DEPARTMENT OF ELECTRICAL ENGINEERING

University College of Engineering (Autonomous)

Osmania University, Hyderabad – 07

Scheme and Syllabi

of

M.E. (ELECTRICAL ENGG.)

(Full-Time & Part-Time)

1. Industrial Drives and Control
2. Power Systems
3. Power Electronic Systems

Osmania University

Hyderabad - 500 007

With effect from the Academic Year 2018-2019

Vision and Mission of the Department

Vision

To strive for excellence in education & research and to meet the requirements of the industry in the field of Electrical Engineering to serve the nation.

Mission

1. To provide knowledge based technology and service to meet the needs of society in electrical and allied industries.
2. To help in building national capabilities for excellent energy management and to explore non-conventional energy sources.
3. To create research oriented culture and to provide competent consultancy.
4. To create and sustain environment of learning in which students acquire knowledge and learn to apply it professionally with due consideration of ethical and economical issues.
5. To be accountable through self-evaluation and continuous improvement.

SCHEME OF INSTRUCTION & EXAMINATION

M.E. (Electrical) 4 Semesters (Full Time)

S.No.	Course Title	Scheme of Instruction		Contact Hrs/wk	Scheme of Examination		Credits
		L/T	P		CIE	SEE	
Semester - I							
1.	Core	3	--	3	30	70	3
2.	Core	3	--	3	30	70	3
3.	Core / Elective	3	--	3	30	70	3
4.	Core / Elective	3	--	3	30	70	3
5.	Elective	3	--	3	30	70	3
6.	Elective	3	--	3	30	70	3
7.	Laboratory - I	--	3	3	50	--	2
8.	Seminar - I	--	3	3	50	--	2
	Total	**18**	**5**	**24**	**280**	**420**	**22**
Semester - II							
1.	Core	3	--	3	30	70	3
2.	Core	3	--	3	30	70	3
3.	Core / Elective	3	--	3	30	70	3
4.	Core / Elective	3	--	3	30	70	3
5.	Elective	3	--	3	30	70	3
6.	Elective	3	--	3	30	70	3
7.	Laboratory - II	--	3	3	50	--	2
8.	Seminar - II	--	3	3	50	--	2
	Total	**18**	**6**	**24**	**280**	**420**	**22**
Semester - III							
1.	(Dissertation +	--	4	4	100**		8
	Dissertation Seminar)*						
Semester – IV							
1.	Dissertation	--	6	6		200	16

CIE: Continuous Internal Evaluation; SEE: Semester End Evaluation

Note: Six Core subjects, Six Elective subjects, Two Laboratory Courses and Two Seminars should normally be completed by the end of semester II

* One Dissertation seminar presentation.

** 50 marks to be awarded by Supervisor and 50 marks to be awarded by viva-voice committee comprising Supervisor and two internal faculty members

SCHEME OF INSTRUCTION & EXAMINATION

M.E. (Electrical) 6 Semesters (Part Time)

S.No.	Course Title	Scheme of Instruction		Contact Hrs/wk	Scheme of Examination		Credits
		L/T	P		CIE	SEE	
Semester - I							
1.	Core	3	--	3	30	70	3
2.	Core / Elective	3	--	3	30	70	3
3.	Elective	3	--	3	30	70	3
4.	Lab. I /Seminar - I	--	3	3	50	--	2
	Total	**9**	**2**	**11**	**140**	**210**	**11**
Semester - II							
1.	Core	3		3	30	70	3
2.	Core / Elective	3	--	3	30	70	3
3.	Elective	3	--	3	30	70	3
4.	Lab. I /Seminar - I	--	3	3	50	--	2
	Total	**9**	**2**	**11**	**140**	**210**	**11**
Semester - III							
1.	Core	3	--	3	30	70	3
2.	Core / Elective	3	--	3	30	70	3
3.	Elective	3	--	3	30	70	3
4.	Lab. II / Seminar - II	--	3	3	50	--	2
	Total	**9**	**3**	**12**	**140**	**210**	**11**
Semester - IV							
1.	Core	3	--	3	30	70	3
2.	Core / Elective	3	--	3	30	70	3
3.	Elective	3	--	3	30	70	3
4.	Lab. II / Seminar - II	--	3	3	50	--	2
	Total	**9**	**3**	**12**	**140**	**210**	**11**
Semester - V							
1.	(Project+ Seminar)*	--	4	4	100**	--	8
Semester - VI							
1.	Dissertation	--	6	6	--	200	16

Note: Six Core subjects, Six Elective subjects, Two Laboratory Courses and Two Seminars should normally be completed by the end of semester II

* One Dissertation seminar presentation.

