course Objective(s):

1. To manage the sub-systems within a building to ensure pleasant, controlled and safe environment
2. To control all or some of the following in a building: HVAC, CCTV, Access Control, Fire and Intruder Alarms, Lighting and Power Consumption

Course Outcome(s):

After completing this course, the student will be able to:

CO1 : Understand the basics of building automation and its design concepts

CO2 : Analyze electronics and electrical components and systems, and get familiarized with different tools of building automation

CO3 : Achieve networking in automation with necessary security systems

CO4 : Operate and program the PLC, SCADA and HMI for automation of buildings

CO5 : Understand the working concepts of alarms, panels & controls pertaining to building control and management

Course Topics:

UNIT I: INTRODUCTION TO BUILDING MANAGEMENT SYSTEM 9 Hours

Basic criteria of designing – BMS – components, Design concepts – Energy management systems – MEP fundamentals – Components of building automation system – HVAC, electrical, lighting, security, fire-fighting, communication – Integrated approach in design, maintenance and management system – Current trend and innovation in building automation systems – Impact of Information Technology – Application of expert system in building automation – Stages in development of expert system, expert system application in architecture – Computerizing building management information.

UNIT II: BASIC ELECTRONICS AND ELECTRICAL ENGINEERING

9 Hours

Electronic components – Network theory – Power electronics components – Familiarization of tools Multi-meter, Soldering, De-soldering – Selection of components – Single phase and three phase systems – Types of load & calculation – Measurement of current voltage, power – Types of motors – Basics of motors-dc motor, stepper, servo – Selection of servo motor and drives - Different types of earthing – Concept of two wire/ three wire controls.

UNIT III: NETWORKING AND SECURITY SYSTEMS 9 Hours

Concept of LAN, WAN – Implementing of networks – Sharing of files, printers, scanners etc – Network protocols- TCP/IP, ETHERNET – MODBUS, CANBUS, PROFIBUS – Transmission techniques – CCTV – Installation – Selection of camera – Cabling and termination – Different types of cameras – Night vision systems – DVR configuration – Intruder Alarms – GSM enabled control panel – PIR sensors – Vibration sensors – Gas leakage detectors – EM locks.

UNIT IV: PLC, SCADA / HMI 9 Hours

Monitoring the process through sensors – NO/ NC concept – Data file handling – forcing I/O – Wiring and fault correction – Programming practices – SCADA and HMI packages – Role of SCADA and HMI in building automation – Programming – Configuring alarms – Real time project development.

UNIT V: FIRE ALARMS, PANELS & CONTROLS 9 Hours

Sensors-heat, smoke, PIR – Conventional fire alarm panels – Addressable fire alarm panels – Cabling and safety standards – Biometric Access Control – Video door phones – Lighting controls – Solar panels – Ups and generators – Surge & lightening protection systems – Automatic gates & barriers – Security Automation – Biometric access control – RFID, Finger print, Magnetic locks.

Text Book(s):

1. G. J. Levermore, "Building Energy Management Systems: Applications to Low-energy HVAC and Natural Ventilation Control", Taylor & Francis, 2000
2. Shengwei Wang, "Intelligent Buildings and Building Automation", Routledge, Technology & Engineering, 2009
3. Doug Oughton, Steve Hodkinson, "Faber & Kell's Heating & Air-conditioning of Buildings", Routledge, Technology & Engineering, 2008

Reference(s):

1. Lal Jayamaha, "Energy-Efficient Building Systems : Green Strategies for Operation and Maintenance: Green Strategies for Operation and Maintenance", McGraw Hill Professional, 2006

213EEE2161 INSTRUMENTATION SYSTEMS

213EEE2161 INSTRUMENTATION SYSTEMS	***L***	***T***	***P***	***C***
	3	***0***	***0***	***3***
Co-requisite:- Nil	**Course Category:** Open Elective - Theory			

Course objectives:-

Instrumentation systems helps to create, construct and maintain measuring devices and systems found in manufacturing plants and research institutions. Its main objective is to ensure that systems and processes operate safely and efficiently. This course will provide anadequate exposure to various sensors, transducers, signal conditioning processes, data acquisition and interfacing. This course also provides detail knowledge about the usage of suitable sensing elements for the vital parameters like pressure, temperature, Speed, magnetic field, Current, Voltage & liquid level.

Course Outcome(s):

After completing this course, the student will be able to:

CO1 : Traceability of standards pertaining to calibration of instruments
CO2 : Understand the need of signal conditioning for sensors and transducers
CO3 : Understand the building blocks of Data Acquisition systems

CO4 : Find the suitable sensors/transducers for the measurement of pressure, temperature, speed and liquid level

CO5 : Find the suitable sensors/transducers for the measurement of magnetic field and electrical quantities

Mapping of Course Outcome(s):

CO / PSO	PSO														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
CO1	S	S			S								S		
CO2	S													S	
CO3		M	S		M								M		
CO4	S		S											M	
CO5	S	S	M												

Course Topics:

Unit-I: Introduction to Instrumentation

Role & Needs of instrumentation – Classification of Instrument - Functional elements of an instrumentation system –Generalised input and output configuration of instruments– Selection of Instruments – Calibration and Traceability of measuring Instruments - Phasor Measurement Unit (PMU) and its applications – Case Studies

Unit-II: Sensors and Transducers

Introduction to various Sensors- two wire, three wire & four wire sensors; Transducers and actuators – Review of signal conditioning/Processing – Review of signal transmission - noise and noise reduction Techniques – Grounding – Shielding – Display methods – SMART Sensors – MEMS - Nano Sensors

Unit-III: Data Acquisition and Interfacing

Data acquisition systems – Data acquisition configurations – Data Transmission – Pneumatic loop – Current Loop – Serial Interfaces-RS232 –RS485 – Communication Protocol – Highway Addressable Remote Transmitter (HART) - Fieldbus - Process Fieldbus(PROFIBUS)

