Course Scheme and Syllabus

For

Bachelor of Technology

in

Electrical & Electronics Engineering

(Four Years Course)

2020-2024

SAMBALPUR UNIVERSITY INSTITUTE OF INFORMATION TECHNOLOGYJYOTI VIHAR, BURLA

Programme Educational Objectives

PEO1	Understand the nature and basic concepts relating to the B.TECH Degree in Electrical & Electronics Engineering.
PEO2	Analyse the relationships among different concepts.
PEO3	Perform procedures as laid down in the areas of study.
PEO4	Apply the Basic Concepts learned to execute them.

Programme Outcome

PO-1	**Critical Thinking:** Take informed actions after identifying the assumptions that frame our thinking and actions
PO-2	**Effective Communication:** Will be able to speak, read, write and listen clearly inperson and through electronic media in English and in one Indian Language
PO-3	**Social Interaction (Interpersonal Relation):** Elicit views of others, mediate disagreements and prepared to work in team
PO-4	**Entrepreneurship Capability:**Demonstrate qualities to be prepared to become anentrepreneurship
PO-5	**Ethics:**Recognize different value systems including your own, understand the moral dimensions and accept responsibility for them
PO-6	**Environment and Sustainability:** Understand the issues of environmental contextsand sustainable development
PO-7	**Life-Long Learning:**Acquire the ability to engage in independent and life-long learning in the context of socio-technological changes

First Semester

Sl. No	Course Code	Course Title	Hours Per Week			Total Contact Hours	Credit
			Lecture	Tutorial	Practical		
1	MAC111	Mathematics-1	3	1	0	4	4
2	PHC112	Physics-1	3	1	0	4	3
3		Programming in C	3	1	0	4	3
4	EEC114	Basic Electrical Engineering	3	1	0	4	3
5	HSC115	Communicative English	3	1	0	4	3
Laboratory Courses							
6	EEL116	Basic Electrical Laboratory	0	0	3	3	2
7		Programming in C Laboratory	0	0	4	4	2
8	PHL118	Physics-1 Laboratory	0	0	3	3	2
Total Credits							22

Second Semester

Sl. No	Course Code	Course Title	Hours Per Week			Total Contact Hours	Credit
			Lecture	Tutorial	Practical		
1	MAC121	Mathematics-2	4	0	0	4	4
2	PHC122	Physics-2	3	1	0	4	4
3	ECC123	Basic Electronics	3	1	0	4	3
4		Data Structure Using C	3	1	0	4	3
5	HSC125	Environmental Studies	3	1	0	4	0
Laboratory Courses							
6	ECL126	Basic Electronics Laboratory	0	0	3	3	2
7	EDC127	Engineering Graphics Lab	0	0	3	3	2
8	CSL128	Data Structure Laboratory	0	0	4	4	2
Total Credits							20

Third Semester

Sl. No	Course Code	Course Title	Hours Per Week			Total Contact Hours	Credit
			Lecture	Tutorial	Practical		
1	MAC231	Mathematics-3	3	1	0	4	4
2	ECC232	Analog Electronics Circuit	3	1	0	4	3
3	EEC233	Network Analysis and Synthesis	3	1	0	4	3
4	EEC234	Electrical Machine - 1	3	1	0	4	3
5		Electromagnetic Field Theory	3	1	0	4	3
Laboratory Courses							
6	EEL236	Electrical Machine-1 Laboratory	0	0	3	3	2
7	EEL237	Network Analysis and Synthesis Laboratory	0	0	3	3	2
8	ECC238	Analog Electronics Laboratory	0	0	3	3	2
Total Credits							22

Fourth Semester

Sl. No	Course Code	Course Title	Hours Per Week			Total Contact Hours	Credit
			Lecture	Tutorial	Practical		
1	MAC241	Mathematics-4	3	1	0	4	4
2		Digital Circuits and Systems	3	1	0	4	3
3	HSC243	Organizational Behaviour	3	1	0	4	3
4	EEC244	Electrical Machine – 2	3	1	0	4	3
5		Signal and System	3	1	0	4	3
Laboratory Courses							
6	EEL246	Electrical Machine-2 Laboratory	0	0	3	3	2

7		**Digital Electronics Laboratory**	**0**	**0**	**3**	**3**	**2**
Total Credits							**20**

Fifth Semester

Sl. No	**Course Code**	**Course Title**	**Hours Per Week**			**Total Contact Hours**	**Credit**
			Lecture	**Tutorial**	**Practical**		
1	**EEC351**	**Control System Engineering-I**	**3**	**1**	**0**	**4**	**3**
2	**EEC352**	**Power Electronics**	**3**	**1**	**0**	**4**	**3**
3		**[Professional Elective-1]**	**3**	**1**	**0**	**4**	**3**
4	**ECE354**	**Microprocessor and Microcontroller**	**3**	**1**	**0**	**4**	**3**
5		**[Open Elective-1]**	**3**	**1**	**0**	**4**	**3**
Laboratory Courses							
6	**EEL356**	**Control System Laboratory**	**0**	**0**	**3**	**3**	**2**
7	**EEL357**	**Power Electronics Laboratory**	**0**	**0**	**3**	**3**	**2**
8	**ECL358**	**Microprocessor and Microcontroller Laboratory**	**0**	**0**	**3**	**3**	**2**
MOOCs (Elective paper)							
9	**EMOC359**	**MOOCs1**	**-**	**-**	**-**	**-**	**3**
Total Credits							**24**

Sixth Semester

Sl. No	**Course Code**	**Course Title**	**Hours Per Week**			**Total Contact Hours**	**Credit**
			Lecture	**Tutorial**	**Practical**		
1	**EEC361**	**Electrical Power Transmission and Distribution System**	**3**	**1**	**0**	**4**	**3**
2	**EEC362**	**Electrical and Electronics Measurement**	**3**	**1**	**0**	**4**	**3**
3		**[Professional Elective-2]**	**3**	**0**	**0**	**4**	**3**

4		**[Professional Elective – 3]**	**3**	**0**	**0**	**4**	**3**
5		**[Open Elective-2]**	**3**	**0**	**0**	**4**	**3**
Laboratory Courses							
6	**EEL366**	**Measurement and Instrumentation Laboratory**	**0**	**0**	**3**	**3**	**2**
7	**EEL367**	**Electrical Engineering Simulation Laboratory**	**0**	**0**	**3**	**3**	**2**
8	**ECL368**	**Signal and Systems Laboratory**	**0**	**0**	**3**	**3**	**2**
MOOCs (Elective paper)							
9	**EMOC369**	**MOOCs2**	**-**	**-**	**-**	**-**	**3**
Total Credits							**24**

Seventh Semester

Sl. No	**Course Code**	**Course Title**	**Hours Per Week**			**Total Contact Hours**	**Credit**
			Lecture	**Tutorial**	**Practical**		
1	**EEC471**	**Power System Operation and Control**	**3**	**1**	**0**	**4**	**3**
2		**[Professional Elective-4]**	**3**	**1**	**0**	**4**	**3**
3		**[Professional Elective-5]**	**3**	**1**	**0**	**4**	**3**
4	**EEE474**	**Open Elective-3**	**3**	**1**	**0**	**4**	**3**
Laboratory Courses							
5	**EEL475**	**Power System Simulation Laboratory**	**0**	**0**	**3**	**3**	**2**
6	**EES476**	**Seminar**	**0**	**0**	**3**	**3**	**2**
7	**EEP477**	**Minor Project**	**0**	**0**	**3**	**3**	**2**
Total Credits							**18**

Eighth Semester

Sl. No	Course Code	Course Title	Hours Per Week			Total Contact Hours	Credit
			Lecture	Tutorial	Practical		
1	EEC481	Power System Protection	3	1	0	4	3
2		Professional Elective-6	3	1	0	4	3
3		Open Elective-4	3	1	0	4	3
Laboratory Courses							
4	EEV485	Comprehensive Viva	0	0			2
5	EEP484	Major Project	0	0			8
Total Credits							19

SEMESTER WISE CREDIT DISTRIBUTION									
Year	Credit (42)		Credit (42)		Credit (48)		Credit (37)		
Semester	I	II	III	IV	V	VI	VII	VIII	TOTAL
Total Credit	22	20	22	20	24	24	18	19	169

List of Courses for Professional Electives		
Professional Elective-1		
1	EEE353	Power Station Engineering
2	EEE358	Computer Architecture
3	EEE359	Internet of Things
Professional Elective-2		
1	EEE363	Control System Engineering II
2	EEE365	Batteries, fuel cells and their applications
3	EEE367	Adaptive and Optimal Control
Professional Elective-3		
1	EEE364	Electric Drives and Traction
2	EEE368	Energy Conservation and Audit
3	EEE369	Electrical and Hybrid Vehicles
Professional Elective-4		
1	EEE473	Power Quality
2	EEE476	Nano-Technology
3	EEE477	HVDC Transmission
Professional Elective-5		
1	EEE474	Renewable Energy Sources
2	EEE478	Digital Control System
3	EEE479	High Voltage Engineering

Professional Elective-6			
1	EEE482	Flexible AC Transmission System	
2	EEE485	Industrial Instrumentation	
3	EEE487	Electrical Engineering Material	

List of Courses for MOOCs Electives			
MOOCs Elective-1			
1	EMOC355	Special Electrical Machines	
2	EMOC356	Biomedical Instrumentation	
3	EMOC357	Sensors and Transducers	
4	EMOC358	Any other subject as recommended by Teachers council of Department of EEE	
MOOCs Elective-2			
1	EMOC365	Distributed Generation and Micro-grid	
2	EMOC366	Soft Computing and Applications	
3	EMOC367	Embedded and Real time Systems	
4	EMOC368	Any other subject as recommended by Teachers council of Department of EEE	

List of Courses for Open Electives			
Open Elective-1			
1	HSC355	Engineering Economics and Costing	
2	CSE355	Database Management Systems	
3	ECE356	Advanced Electronic Circuit	
Open Elective-2			
1	ECE365	Principle of Communication	
2	CSE365	Software Engineering	
3	ECE366	Digital Signal Processing	
Open Elective-3			
1	ECE474	VLSI Engineering	
2	CSE474	Big Data Analysis	
3	ECE475	Satellite Communication	
Open Elective-4			
1	HSC483	Entrepreneurial Management	
2		Artificial Intelligence	
3	CSE484	Machine Learning	

N.B-

- A student has to complete the MOOCs courses/elective papers as recommended by the department.
- As the elective papers are of three (03) credits, therefore the MOOCs courses will also have the same three credits.

- Thus, two MOOCs courses/elective papers each of three (03) credits will be included in the fifth and sixth semester of B-Tech program as per the resolution of academic council held on 25-11-2021.
- Existing evaluation and grading scheme of SUIIT will be applicable for the MOOCs courses/elective papers.
- There will be two options. (i)The students can register for these courses through SWAYAM (Govt. of India) directly as per the courses offered in Odd/Even Semesters by SWAYAM. (ii) Being an elective paper, the concerned department can also offer the MOOCs course as a subject in the respective semester.
- For students enrolled in SWAYAM, it usually charges minimal fee per course and awards a certificate of completion. Students need to register for the course on payment of their own and submit the certificate to the institute.
- For registration to MOOCs, the students shall abide by the norms and policies proposed by SWAYAM.
- For technical seminar, students shall choose a topic from the latest technological developments / research in Electrical and Electronics Engineering or in allied fields in consultation with the faculty. They shall submit synopsis for the presentation in an approved format on the day of presentation.
- Project work and Comprehensive Viva-Voce shall be as per Academic & Examination Guidelines of SUIIT.

DETAILED SYLLABUS

Basic Electrical Engineering(EEC114)

Prerequisite	**None**	
Course Objective	**The objective of the subject is to provide a basic idea about basics of electrical engineering to engineering students irrespective of the discipline**	
Course Outcome	CO-1	Remember and understand the basic concepts/principles of basic electrical engineering
	CO-2	Analyze the various concepts to understand them through case studies
	CO-3	Apply knowledge in understanding practical problems
	CO-4	Execute/create the projects or field assignment as per knowledge gained in the course
Accompanied by Laboratory Course	**Yes**	
Course Credits	**3-0-0**	
Course Type	**CORE**	

Module-I (12 Hours)

Preliminaries: Basic electrical components (Active and Passive), Ideal Sources, Dependent and Independent Sources, Voltage and Current relations of resistor, capacitor and inductor**Network Theorems in DC Networks:**Ohm’s Law, Kirchhoff's laws, Nodal and Mesh analysis, Super Node and Super Mesh Analysis, SuperpositionTheorem,Thevenin and Norton's theorem.**Single Phase AC Circuits:** Single phase EMF generation, average and effective values of sinusoids, j operations, complex representation of impedances, phasor diagrams, power factor, power in complex notation, solution of series and parallel circuits. Transient response of R-L, R-C circuit with DC excitation**Resonance in AC Circuit:** Series and Parallel Resonance. **Three Phase AC Circuit:** Three phase EMF generation, delta and star connection, Line and Phase quantities. Solutions of 3-phase circuits with balanced load. Power and Power Factor in 3-phase balanced circuits.

Module-II (10 Hours)

Magnetic Circuits: Faraday’slaw, induced EMF, BiotSavart’s law, Inductance, Self and Mutual Inductance, Dot Convention, Magneto Motive Force, Reluctance, Permeability, Relative Permeability, Ampere’s Law, Types of Magnetic Material, B-H Curve, Hysteresis and Eddy current losses.

Module-III (10 Hours)

DC Generator: Different types, Principle of Operation of DC generator, EMF equation, Types of generator and methods of excitation. **DC Motor**: Back e.m.f., speed and torque of a DC Motor, Conditions for maximum Power. Speed control of DC shunt motor.

Transformers: Construction and Principle of operation of single-phase transformer, EMF equation, Single-phase autotransformer.

Module-IV (8 Hours)

Induction Motor: Construction and principle of operation, types; Slip-torque characteristics.

Synchronous Machines: Construction & principle of operation of Synchronous generator and motor. EMF equation, Voltage regulation, Applications and starting of Synchronous motor.

Measuring Instruments: Moving iron and Moving Coil Instruments, DC PMMC instruments and their range extension, Dynamometer type Watt meters, Induction type Energy Meter.

Text Books:

1. Edward Hughes (revised by Ian McKenzie Smith), **Electrical and Electronic Technology**, Pearson Education Limited, Indian Reprint, 2002.
2. AbhijitChakrabarti, SudiptaNath, Chandan Kumar Chanda, **Basic Electrical Engineering**, Tata McGraw Hill
3. D C Kulshreshtha, **Basic Electrical Engineering**, Tata McGraw Hill

Reference Books

1. B L Theraja, A K Theraja,**A Textbook ofElectricalTechnology**, S Chand
2. V N Mittle, ArvindMittle, **Basic Electrical Engineering**, McGraw Hill
3. Vincent Del Toro, **Electrical Engineering Fundamentals**, Pearson
4. Parker Smith, **Problems in Electrical Engineering**, CBS Publishers
5. Jimmie J.Cathey, Syed A. Nasar,**Schaum's Outline Basic Electrical Engineering,** McGraw Hill

Network Analysis and Synthesis (EEC233)

Prerequisite	**None**	
Course Objective	**The objective of the program is to provide knowledge about different network theorems and principles to undergraduate students of electrical and electronics engineering**	
Course Outcome	CO-1	Remember and understand the basic concepts/principles of Network Analysis and Synthesis
	CO-2	Analyze the various concepts to understand them through case studies
	CO-3	Apply knowledge in understanding practical problems
	CO-4	Execute/create the projects or field assignment as per knowledge gained in the course
Accompanied by Laboratory Course	**Yes**	
Course Credits	**3-0-0**	
Course Type	**CORE**	

Module-1(10 Hours)

DC Circuit Analysis and Network Topology: Ohm's law, Kirchhoff's law, mesh and nodal analysis, Super Mesh and Super Node Analysis **Network Reduction:** voltage & current division, source transformation, star-delta conversion.**Network Topology**: Graph of network, concept of tree, Tie-set & cut-set matrix.**DC Theorems**: Thevenin, Norton, Superposition, Maximum power transform, Reciprocity,compensation,millimann, Tellegen's Theorem.