** 50 marks to be awarded by Supervisor and 50 marks to be awarded by viva-voice committee comprising Supervisor and two internal faculty members

Scheme of Instruction & Examination

M. E. (Industrial Drives and Control)

Course Code	Course Title	Contact Hrs/wk	Scheme of Examination		Credits
			CIE	SEE	
	Core Subjects				
EE3101	Static Control of D.C. Drives	3	30	70	3
EE3102	Machine Modeling and Analysis	3	30	70	3
EE3103	Control of Electric Drives	3	30	70	3
EE3104	Dynamics of Electric Machines	3	30	70	3
EE3105	Static Control of A.C. Drives	3	30	70	3
EE3301	Power Electronic Converters	3	30	70	3
	Elective Subjects				
EE3111	Special Electrical Machines	3	30	70	3
EE3112	Microcontroller Applications to Power Electronics	3	30	70	3
EE3113	Neural Networks and Fuzzy Logic	3	30	70	3
EE3302	Industrial Controllers	3	30	70	3
EE3304	Power Electronic Converters for Renewable Energy	3	30	70	3
	Elective Subjects (Common to IDC, PS & PES)				
EE3001	Power Electronic Applications to Power Systems	3	30	70	3
EE3002	Renewable Energy Sources	3	30	70	3
EE3003	Electric and Hybrid Electrical Vehicles	3	30	70	3
EE3004	Modern Control Theory	3	30	70	3
EE3005	Reliability Engineering	3	30	70	3
EE3006	Optimization Methods	3	30	70	3
EE3007	Advanced Microprocessors	3	30	70	3
EE3008	Artificial Intelligence & Expert Systems	3	30	70	3
EE3009	Programmable Logic Controllers	3	30	70	3
EE3010	Digital Signal Processing	3	30	70	3
EE3011	Smart Grid Technology	3	30	70	3
ME2001	Engineering Research Methodology	3	30	70	3
	Departmental Requirements				
EE3131	Drives Lab-I	3	50	-	2
EE3132	Drives Lab-II	3	50	-	2
EE3133	Seminar-I	3	50	-	2
EE3134	Seminar-II	3	50	-	2
EE3135	Project Seminar	4	100	-	8
EE3136	Dissertation	6		200	16
		58	**660**	**1040**	**68**

Note

1) Six Core subjects, Six Elective Subjects, Two Laboratory Courses and Two Seminars should be completed by the end of Semester-II
2) Semesters III & IV are for the Project work

M.E. Industrial Drives and Control

Program Educational Objectives (PEOs):

PEO-1: To prepare the students for acquiring the knowledge and applications of different types of Industrial drives including special electric drives controlled with various power electronic converters.

PEO-2: To develop ability and to exhibit creative & critical reasoning skills to comprehend, analyze, design and implement solutions for problems in power electronic converter based drives.

PEO-3: To prepare the students for successful carrier in industry, academia and research with proficiency in control of electric drives.

Program Outcomes (POs):

PO-1: An ability to independently carry out research/ investigation and development to solve practical problems.

PO-2: An ability to write and present a substantial technical report/document.

PO-3: Students should be able to demonstrate a degree of mastery over the area of industrial drives and control specialization of the problem. The mastery should be at level higher than the requirements in the appropriate bachelor program.

PO-4: The student will be able to apply critical and innovative skills to model design and develop simulation software solutions to solve the problems of power electronic converters and drives.

PO-5: Students will be able to analyze and design different types of renewable energy generation topologies for various electrical applications.

PO-6: Students will be able to acquire knowledge in state of the art technologies, with effective communication.

M. E. (Power Systems)

Course Code	Course Title	Contact Hrs/wk	Scheme of Examination		Credits
			CIE	SEE	
Core Subjects					
EE3201	Distribution System Planning and Automation	3	30	70	3
EE3202	Advanced Computer Methods in Power Systems	3	30	70	3
EE3203	Advanced Synchronous Machine Theory	3	30	70	3
EE3204	Power System Stability	3	30	70	3
EE3205	Real Time Applications in Power Systems	3	30	70	3
EE3206	Advanced Power System Protection	3	30	70	3
	Elective Subjects				
EE3211	Advanced Power System Operation and Control	3	30	70	3
EE3212	Power Quality Engineering	3	30	70	3
EE3213	Power System Deregulation	3	30	70	3
EE3214	High Voltage Engineering	3	30	70	3
EE3215	Reactive Power Control and Voltage Stability	3	30	70	3
EE3216	Artificial Neural Networks	3	30	70	3
	Elective Subjects (Common to IDC, PS & PES)				
EE3001	Power Electronic Applications to Power Systems	3	30	70	3
EE3002	Renewable Energy Sources	3	30	70	3
EE3003	Electric and Hybrid Electrical Vehicles	3	30	70	3
EE3004	Modern Control Theory	3	30	70	3
EE3005	Reliability Engineering	3	30	70	3
EE3006	Optimization Methods	3	30	70	3
EE3007	Advanced Microprocessors	3	30	70	3
EE3008	Artificial Intelligence & Expert Systems	3	30	70	3
EE3009	Programmable Logic Controllers	3	30	70	3
EE3010	Digital Signal Processing	3	30	70	3
EE3011	Smart Grid Technology	3	30	70	3
ME2001	Engineering Research Methodology	3	30	70	3
	Departmental Requirements				
EE3231	Power System Lab I	3	50	-	2
EE3232	Power System Lab II	3	50	-	2
EE3233	Seminar I	3	50	-	2
EE3234	Seminar II	3	50	-	2
EE3235	Project Seminar	4	100	-	8
EE3236	Dissertation	6	-	200	16
		58	**660**	**1040**	**68**

M.E. Power System

The Program Educational Objectives (PEOs)

PEO-1: To impart knowledge to cater the changing needs of electrical Power systems.

PEO-2: To prepare the students for attaining latest technology in research and development in sustainable technologies related to Power Systems.

PEO-3: To prepare the students for successful career, capable of extending technical services to industry with proficiency in the field of Power systems.