Unit-IV: Application of Sensors for Physical Quantity Measurements

Pressure Measurement: Principles of pressure – Standards - Types of Sensors – Diaphragm - Bourdon Tube – Pirani Gauge – principle, operations & applications; **Temperature Measurement:** Temperature standards - Types of Sensors – Bimetallic strip – Resistance Temperature Detectors (RTD) – Thermistors – Thermocouples – Specifications- principle, operations & applications; **Speed Measurement**: Contact type - Tachometer generator, Non-Contact Type - Stroboscopic tachometer; **Liquid Level Measurement:** Various sensing methods- Float – Capacitive devices - Ultrasonic type – Fibre optic type - principle, operations & applications;

Unit-V: Application of Sensors for Magnetic and Electrical Quantity Measurements

Magnetic Field Measurement: Oscillating search coil – three orthogonal search coils – principles and applications; **Current & Voltage Measurement:** Hall effect sensor - Rogowski coil; Application of various sensors for the measurement of above said parameters.

Reference(s):

1. B.E. Noltingk, "Jones' Instrument Technology"- Instrumentation Systems, 4th Edition, Butterworths & Co., (Publishers) Ltd., 2016.
2. Tasuku Senbon, Futoshi Hanabuchi (Eds.), "Instrumentation Systems – Fundamentals and Applications", Springer-Verlag Berlin Heidelberg GmbH, 2013.

213EEE3162 EMBEDDED SYSTEM DESIGN

213EEE3162 EMBEDDED SYSTEM DESIGN	*Credits*			
	L	***T***	***P***	***Total***
	3	**0**	**0**	**3**
Pre-requisite: Nil	**Course Category:** Open Elective - Theory			

Course Objective(s):

1. To optimize hardware designs of custom single-purpose processors.
2. To compare different approaches in optimizing general-purpose processors.
3. To introduce different peripheral interfaces to embedded systems.
4. To understand the design trade-offs made by different models of embedded systems.
5. To apply knowledge gained in software-hardware integration in team-based projects

Course Outcome(s):

After completing this course, the student will be able to:

CO1 : Design the embedded process for simple application

CO2 : Describe the processor and component interfacing

CO3 : Understand the network protocols

CO4 : Analyze the different scheduling algorithm

CO5 : Design simple product using system design technology

Course Topics:

Unit 1: **EMBEDDED ARCHITECTURE**

Embedded computers, characteristics of embedded computing applications - challenges in embedded computing system design - embedded system design process – requirements – specification - architectural design - designing hardware and software components - system integration - formalism for system design – structural description - behavioural description - design example: model train controller.

Unit 2: **EMBEDDED PROCESSOR AND COMPUTING PLATFORM**

ARM processor – processor and memory organization - data operations - flow of control - memory devices - input/output devices - component interfacing - designing with microprocessor development and debugging - design example: alarm clock - component interfacing using LPC1768 controller.

Unit 3: **NETWORKS**

Distributed embedded architecture – hardware and software architectures - networks for embedded systems – I2C, CAN Bus - SHARC link p ports - ethernet, myrinet, internet, network – based design – communication analysis - system performance analysis - hardware platform design - allocation and scheduling - design example: elevator Controller - I2C and CAN bus interfacing using LPC1768 controller.

Unit 4: **REAL-TIME CHARACTERISTICS**

Clock driven approach - weighted round robin approach - priority driven approach - dynamic versus static systems - effective release times and deadlines - optimality of the Earliest Deadline First (EDF) algorithm - challenges in validating timing constraints in priority driven systems - off-line versus on-line scheduling - Task Scheduling.

Unit 5: S**YSTEM DESIGN TECHNIQUES**

Design methodologies - requirement analysis – specification - system analysis and architecture design - quality assurance - design example: telephone PBX – system architecture - ink jet printer – hardware design and software design - personal digital assistants - set-top boxes.

Text Book(s):

1. Wayne Wolf, Computers as Components: Principles of Embedded Computing System Design, Morgan Kaufman Publishers, 2016.
2. Jane.W.S. Liu Real–Time systems, Pearson Education Asia, 2004.

Reference(s):

1. C. M. Krishna and K. G. Shin, Real–Time Systems, McGraw–Hill, 2011.

2. Frank Vahid and Tony Givargi, Embedded System Design: A Unified Hardware/Software Introduction, s, John Wiley & Sons, 2011.

Experiential Electives

215EEE4163 ENERGY STORAGE SYSTEM

215EEE4163 ENERGY STORAGE SYSTEM	Credits			
	L	*T*	*P*	*Total*
	3	*0*	*0*	*3*
Prerequisite: Nil	**Course Category:** Honors - Elective			

Course Objective(s):

Understand the necessity and usage of different energy storage schemes for different purposes
Have a technological overview of various energy storage schemes
Understand the operational mechanisms of each energy storage system
Be able to characterize and analyze electrochemical energy storages

Course Outcome(s):

After completing this course, the student will be able to:

CO1: Apply engineering fundamentals to design and implement alternate energy storage technologies
CO2: To understand the principles behind the hydrogen storage
CO3: To understand knowledge on various kinds of batteries
CO4: To acquire knowledge on battery charging and charge controller
CO5: To fabricate and investigate the performance of selected energy storage solutions (e.g. fuel cells)

Mapping of Course Outcome(s):

CO / PSO	PSO														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CO1	S												S		
CO2	S	S											S		
CO3	S	S											S		
CO4	S	S	S	S				M					S	S	M
CO5	S	S	S	M				S				M	S	M	S

Course Topics:

Unit1: ENERGY STORAGE METHODS 9 Hours

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.

Unit2: HYDROGEN ENERGY STORAGE SYSTEMS 9 Hours

Block diagram of Hydrogen energy systems - Properties of Hydrogen - Extraction methods of Hydrogen: Thermochemical methods - Electrolysis of water-Thermolysis of water- Bio photolysis - Hydrogen storage techniques Delivery of Hydrogen-Conversion of Hydrogen - Applications-Safety Issues.