Module-2(10 Hours)

AC Circuit Analysis: RLC Series and Parallel Circuits, Sinusoids and phasors, Sinusoidal steady state analysis and theorems, AC Power Analysis **Resonance& Coupled Circuit**: series & parallel resonance-their frequency response, Q-factor & bandwidth, self & mutual inductance, coefficient of coupling, Tuned circuit.**Transient Response**: Transient response of R-L, R-C and RLC circuits.

Module-3(10 Hours)

Two port Network function & Response: Z, Y, ABCD andh-parameters, Reciprocity and Symmetry, Interrelation of two-port parameters, Interconnection of two-port networks, Network Functions, Significance of Poles and Zeros, Restriction on location of Poles and Zeros, Time domain behaviour from Pole-Zero plots. **Filter Design by co-efficient matching:** Brief idea about network filters (Low pass, High pass, Band pass and Band elimination) and their frequency response.

Module-4 (10 Hours)

Network synthesis: Hurwitz polynomial, Properties of Hurwitz polynomial, Positive real functions and their properties, Concepts of network synthesis, Realization of simple R-L, R-C and L-C functions in Cauer-I, Cauer-II, Foster-I and Foster-II forms.

Text Books

1. Charles Alexander, Matthew N. O. Sadiku, **Fundamentals of Electric Circuits**, Tata McGraw Hills.
2. AbhijitChakrabarty, **Circuit Theory (Analysis and Synthesis)**, DhanpatRai and Co.
3. William H. Hayat, Jack Kemmerly, Steven M Durbin, **Engineering Circuit Analysis**, Tata McGraw Hill, New Delhi.
4. M.E Valkenburg, **Network Analysis and Synthesis**, Pearson Publication
5. John O'Malley, **Schaum's Outline of Basic Circuit Analysis**,McGraw Hill

Reference Books

1. M L Soni and J C Gupta, **A Course on Electrical Circuit and Analysis**, DhanpatRai
2. Kuo F. F., **Network Analysis and Synthesis**, Wiley India., 2008

Electrical Machines- I (EEC234)

Prerequisite	**Basic electrical engineering**	
Course Objective	**The course aims to provide a detailed idea about DC machine and transformers (single and 3-phase) for undergraduate students of electrical engineering**	
Course Outcome	CO-1	Remember and understand the basic concepts/principles of electrical machine-1
	CO-2	Analyze the various concepts to understand them through case studies
	CO-3	Apply knowledge in understanding practical problems
	CO-4	Execute/create the projects or field assignment as per knowledge gained in the course
Accompanied by Laboratory Course	**Yes**	
Course Credits	**3-0-0**	
Course Type	**CORE**	

Module- I (10 Hours)

Basic Concepts of Rotating Electrical Machine, **General Principles of DC Machine:** Construction and geometry of DC machine, Heating and Cooling of DC machine, Ventilation and enclosures, insulation type of DC machine, Types of DC machine, Armature Windings (Simplex Lap and Simplex Wave), Methods of Excitation, Expression for EMF Induced and Torque Developed in the Armature, Counter Torque and Counter or Back EMF, Armature Reaction, Commutation techniques, Brush Shift and its Effects, Interpoles, Compensating Windings.

Characteristics of DC Generator: Characteristics for Separately Excited DC Generator (No-Load and Load), Conditions for Self Excitation, Critical Resistance and Critical Speed, Characteristics for Self Excited DC Shunt Generator (No-Load and Load), Voltage Regulation, Parallel Operation of DC Shunt Generators and DC Series Generators.

Module- II (10 Hours)

Characteristics of DC Motor: Characteristic for Speed~Armature Current, Torque~Armature Current and Speed~Torque of (i) Separately Excited DC Motor, (ii) DC Shunt Motor, (iii) DC Series Motor, and (iv) DC Compound Motor **Starter for DC Motor:**Necessityand Types /of starter, Starting of DC Shunt, Series and Compound Motors, Precautions During Starting of DC Series Motor **Speed Control of DC Motors:** Techniques of Speed Control of DC motor. **Efficiency and Testing of DC Motor:** Classification of Losses, Efficiency Evaluation from Direct and Indirect Methods (i) Brake Test (Direct method), (ii) Swinburne's Test (Indirect method), (iii) Regenerative/Hopkinson's Test (Indirect method).

Module- III (10 Hours)

Single-phase transformer: Construction, geometry and material for transformer, EMF Equation, Phasor Diagrams at No-Load and Load Conditions, Equivalent Circuit, **Efficiency and Testing of Transformer:** Types of losses, Polarity Test, Open Circuit Test and Short Circuit Test, Back to Back test, Voltage Regulation, Per Unit Calculation, Auto Transformers and their application.

Module- IV (10 Hours)

Three-phase Transformer: Constructional features of three phase transformers – three phase connection of transformers (Dd0, Dd6, Yy0, Yy6, Dy1, Dy11, Yd1, Yd11, zigzag), Scott connection, open delta connection, three phase to six phase connection, oscillating neutral, tertiary winding, three winding transformer, equal and unequal turns ratio, parallel operation, load sharing, Distribution transformers, all day efficiency, Autotransformers, saving of copper, applications, tap-changing transformers, cooling of transformers

Text Book:

1. A.E. Fitzgerald, Charles Kingsley Jr., S. D. Umans, **Electric Machinery**, Tata McGraw Hill.
2. P. S. Bimbhra**, Electrical Machinery**, Khanna Publishers
3. D P Kothari and I J Nagrath, **Electric Machine**, Tata McGraw Hill.
4. Syed Nasar, **Schaum's outline of Electric Machines and Electro mechanism**, McGraw Hill
5. R K Rajput**, Electrical Machines,** LP

Reference Book(s):

1. A.E. Clayton and N N Hancock, **Performance and Design of DC Machines**, CBS Publishers
2. B.L.Theraja, A.K. Theraja,**A Text Book of Electrical Technology:Volume-II , AC and DC Machines,** S Chand Publisher

Electrical Machine-II (EEC244)

Prerequisite	**Electrical Machine-1**	
Course Objective	**The course aims to provide a detailed knowledge of AC machines**	
Course Outcome	CO-1	Remember and understand the basic concepts/principles of electrical machine-2
	CO-2	Analyze the various concepts to understand them through case studies
	CO-3	Apply knowledge in understanding practical problems
	CO-4	Execute/create the projects or field assignment as per knowledge gained in the course
Accompanied by Laboratory Course	**Yes**	
Course Credits	**3-0-0**	
Course Type	**CORE**	

Module-I (10 Hours)

Fundamental Principles of A.C. Machines: E.M.F. equation of an elementary alternator, Phase, relation between speed & frequency, factors affecting the induced e.m.f., full pitch &fractional pitch windings, winding factors, armature reaction, the rotating field leakage reactance. Concept of time phasor& space phasor.

Synchronous Generator: Various types & construction, cylindrical rotor theory, phasor diagram, open circuit & short circuit characteristics, armature reaction reactance, synchronous reactance, SCR, load characteristics, potier reactance, voltage regulation, EMF method, MMF method, modified MMF method, ZPF method, power angle characteristics.

Module-II (10 Hours)

Theory of Salient Pole Machine: Blondel's two reaction theory, phasor diagram, direct axis and quadrature axis synchronous reactances, power angle characteristics, Slip Test.**Parallel operation:** Synchronizing method, effect of wrong synchronizing, load sharing between alternators in parallel. Sudden Short Circuit of a Synchronous Generator, Transient and Sub-transient reactances.

Synchronous Motor: General Physical consideration, torque and power relations in non-salient pole and salient pole motors, V-curves & inverted V-curves, Effect of change of excitation, synchronous conductor, starting of Synchronous Motor, performance characteristics, of synchronous motor. Hunting.

Module-III (10 Hours)

Three Phase Induction Machine: Constructional Features of Squirrel Cage Rotor type and Slip Ring/Wound Rotor type of Induction Motors, Principle of Operation, Concept of Slip, Slip Speed, Equivalent Circuit and Phasor Diagram, No-Load and Blocked Rotor tests, Determination of Parameters, Slip~Torque Characteristics and Effect of Rotor resistance on it, Losses and Efficiency. Starting of Squirrel Cage Rotor type and Slip Ring/Wound Rotor type of Induction Motors, Speed Control of Induction Motors, Cogging, Crawling and Electrical Braking of Induction Motors, Brief Idea on Induction Generators.

Module-IV (10 Hours)

Single Phase Induction Motor: theory of operation (Double revolving field theory, equivalent circuit,Determination of parameters) Methods of starting, split phase starting, Repulsion starting, shaded pole starting, performance characteristics. Single phase series motor, Theory, operation, performance and application, Universal motor.

Text Books

1. A. E. Fitzgerald, C. Kingsley, and S. Umans, **Electric Machinery**, TMH Publisher.
2. I. J. Nagrath, D. P. Kothari, **Electric Machines**, TMH Publishers.
3. B.L Theraja,A.K. Theraja**Electrical Technology**, **Vol.2, DC & AC machines**. S Chand Publishers.

Reference Books

1. M. G. Say, **Performance and Design of Alternating Current machines**, CBS Publishers.
2. A. S. Langsdorf, **Theory of Alternating Current Machinery**, TMH Edition.
3. P S Bimbhra, **Generalized Theory of Electrical Machines,** Khanna Publishers
4. E. O. Taylor, **The Performance & Design of A.C. Commutator motors**, Wheeler Publishing, New Delhi.
5. Syed Nasar, **Schaum's outline of Electric Machines and Electro mechanism**, McGraw Hill

Control System Engineering-I (EEC351)

Prerequisite	**None**	
Course Objective	**The students will have an idea of different concepts of linear control system engineering**	
Course Outcome	CO-1	Remember and understand the basic concepts/principles of Control System-1
	CO-2	Analyze the various concepts to understand them through case studies
	CO-3	Apply knowledge in understanding practical problems
	CO-4	Execute/create the projects or field assignment as per knowledge gained in the course
Accompanied by Laboratory Course	**Yes**	
Course Credits	**3-0-0**	
Course Type	**CORE**	

Module-I (10 Hours)

Introduction to Control Systems: Basic Concepts of Control Systems, Open loop and closed loop systems, **Mathematical Models of Physical Systems:** Differential Equations of Physical Systems: Mechanical Translational Systems, Rotational systems, Electrical Systems, Analogy between Mechanical and electrical quantities, Servo Mechanism/Tracking System Derivation of Transfer functions, Block Diagram Algebra, Signal flow Graphs, Mason's Gain Formula. Feedback characteristics of Control Systems: Effect of negative feedback on sensitivity, bandwidth, Disturbance, linearizing effect of feedback, Regenerative feedback.

Control Components: Servomotors, A.C. Tachometer, Synchros, Stepper Motors.

Module-II (10 Hours)

Time response Analysis: Standard Test Signals: Time response of first order systems to unit step and unit ramp inputs. Time Response of Second order systems to unit step input, Time Response specifications, Steady State Errors and Static Error Constants of different types of systems. Generalised error series and Generalized error coefficients (IAE, ISE, ITAE and ITSE).

Module-III (8 Hours)

Concept of stability: Necessary conditions of stability, Hurwitz stability criterion, Routh stability criterion, Application of the Routh stability criterion to linear feedback system, Relative stability by shifting the origin in s-plane. **Root locus Technique:** Root locus concepts, Rules of Construction of Root locus, Determination of Roots from Root locus for a specified open loop gain, Root contours, Systems with transportation lag. Effect of addition of open loop poles and zeros.

Module-IV: (12 Hours)

Frequency Response Analysis: Frequency domain specifications, correlation between Time and Frequency Response with respect to second order system, Polar plots, Bode plot. Determination of Gain Margin and Phase Margin from Bode plot. **Stability in frequency domain**: Principle of argument, Nyquist stability criterion, Application of Nyquist stability criterion for linear feedback system. **Closed loop frequency response:**Constant M-circles, Constant N-Circles, Nichol's chart. **Controllers**: Concept of Proportional, Derivative and Integral Control actions, P, PD, PI, PID controllers. Zeigler-Nichols method of tuning PID controllers

Text Books

1. K Ogata, **Modern Control Engineering**, PHI, 5th edition.

2. I. J. Nagrath and M. Gopal,**Control Systems Engineering**, New Age International Publishers.
3. Richard C.Dorf, Robert H. Bishop, **Modern Control Systems**, Pearson Education
4. Joseph Distefano, **Schaum's Outline of Feedback and Control Systems**, McGraw Hill

Reference Books

1. R.T. Stefani, B. Shahian, C.J. Savator, G.H. Hostetter, **Design of Feedback Control Systems**, Oxford University Press.
2. M. Gopal, **Control Systems (Principles and Design),**TMH.
3. F Golnaraghi, B.C Kuo, **Automatic Control System**, John Wiley Publishers
4. B S Manke, **Linear Control System with MATLAB Applications,** Khanna Publisher

Power Electronics (EEC352)

Prerequisite	**Basics of Circuit Theory and Semiconductor Devices**	
Course Objective	**The course aims to provide details of different power semiconductor devices, power converter to the students**	
Course Outcome	CO-1	Remember and understand the basic concepts/principles of power electronics
	CO-2	Analyze the various concepts to understand them through case studies
	CO-3	Apply knowledge in understanding practical problems
	CO-4	Execute/create the projects or field assignment as per knowledge gained in the course
Accompanied by Laboratory Course	**Yes**	
Course Credits	**3-0-0**	
Course Type	**CORE**	

Module-I (10 Hours)

Power Semiconductor Devices: Static V-I characteristics, switching characteristics,Turn-On & Turn-Off Mechanism, Protection, cooling and mounting techniques. Triggering and commutation techniques, Driver Circuits for power diode, power transistor, power MOSFET, IGBT, GTO, and Thyristor family

Module-II (10 Hours)

Uncontrolled AC-DC Converter:1-Phase and 3-phase Half & Full Wave Un-Controlled Rectifier with various loads (R, RL, RLE (motor)). **Controlled AC-DC Converter**: 1-phase and 3-phase Half & Full wave Controlled Rectifier with different loads, Inverter Mode of Operation. Continuous and discontinuous modes, Effect of source inductance assuming constant load current. Effect of freewheeling diode Single phase and three-phase semi-controlled bridge rectifier, **Performance Parameters:**Input Line Current Harmonics, Power factor, current distortion and displacement factor,

Module-III (10 Hours)

DC-DC Chopper: Operating principleof step-up and step-down chopper, DC-DC Converter, PWM generation, **Types**: Analysis and quadrant operation of different type of choppers (Type-A, Type-B, Type-C, Type-D, Type-E),

AC-AC Converters: Single phase AC Voltage regulators and its basic analysis, Single-phase mid-point and bridge type step-up and step-down Cyclo-converters.

Module-IV (10 Hours)

DC-AC Inverter: Single-phase Half and Full-bridge Inverter, Pulse Width Modulated (PWM) technique for voltage control, SPWM Technique Single-phase inverters, Auxiliary Commutated (Mc-Murray) and Complementary Commutated (Mc-Murray Bedford) Inverters, Three-phase Voltage Source Bridge type of Inverters. (120° and 180° conduction modes), Current Source Inverter.

Text Books

1. M. H. Rashid, **Power Electronics: Devices, Circuits and Applications**, Pearson
2. P S Bimbhra, **Power Electronics**, Khanna Publishers, 2010
3. Robert W. Erickson, DraganMaksimovic, **Fundamental of Power Electronics**, 2e, Springer
4. Ned Mohan, Undeland and Robbins, **Power Electronics: Converters, Applications and Design**, Wiley Student Edition.