Program Outcomes (POs):

PO1: An ability to independently carry out research /investigation and development work to solve practical problems.

PO2: An ability to write and present a substantial technical report/document.

PO3: Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.

PO4: The student will develop an attitude to learn with self motivation.

PO5: The student will be able to use simulation software to solve problems of real time power systems.

PO6: The student will be able to design, analyze and conduct experiments for practical power system networks.

M. E. (Power Electronic Systems)

Course Code	Course Title	Contact Hrs/wk	Scheme of Examination		Credits
			CIE	SEE	
Core Subjects					
EE3301	Power Electronic Converters	3	30	70	3
EE3302	Industrial Controllers	3	30	70	3
EE3303	Industrial Electronic Systems	3	30	70	3
EE3304	Power Electronic Converters for Renewable Energy	3	30	70	3
EE3305	Advanced Topics in Power Electronics	3	30	70	3
EE3306	Static Control of Electric Drives	3	30	70	3
	Elective Subjects				
EE3102	Machine Modeling and Analysis	3	30	70	3
EE3111	Special Electrical Machines	3	30	70	3
EE3112	Microcontroller Applications to Power Electronics	3	30	70	3
EE3113	Neural Networks and Fuzzy Logic	3	30	70	3
EE3212	Power Quality Engineering	3	30	70	3
	Elective Subjects (Common to IDC, PS & PES)				
EE3001	Power Electronic Applications to Power Systems	3	30	70	3
EE3002	Renewable Energy Sources	3	30	70	3
EE3003	Electric and Hybrid Electrical Vehicles	3	30	70	3
EE3004	Modern Control Theory	3	30	70	3
EE3005	Reliability Engineering	3	30	70	3
EE3006	Optimization Methods	3	30	70	3
EE3007	Advanced Microprocessors	3	30	70	3
EE3008	Artificial Intelligence & Expert Systems	3	30	70	3
EE3009	Programmable Logic Controllers	3	30	70	3
EE3010	Digital Signal Processing	3	30	70	3
EE3011	Smart Grid Technology	3	30	70	3
ME2001	Engineering Research Methodology	3	30	70	3
	Departmental Requirements				
EE3331	Power Electronic Systems Lab I	3	50	-	2
EE3332	Power Electronic Systems Lab II	3	50	-	2
EE3333	Seminar I	3	50	-	2
EE3334	Seminar II	3	50	-	2
EE3335	Project Seminar	4	100	-	8
EE3336	Dissertation	6	-	200	16
		58	**660**	**1040**	**68**

EE3101

Static Control of D.C. Drives

(Core - IDC)

Instruction	**:** 3 Hours/Week
Duration of Univ. Examination	**:** 3 Hours
SEE	**:** 70 Marks
CIE	**:** 30 Marks

Course Objectives:

- To understand the operation and performance characteristics of various converters such as Semi Converters, Full converters, Dual converters and choppers for control of separately exited and self excited DC Motors.
- To understand the power factor improvement methods of single phase and three phase converters.
- To understand the closed loop control of DC motors.

Course Outcomes:

After the completion of this course, the students shall be able to:

- Identify and Analyze suitable power converter from the available configurations to achieve efficient performance of the DC Motor for specific application.
- Choose proper gain values for speed and current controllers.
- Design Input filter for Chopper.
- Identify and Analyze suitable braking methods for specific application.

UNIT-I

Single Phase Drives: Performance parameters, Operation of Full converter and Semi –converter fed separately excited d.c. motors and d.c series motors, Speed-torque characteristics, Performance characteristics, Comparison, Three Phase Drives, Principle and operation.

UNIT-II

Power Factor Improvement: Extinction angle control, Symmetrical angle control, Pulse Width Modulation control, Sequence control of single phase series converters, Full converter and Semi-converter, Sequence control three phase series converters with shifted voltages.

UNIT-III

Dual Converter Drives: Ideal dual converter and Firing control scheme, Non-ideal dual converter – Without circulating Current, Control strategies, With circulating current – Closed loop system, Dual mode dual converter, PWM Control, Reversible drives – Armature current reversal and Field current reversal.

UNIT-IV

Chopper Drives: One quadrant, two quadrant choppers and four quadrant d.c drives, Analysis, Design of input filter, Multiphase choppers, Dynamic braking and Regenerative braking of phase controlled drives and chopper drives.

UNIT-V

Closed Loop Control: Single phase d.c drive with dynamic braking, Three phase dual converter reversible drive, Speed control with inner current loop & field weakening, Phase locked loop control, Micro computer control.

Suggested Reading:

1. Sen PC, *Thyristor D.C Drives,* John Wiley, 1981.
2. Singh M.D and Khanchandani K.B, *Power Electronics,* Tata McGraw Hill, 1998.
3. Sen P.C, *Power Electronics,* Tata McGraw Hill Pvt. Ltd., New Delhi.
4. G.K.Dubey, *Power Semi-Converter Controlled Drives,* Prentice Hall, Eaglewood, Cliffs,1989.