Unit3: ENERGY STORAGE USING BATTERIES 9 Hours

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.

Unit4: BATTERY CHARGING AND CHARGE CONTROLLERS 9 Hours

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 5: APPLICATIONS OF ENERGY STORAGE 9 Hours

Renewable energy storage-Battery sizing and stand-alone applications, stationary (Power Grid application), Small scale application-Portable storage systems and medical devices, Mobile storage Applications- Electric vehicles (EVs), types of EVs, batteries and fuel cells, future technologies, hybrid systems for energy storage.

Text Book(s):

1. Ter-Gazarian, A.G.Energy Storage for Power Systems, 2nd Edition, IET Publications, 2011.
2. Khan B.H.,"Non-Conventional Energy Resources", Tata McGraw Hill Publication, 2nd Edition, 2009.
3. Chetan Singh Solanki., "Solar Photovoltaics: Fundamentals, Technologies and Applications", PHI Learning Private Limited, 2nd Edition, 2012.

Reference(s):

1. Robert A. Huggins, "Energy Storage", Springer Science & Business Media, 2010.
2. **Huggins**, Robert, "Energy Storage Fundamentals, Materials and Applications",2nd Edition, Springer International Publishing, 2016

215EEE4164 ADVANCED CONTROL THEORY

215EEE4164 ADVANCED CONTROL THEORY	*Credits*			
	L	***T***	***P***	***Total***
	3	***0***	***0***	***3***
Pre-requisite:Nil	**Course Category:** Honors Elective – Theory			

Course Objective(s):

To gain knowledge in the field of the advanced methods of automatic control for real dynamic systems.

To learn the various models, analysis and design using state variable techniques (e.g. robots) with parametric uncertainty and signal disturbances

To provide adequate knowledge in the Phase plane analysis, describing function analysis and stability analysis of linear and non-linear systems.

To give a basic knowledge in describing function analysis.

To analyze the stability of the systems using different techniques.

To study the design of optimal controller

Course Outcome(s):

After completing this course, the student will be able to:

CO1: Design the Controllers & Compensators

CO2: Determine the time and frequency responses of I and II order systems for various inputs

CO3: Analyze the stability of the system using Time domain and frequency domain methods

CO4: Design the compensators using Bode plot and root locus techniques

CO5: Solve the state equation by transformation methods.

Mapping of Course Outcome(s):

CO / PSO	PSO														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CO1	S	S	S	S	S								S		
CO2	S	S	S	S	S								S	S	
CO3	S	S	M	S	S							M	S	M	
CO4	S	S	S	S	M								S	S	
CO5	S	S	S										S		

Course Topics:

Unit 1: CONTROL SYSTEM DESIGN BY FREQUENCY RESPONSE APPROACH 9 Hours

Control system design by frequency response approach- root locus method-lead, lag and lead lag compensation. PI, PD and PID controllers design procedures and examples.

Unit 2: STATE SPACE ANALYSIS 9 Hours

Concept of state , State Variable and State Model, State Space Representation, Solution of State Equation, State Transition Matrix, State models for linear and continuous time systems – Solution of state and output equation, Canonical Forms – Controllable Canonical Form, Observable Canonical Form, Jordan Canonical Form. Controllability and Observability. Discritisation of continuous time state equations. Solution of state difference equation, controllability and Observability tests for continuous time systems &Digital Control Systems.

Unit 3: EIGEN VALUE AND EIGENVECTOR SENSITIVITIES IN LINEAR SYSTEM 9 Hours

Continuous time systems: Introduction, first-order Eigen value sensitivities, first order eigenvector - Sensitivities, second-order Eigen value sensitivities, second-order Eigenvector sensitivities. Mode-Controllability Matrix: Distinct Eigen-values, confluent Eigen-values associated with single Jordan block, confluent Eigen-values associated with number of distinct Jordan blocks, confluent Eigen-values associated with a number of non-distinct Jordan block. Mode –Controllability structure of multivariable linear systems

Unit 4: OBSERVABILITY MATRICES &PHASE PLANE ANALYSIS 9 Hours

Distinct Eigen-values, confluent Eigen-values, mode observability structure of multivariable linear systems: Introduction, Features of linear and non-linear systems: Common physical nonlinearities: Methods of linearizing non-linear systems ,Concept of phase portraits Plane Analysis , – Phase plane analysis of linear and non-linear systems – basic concept, Singular points – Limit cycles construction of phase trajectories – Isocline and delta methods, Describing function – basic concept – derivation of describing functions – stability analysis by describing function method.

Unit 5: LYAPUNOV STABILITY ANALYSIS: 9 Hours

Stability of equilibrium state, asymptotic stability, graphical representation, Second method of Lyapunov, stability in the sense of Lyapunov, Lyapunov's first and second methods Stabilitydefinitions, Stability theorems, Lyapunov functions for linear and non-linear systems Lyapunov stability theorems, stability analysis of linear systems, nonlinear systems, construction of Lyapunov functions using Krasovskii method, variable gradient method Lyapunov stability analysis of linear time varying systems.Lyapunov stability Analysis-Basic concepts.

Text Book(s):

1. Advanced Control Systems B. N. Sarkar, PHI Learning Private Limited (2014).
2. Advanced Control Theory, Somanath Majhi, Cengage Learning,2017
3. Digital Control And State Variable Methods 5th Edition,M.Gopal, Tata Mcgraw –Hill (Sep-08)
4. Optimal Control Theory: An Introduction. Donald E. Kirk, Dover Publications (30-apr-06)
5. Digital Control Systems Second Edition, Benjamin C. Kuo , Oxford University Press (2017)

Reference(s):

1. M. Gopal, "Modern Control System Theory", Wiley Eastern Ltd., New Delhi,2017
2. G. J. Thaler, "Automatic Control Systems", Jaico Publishing House, 2013.
3. Modal Control theory and applications – Brian Porter & Roger Corssley.
4. K. Ogata, "Modern Control Engineering", 3 ed. Prentice Hall of India (P) Ltd.,New Delhi.
5. Dr. K.P. Mohandas, .Modern Control Engineering., revised edition, SanguinePublishers, Bangalore, 2006.