Reference Books:

1. L. Umanand, **Power Electronics: Essential and Application**, Wiley
2. Philip T Krein, **Elements of Power Electronics**, Oxford University Press

3. Jai P Agrawal, **Power Electronics Systems**, Pearson
4. O.P Arora, **Power Electronics Laboratory Theory, Practice and Organization**, Narosa

Power Station Engineering (EEE353)

Prerequisite	**None**	
Course Objective	**The course provides an overall idea about electric power generation using different sources**	
Course Outcome	CO-1	Remember and understand the basic concepts/principles of power electronics
	CO-2	Analyze the various concepts to understand them through case studies
	CO-3	Apply knowledge in understanding practical problems
	CO-4	Execute/create the projects or field assignment as per knowledge gained in the course
Accompanied by Laboratory Course	**No**	
Course Credits	**3-0-0**	
Course Type	**Professional Elective-1**	

Module-I (10 Hours)

Generation of Electrical Energy: Different sources of energy**Choice of size and number of generating units:** Review of the terms maximum demand, load factor, diversity factor, plant capacity and use factor, load & load duration curve and their effect on the generatingcapacity. Reserve units (hot, cold and spinning- reserve), **Economics of Power Generation:** Cost of electrical energy, Capital cost of plant, annual fixed cost, operating cost, generation cost, depreciation **Electricity Tariffs and Power Factor Improvement:**Different types of electricity tariffs, Effect of power factor on tariff, Method and Economics of power factor improvement.

Module-II (10 Hours)

Hydro power plant: Classification of hydro power plants, Selection of site for hydro power plant, Catchment area, Reservoir, Dam, Head Gate, Spillways, Pen stock, surge tank, draft tube and tail race base load and peak load station, Storage and Pondage, Turbines, Operational principle of Kaplan and Francis Turbine and Pelton wheel, Speed and Pressure Regulation, Work done and Efficiency, head gate, Speed Governors, power plant auxiliaries.

Module-III (10 Hours)

Thermal Power Plant: Operating principle of thermal power plants, Boilers (Fire Tube and Water Tube), steam turbines, super heater, economizer, air preheater, coal handling and ash handling units, Pulverizing plant, draft fans, chimney, condensers, feed water heaters, cooling water system; Governors,plant layout and station auxiliaries.Different types of generators and Exciters, earthing of a power system

Module-IV (10 Hours)

Nuclear Power Plant: Fission & fusion, controlled chain reaction, nuclear fuel, Nuclear reactors (Boiling water, pressurized water, CANDU), sodium graphite, breeder, layout of nuclear power plant, Radiation shielding, Radioactive and waste disposal safety aspect

Text Books

1. Bernhardt Skrotizki and William Vopat, **Power Station Engineering & Economy**, TMH Publishers
2. M V Deshpande, **Elements of Electrical Power Station Design**, PHI
3. S C Arora, S Domkundawar, **Power Plant Engineering**, DhanpatRai
4. R K Rajput, **A Textbook of Power Plant Engineering**, LP

Reference Books

1. Black and Veatch, **Power Plant Engineering**,Springer
2. S L Uppal, S Rao, **Electrical Power Systems**, Khanna Publishers
3. P K Nag, **Power Plant Engineering**, Tata McGraw Hill
4. V K Mehta, Rohit Mehta, **Principles of Power System**, S Chand

Electrical Power Transmission and Distribution Systems (EEC361)

Prerequisite	**None**	
Course Objective	**The course provides constructional and operating principles of different components of electrical power transmission and distribution system**	
Course Outcome	CO-1	Remember and understand the basic concepts/principles of Transmission and Distribution System
	CO-2	Analyze the various concepts to understand them through case studies
	CO-3	Apply knowledge in understanding practical problems

	CO-4	Execute/create the projects or field assignment as per knowledge gained in the course
Accompanied by Laboratory Course	**No**	
Course Credits	**3-1-0**	
Course Type	**CORE**	

Module-I (10 Hours)

Lines Constants: Resistance, inductance and capacitance of single and three phase lines with symmetrical and unsymmetrical spacing transposition, charging current, skin effect and proximity effect, **Performance of transmission lines:** Analysis of short, medium and long lines, equivalent circuit, representation of the lines and calculation of transmission parameters, Power flow through transmission line, Series and shunt compensation.

Module-II (10 Hours)

Corona: Power loss due to corona, practical importance of corona, use of bundled conductors in E.H.V. transmission lines and its advantages, Overhead line Insulators, voltage distribution in suspension type insulators, string efficiency, grading. Sag and stress calculation of overhead conductors, vibration dampers.

Module-III (10 Hours)

Underground Cables: Introduction, Insulation, Sheath, Armour and Covering, Classification of Cables, Pressurized Cables, Effective Conductor Resistance, Conductor Inductive Reactance, Parameters of Single Core Cables, Grading of Cables, Capacitance of Three Core Belted Cable, Breakdown of Cables, Cable Installation, Current Rating of Cables, System Operating Problems with Underground Cables.

Module-IV (10 Hours)

Distribution: Comparison of various Distribution Systems, AC three-phase four-wire Distribution System, Types of Primary Distribution Systems, Types of Secondary Distribution Systems, Voltage Drop in DC Distributors, Voltage Drop in AC Distributors, Kelvin's Law, Limitations of Kelvin's Law, General Design Considerations, Load Estimation, Design of Primary Distribution, Sub-Stations, Secondary Distribution Design, Economical Design of Distributors, Design of Secondary Network, Lamp Flicker, Application of Capacitors to Distribution Systems.

Text Books

1. C L Wadhwa, **Electrical Power Systems**, New Age
2. B R Gupta, **Power System Analysis & Design**, S Chand
3. S N Singh, **Electrical Power Generation Transmission and Distribution**, PHI

Reference Books

1. B M Weedy, B J Cory,**Electric Power Systems**, Wiley
2. Luces M. Fualkenberry, Walter Coffer, **Electrical Power Distribution and Transmission**, Pearson
3. V K Mehta, Rohit Mehta, **Principles of Power System**, S Chand

Control System Engineering – II (EEE363)

Prerequisite	**Control System Engineering-1**	
Course Objective	**The course provides an outline of state-space analysis, digital control and nonlinear control and their stability aspect**	
Course Outcome	CO-1	Remember and understand the basic concepts/principles of Control System-2
	CO-2	Analyze the various concepts to understand them through case studies
	CO-3	Apply knowledge in understanding practical problems
	CO-4	Execute/create the projects or field assignment as per knowledge gained in the course
Accompanied by Laboratory Course	**No**	
Course Credits	**3-0-0**	
Course Type	**Professional Elective-II**	

Module-I: (10 Hours)

State Variable Analysis and Design: Introduction, Concepts of State, Sate Variables and State Model, State Models for Linear Continuous-Time Systems, State Variables and Linear Discrete-Time Systems, Diagonalization, Solution of State Equations, Concepts of Controllability and Observability, Pole Placement by State Feedback, Observer based state feedback control.

Module-II: (10 Hours)

Discrete - Time Control Systems: Introduction: Discrete Time Control Systems and Continuous Time Control Systems, Sampling Process. **Digital Control Systems:**Sample and Hold, Analog to digital conversion, Digital to analog conversion. **Z-transform:**Discrete-TimeSignals, Z-transform of Elementary functions, Important properties and Theorems of the Z-transform, inverse Z-transform, Z-Transform method for solving Difference Equations. Z-Plane Analysis of Discrete Time Control Systems: Impulse sampling & Data Hold, Reconstruction of Original signals from sampled signals: Sampling theorem, Aliasing Effect.

Module-III: (8 Hours)

Pulse Transfer function: Starred Laplace Transform of the signal involving both ordinary and starred Laplace Transforms; General procedures for obtaining pulse Transfer functions, Pulse Transfer function of open loop and closed loop systems. Mapping between the s-plane and the z-plane, Stability analysis of closed loop systems in the z-plane:Stability analysis by use of the Bilinear Transformation and Routh stability criterion, Jury's stability Test. Design of control system , **Introduction of Design**: The Design Problem, Preliminary Considerations of Classical Design, Realization of Basic Compensators, Cascade Compensation in Time and frequency Domain, Introduction to feedback compensation.

Module –IV: (12 Hours)

Nonlinear Systems: Behaviour of Nonlinear Systems, Investigation of nonlinear systems, **Common Physical Nonlinearities:** Saturation, Friction, Backlash, Relay, **The Phase Plane Method:** Basic Concepts, Singular Points,Nodal Point, Saddle Point, Focus Point, Centre or Vortex Point, Stability of Non Linear Systems: Limit Cycles, Construction of Phase Trajectories, The Describing Function Method: Basic Concepts: Derivation of Describing Functions, Backlash. Stability Analysis by Describing Function Method: Relay with Dead Zone, Jump Resonance. Liapunov's Stability Analysis: Introduction, Liapunov's Stability Critrion: Basic Stability Theories. Popov's Criteria.

Text Books:

1. KOgata, **Modern Control Systems**, PHI.
2. K Ogata, **Discrete-time Control Systems,** PHI.
3. MadanGopal, **Digital Control and State Variable Method**, McGraw Hill
4. Kanan M. Moudgalya, **Digital Control**, Wiley India

Reference Books

1. Hassan K. Khalil, **Nonlinear Systems**, Pearson

Electrical and Electronic Measurements (EEC362)

Prerequisite	**Basics of Electrical Engineering and network analysis**	
Course Objective	**The course provides a detailed idea of measurement of different electrical parameters, construction of different electrical instrument**	
Course Outcome	CO-1	Remember and understand the basic concepts/principles of Electrical and Electronic Measurement
	CO-2	Analyze the various concepts to understand them through case studies
	CO-3	Apply knowledge in understanding practical problems
	CO-4	Execute/create the projects or field assignment as per knowledge gained in the course
Accompanied by Laboratory Course	**Yes**	
Course Credits	**3-0-0**	
Course Type	**Core**	

Module-I (10 Hours)

Standards: Standards for EMF, Resistance, Frequency dependence of resistance, inductance, Capacitance, Time and frequency standard**,** Static and dynamic characteristics of instruments, error analysis, **Measuring Instruments:** Classification, Absolute and secondary instruments, indicating instruments, control,balancing and damping, constructional details, **Permanent Magnet Moving Coil, Permanent Magnet Moving Iron, electrodynamometer instrument, induction type:** Construction, operating principle,**Power measurement:** DC power measurement, single-phase AC power measurement, polyphase AC power measurement, Blondel Theorem, 2-wattmeter method, Active and reactive power measurement, phasor diagram, Errors in wattmeter method, **Energy measurement:** Construction and operating principle of Watthour meter, phasor diagram, error in watthour meter, testing of watthour meter, Electronic energy meter, Trivector meter, maximum demand meter

Module-II (10 Hours)

Instrument Transformers: Potential and current transformers, ratio and phase angle errors, phasor diagram, methods of minimizing errors; testing and applications.**Galvanometers:** General principle and performance equations of D'Arsonval Galvanometers, VibrationGalvanometer and Ballistic Galvanometer.**Potentiometers:** DC Potentiometer, Crompton potentiometer, construction, standardization, application. **AC Potentiometer:**Drysdale polar potentiometer; standardization, application

Module-III (10 Hours)

Measurement of Resistance: Ohm meter, Voltmeter-Ammeter Method, Wheatstone Bridge, error and sensitivity of wheatstone bridge, Carey Foster-Heydweiller Bridge, Kelvin's double bridge, Price guard wire method, loss of charge method for high resistance measurement, **Meggar:** Construction and Operating principle, Measurement of insulation and ground resistance **AC Bridges:** Maxwell's Inductance Bridge, Maxwell's Inductance-Capacitance Bridge, Hay's Bridge, Anderson Bridge, Owen's Bridge,Heydweiller mutual inductance bridge, De Sauty's Bridge, Schering Bridge, Wien's Bridge, Wagner's Earthing Device, **Loop Test:** Murray and Varley loop test for localization of cable fault, **Magnetic Measurement:** Ballistic galvanometer, Fluxmeter**, Measurement of flux density and magnetic force,** Determination of B-H curve and hysteresis loop, Measurement of iron losses with Llyod Fisher square, **Permeameters:** Bar and Yoke Method, Ewing Double bar method, Illovicipermeameter, Burrows permeameter

Module-IV (10 Hours)

Cathode Ray Oscilloscope: Block diagram, Principle of operation, Dual-trace oscilloscope, Measurement of voltage, frequency, phase, pulse measurement, oscilloscope probe, Lissajous figure, Time measurement, specification, **Special type oscilloscope:** Delay line, digital storage, sampling time oscilloscope, **Waveform Generator:** Function generator, pulse generator, Arbitrary waveform generator, sweep frequency generator, RF signal generator, frequency synthesizer, Spectrum analyser, **Digital Voltmeter and Multimeter**: Different types of digital voltmeter and multimeter, operating principle, Digital frequency meter, Digital Q meter, Distortion meter, Wavemeter

Text Books

1. A K Sawhney**, A Course in Electrical and Electronic Measurement and Instrumentation,** DhanpatRai and Co.
2. E.W. Golding, F.C. Widdis, **Electrical Measurements and Measuring Instruments**, Reem Publishers.
3. PrithwirajPurkait, Budhaditya Biswas, Santanu Das, ChiranjibKoley, **Electrical Electronics Measurements and Instrumentation,** McGraw Hill
4. Joseph J Carr, **Elements of Electronic Instrumentation and Measurement**, Pearson

Reference Books

1. Clyde F. Coombs Jr., **Electronic Instrument Handbook**, McGraw Hill
2. Albert D. Helfrick, Willim D. Cooper, **Modern Electronic Instrumentation and Measurement Techniques,** Pearson
3. S Tumanski, **Principles of Electrical Measurement**, Taylor and Francis

Electric Drives and Traction (EEE364)

Prerequisite	**Electrical Machine-I, Electrical Machine-II, Power Electronics**	
Course Objective	**The course provides detailed description of power electronics based motor drives and related control aspects of motor drives**	
Course Outcome	CO-1	Remember and understand the basic concepts/principles of Electric Motor and Drives
	CO-2	Analyze the various concepts to understand them through case studies
	CO-3	Apply knowledge in understanding practical problems
	CO-4	Execute/create the projects or field assignment as per knowledge gained in the course
Accompanied by Laboratory Course	**No**	
Course Credits	**3-0-0**	
Course Type	**Professional Elective-3**	

Module-I (10 Hours)

Introduction to AC and DC drives, Basic power electronic drive system, components of Electric Drives, Different types of loads, motor shaft, load coupling systems, Requirements of electrical drives, size and rating of motors (short time, intermittent, continuous), Heating and cooling of motors, Classes and duty and selection of motors

Module-II (10 Hours)

DC Motor: Torque-SpeedCharacteristic of DC motor (starting, running, speed control, braking), **DC Drives:** Classification of DC drives, **Thyristor fed DC drives**: Single, two and four quadrant operations. **Chopper Fed DC Drives:** Single, two and four quadrant operations, **Closed-loop control of DC drives:**Modeling of DC drives, Block diagram and transfer function representation, Controller design

Module-III (10 Hours)

Torque-Speed characteristics of three-phase induction motor,**Three-phase Induction Motor Drives:** Speed control of Induction motors - Stator voltage control - stator voltage and frequency control, Inverter, cycloconverter fed induction motor drives. Rotor control - Rotor resistance control and slip-power recovery schemes, static control of rotor resistance using DC chopper, static kramer and scherbius drives. Torque-Speed characteristics of three-phase Synchronous motor,**Speed control of 3-phase synchronous motors:** VSI & CSI fed synchronous motors, cyclo converter fed synchronous motors. Effects of harmonics on the performance of AC motors PWM inverter fed synchronous motors.