EE3102

Machine Modeling and Analysis

(Core– IDC& Elective -PES)

Instruction	**:** 3 Hours/Week
Duration of Univ. Examination	**:** 3 Hours
SEE	**:** 70 Marks
CIE	**:** 30 Marks

Course Objectives:

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

Course Outcomes:

At the end of the course the student will be able to:

- Develop models for linear and nonlinear magnetic circuits
- Determine the developed torque in an electrical machine using the concepts of field Energy and co-energy and determine the dynamic model of a DC machine
- Determine the dynamic model of an induction machine based on the dq0 Transformation and determine instantaneous torque developed in an induction Machine- which leads to advanced control strategies such as vector control and direct torque control
- Determine the torque developed in a salient pole synchronous machine using the Park’s transformation and identify contribution of saliency torque- damping torque and excitation torque

UNIT I

Basic Principles for Electric Machine Analysis: Magnetically coupled circuits, Electromechanical energy conversion, Basic Two pole DC Machine – primitive 2 axis machine – Voltage and Current relationship – Torque equation.

Theory of DC Machines: Mathematical model of separately excited DC Motor, DC Series Motor, DC shunt motor and D.C. Compound Motor in state variable form – Transfer function of the motor.

UNIT II

Reference Frame Theory: Equations of transformation - Change of variables, Stationary circuit variables Transformed to the Arbitrary Reference Frame, Commonly used reference frames, Transformation between reference frames, Transformation of a balanced set, Balanced steady state phasor Relationships, Balanced steady state equations, Variables observed from various frames.

UNIT III

Theory of Symmetrical Induction Machines: Voltage and torque equations in machine variables, Equations of transformation for Rotor circuits, Voltage and torque equations in arbitrary reference frame variables, Analysis of steady state operation-state-space model of induction machine in 'd-q' variables, Free Acceleration Characteristics, Dynamic Performance-during sudden changes in load- during a 3 phase fault at the machine terminals.

UNIT IV

Theory of Synchronous Machines: Voltage and Torque equations in machine variables, Stator Voltage equations in Arbitrary Reference Frame Variables, Voltage Equations in Rotor Reference Frame Variables: park's Equations, Torque Equations in Substitute Variables, Analysis of steady state operation, Dynamic performance - During sudden changes in Input Torque - During a 3 phase fault at the machine terminals.

UNIT V

Linearized Machine Equations: Introduction, Machine equations to be linealized-Induction machine, Synchronous machine. Linearized machine equations-Induction machines, Synchronous machines. Small-displacement stability-Eigan values, Eigan values of typical Induction machines and synchronous machines.

Suggested Reading:

1) Paul C. Krause, Oleg Wasynczuk, Scott D.Sudhoff, "*Analysis of Electric Machinery and drive systems*" John Wiley and Sons, 2nd Edition, 2006

2) C.V. Jones, *"Unified Theory of Electrical Machines"* Butterworths Publishers.

3) P.S. Bhimbra, "*Generalized Theory of Electrical Machines"*, Khanna publishers, 2002.

4) J. Meisel, "*Principles of Electromechanical Energy Conversion" McGraw Hill, 1966.*

EE3103

Control of Electric Drives

(Core - IDC)

Instruction	**:** 3 Hours/Week
Duration of Univ. Examination	**:** 3 Hours
SEE	**:** 70 Marks
CIE	**:** 30 Marks

Course objective:

- Understand the concepts of development of control circuits, remote control and electric interlocking in an industry
- Understand the construction and operation of various control components for the control circuits
- Understand the development of control circuits for various operations of both DC and AC machines.
- To understand the procedure for trouble shooting of circuits
- To understand the driver circuits for step motor

Course Outcomes:

At the end of the course the student will be able to:

- Develop the control circuits for remote control and interlocking of electric drives
- Develop the control circuits for starting and braking of DC machines and Induction machines
- Trouble shoot the control circuits
- Develop the driver circuits for step motor

UNIT I

Introduction of Electrical Control of Machines: Manual control – Magnetic control – Semi-automatic and Automatic control of Modern machinery – Development of Control circuits–Two wire and Three wire control – Remote control – Interlocking of drives – Control circuit components –Symbols for control components–Fuses, Switches and Fuse Switch units.

UNIT II

Protection of motors : Moulded– Case Circuit Breaker (MCCB) and Miniature Circuit Breaker (MCB) –Contactors – Types of contactors – Contactor ratings, Relays – D.C Series current relay – Frequency responsive relay – Latching relay – Over load relays – Bimetallic Thermal over load relay – time delay relay (Timers) – Motor drivers Electronic timer – Phase failure relay – Push button switches – Types, Limit switch – Float switch.

UNIT III

Control of Three-Phase Induction Motors: Motor current at start and during acceleration – Automatic starters – Increment Resistor type starter – Automatic Auto-transformer starter – Open circuit and closed circuit transition – Part winding motor starters Two step and Three step starting – Automatic Star-Delta starters Open circuit and closed circuit transition – Starters for multi-speed motors. Starters for Wound rotor motors – Control circuit using contactor and flux delay relays.

UNIT IV

Control of Synchronous Motors: Manual Push button synchronizing Starter, Timed Semi-Automatic Synchronizing, Automatic Starter using Polarised Field Frequency Relay.

Control of D.C motors: Principles of acceleration – Types of starters for automatic acceleration – Control circuits for DCL, Current limit acceleration starters – Reviewing of D.C motors – Control circuit for direct reversing and forward stop reverse operation – Jogging operation of D.C motor – Control circuits for braking action.