215EEE4165 DISTRIBUTED GENERATION AND MICRO GRID

215EEE4165 DISTRIBUTED GENERATION AND MICRO GRID	***Credits***			
	L	***T***	***P***	***Total***
	3	***0***	***0***	***3***
Pre requisite: Nil	**Course Category:** Honors– Elective			

COURSE OUTCOMES:

After successful completion of course, the students will be able,

CO1 - To understand the energy crises and its remedies
CO2 - To understand the principles and standards of Distributed generation
CO3 - To analyze the impact of DG with grid
CO4 - To understand the concept of microgrid
CO5 - To analyze the issues for power quality in microgrid

Mapping of Course Outcome(s):

CO / PSO	**PSO**														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
CO1	S												S		
CO2	S	S											S		
CO3	S	S											S		
CO4	S	S	S	S				M					S	S	M
CO5	S	S	S	M				S				M	S	M	S

Unit 1 INDRODUCTION

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

Unit 2 DISTRIBUTED GENERATION

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 3 IMPACT OF GRID INTEGRATION

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 4 MICROGRIDS

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

Unit 5 POWER QUALITY ISSUES IN MICROGRIDS

Modelling and Stability analysis of Microgrid, regulatory standards, Microgrid economics, smart microgrids.

REFERENCE BOOKS

1. AmirnaserYezdani, and Reza Iravani, "Voltage Source Converters in Power Systems: Modeling, Control and Applications", IEEE John Wiley Publications, 2009.
2. Dorin Neacsu, "Power Switching Converters: Medium and High Power", CRC Press, Taylor & Francis, 2006.
3. Chetan Singh Solanki, "Solar Photo Voltaics", PHI learning Pvt. Ltd., New Delhi, 2009.

TEXT BOOKS

1. J.F. Manwell, "Wind Energy Explained, theory design and applications," J.G. McGowan Wiley publication, 2002.
2. D. D. Hall and R. P. Grover, "Biomass Regenerable Energy", John Wiley, New York, 1987.
3. John Twidell and Tony Weir, "Renewable Energy Resources" Tyalor and Francis Publications, 2005.

215EEE4166 POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEM

215EEE4166 POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEM	***Credits***			
	L	***T***	***P***	***Total***
	3	***0***	***0***	***3***
Pre-requisite:Nil	**Course Category:** Honors Elective – Theory			

Course Objective(s):

To Provide knowledge about the stand alone and grid connected renewable energy systems and to analyze the various operating modes of wind electrical generators and solar energy systems. To develop maximum power point tracking algorithms.

Course Outcome(s):

After completing this course, the student will be able to:

CO1: To provide knowledge about the stand alone and grid connected renewable energy systems.

CO2: To equip with required skills to derive the criteria for the design of power converters for renewable energy applications

CO3: To analyze and comprehend the various operating modes of wind electrical generators and solar energy systems.

CO4: To design different power converters namely AC to DC, DC to DC and AC to AC converters for renewable energy systems.

CO5: To develop maximum power point tracking algorithms

Mapping of Course Outcome(s):

CO / PSO	PSO														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
CO1	S												S		
CO2			S				S					S	S	S	S
CO3	S		S	S	M	S	S					S	S	S	S
CO4	M	S				S	M						M		M
CO5	S		M	M	S	S	S					M	S	S	M

Course Topics:

Unit 1: INTRODUCTION 9 Hours

Environmental aspects of electric energy conversion: impacts of renewable energy generation on environment (cost-GHG Emission) - Qualitative study of different renewable energy resources: Solar, wind, ocean, Biomass, Fuel cell, Hydrogen energy systems and hybrid renewable energy systems

Unit 2: ELECTRICAL MACHINES FOR RENEWABLE ENERGY CONVERSION 9 Hours

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

Unit 3: POWER CONVERTERS 9 Hours

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

Unit 4: ANALYSIS OF WIND AND PV SYSTEMS 9 Hours

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

Unit 5: HYBRID RENEWABLE ENERGY SYSTEMS 9 Hours

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

Text Book(s):

1. S. N. Bhadra, D.Kastha, S.Banerjee, "Wind Electrical Systems", Oxford University Press,2005.
2. B.H.Khan Non-conventional Energy sources Tata McGraw-hill Publishing Company,New Delhi,2009.

Reference(s):

1. Rashid .M. H "power electronics Hand book", Academic press, 2001.
2. Ion Boldea, "Variable speed generators", Taylor & Francis group, 2006.
3. Rai. G.D, "Non-conventional energy sources", Khanna publishes, 1993.
4. Andrzej M. Trzynnadlowski, 'Introduction to Modern Power Electronics', Second edition, wiley India Pvt. Ltd, 2012.

215EEE4167 POWER SYSTEM STABILITY AND CONTROL

215EEE4167 POWER SYSTEM STABILITY AND CONTROL	Credits			
	L	*T*	*P*	*Total*
	3	*0*	*0*	*3*
Prerequisite: Nil	**Course Category:** Honors – Elective – Theory			

Course Objective(s):

• To understand the fundamental concepts of stability of power systems and its classification.
• To expose the students to dynamic behaviour of the power system for small and large disturbances.
• To understand and enhance the stability of power systems.

OUTCOMES:

1. Learners will attain knowledge about the stability of power system
2. Learners will have knowledge on small-signal stability,
3. Learners will have knowledge on transient stability
4. Learners will be able to understand the dynamic behaviour of synchronous generator for different disturbances and voltage stability.
5. Learners will be able to understand the various methods to enhance the stability of a power system.