Module-IV (10 Hours)

Electric Traction: System of electric traction, **Mechanics of Train Movement:** Speed-time, distance- time and simplified speed-time curves, Attractive effort for acceleration and propulsion, effective weight, train resistance, adhesive weight, specific energy output and consumption. **Traction Motors:** Review of characteristics of different types of DC and AC motors used in traction and their suitability

Text Books

1. Gopal K Dubey, S R Doradla, A. Joshi and R M K Sinha, **Thyristorised Power Controllers**, New Age International Publishers
2. VedamSubrahmanyam, **Electric Drives: Concepts and Applications**, Tata McGraw Hill
3. Gopal K. Dubey, **Fundamentals Electrical Drives**, Norasa
4. Bimal K Bose, **Modern Power Electronics and AC Drives**, PHI Publishers
5. N V Suryanarayana, **Utilization of Electric Power: including Electric Drives and Electric Traction**, New Age International Publishers

Reference Books

1. Muhammad H. Rashid, Fang Lin Luo**, Power Electronics Handbook: Devices, Circuits and Applications,** Elsevier Academic Press
2. Paul C. Krause, Oleg Wasynczuk, Scott D. Sudhoff, **Analysis of Electric Machinery and Drive Systems,** Wiley
3. N K De and P K Sen, **Electric Drives,** PHI
4. Ned Mohan, **Electric Machines and Drives: A First Course,** Wiley

Batteries, Fuel cells and their Applications (EEE365)

Prerequisite	**None**	
Course Objective	To discuss the current status of various rechargeable batteries and fuel cells for different applications (Ex: Medical, military, electric vehicle)	
Course Outcome	CO-1	Remember and understand the basic concepts/principles of Batteries, Fuel cells and their applications.
	CO-2	Analyze the various concepts to understand them through case studies
	CO-3	Apply knowledge in understanding practical problems
	CO-4	Execute/create the projects or field assignment as per knowledge gained in the course
Accompanied by Laboratory Course	**No**	
Course Credits	**3-0-0**	
Course Type	**MOOCs Elective**	

Module-I (10 Hours)

Current Status of Rechargeable Batteries and Fuel Cells: Rechargeable Batteries, Fundamental Aspects of a Rechargeable Battery, Rechargeable Batteries Irrespective of Power Capability, Rechargeable Batteries for Commercial and Military Applications, Batteries for Low-Power Applications, Fuel Cells.

Module-II (10 Hours)

Batteries for Aerospace and Communications Satellites: Introduction, On-board Electrical Power System, Battery Power Requirements and Associated Critical Components, Cost-Effective Design Criterion for Battery-Type Power Systems for Spacecraft, Spacecraft Power System Reliability, Ideal Batteries for Aerospace and Communications Satellites, Performance Capabilities and Battery Power Requirements for the Latest Commercial and Military Satellite Systems, Military Satellites for Communications, Surveillance, Reconnaissance, and Target Tracking, Batteries Best Suited to Power Satellite Communications Satellites.

Module-III (10 Hours)

Fuel Cell Technology:Introduction, Performance Capabilities of Fuel Cells Based on Electrolytes, Low-Temperature Fuel Cells Using Various Electrolytes, Fuel Cells Using a Combination of Fuels, Fuel Cell Designs for Multiple Applications, Ion-Exchange Membrane

Fuel Cells, Potential Applications of Fuel Cells, Fuel Cells for Aircraft Applications, Fuel Cells for Commercial, Military, and Space Applications, Fuel Cells Capable of Operating in Ultra-High-Temperature Environments, Fuel Cell Requirements for Electric Power Plant Applications.

Module-IV (10 Hours)

Batteries for Electric and Hybrid Vehicles: Introduction, Chronological Development History of Early Electric Vehicles and Their Performance Parameters, Electric and Hybrid Electric Vehicles Developed Earlier by Various Companies and Their Performance Specifications, Development History of the Latest Electric and Hybrid Electric Vehicle Types and Their Performance Capabilities and Limitations, Performance Requirements of Various Rechargeable Batteries, Materials for Rechargeable Batteries, Critical Role of Rare Earth Materials in the Development of EVs and HEVs. Batteries for Medical Applications.

Text Books

1. A.R.Jha, **Next-Generation Batteries and Fuel Cells for Commercial, Military, and Space Applications**, CRC Press, 1st Edition, 2012.
2. Vladimir S. Bagotsky, **Electrochemical Power Sources: Batteries, Fuel Cells, and Super capacitors**, John Wiley, 1st Edition, 2015.
3. M. HashemNehrir, Cashing Wang,**Modelling and Control of Fuel Cells: Distributed Generation Applications**, Wiley, 1st Edition, 2009.

Reference Books

1. ShripadRevankar, PradipMajumdar, **Fuel Cells Principles, Design and Analysis**, CRC press, 2012
2. James Larminie, Andrew Dicks, **Fuel Cell Systems Explained**, Wiley, 2nd Edition, 2003

Energy Conservation and Audit (EEE489)

Prerequisite	**Power Systems, Electrical Machines, etc**	
Course Objective	The course aims to provide a detailed knowledge about the concept of energy conservation, different approaches of energy conservation in industries, economic aspects of energy conservation project and energy audit and measuring instruments in commercial and industrial sector.	
Course Outcome	CO-1	Remember and understand the basic

		concepts/principles of Energy Conversion and Audit
	CO-2	Analyze the various concepts to understand them through case studies
	CO-3	Apply knowledge in understanding practical problems
	CO-4	Execute/create the projects or field assignment as per knowledge gained in the course
Accompanied by Laboratory Course	**No**	
Course Credits	**3-0-0**	
Course Type	**Professional Elective-6**	

Module-I (10 Hours)

Energy Audit Methodology and recent trends: General Philosophy, need of Energy Audit and Management, EC Act, Definition and Objective of Energy Management, General Principles of Energy Management. Energy Management Skills, Energy Management Strategy.
Economics of implementation of energy optimization projects, it's constraints, barriers and limitations, Financial Analysis: Simple Payback, IRR, NPV, Discounted Cashflow.

Report-writing, preparations and presentations of energy audit reports, Post monitoring of energy conservation projects, MIS, Case-studies / Report studies of Energy Audits. Guidelines for writing energy audit report, data presentation in report, findings recommendations, impact of renewable energy on energy audit recommendations. Instruments for Audit and Monitoring Energy and Energy Savings, Types and Accuracy. Case studies of implemented energy cost optimization projects in electrical utilities as well as thermal utilities.

Module-II (10 Hours)

Electrical Distribution and Utilization: Electrical Systems, Transformers loss reductions, parallel operations, T & D losses, P.F. improvements, Demand Side management (DSM), Load Management, Harmonics & its improvements.
Energy efficient motors and Soft starters, Automatic power factor Controllers, Variable speed drivers, Electronic Lighting ballasts for Lighting, LED Lighting, Trends and Approaches.
Study of 4 to 6 cases of Electrical Energy audit and management (Power factor improvement, Electric motors, Fans and blowers, Cooling Towers, Industrial/Commercial Lighting system, etc.)

Module-III (10 Hours)

Thermal Systems: Boilers- performance evaluation, Loss analysis, Water treatment and its impact on boiler losses, integration of different systems in boiler operation. Advances in boiler technologies, FBC and PFBC boilers, Heat recovery Boilers- it's limitations and constraints. Furnaces- Types and classifications, applications, economics and quality aspects, heat distributions, draft controls, waste heat recovering options, Furnaces refractory- types and sections. Thermic Fluid heaters, need and applications, Heat recovery and its limitations. Insulators- Hot and Cold applications, Economic thickness of insulation, Heat saving and application criteria. Steam Utilization Properties, steam distribution and losses, steam trapping, Condensate, Flash steam recovery.

Module-IV (10 Hours)

System Audit of Mechanical Utilities: Pumps, types and application, unit's assessment, improvement option, parallel and series operating pump performance. Energy Saving in Pumps & Pumping Systems. Bloomers (Blowers) types & application, its performance assessment, series & parallel operation applications & advantages. Energy Saving in Blowers Compressors, types & applications, specific power consumption, compressed air system,& economic of system changes. Energy Saving in Compressors & Compressed Air Systems Cooling towers, its types and performance assessment & limitations, water loss in cooling tower. Energy Saving in Cooling Towers .Study of 4 to 6 cases of Energy Audit & Management in Industries (Boilers, Steam System, Furnaces, Insulation and Refractory, Refrigeration and Air conditioning, Cogeneration, Waste Heat recovery etc.)Study of Energy Audit reports for various Industries and Organizations.

Text Books

1. W.C. Turner, John Wiley and Sons, **Energy Management Handbook**, A Wiley Interscience.
2. L.C. Witte, P.S. Schmidt, D.R. Brown, **Industrial Energy Management and Utilization**, Hemisphere Publication, Washington, 1988
3. D.A. Reay, **Industrial Energy Conservation**, Pergammon Press
4. Albert Thumann, P.E., C.E.M. William J. Younger, C.E.M, **Hand Book of Energy Audits,** CRC Press.

Reference Books

1. Energy Audit and Management, Volume-I, IECC Press
2. Energy Efficiency in Electrical Systems, Volume-II, IECC Press

Electric and Hybrid Vehicles (EEE369)

<table>
<tr><td>Prerequisite</td><td colspan="2">Electrical Machine-I, Electrical Machine-II, Power Electronics</td></tr>
<tr><td>Course Objective</td><td colspan="2">The course aims to provide a detailed overview of electric and hybrid electric vehicles</td></tr>
<tr><td rowspan="4">Course Outcome</td><td>CO-1</td><td>Remember and understand the basic concepts/principles of Electrical and Hybrid Vehicles</td></tr>
<tr><td>CO-2</td><td>Analyze the various concepts to understand them through case studies</td></tr>
<tr><td>CO-3</td><td>Apply knowledge in understanding practical problems</td></tr>
<tr><td>CO-4</td><td>Execute/create the projects or field assignment as per knowledge gained in the course</td></tr>
<tr><td>Accompanied by Laboratory Course</td><td colspan="2">No</td></tr>
<tr><td>Course Credits</td><td colspan="2">3-0-0</td></tr>
<tr><td>Course Type</td><td colspan="2">Professional Elective-3</td></tr>
</table>

Module-I (10 Hours)

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.

Conventional Vehicles: Basics of vehicle performance, vehicle power source characterization, transmission characteristics, mathematical models to describe vehicle performance.

Hybrid Electric Drive-trains: Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis

Module-II (10 Hours)

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

Module-III (10 Hours)

Energy Storage: Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Hybridization of different energy storage devices.

Sizing the drive system: Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power

Module-IV (10 Hours)

Communications, supporting subsystems: In vehicle networks- CAN, Energy Management Strategies: Introduction to energy management strategies used in hybrid and electric vehicles, classification of different energy management strategies, comparison of different energy management strategies

Text Books

1. Iqbal Hussein, **Electric and Hybrid Vehicles: Design Fundamentals,** CRC Press, 2003

Reference Books

1. James Larminie, John Lowry, **Electric Vehicle Technology Explained**, Wiley, 2003
2. MehrdadEhsani, YimiGao, Sebastian E. Gay, Ali Emadi, Modern Electric, **Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design**, CRC Press, 2004

Power System Operation and Control (EEC471)

Prerequisite	**None**	
Course Objective	**The course provides an overall idea about power systems and its components. Different issues related to power systems have also been addressed in the course**	
Course Outcome	CO-1	Remember and understand the basic concepts/principles of Power System Operations and Control
	CO-2	Analyze the various concepts to understand them through case studies
	CO-3	Apply knowledge in understanding practical problems
	CO-4	Execute/create the projects or field assignment as per knowledge gained in the course

Accompanied by Laboratory Course	**Yes**
Course Credits	**3-0-0**
Course Type	**Core**

Module – I (10 Hours)

Fundamentals of Power System, Per-Unit Quantities, Changing the Base in Per- Unit Quantities, One Line Diagram, Impedance and Reactance Diagrams.

The Admittance Models & Network Calculations Branch and Node Admittances, Mutually Coupled Branches in Y bus, An Equivalent Admittance Network, The Network Incidence Matrix and Y bus.

Module – II (10 Hours)

The static load flow equations (SLFE), Power Flow Solutions, The Gauss-Seidal Method, The Newton-Raphson Method, The Newton-Raphson Method, Power-Flow Studies in System Design and Operation, Regulating Transformers, The Decoupled Method.

Economic Operation of Power System: Distribution of Load between Units within a Plant, Distribution of Load between Plants, Concept of Unit Commitment, Coordination equation,The Transmission-Loss Equation, Classical Economic Dispatch with Losses.

Module – III (10 Hours)

Automatic Generation Control: Load Frequency Control, Control Area Concept

Automatic Load-Frequency Control of Single Area Systems: Speed-Governing System, Static Performance of Speed Governor, Closing the ALFC Loop, Concept of Control Area, The Secondary (“Reset”) ALFC Loop, Economic Dispatch Control. Two Area Systems

ALFC of Multi-Control-Area Systems (Pool Operation): The Two Area Systems, Modeling the Tie-Line, Block Diagram Representation of Two Area System, Dynamic Response of Two Area System, Static System Response, Tie-Line Bias Control.

Module – IV (10 Hours)

Power System Stability: The Stability Problem, Rotor Dynamics and the Swing Equation, Further Considerations of the Swing Equations, The Power-Angle Equation, Synchronizing Power Coefficients, Equal- Area Criterion for Stability, Further Applications of the Equal-Area Criterion, Multi-machine Stability Studies: Classical Representation, Factors Affecting Transient Stability.

Text Books:

1. John. J. Grainger & W. D. Stevenson, Jr, **Power System Analysis**, TMH
2. Olle I. Elgerd, **Electric Energy Systems Theory: An Introduction**, Tata McGraw Hill
3. PrabhaKundur, **Power System Stability & Control**, McGraw Hill
4. Hadi Sadat, **Power System Analysis**, Tata McGraw Hill

Reference Books:

1. AbhijitChakrabarti and SunitaHaldar, **Power System Analysis Operation and Control**, PHI Publications
2. D.P. Kothari and I.J. Nagrath, **Modern Power System Analysis**, Tata McGraw Hill

Renewable Energy Systems(EEE473)

Prerequisite	**None**	
Course Objective	**The course provides a detailed exposure to different type of renewable energy sources, their principle of operation and their application to generate clean energy**	
Course Outcome	CO-1	Remember and understand the basic concepts/principles of Renewable Energy Systems
	CO-2	Analyze the various concepts to understand them through case studies
	CO-3	Apply knowledge in understanding practical problems
	CO-4	Execute/create the projects or field assignment as per knowledge gained in the course
Accompanied by Laboratory Course	**No**	
Course Credits	**3-0-0**	
Course Type	**Professional Elective-4**	

Module I (12 Hours)

Introduction: Impact of fossil fuel based systems, Non-conventional energy: seasonal variations and availability, Renewable energy: sources and features, Hybrid energy systems: Distributed energy systems and dispersed generation (DG) **Solar Photovoltaic systems**: Operating principle, Photovoltaic cell concepts, Different types of PV Cells, Mathematical Model, Series and parallel connections, Estimation of Insolation, Effect of illumination and temperature on PV panel, Solar processes and spectral composition of solar radiation,Radiation flux at the Earth’s surface,Solar tilt angle, **Solar collectors:**Types and performance characteristics**Efficiency of PV:** Shockley-Queisser formula, Sizing of PV array, Different algorithms of maximum power point tracking. **Applications:**Battery charging, Pumping, Peltierrefrigeration

Module II: (10 Hours)

Wind Energy: Wind energy conversion, **Efficiency limit**: Betz's Law, Types of converters, aerodynamics of wind rotors, power ~ speed and torque ~ speed characteristics of wind turbines, wind turbine control systems; conversion to electrical power: induction and synchronous generators, grid connected and self-excited induction generator operation, constant voltage and constant frequency generation with power electronic control, single and double output systems, reactive power compensation; Characteristics of wind power plant.