UNIT V

Control of stepper motors: Control circuit for Stepper motor – Block diagram of a typical step motor control – Types of drive circuits – simple power drive circuit – L/R drive Bi-level drive – Chopper drive – Linear constant current drive – Bipolar drives for Stepper motor – H type and L/R type bipolar drives – Bipolar Chopper drives. Trouble shooting in control circuits – Trouble spots –General procedure for trouble shooting.

Suggested Reading:

1. Bhattacharya S.K and Brijinder Singh, *Control of Electrical Machines,* New Age International Publishers, New Delhi, 1996.
2. Athani V.V., *Stepper Motors — Fundamentals, Applications and Design,* New Age International Publishers, New Delhi, 1997.

EE3104

Dynamics of Electric Machines

(Core- IDC)

Instruction	**:** 3 Hours/Week
Duration of Univ. Examination	**:** 3 Hours
SEE	**:** 70 Marks
CIE	**:** 30 Marks

Course Objectives:

- Analyze the dynamic and Transient performance of DC generators, DC Motors and Induction Machines for sudden changes.
- To understand the harmonic and inrush current phenomenon in transformers
- To study the dynamic operation of synchronous machines during load changes and braking.

Course Outcomes:

- To model and design the machines keeping in view of the sudden changes or disturbances.
- To develop the controllers for DC machines, AC Machines when subjected to sudden changes.

UNIT I

Dynamics of Separately Excited DC Generator: Steady state analysis, Transient analysis-Sudden step field excitation at no-load and load–Sudden short circuit of armature terminals–Sudden short circuit of field terminals, Generator operation with displaced brushes.

UNIT II

Dynamics of DC Motors: Separately Excited DC Motor–Steady state analysis, Transient analysis–Sudden application of voltage and load torque–Sudden application of inertia load, Transfer function– Dynamic behaviour. DC Series Motor: Steady state analysis– Linearization techniques for small perturbations.

UNIT III

Transformer Transients: Excitation phenomena–Harmonics in single –phase transformers, Over current transients–Qualitative and Analytical approaches. Estimation of inrush current, External and Internal over voltages –Transformer equivalent circuit with over voltages-Initial voltage distribution for solidly grounded neutral and isolated neutral.

UNIT IV

Induction Machine Dynamics: Dynamics during starting and braking–Accelerating time– Dynamics during normal operation, Operation on unbalanced supply voltages–Equivalent circuit, Operation on Single phasing– Equivalent circuit.

UNIT V

Synchronous Machine Dynamics: Electro-mechanical equation- Motor operation-Generator operation- Linearized analysis, Cyclic variations of shaft torque, Electric braking-Plugging and Dynamic braking.

Suggested Reading:

1. Bhimbra P.S. *Generalized Theory of Electrical Machines,* Khanna Publishers, 2002.
2. Nagrath I.J. & Kothari D.P, *Electric Machines*, Tata McGraw Hill Publishers, 2004.

EE3105

Static Control of A.C. Drives

(Core - IDC)

Instruction	**:** 3 Hours/Week
Duration of Univ. Examination	**:** 3 Hours
SEE	**:** 70 Marks
CIE	**:** 30 Marks

Course Objectives:

- To understand the control of Induction motor drives using scalar control, Vector control and Direct torque control.
- To understand the control of Synchronous motor using VSI, CSI and cyclo converter.
- To understand the control of special machines such as BLDC, PMSM, Stepper motor and SRM

Course Outcomes:

After the completion of this course, the students shall be able to:

- Identify, Analyze and Design suitable control technique to achieve efficient performance of the Induction motor and synchronous motor drives for specific application.
- Model existing and new control Techniques for control of AC drives under Transient and Steady state conditions.
- Analyze and Design Power converters and control techniques for control of special machines.

UNIT I

Static Control of Induction Motor Drives: Stator Voltage Control, Static rotor resistance control, Slip power recovery schemes – Static Krammer drive, Static Scherbius drive, Closed loop control of the above schemes.

UNIT II

Inverter Fed Induction Motor Drives: Voltage Source Inverter and Current Source Inverter fed Induction motors, Analysis of Stepped waveform and PWM waveform, Harmonic equivalent circuit and motor performance.

UNIT III

Vector Control: Principle of vector control, Direct vector control –Flux & Torque processor using terminal voltages and Induced emf, Principle of Space vector modulation, Indirect vector control – Flow chart and implementation.

UNIT IV

Static Control of Synchronous Drives: Self control and Separate control of synchronous motor fed from VSI, Cyclo-converter fed self control of synchronous motor, CSI fed synchronous motor drive, LCI self controlled synchronous motor.

UNIT V

Special Machines: Brushless D.C Motor – Unipolar and Bipolar Brushless D.C motors, Applications, Stepper Motors – Variable reluctance and Permanent magnet stepper motors –Characteristics & Drive circuits, Switched reluctance motor.

Suggested Reading:

1. R.Krishrian, *Electric Motor Drives*, Prentice Hall of India Pvt. Ltd., New Delhi, 2002.
2. G.K.Dubey, *Fundamentals of Electrical Drives*, Narosa Publishing House, New Delhi, 1999.
3. W.Shepard, LN.Hulley and D.T.W.Liang, *Power Electronics and Motor Control*, Cambridge University Press, 1995.
4. B.K.Bose, *Modern Power Electronics and A.C.Drives*, Prentice Hall, 2002.