UNIT I INTRODUCTION TO STABILITY

Fundamental concepts - Stability and energy of a system - Power System Stability: Definition, Causes, Nature and Effects of disturbances, Classification of stability, Modelling of electrical components - Basic assumptions made in stability studies, Modelling of Synchronous machine for stability studies(classical model) - Rotor dynamics and the swing equation.

Unit II: SMALL-SIGNAL STABILITY

Basic concepts and definitions – State space representation, Physical Interpretation of small–signal stability, Eigen properties of the state matrix: Eigen values and eigenvectors, modal matrices, eigen value and stability, mode shape and participation factor. Small– signal stability analysis of a Single-Machine Infinite Bus (SMIB) Configuration with numerical example.

UNIT III TRANSIENT STABILITY

Review of numerical integration methods: modified Euler and Fourth Order Runge-Kutta methods, Numerical stability, and Interfacing of Synchronous machine (classical machine) model to the transient stability algorithm (TSA) with partitioned – explicit approaches Application of TSA to SMIB system.

UNIT IV VOLTAGE STABILITY

Factors affecting voltage stability- Classification of Voltage stability-Transmission system characteristics- Generator characteristics- Load characteristics- Characteristics of reactive power compensating Devices- Voltage collapse.

UNIT V ENHANCEMENT OF SMALL-SIGNAL STABILITY AND TRANSIENT STABILITY

Power System Stabilizer –. Principle behind transient stability enhancement methods: high-speed fault clearing, regulated shunt compensation, dynamic braking, reactor switching, independent pole-operation of circuit-breakers, single-pole switching, fast valving, high-speed excitation systems.

TEXT BOOKS:

1. Power system stability and control, P. Kundur ; edited by Neal J. Balu, Mark G. Lauby, McGraw-Hill, 1994.

2. R.Ramnujam," Power System Dynamics Analysis and Simulation, PHI Learning Private Limited, New Delhi, 2009

3. T.V. Cutsem and C.Vournas, "Voltage Stability of Electric Power Systems", Kluwer publishers, 1998.

REFERENCES

1. Peter W., Saucer, Pai M.A., "Power System Dynamics and Stability, Pearson Education (Singapore), 9th Edition, 2007.

2. EW. Kimbark., "Power System Stability", John Wiley & Sons Limited, New Jersey, 2013.

3. SB. Crary., "Power System Stability", John Wiley & Sons Limited, New Jersey, 1955.

4. K.N. Shubhanga,"Power System Analysis" Pearson, 2017.

5. Power systems dynamics: Stability and control / K.R. Padiyar, BS Publications, 2008

6. Power system control and Stability P.M. Anderson, A.A. Foud, Iowa State University Press, 1977.

215EEE4168 POWER SYSTEM RESTRUCTURING

215EEE4168 POWER SYSTEM RESTRUCTURING	Credits			
	L	*T*	*P*	*Total*
	3	*0*	*0*	*3*
Prerequisite: Nil	**Course Category:** Honors – Elective – Theory			

Course Objective(s):

To expose the flexibility of restructuring.

To Study about private sectors

Course Outcome(s):

After completing this course, the student will be able to:

CO1: To elucidate the concept of Deregulation, different entities, market structures and bidding

CO2: To understand the transmission pricing issues and Ancillary services

CO3: To address the technical challenges in Restructuring

CO4: To know the concepts of ancillary services management

CO5: To understand the concepts of technical challenges and availability of tariff

Mapping of Course Outcome(s):

CO / PSO	PSO														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
CO1	S												S		
CO2	S	S											S		
CO3	S	S											S		
CO4	S	S	S	S				M					S	S	M
CO5	S	S	S	M				S				M	S	M	S

Course Topics:

Unit1: INTRODUCTION 9 Hours

Introduction about deregulation – Structure of restructured electric utility – Different entities – Deregulation situation around the world (Qualitative treatment) – Benefits from competitive electricity market – After effects of deregulation. Role of Load Managers

Unit2: POWER SYSTEM OPERATION IN COMPETITIVE ENVIRONMENT 9 Hours

Role of ISO – Comparison of two different market structures – Operational planning activities of ISO – ISO in bilateral markets – Operational planning activities of GENCO – GENCO in pool and bilateral markets – Market participation issues – Competitive bidding

Unit3: TRANSMISSION OPEN ACCESS AND PRICING ISSUES 9 Hours

Power wheeling – Types of transmission services in open access – Cost components in transmission – Pricing of power transactions – Pricing mechanisms in various countries. Open-access Coordination Strategies; Power Wheeling- Transmission Cost Allocation Methods

Unit4: ANCILLARY SERVICES MANAGEMENT 9 Hours

General description of some ancillary services – Ancillary service management in various countries – Reactive power as an ancillary service – Synchronous generators as ancillary service

providers, Open Access Distribution – Changes in Distribution Operations-The Development of Competition – Maintaining Distribution Planning

Unit5: TECHNICAL CHALLENGES AND AVAILABILITY BASED TARIFF **9 Hours**

Total Transfer Capability – Limitations - Margins – Available transfer capability (ATC) – Procedure - Methods to compute ATC – Static and Dynamic ATC –Concept of Congestion Management – Bid, Zonal and Node Congestion Principles - Generation Rescheduling. Availability based tariff – Necessity – Working Mechanism – Beneficiaries– Trading Surplus Generation – Applications. Indian energy exchange- Indian power exchange- Infrastructure model for power exchanges Congestion Management-Day Ahead Market- Online power trading.

Text Book(s):

1. Kankar Bhattacharya, Math H.J. Bollen and Jaap E. Daalder, "Operation of Restructured Power Systems", Kluwer Academic Publishers, First Edition, 2001.
2. Loi Lei Lai, "Power system Restructuring and Regulation", John Wiley sons, 2001.
3. Loi Lei Lai, 'Power System Restructuring and Deregulation', John Wiley& Sons Inc., New York, HRD Edition, 2001.
4. 4. Mohammad Shahidehpour, Hatim Yamin, 'Market Operations in Electric Power Systems', John Wiley & Sons Inc., 2002.
5. 5. Lorrin Philipson, H. Lee Willis, 'Understanding Electric Utilities and Deregulation', Taylor & Francis, New York, 2nd Edition, 2006.