Module III (10 hours)

Fuel Cell: Introduction and overview of fuel cells technology, low and high temperature fuel cells, Fuel cell thermodynamics, Fuel cell reaction kinetics: Introduction to electrode kinetics, Exchange current and electrocatalysis, Simplified activation kinetics, Catalystelectrodedesign.Fuel cell performance characteristics – current/voltage, voltage efficiency and power density, ohmic resistance, kinetic performance, mass transfer effects – membrane electrode assembly components, fuel cell stack, bi-polar plate, humidifiers and cooling plates.

Module IV(8 hours)

Energy storage and hybrid system configurations: Energy storage, Battery – types, equivalent circuit, performance characteristics, battery design, charging and charge regulators. Battery management. Flywheel-energy relations, components, benefits over battery.Standalone systems, Concept of Micro-Grid and its components, Hybrid systems – hybrid with diesel, with fuel cell, solar-wind, wind –hydro systems, mode controller, load sharing, system sizing. Hybrid system economics, Interface requirements, Stable operation.

Text Books:

1. D. P. Kothari, K. C. Singal, R. Ranjan, **Renewable Energy Sources and Emerging Technologies**, Prentice Hall of India.
2. S. N. Bhadra, D. Kastha, S. Banerjee, **Wind Electrical Systems**, Oxford Univ. Press
3. Colleen Spiegel, **PEM fuel cell modelling and simulation using MATLAB**, Elsevier
4. H P Garg, J Prakash, **Solar Energy: Fundamentals & Applications**, Tata McGraw Hill, New Delhi

5. B H Khan, **Non-Conventional Energy Resources**, Tata McGraw Hill

Reference Books:

1. S. A. Abbasi, N. Abbasi, **Renewable Energy Sources and Their Environmental Impact**, Prentice Hall of India
2. S Sumathi, L Ashok Kumar, P Surekha, **Solar PV and Wind Energy Conversion Systems: An Introduction to Theory, Modeling with MATLAB/Simulink, and the role of soft computing techniques,** Springer
3. Ali Keyhani, Mohammad N Marwali, Min Dai, **Integration of green and renewable energy in electric power systems,** Wiley

Digital Control System (EEE487)

Prerequisite	**Control System Engineering-I and II, Signal and System**	
Course Objective	**The purpose of the proposed course is to present control theory that is relevant to the analysis and design of computer controlled system with an emphasis on basic concepts and ideas.**	
Course Outcome	CO-1	Remember and understand the basic concepts/principles of Digital Control System
	CO-2	Analyze the various concepts to understand them through case studies
	CO-3	Apply knowledge in understanding practical problems
	CO-4	Execute/create the projects or field assignment as per knowledge gained in the course
Accompanied by Laboratory Course	**No**	
Course Credits	**3-0-0**	
Course Type	**Professional Elective-6**	

Module-I (10 Hours)

Sampling and Reconstruction: Introduction, Examples of data control system- Digital to Analog conversion, sample and hold operations, **The Z-Transforms:** Introduction, Linear difference equations, pulse response, Z-transforms, theorems of Z-transforms, the inverse Z-transforms, modified Z-transforms, Z- transform for solving difference equations; Pulse transform function, block diagram analysis of sampled data systems, mapping between S-plane and Z-plane.

Module-II (10 Hours)

State Space Analysis: State space representation of discretetime systems, pulse transfer function matrix solving discrete time state space equations, state transition matrix and its properties, methods of computation of state transition matrix, discretization of continuous time state space equations. Concept of controllability and Observability, test for controllability and Observability, duality between controllability and Observability, controllability and Observability conditions for pulse transfer function.

Module-III (10 Hours)

Stability Analysis: Mapping between S-plane and Z-plane – primary and complementary strips, constant frequency loci, constant damping ratio loci, stability analysis of closed loop systems in z-plane, jury stability test- stability analysis by use of the bilinear transformation and Routh criterion.

Module-IV (10 Hours)

Design of Discrete time control system by conventional methods: transient and Steady state analysis and design based on the frequency response method- bilinear transformation and design procedure in W-plane, lead, lag and lag-lead compensators and digital PID controllers. **State feedback controllers and observers:** Design state feedback controller through pole placement-necessary and sufficient conditions, Ackerman's formula, state observers- full order and reduced order observers.

Text Books:

1. K Ogata,**Discrete Time Control Systems,** Pearson Education
2. Kuo,**Digital Control Systems**, Oxford University Press.

Reference Books:

1. M Gopal,**Digital Control and State Variable Methods**, TMH Publication.

High Voltage Engineering (EEE477)

Prerequisite	**Electrical Engineering Material**	
Course Objective	**To give students a deeper insight about high voltage engineering, insulation breakdown and ageing effect of high voltage components**	
Course Outcome	CO-1	Remember and understand the basic concepts/principles of High Voltage Engineering
	CO-2	Analyze the various concepts to understand them through case studies
	CO-3	Apply knowledge in understanding practical

		problems
	CO-4	Execute/create the projects or field assignment as per knowledge gained in the course
Accompanied by Laboratory Course	**No**	
Course Credits	**3-0-0**	
Course Type	**Professional Elective-4**	

Module-I (10 Hours)

Conduction and breakdown in gases: Gases as insulating media, Ionization processes, Townsend current growthequation. Current growth in the presence of secondary processes. Townsend's criterion for breakdown.Experimental determination of ionization coefficients. Breakdown in electronegative gases, time lags for breakdown, streamer theory of breakdown in gases,Paschen's law, Breakdown in non-uniform field and corona discharges,Post breakdown phenomena and applications, practical considerations in using gases for insulationpurposes.

Module-II (10 Hours)

Conduction and breakdown in liquid dielectrics: Pure liquids and commercial liquids, conduction and breakdownin pure liquids.Breakdown in solid dielectrics: Introduction, Intrinsic breakdown. Electromechanical breakdown, Thermal breakdown, Breakdown of solid dielectrics in practice.

Module-III (10 Hours)

Generation of high voltage and currents: Generation of high DC voltages, Generation of high alternatingvoltages, Generation of Impulse voltages. Tripping and control of impulse generators. Generation of Impulsecurrents.Measurements of high voltages and currents: Measurement of high D.C. voltages. Measurement of high DC and impulse voltages, Measurement of high DC, AC impulse currents, cathode ray oscillographsfor impulse voltages and currents measurements.

Module-IV (10 Hours)

Non-destructive testing of materials and electrical apparatus: Introduction. Measurement of D.C. resistivity.Measurement of dielectric constant and loss factor. Partial discharge measurements.High voltage testing of electrical apparatus: Testing of insulators and bushings. Testing of isolators and circuitbreakers, cables. Testing of transformers, surge diverterRadio Interference measurements.

Text Books

1. M S Naidu, V Kamaraju, **High Voltage Engineering,** McGraw Hill
2. E Kuffel, W S Zaengl, J Kuffel, **High Voltage Engineering: Fundamentals,**Newnes
3. C L Wadhwa, **High Voltage Engineering,** New Age Publishers

Reference Books

1. Peter Mackintosh, **High Voltage Engineering**, Laresen and Keller Education
2. Farouk A M Rizk, Giao N Trinh,**High Voltage Engineering**, CRC Press
3. Subir Ray, **High Voltage Engineering**, PHI

Power Quality (EEE474)

Prerequisite	**Power System Operation and Control**	
Course Objective	**The course provides a detailed analysis of need of power quality in power system**	
Course Outcome	CO-1	Remember and understand the basic concepts/principles of Power Quality
	CO-2	Analyze the various concepts to understand them through case studies
	CO-3	Apply knowledge in understanding practical problems
	CO-4	Execute/create the projects or field assignment as per knowledge gained in the course
Accompanied by Laboratory Course	**No**	
Course Credits	**3-0-0**	
Course Type	**Professional Elective-5**	

Module-I (10 Hours)

Overview of Power Quality and Power Quality Standard, Interest in Power Quality, Power Quality, Voltage Quality, Overview of Power Quality Phenomena, Power Quality and EMC Standards,Long Interruptions and Reliability Evaluation, Introduction, Observation of System Performance, Standards and Regulations, Overview of Reliability Evaluation,Basic Reliability Evaluation Technique, Costs of Interruptions

Module-II (10 Hours)

Short Interruptions: Introduction, Terminology,Origin of Short Interruptions, Monitoring of Short Interruptions,Influence of Equipment, Single Phase Tripping, Stochastic Prediction of Short Interruptions

Module-III (10 Hours)

Voltage Sags: Characterization, Introduction, Magnitude and Duration, Three Phase Unbalance Phase Angle Jumps,Magnitude and Phase-Angle Jumps for three phase

Unbalanced Sags, Other Characteristics of Load Influence on Voltage Sags, Sags due to Starting of Induction Motors

Module-IV (10 Hours)

Mitigation of Interruptions and Voltage Sags: Overview of Mitigation Methods, Power System Design Redundancy through Switching, Power System Design, Redundancy through Parallel Operation, the System – Equipment Interface

Text Books

1. Math H.J Bollen, **Understanding Power Quality Problems: Voltage Sags and Interruptions,** IEEE Press
2. Roger C. Dugan, Mark F. Mcgranaghan, Surya Santoso, H. Wayne Beaty, **Electrical Power Systems Quality**, McGraw Hill Education.
3. Allan Greenwood, **Electrical Transients in Power Systems**, Wiley
4. C S Indulkar, **Power System Transients: A Statistical Approach**, PHI
5. Bhim Singh, Ambarish Chandra, Kamal Al-Haddad, **Power Quality Problems and Mitigation Techniques**, Wiley

Reference Books

1. C. Sankaran, **Power Quality**, CRC Press
2. A Moreno Munoz**, Power Quality: Mitigation Technologies in a Distributed Environment**, Springer
3. SurajitChattopadhyay, MadhuchandaMitra, SamarjitSengupta, **Electric Power Quality (Power Systems)**, Springer
4. B Kennedy, **Power Quality Primer**, McGraw Hill

HVDC Transmission System (EEE478)

Prerequisite	Power Electronics, Transmission and Distribution System, Control System	
Course Objective	Understand the architecture of HVDC transmission system, converter operation, protection, control and harmonic aspects	
Course Outcome	CO-1	Remember and understand the basic concepts/principles of HVDC Transmission System.
	CO-2	Analyze the various concepts to understand them through case studies
	CO-3	Apply knowledge in understanding practical problems
	CO-4	Execute/create the projects or field assignment as per knowledge gained in the

		course
Accompanied by Laboratory Course	**No**	
Course Credits	**3-0-0**	
Course Type	**Professional Elective-5**	

MODULE-I (10 HOURS)

DC power transmission system: Comparison between HVAC and HVDC transmission system, Application of HVDC transmission system, Different types of HVDC transmission link, Comparison of cost of HVDC and HVAC transmission system, CIGRE benchmark model of HVDC system

Components of HVDC system: Pulse number,3-phase 6-pulse Converter, 3-phase Inverter, DC smoothing reactor, AC filters, Tap Changers, 12 pulse converter and phase shifting transformer, converter and transformer utilization factor

Multi terminal HVDC: Types of MTDC systems, Comparison of series and parallel MTDC system,

MODULE-II (10 HOURS)

Thyristor Triggering: Series and Parallel Connection of Thyristor and triggering, Gate triggering mechanism for phase controlled converter **HVDCConverter Operation**: Circuit diagram and Different Modes of Operation of 6-pulse line commutated converter (Converter and inverter mode of operation), Effect of source impedance and overlap angle, Different modes of valve operation with respect to overlap angle (overlap angle less than and greater than 60°), output voltage waveforms and DC voltage in rectification operation, output voltage waveforms and DC voltage in inverter operation, valve voltages, Equivalent electrical circuits, converter chart.

MODULE-III (10 HOURS)

Harmonics and Filter: Basic idea of harmonics (inter harmonic, sub harmonic, triplen harmonic), Standards of harmonics, Generation of Harmonics in Line commutated Converter, Characteristics and Uncharacteristic Harmonics in line commutated converter, Issues due to harmonics, Telephone interference, Design Criteria for AC filters, Tuned filter, self-tuned filters, series and shunt filter, High pass filters, Type C damped filters, DC filters

Converter Faults and Protection: Converter mal-operations (Commutation failure, arc through, misfire, arc quenching), DC line fault, AC line fault, internal fault (Converter short circuit), Protection against over current in HVDC system, Protection against over voltages in Converter station,Protection against dv/dt and di/dt.

MODULE-IV (10 HOURS)

HVDC control characteristics, Hierarchical control scheme of HVDC, Constant current and constant voltage control, constant extinction angle control, constant ignition angle control, Tap changer control, Reactive power compensation in HVDC system, Power flow in HVDC system

Text Books

1. Edward Wilson Kimbark, **Direct Current Transmission** Vol. I, Wiley-Interscience
2. DraganJovcic, Khaled Ahmed, **High Voltage Direct Current Transmission Converters, Systems and DC Grids**, Wiley, 2015
3. K R Padiyar, **HVDC Power Transmission Systems**, New Age International Publishers
4. Jos Arrillaga, **High Voltage Direct Current Transmission**, IET Power Series

Reference Books

1. Jos Arillaga, Bruce Smith**, AC-DC Power System Analysis,** IET Press
2. Chan Ki Kim, Vijay K Sood, Gil-Soo Jang, Seong-Joo Lim, Seok-Jin Lee, **"HVDC Transmission: Power conversion applications in power systems,"** Wiley-IEEE
3. Colin Adamson and N G Hingorani, **"High voltage direct current power transmission,"** Garraway Limited
4. J Arrillaga**, "High voltage direct current transmission,"** Peter Pregrinus, London

Adaptive and Optimal Control (EEE479)

Prerequisite	**Control System Engineering-1, Control System Engineering-2**	
Course Objective	**The course aims to provide advanced concepts of system identification, adaptive control and optimal control to UG students**	
Course Outcome	CO-1	Remember and understand the basic concepts/principles of Adaptive and Optimal Control
	CO-2	Analyze the various concepts to understand them through case studies
	CO-3	Apply knowledge in understanding practical problems
	CO-4	Execute/create the projects or field assignment as per knowledge gained in the course
Accompanied by Laboratory Course	**No**	

Course Credits	**3-0-0**
Course Type	**Professional Elective-5**

Module-1 (10 Hours)

System Identification: Basics of system identification, need of system identification, types of system identification (Parametric and Non-parametric), **Experimental system design:** Different signals for identification (Chirp, PRBS), **Model structures:** Linear model structures (ARX, ARMAX, OE and BJ), nonlinear (NARX, NARMAX) and block oriented model structure (Wiener, Hammerstain, Wiener-Hammerstain, Hammerstain-Wiener), **Parameter estimation:** Least square, Recursive least square, variants of recursive least square, Prediction Error Method, Instrumental Variable Method Model validation

Module-II (10 Hours)

Adaptive Control: Introduction to adaptive control, Effects of process variations, Types of adaptive control**Self-tuning regulator:**deterministic in-direct self-tuning regulators, Deterministic direct self-tuningregulators, Introduction to stochastic self-tuning regulators.