EE3301

Power Electronic Converters

(Core-IDC & PES)

Instruction	**:** 3 Hours/Week
Duration of Univ. Examination	**:** 3 Hours
SEE	**:** 70 Marks
CIE	**:** 30 Marks

Course Objectives:

- To understand the concept of Power Electronic converters.
- To prepare the students for acquiring the knowledge of different types of power semiconductor devices, phase controlled rectifier circuits switched mode converters and pulse width modulated inverters.
- To develop the ability to comprehend, analyze, design various types of switched mode DC-DC converters and pulse width modulated inverters used in variable speed drives.

Course Outcomes:

On successful completion of program

- The Student will be able to acquire knowledge in state of the art technologies. The student will be able to select and design power electronic converters for broad range of energy conversion applications.
- The student will be able to use power electronic simulation tools for analyzing and designing power electronic converter circuits.
- The student can experimentally evaluate the performance of power electronic conversion systems for different types of electrical applications.

UNIT-I

Power semiconductor switches- Diodes, Bipolar Power Transistors, Power MOSFETS, IGBTS, Analysis of power semiconductor switched circuits with R, L, RL, RC loads, D.C motor load, battery charging circuit.

UNIT-II

Rectifiers - Uncontrolled Rectifier, Rectifier circuits-Single-phase & Three-Phase circuits, Controlled Rectifiers- Single-phase & Three-Phase controlled Rectifier circuits.

UNIT-III

DC-DC Linear Regulators, DC-DC Switched mode Converters- Buck, Boost, Buck-Boost, Cuk, Flyback, Forward, Push-Pull, Half & Full-bridge .

UNIT-IV

DC-AC Switched Mode Converters-Single phase and Three phase inverters, Voltage source and Current source inverters, Pulse modulation techniques, sinusoidal pulse-Width Modulation, Space vector Modulation, advanced PWM techniques, V/F control of induction motor drives.

UNIT V

AC to AC power conversion using voltage regulators, cyclo-converters and Matrix converters.

Suggested Reading:

1. Ned Mohan, Undeland and Robbin, 'Power Electronics: converters, Application anddesign', John Wiley and Sons.Inc, Newyork, 2006.
2. Rashid M.H., 'Power Electronics-Circuits, Devices and Applications' Prentice HallIndia, New Delhi, 2009.
3. L. Umanand, 'Power Electronics Essentials &Applications', Wiley publishing Company, 1st Edition,2014

EE3111

Special Electrical Machines

(Elective to IDC & PES)

Instruction	**:** 3 Hours/Week
Duration of Univ. Examination	**:** 3 Hours
SEE	**:** 70 Marks
CIE	**:** 30 Marks

Course Objectives:

- To understand the concepts and control strategies of permanent magnet synchronous motors and Brushless DC motors.
- To study the operating principles and control methods of switched reluctance motors.
- To introduce the concepts and control of different types of stepper motors and its applications.
- To analyse the working of linear induction and linear synchronous machines

Course Outcomes:

- Ability to optimally design magnetics required in special machines based drive systems using FEM based software tools.
- To develop new control strategies for different types of special machines.
- Ability to design and conduct experiments towards research.

UNIT -I

Stepper Motors: Constructional features, Principle of operation, Variable Reluctance (VR) stepping motor-Single Stack, Multi-Stack, Permanent Magnet Step motor, Hybrid Step Motor, Torque Equation Open Loop Drive, Open loop and closed loop control of Step Motor, Applications.

UNIT -II

Switched Reluctance Motors: Constructional features, Principle of Operation, Torque equation, Torque-speed characteristics, Power Converter for SR Motor-Asymmetrical converter, DC Split converter, Control of SRM, Rotor Position sensors, Current Controllers, Applications.

UNIT-III

Permanent Magnet Synchronous Motor: Permanent magnets and their characteristics, Machine Configurations-SPM, SIPM, IPM and Interior PM with circumferential, Sensorless control, Applications.

UNIT -IV

Brushless DC Motor: Construction, Principle of Drive operation with inverter, Torque speed Characteristics, Closed loop control, Sensorless control, Applications.

UNIT-V

Linear Induction Motors and Linear Synchronous Motors: Linear induction motor, Construction details, LIM Equivalent Circuit, Steps in design of LIM, Linear Synchronous Motor: Principle and Types of LSM, LSM Control, Applications.

Suggested Reading:

1. R.Krishnan, *Electric Motor Drives*, Pearson , 2007
2. B.K.Bose, *Modern Power Electronics and AC Drives*, PHI, 2005
3. Venkataratnam, *Special electrical Machines*, University Press, 2008
4. E.G.Janardanan, *Special Electrical Machines*, PHI, 2014
5. T.J.E.Miller, *Brushless Permanent Magnet and Reluctance Motor Drive*, Clarendon Press, Oxford, 1989

EE3112

Microcontroller Applications to Power Electronics

(Elective to IDC & PES)

Instruction	**:** 3 Hours/Week
Duration of Univ. Examination	**:** 3 Hours
SEE	**:** 70 Marks
CIE	**:** 30 Marks

Course Objectives:

- To understand the concept of architecture and peripheral modules of microcontrollers and digital signal processors
- To prepare the students for acquiring the knowledge of Implementing digital processor based control systems for power electronics
- To know the use of microcontrollers for pulse generation in power converters..
- To understand PIC16F876 micro-controller and analog to digital converter modules

Course Outcomes:

- The Student will be able to acquire knowledge in CPU details, addressing modes, interrupt structure, hardware multiplier
- The student will be able to implement Numerical integration methods using digital processor based control systems.
- The students can able to write PIC microcontroller programmes.
- The students can able to write using MPLAB and PICSTART plus

UNIT-I

Review of microcontrollers and digital signal processors, architecture, peripheral modules.; Typical processors for control implementation: memory organization, CPU details, addressing modes, interrupt structure, hardware multiplier, pipelining.; Fixed- and floating-point data representations , Assemblers, linkers and loaders. Binary file formats for processor executable files. Typical structure of timer-interrupt driven programs.