Reference(s):

6. Shahidehpour.M and Alomoush.M, "Restructuring Electrical Power Systems", Marcel Decker Inc., 2001.
7. G.Zaccour, "Deregulation of Electric Utilities", Kluwer Academic Publishers 1998.
8. M.Illic, F.Galiana and L.Fink, "Power Systems Restructuring: Engineering and Economics", Kluwer Academic Publishers, 2000.
9. Mohammad Shahidehpour, Muwaffaq Alomoush, 'Restructured Electrical Power Systems', Marcel Dekker, INC., New York, 1st Edition, 2001.

215EEE4169 DIGITAL RELAYING AND PHASOR MEASUREMENT UNIT

215EEE4169 DIGITAL RELAYING AND PHASOR MEASUREMENT UNIT	***Credits***			
	L	***T***	***P***	***Total***
	3	***0***	***0***	***3***
Prerequisite: Nil	**Course Category:** Honors – Elective – Theory			

Course Objective(s):

The goal of this course is to understand the operating principles of a computer relay s and wide area measurement systems. Learning about main classification of relay types, wide area measurement systems and their behavior, mathematical background for understanding relaying algorithms and also examining line relaying algorithms and protection of power system components. It will be discussed about several hardware related question-such as the computer hierarchy in the substation, subsystems of a computer relay and analog to digital converters as and system relaying and control.

Course Outcome(s):

After completing this course, the student will be able to:

CO1: To know the basic concepts of protection algorithm
CO2: To understand the basic elements of digital protection
CO3: To gain the knowledge in phasor measurement
CO4: To understand the applications of phasor measurement UNIT
CO5: To understand the concept of adaptive protection

Mapping of Course Outcome(s):

CO / PSO	PSO														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
CO1	S												S		
CO2	S	S											S		
CO3	S	S											S		
CO4	S	S	S	S				M					S	S	M
CO5	S	S	S	M				S				M	S	M	S

Course Topics:

Unit1: MATHEMATICAL BACKGROUND TO PROTECTION ALGORITHMS **9 Hours**

Finite difference technique-Numerical differentiation-Least Squares Method-Fourier analysis-Fourier analysis of analog signals-Fourier analysis of discrete signals-Walsh function analysis.

Unit2: BASIC ELEMENTS OF DIGITAL PROTECTION **9 Hours**

Signal conditioning subsystem-Transducers-Surge protection circuits-Analog filtering-Analog multiplexers-Conversion subsystem-Sampling theorem-Signal aliasing error-Sample and hold circuit-Digital multiplexing-Digital-to-Analog Conversion-Analog-to-Digital Conversion-Processor-Data and Program memory-Digital relay hardware unit.

Unit3: PHASOR MEASUREMENT **9 Hours**

Introduction-Phasor representation of sinusoids-Phasor Estimation of Nominal Frequency Signals-Formulas for updating phasors –Nonrecursive updates-Recursive updates-Frequency Estimation.

Unit4: PHASOR MEASUREMENT APPLICATIONS **9 Hours**

State Estimation-History-Operator's load flow-Weighted least square -Linear weighted least squares; Nonlinear weighted least squares-Static state estimation-State estimation with Phasor measurements-linear state estimation.

Unit5: ADAPTIVE PROTECTION **9 Hours**

Differential and distance protection of transmission lines-Adaptive out-of-step protection.

Text Book(s):

1. Arun G. Phadke, James S. Thorp, 'Computer Relaying for Power Systems', A John Wiley and Sons Ltd., Research Studies Press Limited, 2009.
2. A.G. Phadke, J.S. Thorp, 'Synchronized Phasor Measurements and Their Applications', Springer, 2008.

Reference(s):

1. Arun G Phadke James S Thorp, 'Computer Relaying for Power Systems, Wiley Publication, 2nd Edition, 2009.

215EEE4170 POWER SYSTEM OPTIMIZATION

215EEE4170 POWER SYSTEM OPTIMIZATION	*Credits*			
	L	***T***	***P***	***Total***
	3	***0***	***0***	***3***
Pre-requisite: Nil	**Course Category:** Honors Elective – Theory			

Course Objective(s):

Introduction to power system optimization problems, importance, and linkages. Understanding solution techniques suitable for specific problems

Course Outcome(s):

After completing this course, the student will be able to:

CO1: To apply well-known optimization techniques to power system problem.

CO2: To solve the economic dispatch and UNIT commitment problem using optimization techniques.

CO3: To analyze the hydro thermal scheduling problems

CO4: To solve the optimal power flow problem of electrical power systems

CO5: To understand the knowledge of maintenance scheduling of thermal plants

Mapping of Course Outcome(s):

CO / PO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	S	S											S		
CO2	S	S	S	M	S	S							S	S	
CO3	S	M	S	S	S	M							S	S	
CO4	S	S	S	S	M								S	S	
CO5	S					S	S					S	S	M	S

Course Topics:

Unit 1: OPTIMIZATION TECHNIQUES

Introduction, Statement of an optimization problem, design vector, design constraints, constraint surface, objective function, classification of optimization problem. Classical optimization Techniques, single variable optimization, multivariable optimization with equality constraints, Direct substitution method, constrained variation method, Lagrange Multiplier method, formulation of multivariable optimization, Kunh-Tucker conditions.