Model reference adaptive controller: The MIT rule, Lyapunov theory, Design ofmodel reference adaptive controller using MIT rule and Lyapunov theory, Relationbetween model reference adaptive controller and self-tuning regulator

Module-III (10 Hours)

Optimal Control: Introduction, Performance Index, Constraints, Formal Statement Of Optimal Control System, Calculus Of Variations, Function, Functional, Increment, Differential And Variation And Optimum Of Function And Functional, The Basic Variational Problem Extrema Of Functions And Functional With Conditions , variation of Approach To Optimal Control System

Module-IV (10 Hours)

Linear Quadratic Optimal Control: Problem Formulation, Finite Time Linear Quadratic Regulator, **Infinite Time LQR System:** Time Varying Case, Time-Invariant Case, Stability issues of Time Invariant Regulator, **Linear Quadratic Tracking System:** Fine Time Case And Infinite Time Case **Pontryagin Minimum Principle**: Introduction **Dynamic Programming**: Principle Of Optimality, Optimal Control Using Dynamic Programming, Optimal Control Of Continuous Time And Discrete-Time Systems, Hamilton-Jacobi-Bellman Equation

Text Books

1. L Ljung, **System Identification: Theory for users**, Prentice Hall

2. Arun K Tangirala, **Principles of System Identification: Theory and Practice**, CRC press
3. Karl J Astrom, Bjorn Wittenmark, **Adaptive Control**, Pearson
4. Donald E. Kirk, **Optimal Control Theory: An Introduction**, Dover Publications

Reference Books

1. Shankar Sastry, **Adaptive Control: Stability, Convergence and Robustness**, Dover Publication
2. D. Subbaram Naidu, **Optimal Control Systems**, Dover Publication

Power System Protection (EEC481)

Prerequisite	**Power System Operation and Control**	
Course Objective	**The course provides a detailed idea of different type of protection devices used in power system.**	
Course Outcome	CO-1	Remember and understand the basic concepts/principles of Power System Protection
	CO-2	Analyze the various concepts to understand them through case studies
	CO-3	Apply knowledge in understanding practical problems
	CO-4	Execute/create the projects or field assignment as per knowledge gained in the course
Accompanied by Laboratory Course	**No**	
Course Credits	**3-0-0**	
Course Type	**Core**	

Module-I (10 Hours)

Symmetrical and unsymmetrical fault analysis for power system, Z bus method in fault analysis.Philosophy of protection, Nature, Causes and consequences of faults, Zone of protection, Requirements of a protective scheme, Basic terminology components of protection scheme. Relay classification, Principle of different types of electromagnetic relay. General equation of phase and magnitude comparators, Duality of comparators, Electromagnetic relays, over current relays Directional relays, Distance relay- impedance, Reactance and Mho type, Differential relays.Feeder Protection, Generator Protection, Transformer Protection, Bus Zone Protection

Module-II (10 Hours)

Circuit Breakers: Formation of arc during circuit breaking. Theories of arc Interruption. Recovery and Restriking voltage, Interruption of capacitive and inductive currents. Current chopping. circuit breaker rating, Different types of circuit breakers. Air break and Air blast circuit breaker. Plain break and controlled break all circuit breakers. Minimum oil circuit breakers. Vacuum circuit breaker, SF6 circuit breaker. D.C. Circuit breaker.

Module-III (10 Hours)

Concept of Static and Numerical relay. Amplitude comparator, Phase Comparator, Coincidence type phase comparator, Basic elements of a static relay, Over Current Relays, Differential Protection, Block Diagram of Numerical Relay, Signal Sampling & Processing.

Module-IV (10 Hours)

Arrangement of Bus bar, Circuit breaker and isolator. Current limiting reactors in power system and their arrangement calculation of fault MVA for symmetrical short circuits. Circuit breaker capacity.

Text Books

1. S S Rao, **Switchgear Protection,** Khanna Publishers
2. Y.G. Paithankar and S.R Bhide, **Fundamentals of Power System Protection**, Prentice-Hall of India
3. A Chakraborti, M L Soni, P V Gupta, U S Bhatnagar, **A Text Book on Power System Engineering**, DhanpatRai
4. Badri Ram, D N Vishwakarma**, Power System Protection and Switchgear,** Tata McGraw Hill
5. B Ravindranath, M Chander, **Power System Protection and Switchgear**, New Age International Publishers
6. A.R. van C. Warrington, **Protective Relays: Their Theory and Practice**, Vol. I and II, Springer

Reference Books

1. J L Blackburn, T J Domin, **Protective Relaying: Principles and Applications,** CRC Press
2. T S Madhava Rao, **Power System Protection: Static Relays with Microprocessor Applications**, Tata McGraw Hill
3. V K Mehta, Rohit Mehta, **Principles of Power System**, S Chand

Flexible AC Transmission System (EEE482)

Prerequisite	**Power System Operation and Control**	
Course Objective	**The course provides application aspects of electrical energy in a wide range of areas**	
Course Outcome	CO-1	Remember and understand the basic concepts/principles of Flexible AC Transmission System
	CO-2	Analyze the various concepts to understand them through case studies
	CO-3	Apply knowledge in understanding practical problems
	CO-4	Execute/create the projects or field assignment as per knowledge gained in the course
Accompanied by Laboratory Course	**No**	
Course Credits	**3-0-0**	
Course Type	**Professional Elective-6**	

Module-I (10 Hours)

Introduction to FACTS, Transmission Interconnections, Flow of Power in an AC System, What limits the Loading Capability, Power Flow and Dynamic Stability Considerations of a Transmission Interconnection, Relative Importance of Controllable Parameters, Basic Types of FACTS Controllers, Basic Description and Definitions of FACTS Controllers.

Module-II (10 Hours)

Static Series Compensators: Objective of Series Compensation (GCSC, TSSC, TCSC), Variable Impedance Type Series Compensators, Switching Converter Type Series Compensators (SSSC) Static Voltage and Phase Angle Regulators: Objectives of Voltage and Phase Angle Regulators, Approaches to Thyristor-Controlled Voltage and Phase Angle Regulators (TCVRs and TCPARs).

Module-III (10 Hours)

Static Shunt Compensation: Objectives of Shunt Compensation, Methods of Controllable VAR Generation, Static VAR Compensators, SVC and STATCOM

Module-IV (10 Hours)

Combined Compensators: Introduction, Unified Power Flow Controller (UPFC), The Interline Power Flow Controller (IPFC), Generalized and Multifunctional FACTS Controllers.

Text Books

1. Narain G Hingorani, **Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems**, Standard Publishers
2. K S Padiyar, **FACTS controllers in power transmission and distribution**, New Age
3. Mohan Mathur R, Rajiv K Varma, **Thyristor based FACTS controller for electrical transmission system**, IEEE Press, Wiley

Reference Books

1. Enrique Acha, Claudio R. Fuerte-Esquivel, Hugo Ambriz-Perez, Cesar Angeles-Camacho, **FACTS: Modelling and Simulation in Power Networks**, Wiley
2. Y H Song, Allan T Johns, Flexible AC Transmission System, **Institution of Electrical Engineers Press**

Industrial Instrumentation (EEE485)

Prerequisite	**Basics of measurement and instrumentation**	
Course Objective	**The course covers the basics of measurement system and measurement of physical parameters like temperature, pressure, distance, flow etc**	
Course Outcome	CO-1	Remember and understand the basic concepts/principles of Industrial Instrumentation
	CO-2	Analyze the various concepts to understand them through case studies
	CO-3	Apply knowledge in understanding practical problems
	CO-4	Execute/create the projects or field assignment as per knowledge gained in the course
Accompanied by Laboratory Course	**No**	
Course Credits	**3-0-0**	
Course Type	**Professional Elective-6**	

Module-I (10 Hours)

Generalized concept of measurement system,International Standards, Hierarchy of Standard, Calibration of instrument**, Sensors and Transducer:** Basics of sensor and transducer, Specification of sensors and transducer, Selection of sensors and transducer, signal conditioning element, signal processing element and signal presentation element Analog and MEMS type digital sensor, digital interface of sensor (SPI, I2C, One-wire)

Module-II (10 Hours)

Temperature Measurement: Zeroth law of thermodynamics, thermometric property,Glass-in tube thermometer, Bimetallic thermometers, **RTD:** Operating Principle, three wire and four wire RTD, **Thermistor:** Operating principle, linearization of thermistor, errors in RTD and thermistor **Thermocouple**: Operating Principle, Types, Law of thermocouple, Cold Junction Compensation, Signal Conditioning, Thermopile, Thermostat, Signal conditioning of temperature sensor, **Pyrometers:** Fundamentals of Radiation, Radiation pyrometer, Optical Pyrometer,Total radiation & selective radiation, Two colour radiation pyrometers.

Module-III (10 Hours)

Pressure Measurement: Manometer, Types of Manometer, Errors in Manometers,Bellows, Diaphragms, C-Type Bourdon Tube, Measurement of vacuum: McLeod gauge, Thermal conductivity gauges, Ionization gauge, Pirani gauge, Kundsen gauge, Deadweight tester.**DisplacementMeasurement:**Resistive Potentiometer, Linear Variable Differential Transformer (LVDT), Variable inductance and variable reluctance, Capacitive type displacement measurement, translational and rotational displacement measurement, Piezoelectric type, Eddy current based displacement measurement, Ultrasonic displacement measurement **Force Measurement**: Strain Gauge, Signal conditioning of strain gauge, lead wire and temperature compensation, Load Cell

Module-IV (10 Hours)

Flow Measurement: Streamlined and turbulent flow, Bernoulli's theorem, flow measurement of liquid and gases**Mass Flow meter:** Coriolisflowmeter**, Volume Flow meter:** Venturi tube, orifice plate, nozzles, dall tube **Variable area type flow meter:**Rotameter, positive displacement flow meter, turbine flow meter, electromagnetic flow meter, vortex flow meter, ultrasonic flow meter, Pilot-static tube, Hot-wire anemometer,

Text Books

1. John P. Bentley**, Principles of Measurement Systems,** Pearson, 4th Edition.
2. Ernest O. Doebelin and Dhanesh N Manik**, Dobelin's Measurement Systems,** McGraw Hill, 7th Edition.
3. Fraden Jacob, **Handbook of Modern Sensors: Physics, Design and Applications**, Springer, 4th Edition.
4. Walt Boyes, **Instrumentation Reference Book**, Elsevier, 4th Edition.
5. Alan S. Morris, **Measurement and Instrumentation Principles,** Butterworth Heinemann, Elsevier, 3rd Edition.

Reference Books

1. Gregory K. McMillan and Douglas M. Considine, **Process/Industrial Instruments and Controls Handbook**, McGraw Hill, 5th Edition.
2. Walt Boyes, **Instrumentation Reference Book**, Elsevier, 4th Edition.
3. Ian Sinclair, **Sensors and Transducers**, Newnes, Elsevier, 3rd Edition.
4. D.Patranabis, **Principles of Industrial Instrumentation**, McGraw Hill (India).
5. S. M. Sze, **Semiconductor Sensors**, John Wiley and Sons
6. AlokBarua, **Fundamentals of Industrial Instrumentation**, Wiley

Electrical Engineering Material (EEE488)

Prerequisite	**None**	
Course Objective	**The course aims to provide a introductory idea about different materials used in engineering studies**	
Course Outcome	CO-1	Remember and understand the basic concepts/principles of Electrical Engineering Material
	CO-2	Analyze the various concepts to understand them through case studies
	CO-3	Apply knowledge in understanding practical problems
	CO-4	Execute/create the projects or field assignment as per knowledge gained in the course
Accompanied by Laboratory Course	**No**	
Course Credits	**3-0-0**	
Course Type	**Professional Elective-6**	

Module-I (10 Hours)

Conductivity of Metal: Introduction, factors affecting the resistivity of electrical materials, motion ofan electron in an electric field, Equation of motion of an electron, current carried by electrons, mobility, energy levels of a molecule, emission of electrons from metals, thermionic emission, photo electric emission, field emission, effect of temperature on electrical conductivity of metals, electrical conducting materials, thermal properties, thermal conductivity of metals, thermoelectric effects.

Module-II (10 Hours)

Dielectric Properties: Introduction, effect of a dielectric on the behaviour of a capacitor, polarization, the dielectric constant of monatomic gases, frequency dependence of permittivity, dielectric losses, significance of the loss tangent, dipolar relaxation, frequency and temperature dependence of the dielectric constant, dielectric properties of polymeric system, ionic conductivity in insulators, insulating materials, Ferro electricity, piezoelectricity.

Module-III (10 Hours)

Magnetic properties of Materials: Introduction, Classification of magnetic materials, diamagnetism, Para magnetism, ferromagnetism, magnetization curve, the hysteresis loop, factors affecting permeability and hysteresis loss, common magnetic materials, magnetic resonance.

Module-IV (10 Hours)

Semiconductors: energy band in solids, conductors, semiconductors and insulators, types of semiconductors, Intrinsic semiconductors, impurity type semiconductor, diffusion, the Einstein relation, hall effect, thermal conductivity of semiconductors, electrical conductivity of doped materials.

Text Books

1. C S Indulkar, S Thiruvengadam, **An Introduction to Electrical Engineering Materials,** S Chand
2. S P Seth, **A Course in Electrical Engineering Material**, DhanpatRai
3. W D Callister**, Materials Science and Engineering,** John Wiley and Sons
4. V Rajendran, A Marikani**, Materials Science,** Tata McGraw Hill
5. M S Vijaya, G Rangarajan**, Material Science,** Tata McGraw Hill
6. Raghavan V, **Material Science Engineering: A First Course**, PHI

Reference Books

1. William F. Smith, JavedHashemi, Ravi Prakash**, Material Science and Engineering (in SI Units),** McGraw Hill
2. K G Budinski, **Engineering Material**, PHI
3. A J Dekker, **Electrical Engineering Material**, PHI
4. N Alagappan, **Electrical Engineering Material,** McGraw Hill

Special Electrical Machine (EMOC355)

Prerequisite	**Electrical Machine-I, Electrical Machine-II, Power Electronics**	
Course Objective	**The course is intended to give an exposure to non-conventional electric machines to the students**	
Course Outcome	CO-1	Remember and understand the basic concepts/principles of Special Electrical

		Machines
	CO-2	Analyze the various concepts to understand them through case studies
	CO-3	Apply knowledge in understanding practical problems
	CO-4	Execute/create the projects or field assignment as per knowledge gained in the course
Accompanied by Laboratory Course	**No**	
Course Credits	**3-0-0**	
Course Type	**MOOCs Elective-1**	

Module-I (10 Hours)

Stepper Motor: Constructional feature, winding in stepper motor, principle of operation, EMF and torque equation of stepper motor,Variable reluctance stepper motor, permanent magnet stepper motor, hybrid stepper motor, Single and multistack configuration, Mathematical Modeling

Switched Reluctance Motor: Introduction, principle of operation of SRM, Some design aspects of stator and rotor pole arcs, design of stator and rotor andpole arcs in SR motor-determination of L(θ)-θ profile, power converter for SR motor, Rotor sensing mechanism and logic control, drive and power circuits, derivation oftorque expression, Digital control of Switched Reluctance Motor

Module-II (10 Hours)

Permanent Magnet DC Motor: Constructional feature, principle of operation, EMF equation, power controller**Brushless DC Motor:**Types of construction, principle of operation of BLDC, sensing and switching logic scheme, sensing logic controller, lockout pulses, drive and power circuits, Base drive circuits, power converter circuit, Theoreticalanalysis and performance prediction, modeling of BLDC, Torque Pulsation.

Module-III (10 Hours)

Permanent Magnet Synchronous Motor: Permanent Magnet and characteristics, Principle of operation, EMF, power input and torque expressions, Phasordiagram, Power controllers, Torque speed characteristics, Control Schemes**Synchronous Reluctance Motor:**Constructional features, Types: Axial and Radial flux motors, Operating principles, Variable Reluctance and Hybrid Motors, SYNREL Motors, Voltage and Torque Equations, Phasor diagram, Characteristics.