UNIT-II

Implementing digital processor based control systems for power electronics: Reference frame transformations, PLL implementations, machine models, harmonic and reactive power compensation, space vector PWM.; Numerical integration methods.; Multitasking concepts for power electronics implementations: The need for multitasking, various multitasking methods.

UNIT-III

Use of microcontrollers for pulse generation in power converters - Overview of Zero-Crossing Detectors - typical firing/gate-drive circuits –firing / gate pulses for typical single phaseand three-phase power converters - PIC16F876 Micro-controller – device overview –pin diagrams.

UNIT-IV

PIC16F876 micro-controller memory organization – Special Function Registers - I/O ports –Timers – Capture/ Compare/ PWM modules (CCP).

Analog to Digital Converter module – Instruction set - instruction description – introduction to PIC microcontroller programming- oscillator selection-reset - interrupts -watch dogtimer.

UNIT-V

Introduction to MPLAB IDE and PICSTART plus – Device Programming using MPLAB and PICSTART plus – generation of firing / gating pulses for typical power converters. Example of DSP system A to D signal conversion - DSP Support tools-code composer studio - compiler, assembler and linker

Suggested Reading:

1. PIC16F87X Datasheet 28/40 – pin 8 bit CMOS flash Microcontrollers, Microchip technology Inc., 2001. and MPLAB IDE Quick start guide, Microchip technology Inc., 2007.
2. John B. Peatman, ‘Design with PIC Microcontrollers’, Prentice Hall, 2003.
3. MykePredko, ‘Programming and customizing the PIC Microcontroller’ Tata McGraw-Hill, 3rd Edition, 2008.
4. K Ogata, "Discrete-Time Control Systems", second edition, Pearson Education Asia.
5. N. Mohan, "Power Electronics", third edition, John Wiley and Sons.

EE3113

Neural Networks and Fuzzy Logic

(Elective to IDC & PES)

Instruction	**:** 3 Hours/Week
Duration of Univ. Examination	**:** 3 Hours
SEE	**:** 70 Marks
CIE	**:** 30 Marks

Course Objectives:

- To learn various types of algorithms useful in Artificial Intelligence (AI).
- To convey the ideas in AI research and programming language related to emerging technology.
- To understand the concepts of machine learning, probabilistic reasoning, robotics, computer vision, and natural language processing.
- To understand the numerous applications and huge possibilities in the field of AI that go beyond the normal human imagination.

Course Outcomes:

After the completion of this course, the students shall be able to:

- Design and implement key components of intelligent agents and expert systems.
- To apply knowledge representation techniques and problem solving strategies to common AI applications.
- Apply and integrate various artificial intelligence techniques in intelligent system
- Development as well as understand the importance of maintaining intelligent systems.
- Build rule-based and other knowledge-intensive problem solvers.

UNIT-I

Neural and Fuzzy Intelligence: Fuzziness as multi-valence - Bivalent paradoxes as fuzzy midpoints, Sets as points in cubes - Subset hood and probability, The dynamical system approach to machine intelligence, Brain as a dynamical system – Neural networks as trainable dynamical system, Intelligent behavior as adaptive model free estimation, Generalization and creativity - Learning as change-Rules vs. principles - Symbolic vs. numeric processing, Structured numerical estimators

UNIT-II

Neural Network Theory: Neurons as functions - Signal monotonicity Biological activities and signals, Neuron fields - Neuronal dynamic systems - Common signal, functions - Pulse coded signal functions, Additional neuron dynamics - Additive neural feedback - Additive activation models Bivalent BAM theorem, Hopfield model

UNIT-III

Synaptic Dynamics: Unsupervised learning - Learning laws, Signal Hebbian learning- Competitive learning, Differential Hebbian learning - Supervised learning, The perceptrons – LMS algorithm, Back propagation algorithm - AVQ algorithm, Global stability of feedback neural networks.\

UNIT-IV

Fuzzy Logic: Fuzzy sets and systems-Geometry of fuzzy sets, Fuzzy entropy theorem- Entropy subset - Hood theorem, Fuzzy& neural function estimators-FAM system Architecture, Uncertainty and estimation - Types of uncertainty - Measure offuzziness -Classical measures of uncertainty, Measures of dissonance - Confusion and non-specificity. Fuzzy logic structure, Knowledge base defuzzification, Fuzzy logic in control-Pattern recognition–Planning diagnosis

UNIT-V

Fuzzy Logic and ANN Applications: Fuzzy logic application to Induction motor speed control, Flux programming efficiency improvement of induction motor drive, pulsating torque compensation. Neural Network applied to Space Vector PWM, Vector controlled drive feedback signal estimation, model identification and adaptive drive control. Neuro-Fuzzy systems, ANN based Fuzzy inference system (ANFIS)