Unit 2: ECONOMIC DISPATCH AND UNIT COMMITMENT

Incremental cost curve – co-ordination equations with loss and without loss– solution by direct method and Iteration method – base point and participation factors method – two generator system, coordination equations, incremental losses and penalty factors-Constraints in UNIT commitment – spinning reserve, thermal UNIT constraints, other constraints – solution using priority list

method, dynamic programming method – forward DP approach – Lagrangian relaxation method, adjusting

Unit 3: GENERATION SCHEDULING–THERMAL AND HYDROTHERMAL SYSTEM

Long range hydro scheduling – short range hydro scheduling – hydroelectric plant models – scheduling problems – short term hydrothermal scheduling problem – solution using lamda iteration method – dynamic programming, pumped storage schemes.

Unit 4: OPTIMAL POWER FLOW

Solution of optimal power flow (OPF) – Gradient method, Newton's method, linear sensitivity analysis – LP methods with real power variables only – LP method with AC power flow variables and detailed cost functions – security constrained optimal power flow – interior point algorithm – bus incremental costs.

Unit 5: MAINTENANCE SCHEDULING

Factors considered in maintenance scheduling – generator UNITs, turbines, boilers– maintenance scheduling using mathematical programming.

Text Book(s):

1. Dhillon.J., Kothari.D.P., Power System Optimization, Prentice Hall India,2004.
2. Power System Optimization, Kothari D. P. (Author), Dhillon J. S. (Author), PHI; 2 edition(2010).

Reference(s):

1. Allen J.Wood., Bruce F Wollenberg, Power Generation, Operation and control, John Wiley and sons, Newyork, Third Edition, 2013.
2. Mahalanabis. A.K., et.al., Computer Aided Power System Analysis and Control, Tata McGraw Hill Publishing Co. Ltd., NewDelhi 1988.
3. Power System Engineering, D Kothari (Author), I Nagrath (Author), Mcgraw Hill Education (India) Private Limited; 2 Edition (9 July 2007).

215EEE4171 INDUSTRIAL ELECTRONICS

215EEE4171 INDUSTRIAL ELECTRONICS	***Credits***			
	L	***T***	***P***	***Total***
	3	**0**	**0**	**3**
Pre-requisite:- NIL	**Course Category:** Honors Elective – Theory			

Course Objective(s):

1. To get an overview of different types of power semiconductor devices and their switching characteristics.
2. To understand the operation, characteristics and performance parameters of controlled rectifiers.

3. To study the operation, switching techniques and basic topologies of DC-DC switching regulators.

Course Outcome(s):

After completing this course, the student will be able to:

CO1 : Illustrate the concept of power switches, components and systems.
CO2 : Design and analyze the Power Electronic Converters.
CO3 : Design the control of power electronic converters using different modulation techniques.
CO4 : Control the motor using power electronics converters.
CO5 : Illustrate the application of Industrial Electronics.

Course Topics:

UNIT I: POWER SWITCHES, COMPONENTS AND SYSTEMS

Principles and Methods of power electric conversion – Semiconductor power switches – Components and systems

UNITII: POWER ELECTRONICS CONVERTERS

AC/DC converters (Rectifiers) – DC/AC converters (Inverters) – AC/AC converters (Changers) – DC/DC converters (Choppers)

UNITIII: POWER ELECTRONICS CONTROLS

Phase modulation – Block modulation – Pulse width modulation – Space vector modulation

UNIT IV: MOTOR CONTROL

AC voltage controller – Zero voltage switches – Synchronous tap changer – DC motors phase control – Induction motor – DC series motor chopper control – Stepper motors – Servo – PLL control of DC motors

UNIT V: GENERAL APPLICATIONS

Capacitor charging applications – Power supplies – UPS – Automotive applications – Power electronics and clean energy – Introduction to Industrial Robots

Text Book(s):

1. Muhammad H. Rashid., Power Electronics: Circuits, Devices and Applications, Prentice Hall of India, Pearson education, 4th edition, 2013
2. P.S.Bimbhra, Power Electronics, Khanna Publishers,5th edition,2012.
3. Valery Vodovozov, Introduction to Power Electronics, free e-book at bookboon.com
4. Andrzej M. Trzynadlowski, Introduction to Modern Power Electronics, Wiley India, 2nd Edition, 2010
5. Biswanath Paul, Industrial Electronics and Control: Including Programmable Logic Controller, PHI, 2nd Edition, 2009

Reference(s):

1. P C Sen, Power Electronics, TMH, 2008.

215EEE4172 PWM CONVERTERS AND APPLICATIONS

215EEE4172 PWM CONVERTERS AND APPLICATIONS	L	T	P	C
	3	0	0	3
Pre-requisite:- NIL	**Course Category:** Honors Elective – Theory			

Course Outcomes:
Students will be able to:
CO 1: Knowledge about basic concepts of Power converters.
CO 2: Understand basic operation of PWM Techniques
CO 3: Learn the steady-state and dynamic model of PWM converters along with VFD.
CO 4: Able to understand about ripple calculations in drives.
CO5: Describe about various compensation devices.

Unit 1: PRINCIPLE OF POWER CONVERTERS

AC/DC and DC/AC power conversion, overview of applications of voltage source converters, pulse modulation techniques for bridge converters.

Unit 2: PWM TECHNIQUES

Bus clamping PWM, space vector based PWM, advanced PWM techniques, practical devices in converter; calculation of switching and conduction losses.

Unit 3: DYNAMIC MODEL

Compensation for dead time and DC voltage regulation; dynamic model of a PWM converter, multilevel converters; constant V/F induction motor drives.

Unit 4: RIPPLE CALCULATION

Estimation of current ripple and torque ripple in inverter fed drives; line - side converters with power factor compensation, Power Factor improvement

Unit 5: COMPENSATION USING POWER CONVERTERS

Compensation techniques, Active power filtering-reactive power compensation; harmonic current compensation.

REFERENCES

1. Mohan, Undeland and Robbins,' Power Electronics; Converters, Applications and Design',John Wiley and Sons, 1989.
2. Erickson R W,' Fundamentals of Power Electronics', Chapman and Hall, 1997. Vithyathil J,'Power Electronics: Principles and Applications ', McGraw Hill, 1995.