Module-IV (10 Hours)

Linear Induction Motor (LIM): Construction of LIM, Thrust equation of LIM, Performance Equation Based on Current Sheet Concept, Goodness Factor, Equivalent Circuit of LIM, Characteristic of LIM, Certain Design Aspects of LIM, Control of LIM. Linear Synchronous Motor (LSM): Type and Construction of LSM, Thrust equation of LSM, Control of LSM, Application of LSM. DC Linear Motor (DCLM): Type and Construction of DCLM, Persistent Current Tubular Electromagnetic Launcher, Induction Tubular EML, DC Pulsed Flat Series EML, DC Tubular Series EML. Linear Reluctance Motor (LRM): Construction, Working and Features of LRM, Operation of LRM with AC and DC Supply

Text Book

1. E G Janardanan, **Special Electric Machines**, PHI
2. K VenkatRatnam, **Special Electric Machines**, University Press

Reference Book

1. T J E Miller, **Brushless Permanent-Magnet and Reluctance Motor Drives**, Oxford Science Publication

Biomedical Instrumentation (EMOC356)

Prerequisite	**None**	
Course Objective	**The course covers the details of a wide range of medical instruments and imaging techniques**	
Course Outcome	CO-1	Remember and understand the basic concepts/principles of Biomedical Instrumentation
	CO-2	Analyze the various concepts to understand them through case studies
	CO-3	Apply knowledge in understanding practical problems
	CO-4	Execute/create the projects or field assignment as per knowledge gained in the course
Accompanied by Laboratory Course	**No**	
Course Credits	**3-0-0**	
Course Type	**MOOCs Elective-1**	

Module-I (10 hours)

Basic Biology: Cell and their structures, neuron, axon, synapse, action and resting potential,electro physiology of cardio pulmonary system, respiration and blood circulation,central nervous system and peripheral nervous system, Origin of bioelectric signal, skin-contact impedance, Need of biomedical instruments, **Electrodes:**electrodetheory, bipolarand unipolar electrodes, surface electrodes, micro electrodes, electrode for ECG, EEG and EMG, Motion artefacts

Module-II (10 Hours)

Biomedical Recorder:ECG:Operating principle, lead system and recording methods, Basic principles, typical waveforms, Design of signal conditioning and filtering system for ECG, Chopper amplifier, Isolation amplifier, instrumentation amplifier, data acquisition system design, signal processing algorithms for ECG, Filter design techniques.

Module-III (10 Hours)

Measurement of blood pressure, blood flow, cardiac output, plethysmography,cardiac rate, heart sound, measurement of gas volume, flow rate of CO_2 and O_2 in exhaust air, pH of blood, Blood Cell Counter **Non-invasive measurement:** Skin temperature measurement, Thermography

Module-IV (10 Hours)

Medical Imaging: X-rays: Production & properties, various components of radiographic systems, rating charts of X- ray tubes. Electrical circuit for X-ray machine, filament circuits and mA control, HT circuits, KV control, control of exposure timers, collimators,scatter& grids, absorbed dose, basics of tables & arms, dark room accessories, types of X-ray tubes for variousmedical applications; Principle of photography and radiographic film image, film sensitometry, information contentof an image, image quality factors, MTF.

Text Books

1. Leslie Cromwell, Fred J. Weibell and Erich A. Pleiffer, **Biomedical Instrumentation and Measurements**, Prentice Hall of India
2. L.A. Geddes and L.E. Baker, **Principles of Applied Biomedical Instrumentation**, John Wiley & Sons
3. R S Kandpur, **Handbook of Biomedical Instrumentation,** Tata McGraw Hill
4. John G Webster, **Medical Instrumentation Application and Design**, Wiley
5. W R Hendee, E.R. Ritenour, **Medical Imaging Physics**, Mosbey Year Book

Reference Books

1. Laurence J. Street, **Introduction to Biomedical Engineering Technology,** CRC Press
2. Steven Schreiner, Joseph D. Bronzino, Donald R. Peterson**, Medical Instruments and Devices: Principles and Practices,** CRC Press

3. Michael M. Domach, **Introduction to Biomedical Engineering**, Pearson

Sensors and Transducers (EMOC357)

Prerequisite	**None**	
Course Objective	To discuss need of transducers, their classification, working, advantages, disadvantages and the recent trends in sensor technology and their selection.	
Course Outcome	CO-1	Remember and understand the basic concepts/principles of Sensors and Transducers.
	CO-2	Analyze the various concepts to understand them through case studies
	CO-3	Apply knowledge in understanding practical problems
	CO-4	Execute/create the projects or field assignment as per knowledge gained in the course
Accompanied by Laboratory Course	**No**	
Course Credits	**3-0-0**	
Course Type	**MOOCs Elective-1**	

Module-I (8 Hours)

Sensors and Transducers: Basics of sensors and transducer, classification of sensor and transducers, complete block diagram of analog and digital measurement system, basic of signal conditioning, signal processing and data presentation elements

Module-II (12 Hours)

Resistive sensing element: Potentiometer for linear and angular displacement measurement, semiconductor resistive gas sensor, capacitive displacement sensor: Variable separation displacement sensor, variable area displacement sensor, variable dielectric displacement sensor, capacitive pressure sensor, differential capacitive displacement sensor, capacitive level sensor, inductive displacement sensor: Differential reluctance displacement sensor, Elastic sensing element: Linear and angular accelerometer, piezoelectric sensing element, electrochemical sensing element.

Module-III (10 Hours)

Interface Electronic Circuit:Amplifiers: Non-idealities of Op-Amp, Effect of Non-idealities, Differential Amplifier, Trans-impedance Amplifier, Cascaded Amplifiers, CMRR, Performance Analysis of Amplifiers, push-pull configuration for improvement of linearity and sensitivity Amplifiers Instrumentation amplifier, Charge amplifier, Programmable gain amplifier,Bridge Circuit:Deflection bridges: design of resistive and reactive bridges, Temperature Compensated Resistive Bridge,

A.C. carrier systems, phase sensitive demodulators and its applications in instrumentation.

Signal processing elements: A/D conversion: sampling, quantization,encoding,typical converter

Module-IV (10 Hours)

Data Acquisition Systems: Introduction, Objectives and Configuration of Data Acquisition System, General purpose plug-in DAQ board, PCI plug-in DAQ board. Data Acquisition using GPIB: Overview of GPIB, GPIB commands, GPIB programming, Expanding GPIB, Standard commands for programmable instruments. Data Acquisition using Serial Interfaces: Serial communication, Serial interface standards, PC serial port, USB, IEEE1394, Remote I/O modules.

Text Books

1. John P. Bentley, **Principles of Measurement Systems**, Prentice-Hall, 4th Edition, 2005
2. Robert B Northrop, **Introduction to Instrumentation and Measurements**, CRC Press, 2nd Edition, 2005
3. N. Mathivanan, **PC-Based Instrumentation: Concepts and Practice**, Prentice-Hall of India, 2016
4. Mike Tooley, **PC-Based Instrumentation and Control**, Newnes, 2013

Reference Books

1. Walt Boyes, **Instrumentation reference book**, Elsevier, 4th Edition
2. Jacob Farden, **Handbook of modern sensors Physics, Designs and Applications**, 3rd Edition, Springer
3. Ian Sinclair, **Sensors and Transducers**, Newnes, 3rd Edition

Distributed Generation and Micro-grid (EMOC365)

Prerequisite	**Renewable Energy System**	
Course Objective	**To make the students aware about the recent advances of distributed generation scheme**	
Course Outcome	CO-1	Remember and understand the basic concepts/principles of Distributed Generation and Microgrid
	CO-2	Analyze the various concepts to understand them through case studies
	CO-3	Apply knowledge in understanding practical problems
	CO-4	Execute/create the projects or field assignment as per knowledge gained in the course
Accompanied by Laboratory Course	**No**	
Course Credits	**3-0-0**	
Course Type	**MOOCs Elective-2**	

Module-I (10 Hours)

Need for Distributed generation, renewable sources in distributed generation,current scenario in Distributed Generation, **Planning of DGs:** Siting and sizing of DGs, optimal placement of DG sources in distribution systems.**Grid integration of DGs:** Different types of interfaces, Inverter based DGs androtating machine based interfaces, Aggregation of multiple DG units. **Energy storageelements:** Batteries, ultra-capacitors, flywheels.

Module-II (10 Hours)

Technical impacts of DGs: Transmission systems, Distribution systems, reregulation: Impact of DGs upon protective relaying: Impact of DGs upon transient and dynamic stability of existing distribution systems.

Module-III (10 Hours)

Economic and control aspects of DGs: Market facts, issues and challenges, Limitations of DGs. Voltage control techniques, Reactive power control, Harmonics,Power quality issues. **Reliability of DG based systems:**Steady-state and Dynamicanalysis

Module-IV (10 Hours)

Micro Grids: Introduction to micro-grids, Types of micro-grids, autonomous and non-autonomous grids, Sizing of micro-grids **Modelling & Analysis:** Micro-grids with multiple DGs, Micro-grids with power electronic interfacing units. Transients in micro-grids, Protection of micro-grids

Text Books

1. H. Lee Willis, Walter G. Scott, **Distributed Power Generation: Planning and Evaluation**, Marcel Decker Press
2. MGodoySimoes, Felix A.Farret, **Renewable Energy Systems: Design and Analysis with Induction Generators**, CRC press.
3. Robert Lasseter, Paolo Piagi, **Micro-grid: A Conceptual Solution**, PESC 2004

Soft Computing and Applications(EMOC366)

Prerequisite	**None**	
Course Objective	**This course aims to provide basic concepts of soft computing and teach the students the application of soft computing techniques in electrical engineering applications**	
Course Outcome	CO-1	Remember and understand the basic concepts/principles of Soft Computing
	CO-2	Analyze the various concepts to understand them through case studies
	CO-3	Apply knowledge in understanding practical problems
	CO-4	Execute/create the projects or field assignment as per knowledge gained in the course
Accompanied by Laboratory Course	**No**	
Course Credits	**3-0-0**	
Course Type	**MOOCs Elective-2**	

Module-I (10 Hours)

Introduction to Neural network, fuzzy logic and evolutionary computing, **Artificial Neural Network:** Biological Neuron, artificial neuron, Perceptron, Activation function, Adaline, Madaline, Types of learning, Multilayer perceptron: error back propagation algorithm, gradient Descent, Levenberg-Marquardt method, Limitations and variants of error-back-propagation learning, Feed-forward neural network, radial basis function network, Recurrent neural network,

Module-II (10 Hours)

Fuzzy Logic System: Classical sets, fuzzy sets, Operations of fuzzy set, properties of fuzzy set, Fuzzy relations, Equivalence and tolerance relation, Zadeh's compositional rule of inference, Fuzzication techniques, membership function, types of membership function, fuzzy inference system: MAMDANI and Sugeno, Different types of Defuzzification method,

Module-III (10 Hours)

Swarm Optimization: Basic concepts of Genetic algorithm, biological background: detailed algorithm, encoding, fitness function, GA operators, Simple numerical problems, Other techniques: Particle Swarm Optimization, Ant colony Optimization, Honey Bee optimization-differential evolution-step by step algorithm, Comparison of random search techniques with gradient based algorithms.

Module-IV (10 Hours)

Application of neural network in short term load forecasting, load frequency control (single and multi-area models), application of fuzzy logic in controller design application, Application of fuzzy logic in power system stabilizer (PSS), application of swarm optimization techniques in congestion management, transmission pricing model, Problem solving and simulation exposure

Text Books

1. S Rajasekaran, G A VijayalajshmiPai, **Neural Networks, Fuzzy logic and genetic algorithms,** PHI
2. Satish Kumar, **Neural Networks: A Classroom approach,** Tata McGraw Hill
3. Timothy J Ross, **Fuzzy logic with engineering application,** Wiley
4. Simon Haykin, **Neural Networks: A comprehensive foundation,** PHI
5. S Sumathi, Surekha P, **Computational Intelligence Paradigms: Theory and Applications in MATLAB**, CRC Press
6. Devendra K Chaturvedi, **Soft Computing Techniques and Applications in Electrical Engineering,** Springer

Reference Books

1. SivanandamSumathi, S N Sivanandam, S N Deepa, **Introduction to Fuzzy logic with MATLAB**, Springer
2. Lakhmi C Jain, Vasile Palade, Dipti Srinivasan, **Advances in Evolutionary Computing for System Design**, Springer
3. Jatcek M Zurada, **Introduction to Artificial Neural Systems**, Jaico Publishing House
4. B Kosko, **Neural Networks and Fuzzy Systems,** PHI

Embedded and Real Time System (EMOC367)

Prerequisite	**Microprocessor and Microcontroller, Digital Signal Processing**	
Course Objective	**The course provides the basics as well as advanced microcontroller and embedded processor architecture**	
Course Outcome	CO-1	Remember and understand the basic concepts/principles of Embedded and Real time systems.
	CO-2	Analyze the various concepts to understand them through case studies
	CO-3	Apply knowledge in understanding practical problems
	CO-4	Execute/create the projects or field assignment as per knowledge gained in the course
Accompanied by Laboratory Course	**No**	
Course Credits	**3-0-0**	
Course Type	**MOOCs Elective-2**	

Module-I (10 Hours)

Microcontroller: Introduction to 8-bit and 16-bit microcontroller: 8051 family of microcontroller, architecture, memoryorganization, special function registers, timer, counter, serial interface, interrupt organization, instruction sets andprogramming, instruction timing and interfacing. **ATmega16 Architecture**: Memories, Port; Peripheral Features - Physical andOperating Parameters – Serial Communication **-** USART Overview, Registers,Operation and Programming- Serial Peripheral Interface- Operation, Registers, Programming

Module-II (10 Hours)

Embedded Processing Systems: Introduction to Digital Signal Processor, Architecture and features of TMS320C67xx. DSP processorpackaging(Embodiments), Fixed point vs floating point DSP processor, data paths,Memory architecture of a DSP processor (Von Neumann, Harvard, Modified Havard), Addressing modes, pipelining, TMS320 family of DSPs(architecture of C5x).**FPGA**: Overview of Field Programmable Gate Arrays (CPLD, FPGA), Types ofFPGA, basic components

Module-III (10 Hours)

Embedded System: Basics, Area of Application, Categories, Overview of embedded system architecture, Hardware architecture, Software architecture, Application Software, Communication Software, Devices and Buses for device networks, Protocols (UART, SPI, I2C, I2S, One-wire, CAN, Firewire, PCI),

Module-IV (10 Hours)

Real Time Operating Systems (RTOS) : Basics of RTOS: Real-time concepts, Hard Real time and Soft Real-time, Differences between General Purpose OS & RTOS, Basic architecture of an RTOS, Scheduling Systems, Inter-process communication, Performance Matric in scheduling models, Interrupt management in RTOS environment, Memory management, File systems, I/O Systems, Advantage and disadvantage of RTOS. POSIX standards, RTOS Issues – Selecting a Real-Time Operating System, RTOS comparative study

Text Books:

1. F. Vahid and T. Givargis, **Embedded System Design: A Unified Hardware-Software Introduction**, Wiley.
2. R. Kamal, **Embedded Systems: Architecture, Programming and Design,** Tata McGraw-Hill
3. W. Wolf, **Computers as Components : Principles of Embedded Computer System Design**, Elsevier
4. Muhammad AliMazidi, JaniceGillispieMazidi,Rolin D. McKinley,**The 8051 Microcontroller and Embedded System,**Pearson
5. Muhammad AliMazidi, SarmadNaimi, SepehrNaimi, **AVR Microcontroller and Embedded Systems: Using Assembly and C**, Pearson
6. Chris Nagy, **Embedded System Design using the TI MSP 430 Series**, Newnes,

Reference Books

1. Dahnoun N, **Digital signal processing implementation using the TMS320C6000 DSP platform**, Prentice Hall.
2. Andy Bateman, Iain Paterson-Stephens, **The DSP Handbook, Algorithms, Applications and Design Techniques**, Prentice-Hall
3. Steve Furber, **ARM System-on-Chip Architecture**, Addison Wesley
4. Jean J. Labrosse, **MicroC/OS – II - The Real Time Kernel**, CMP Books

Digital Image Processing

Prerequisite	**Digital Signal Processing, Working Knowledge of MATLAB**	
Course Objective	**The course aims to provide basics of digital image acquisition and processing**	
Course Outcome	CO-1	Remember and understand the basic concepts/principles of Digital Image Processing
	CO-2	Analyze the various concepts to understand them through case studies
	CO-3	Apply knowledge in understanding practical problems
	CO-4	Execute/create the projects or field assignment as per knowledge gained in the course
Accompanied by Laboratory Course	**No**	
Course Credits	**3-0-0**	
Course Type	**Open Elective-3**	

Module-I (10 Hours)

Elements of digital image processing systems, Elements of visual perception, brightness, contrast, hue,saturation, mach band effect, Color image fundamentals - RGB, HSI models, Acquisition of Image, Image sampling, Quantization, dither

Module II (10 hours)

Image Enhancement: Histogram equalization and specification techniques, Noise distributions, Spatialaveraging, Directional Smoothing, Median, Geometric mean, Harmonic mean,harmonic mean filters, Homomorphic filtering, Color image enhancement.

Module-III (10 Hours)

Image Restoration: degradation model, Unconstrained restoration –Lagrangemultiplier and Constrained restoration, Inverse filtering-removal of blur caused byuniform linear motion, Wiener filtering, Geometric transformations-spatialtransformations.

Module IV (10 hours)

Edge detection, Edge linking via Hough transform – Thresholding - Region basedsegmentation – Region growing – Region splitting and Merging – Segmentationby morphological watersheds – basic concepts – Dam construction – Watershedsegmentation algorithm.

Text Books

1. Rafael C. Gonzalez, Richard E. Woods, **Digital Image Processing**, Pearson
2. Rafael C. Gonzalez, Richard E. Woods, Steven L. Eddins, **Digital Image Processing using MATLAB**, Pearson Education, Inc.

Reference Books

1. Anil K. Jain, **Fundamentals of Digital Image Processing**, Pearson
2. S Jayaraman, T Veerakumar and S Esakkirajan, **Digital Image Processing,** TMH
3. Willaim K Pratt, **Digital Image Processing,** Wiley

LABORATORIES

Basic Electrical Engineering Laboratory (EEL116)

Prerequisite	**None**	
Course Objective	**The objective of the course is to provide a basic idea of different components/ machines used in Electrical Engineering.**	
Course Outcome	CO-1	Remember and understand the basic concepts/principles of Basic Electrical Engineering
	CO-2	Analyze the various concepts to understand them through case studies
	CO-3	Apply knowledge in understanding practical problems
	CO-4	Execute/create the projects or field assignment as per knowledge gained in the course
Course Credits	**2**	

List of Experiments:

1. Preparation of symbol charts for various components and instruments and study the constructional & operational features.
2. Measurement of armature and field resistance of DC shunt motor by volt-amp method.
3. Study the characteristics of magnetic material using B-H curve

4. Speed control of DC shunt motor using armature and flux control method
5. Determination of open circuit characteristics (OCC) of DC shunt generator at different speeds
6. Measurement of earth resistance using insulation tester
7. Measurement of power and power factor of balanced 3-phase star connected load by 2-wattmeter method
8. Measurement of energy by a single phase induction type energy meter using direct loading.
9. Connection and starting of single-phase induction motor

Reference Book

1. Subhransu Sekhar Dash, K Vijayakumar**, Electrical Engineering Practice Lab Manual,** Vijay Nicole Imprints Private Limited
2. K Jeyachandran, S Natarajan, S Balasubramanian**, A Primer on Engineering Practices Laboratory,** Anuradha Publication
3. T Jeyapoovan, M Saravanapandian, S Pranitha**, Engineering Practices Lab Manuals,**Vikas Publishing House

Electrical Machine-1 Laboratory (EEL236)

Prerequisite	**Basic Electrical Engineering**	
Course Objective	**The laboratory class is used to provide the practical exposure of DC machine and 1-ph transformer**	
Course Outcome	CO-1	Remember and understand the basic concepts/principles of Electrical Machine-1
	CO-2	Analyze the various concepts to understand them through case studies
	CO-3	Apply knowledge in understanding practical problems
	CO-4	Execute/create the projects or field assignment as per knowledge gained in the course
Course Credits	**2**	

List of Experiments:

DC Machine

1. Determination of critical resistance and critical speed from no load test of a DCshunt generator.
2. Plotting of external and internal characteristics of a DC shunt generator.
3. Speed control of DC shunt motor by armature control and flux control method.
4. Determination of efficiency of DC shunt motor by Swinburne's Test
5. Determination of efficiency of DC shunt motor by brake Test.
6. Determination of efficiency of DC machine by Hopkinson's Test.

Transformer

1. Determination of Efficiency and Voltage Regulation by Open Circuit and Short Circuit test on single phase transformer.
2. Polarity test and Parallel operation of two single phase transformers
3. Separation of hysteresis and eddy current losses of single phase transformer.
4. Back-to Back test on two single phase transformers.
5. Three phase connections of transformer
6. Determination of Parameters of 3-phase three winding transformer and trace the waveform of Magnetizing Current & Induced e.m.f.

Reference

1. D P Kothari, B S Umre, **Laboratory manual for electrical machines**, I K International Publishing House
2. S G Tarnekar, P K Kharbanda, S B Bodkhe, S D Naik, D J Dahigaonkar, **Laboratory courses in electrical engineering**, S Chand

Network Analysis and Synthesis Laboratory (EEL237)

Prerequisite	**Fundamentals of Basic Electrical Engg.**	
Course Objective	**The students will be introduced to MATLAB and Multisim (Software) and perform basic network analysis experiments in software**	
Course Outcome	CO-1	Remember and understand the basic concepts/principles of Network Analysis and Synthesis
	CO-2	Analyze the various concepts to understand them through case studies

	CO-3	Apply knowledge in understanding practical problems
	CO-4	Execute/create the projects or field assignment as per knowledge gained in the course
Course Credits	**2**	

List of Experiments:

1. Verification of Thevenin and Norton Theorem
2. Verification of Superposition Theorem
3. Verification of Maximum Power Transfer and Reciprocity Theorem
4. Find out the band width, Q-factor and resonance frequency of a series RLC circuit in DC and AC excitation
5. Study of DC and AC transients in RL, RC and RLC circuit
6. Determination of open circuit and short circuit parameters of a two port network.
7. Determination of Transmission line and Hybrid parameters of a two port network.
8. Spectral Analysis of a non-sinusoidal waveform
9. Study of transformer as a coupled circuit and determine its self and mutual inductance
10. Study the response of single and double tuned coupled circuits
11. Design of passive filters and study the frequency response, attenuation and phase characteristics of low-pass, high-pass, band-pass, all-pass and band-elimination filters.

Control System Laboratory (EEL356)

Prerequisite	**Control System**	
Course Objective	**The objective of the laboratory is to provide a hands on practice of control system**	
Course Outcome	CO-1	Remember and understand the basic concepts/principles of Control System
	CO-2	Analyze the various concepts to understand them through case studies
	CO-3	Apply knowledge in understanding practical problems
	CO-4	Execute/create the projects or field assignment as per knowledge gained in the course
Course Credits	**2**	

List of Experiment:

1. Generation of standard test signals and verification of response of test signal to different transfer functions
2. Study the linear system simulator.
3. Study of a dc motor driven position control system
4. Study of speed torque characteristics of two phase ac servomotor and determination of its transfer function
5. Obtain the frequency response of a lag and lead compensator.
6. To observe the time response of a second order process with P, PI and PID control and apply PID control to servomotor
7. To study the characteristics of a relay and analyse the relay control system (Phase Plane)
8. To study and validate the controllers for a temperature control system.
9. To study the position control system using Synchros.
10. Stability analysis of LTI system using MATLAB.

Power Electronics Laboratory (EEL357)

Prerequisite	**No**	
Course Objective	**The laboratory provides a detailed idea of power semiconductor devices and power converter application**	
Course Outcome	CO-1	Remember and understand the basic concepts/principles of Energy Conversion and Audit
	CO-2	Analyze the various concepts to understand them through case studies
	CO-3	Apply knowledge in understanding practical problems
	CO-4	Execute/create the projects or field assignment as per knowledge gained in the course
Course Credits	**2**	

List of Experiment:

1. Familiarization with power electronics devices (SCR, IGBT, MOSFET, GTO, BJT),
2. To plot the V-Icharacteristics of SCR.

3. To study the operation of single-phase Full and Half wave converters with R and RLE(Motor) loads with and without freewheeling action
4. Study of Three Phase Full and Half wave converters with R and R-L-E(Motor) loads
5. To study different triggering circuits for thyristors (Cosine Law & UJT Triggering)
6. To study single phase AC regulator using Triac (R & R-L Loads)
7. To study the single phase cycloconverter with R and R-L Loads
8. To study IGBT based PWM Inverter.
9. To study the speed control of DC motor using single-phase full wave converter.
10. DC Motor speed control by single quadrant chopper circuit.

Electrical Machine-II Laboratory (EEL246)

Prerequisite	**Electrical Machine-1**	
Course Objective	**The laboratory class is used to provide the practical exposure of AC machine and 3-ph transformer**	
Course Outcome	CO-1	Remember and understand the basic concepts/principles of Electrical Machine-2
	CO-2	Analyze the various concepts to understand them through case studies
	CO-3	Apply knowledge in understanding practical problems
	CO-4	Execute/create the projects or field assignment as per knowledge gained in the course
Course Credits	**2**	

List of Experiments

1. To determine the voltage regulation of alternator by EMF method
2. To determine the V curve and inverted V curve of a 3-Ph synchronous motor
3. Speed control of a 3-phase induction motor using variable frequency drive.
4. Synchronization of alternator with infinite bus.
5. No load and blocked rotor test of single phase induction motor
6. Determination of efficiency and plotting slip-torque characteristics of 3-phase induction motor
7. No load and Blocked rotor test of three phase Induction motor.
8. Determination of power angle characteristics of an Alternator

9. Load test of 3-Ph Induction Motor
10. Determination of Parameters of single phase induction motor
11. Voltage regulation of 3 phase alternator by ZPF method.

Reference

1. D P Kothari, B S Umre, **Laboratory manual for electrical machines**, I K International Publishing House
2. S G Tarnekar, P K Kharbanda, S B Bodkhe, S D Naik, D J Dahigaonkar, **Laboratory courses in electrical engineering**, S Chand

Measurement and Instrumentation Laboratory (EEL366)

Prerequisite	**Basics of electrical measurement and principles.**	
Course Objective	**The objective of the laboratory class is to make the students having a hands-on idea of electrical measuring and electronic measuring instruments**	
Course Outcome	CO-1	Remember and understand the basic concepts/principles of Measurement and Instrumentation Laboratory
	CO-2	Analyze the various concepts to understand them through case studies
	CO-3	Apply knowledge in understanding practical problems
	CO-4	Execute/create the projects or field assignment as per knowledge gained in the course
Course Credits	**2**	

List of Experiments:

1. Measurement of unknown resistance using Kelvin double bridges
2. Measurement of unknown inductance Maxwell bridge
3. Measurement of unknown capacitance using Schering bridges
4. Calibration of voltmeter and ammeter
5. Determination of power and power factor of three-phase balanced star connected load using two-wattmeter method
6. Determination of energy by single-phase induction type energy meter using direct loading
7. Design of function generator to generate sine, pulse, triangular and sawtooth waveform and measurement of relevant parameters
8. Measurement of phase and frequency by Lissajous method.

9. Design of Arbitrary waveform generator, RF oscillator and frequency counter
10. To plot the displacement-voltage characteristics of the given LVDT
11. Measurement of temperature-voltage characteristics of J-type thermocouple
12. Use a strain gauge to plot the curve between strain applied to a beam and the output voltage
13. Study of resistance-voltage characteristics of Thermistors

Signal and Systems Laboratory (ECL368)

Prerequisite	**Knowledge of MATLAB**	
Course Objective	**The laboratory provides a detailed design and analysis approach to control and signal processing.**	
Course Outcome	CO-1	Remember and understand the basic concepts/principles of signal and systems.
	CO-2	Analyze the various concepts to understand them through case studies
	CO-3	Apply knowledge in understanding practical problems
	CO-4	Execute/create the projects or field assignment as per knowledge gained in the course
Course Credits	**2**	

1. Generation of square, triangular, exponential, sinusoidal signals and step, Impulse and RAMP functions.
2. Evaluation of convolution of finite –duration discrete time signals.
3. Frequency response of LTI Systems from Impulse response.
4. Frequency response of LTI systems Describes by differential or difference Equations.
5. Implementation of Decimation and Interpolation concepts
6. Generation of AM wave and analyzing its frequency content.
7. Determination of frequency response from Poles and Zeros.
8. Pole- Zero Plot in the Z-plane and determination of magnitude response.

Electrical Engineering Simulation Laboratory (EEL367)

Prerequisite	**Working knowledge of MATLAB**	
Course Objective	**The laboratory provides a detailed design approach to design different electrical machine**	
Course Outcome	CO-1	Remember and understand the basic concepts/principles of Electrical Engineering Simulation
	CO-2	Analyze the various concepts to understand them through case studies
	CO-3	Apply knowledge in understanding practical problems
	CO-4	Execute/create the projects or field assignment as per knowledge gained in the course
Course Credits	**2**	

List of Experiments:

1. Design of coupled AC inductor and filter inductor
2. Design of high-frequency transformer
3. Design of core and yoke of single-phase cruciform core type transformer
4. Design of core and winding of three-phase three stepped core type transformer
5. Design of main dimension and winding of three phase slip ring induction motor
6. Design of shunt field coils of DC generator
7. Design of three phase uncontrolled and controlled rectifier using Simulink
8. Design of Buck, Boost and Buck-Boost Converter using Simulink
9. Design of single-phase to single-phase Bridge Type step-down Cycloconverter using Simulink
10. Design of 3-phase voltage source DC-AC inverter (180 and 120 conduction mode) using Simulink
11. Design of lead-lag compensator for a system
12. Design of PID controller using Ziegler-Nichols tuning method for FOPDT and SOPDT process
13. Determination of controllability and observability of a system

Reference

1. Devendra K. Chautrvedi, **Modeling and Simulation of Systems using MATLAB and Simulink,** CRC Press
2. L Umanand, S R Bhat, **Design of magnetic components for switched mode power converters**, New Age Publishers
3. Shailendra Jain, **Modeling and Simulation using MATLAB-Simulink,** Wiley
4. K B Raina, S K Bhattacharya, **Electrical Design Estimating and Costing,** New Age Publishers

Power System Simulation Laboratory (EEL476)

Prerequisite	**Basic Knowledge of MATLAB**	
Course Objective	**The laboratory provides a basic knowledge of different power system components**	
Course Outcome	CO-1	Remember and understand the basic concepts/principles of Power System
	CO-2	Analyze the various concepts to understand them through case studies
	CO-3	Apply knowledge in understanding practical problems
	CO-4	Execute/create the projects or field assignment as per knowledge gained in the course
Course Credits	**2**	

List of Experiments:

1. To determine negative and zero sequence synchronous reactance of an alternator.
2. To determine sub-transient direct axis and sub-transient quadrature axis synchronous reactance of a 3-ph salient pole alternator.
3. To determine fault current for L-G, L-L, L-L-G and L-L-L faults at the terminals of an alternator at very low excitation.
4. To study the IDMT over-current relay and with different plug setting and time setting multipliers and plot its time – current characteristics.
5. To determine the operating characteristics of biased different relay with different % of biasing.
6. To determine A, B, C, D parameters of an artificial transmission line.
7. To determine location of fault in a cable using cable fault locator.
8. To study the Ferranti Effect and voltage distribution in HV long transmission lineusing transmission line model.

11. Insulation test for Transformer oil.
12. To formulate the Y-Bus matrix and perform load flow analysis.
13. To compute voltage, current, power factor, regulation and efficiency at the receiving end of a three phase Transmission line when the voltage and power at the sending end are given.
14. Using MATLAB, Solve economic dispatch problem of a power system with only thermal units. Take production cost function as quadratic and neglect any transmission losses.