215EEE4173 POWER SWITCHING DEVICES

215EEE4173 POWER SWITCHING DEVICES		L	T	P	C
		3	0	0	3
Pre-requisite:- NIL	**Course Category:** Honors Elective – Theory				

COURSE OUTCOMES:
After successful completion of course, the students will be able,

CO1: Understand the switching characteristics of Power Switching Devices.
CO2: Understand the construction and characteristics of various current controlled devices and analyze the steady state and dynamic model of current controlled devices.
CO3: Understand the construction and characteristics of various voltage controlled devices and analyze the steady state and dynamic model of voltage controlled devices.
CO4: Design the firing and protection circuit for Power semiconductor devices.
CO5: Design the thermal protection for Power semiconductor devices.

SWITCHING CHARACTERISTICS
Overview of Power switching devices - Attributes of an ideal switch, application requirements, circuit symbols; Power handling capability - Safe Operating Area (SOA); Device selection strategy - On-state and switching losses - EMI due to switching - Power diodes - Types, forward and reverse characteristics, switching characteristics - rating.

CURRENT CONTROLLED DEVICES

BJTs - Construction, static characteristics, switching characteristics; Negative temperature co-efficient and secondary breakdown; Power Darlington - Thyristors - Physical and electrical principle underlying operating mode, Two transistor analogy - concept of latching; Gate and switching characteristics; converter grade and inverter grade and other types; series and parallel operation; comparison of BJT and Thyristor - steady state and dynamic models of BJT & Thyristor.

VOLTAGE CONTROLLED DEVICES

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

FIRING AND PROTECTING CIRCUITS
Necessity of isolation, pulse transformer, optocoupler - Gate drive circuits: SCR, MOSFET, IGBT and base driving for power BJT - Over voltage, over current and gate protections; Design of snubbers.

THERMALPROTECTION
Heat transfer - conduction, convection and radiation; Cooling - liquid cooling, vapour - phase cooling; Guidance for hear sink selection - Thermal resistance and impedance - Electrical analogy of thermal components, heat sink types and design - Mounting type.

TEXT BOOKS

1. B.W Williams "Power Electronics Circuit Devices and Applications".
2. Rashid M.H., "Power Electronics Circuits, Devices and Applications ", Prentice Hall India, Third Edition, New Delhi, 2004.

REFERENCES

1. MD Singh and K.B Khanchandani, "Power Electronics", Tata McGraw Hill, Second Edition, 2009.
2. Mohan, Undcland and Robins, "Power Electronics - Converters, applications and Design, John Wiley and Sons, Third Edition, Singapore, 2003.

215EEE4174 DIGITAL SIGNAL PROCESSING

215EEE4174 DIGITAL SIGNAL PROCESSING	***Credits***			
	L	***T***	***P***	***Total***
	3	***0***	***0***	***3***
Pre-requisite: Nil	**Course Category:** Honors Elective – Theory			

Course Objective(s):

To impart knowledge about the following topics: Signals and systems & their mathematical representation, Discrete time systems, Transformation techniques & their computation, Filters and their design for digital implementation, Programmability digital signal processor & quantization effects.

Course Outcome(s):

After completing this course, the student will be able to:

CO1: Understanding the concepts of Signals and systems & their mathematical representation.
CO2: Analyze the discrete time system by using Z transform
CO3: Compute the discrete DFT by using FFT algorithm
CO4: Design of IR and FIR filters
CO5: Study of digital signal processors

Mapping of Course Outcome(s):

CO / PSO	**PSO**														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
CO1	S												S		
CO2		S	S										S		
CO3		S	S										S		
CO4		M											M		
CO5	M												M		

Course Topics:

Unit1: INTRODUCTION
Classification of systems: Continuous, discrete, linear, causal, stability, dynamic, recursive,time variance; classification of signals: continuous and discrete, energy and power; mathematical representation of signals; spectral density; sampling techniques, quantization, quantization error, Nyquist rate, aliasing effect.

Unit2: DISCRETE TIME SYSTEM ANALYSIS
Z-transform and its properties, inverse z-transforms; difference equation – Solution by ztransform, application to discrete systems – Stability analysis, frequency response – Convolution – Discrete Time Fourier transform, magnitude and phase representation.

Unit3: DISCRETE FOURIER TRANSFORM & COMPUTATION
Discrete Fourier Transform- properties, magnitude and phase representation – Computation of DFT using FFT algorithm – DIT &DIF using radix 2 FFT – Butterfly structure.

Unit4: DESIGN OF DIGITAL FILTERS
FIR & IR filter realization – Parallel & cascade forms. FIR design: Windowing Techniques – Ned and choice of windows – Linear phase characteristics. Analog filter design – Butterworth and Chebyshev approximations; IR Filters, digital design using impulse invariant and bilinear transformation Warping, pre warping.

Unit 5: DIGITAL SIGNAL PROCESSORS
Introduction – Architecture – Features – Addressing Formats – Functional modes – Introduction to Commercial DS Processors, applications: aerospace actuators, wind energy conversion systems, oil pumping or ultrahigh-speed elevators.

Text Book(s):

1. John G Proakis., DimtrisManolakis, G., Digital Signal Processing Principles, Algorithms and Application, Prentice Hall of India, 4th Edition.
2. Alan V Oppenheim, Alan S. Willsky with Hamid Nawab, “Signals & Systems”, Pearson Education, 2nd Edition, 2000

Reference(s):

1. S. Salivahana, A.Vallavaraj, Gnanapriya, “Digital Signal Processing”, McGraw-Hill, 2nd Edition, 2000
2. Simon Haykin and Barry Van Veen, “Signals & Systems”, John Wiley and Sons, 2nd Edition, 2002
3. S.K.Mitra., Digital Signal Processing - A Computer based approach, Tata McGraw Hill, 3rd Edition, 2004