Suggested Reading

1. Bart Kusko, *Neural Networks and Fuzzy System* - Prentice Hall of India, 1994.
2. B. Yegnanarayana, *Artificial Neural Networks*, PHI Learning 1994.
3. B.K. Bose, Modern Power electronics and AC drives, Prentice Hall PTR, 2002.
4. Timothy J. Ross, *Fuzzy Logic with Engineering Applications*, Wiley

EE3304

Power Electronic Converters for Renewable Energy

(Elective IDC & Core PES)

Instruction	**:** 3 Hours/Week
Duration of Univ. Examination	**:** 3 Hours
SEE	**:** 70 Marks
CIE	**:** 30 Marks

Course Objectives:

- To learn the types of renewable sources such as Wind, solar, hydro and geothermal sources.
- To understand the principle and operation of various DC-DC converters.
- To understand the concepts of grid connected inverters and grid connected issues.
- To understand the principle of operation of doubly fed induction generator with rotor side converter topologies.

Course Outcomes:

- Students can explain P-V &I-V characteristics of solar and understand different MPPT .Techniques.

UNIT I

Introduction to renewable sources: world energy scenario, Wind, solar, hydro, geothermal, availability and power extraction.

Introduction to solar energy: Photovoltaic effect, basics of power generation, P-V &I-V characteristics, effect of insolation, temperature, diurnal variation, shading, Modules, connections, ratings, Power extraction (MPP) tracking and MPPT schemes; standalone systems, grid interface, storage, AC-DC loads.

UNIT II

DC-DC converters for solar PV: buck/boost/buck-boost /flyback /forward/cuk, bidirectional converters, Interleaved and multi-input converters.

UNIT III

Grid connected Inverters: 1ph, 3ph inverters with & without transformers, Heric, H6, Multilevel Neutral point clamp, Modular multilevel, CSI; Control schemes: unipolar, bipolar, PLL and synchronization, power balancing / bypass, Parallel power processing; Grid connection issues: leakage current, Islanding, harmonics, active/reactive power feeding, unbalance.

UNIT IV

Introduction to wind energy: P-V, I-V characteristic, wind power system: turbine-generator-inverter, mechanical control, ratings; Power extraction (MPP) and MPPT schemes. Generators for wind: DC generator with DC to AC converters; Induction generator with & w/o converter.

UNIT V

Synchronous generator with back to back controlled/ uncontrolled converter; Doubly fed induction generator with rotor side converter topologies; permanent magnet based generators. Battery: Types, charging discharging. Introduction to AC and DC microgrids.

Suggested Reading:

1. SudiptaChakraborty, Marcelo G. Simes, and William E. Kramer. Power Electronics for Renewable and Distributed Energy Systems: A Sourcebook of Topologies, Control and Integration. Springer Science & Business, 2013.
2. Nicola Femia, Giovanni Petrone, Giovanni Spagnuolo, Massimo Vitelli, Power Electronics and control for maximum Energy Harvesting in Photovoltaic Systems,CRC Press,2013.
3. Chetan Singh Solanki, Solar Photovoltaics: fundamentals, Technologies and Applications, Prentice Hall of India, 2011.
4. N. Mohan, T.M. Undeland& W.P. Robbins, Power Electronics: Converter, Applications & Design, John Wiley & Sons, 1989
5. Muhammad H. Rashid, Power Electronics: Circuits, Devices, and Applications, Pearson Education India, 2004
6. E. Guba, P. Sanchis, A. Ursa, J. Lpez, and L. Marroyo, Ground currents in single-phase transformerless photovoltaic systems, Progress in Photovoltaics: Research and Applications, vol. 15, no. 7, 2007.
7. Remus Teodorescu, Marco Liserre, Pedro Rodriguez, Grid Converters for Photovoltaic and Wind Power Systems, John Wiley and Sons, Ltd., 2011.
8. [8] Ali Keyhani, Design of Smart Power Grid Renewable Energy Systems, Wiley-IEEE Press, 2011.

EE3302

Industrial Controllers

(Core PES & Elective IDC)

Instruction	**:** 3 Hours/Week
Duration of Univ. Examination	**:** 3 Hours
SEE	**:** 70 Marks
CIE	**:** 30 Marks

Course objective:

- To develop knowledge about 8051 Micro controller and its assembly language programming.
- To be familiarize with LF2407 DSP controller, its architecture, programming, GPIOs, Interrupts, ADC, Event Managers and learn how to produce PWM waveforms.
- To be aware of Programmable Logic Controller and how to develop ladder programs.

Course outcomes:

At the end of the course students will be able to

- Utilize the knowledge of 8051micro controller and it's programming in practical applications.
- Understand the LF2407 DSP controller and it's application to Electro mechanical motion control.
- Develop ladder programs for different industrial problems.

UNIT-I

8051 Micro controller: Architecture, memory organization, timing and control, parallel ports, timer/counters, serial port and interrupts. Addressing modes and instruction set of 8051 micro controller and its usage.

UNIT-II

TMSLF2407 DSP Controller: Introduction, brief introduction to peripherals, types of physical memory, software tools. **C2XX DSP CPU and instruction set:** C2xx DSP Core and code generation, mapping external devices to the C2xx DSP core and the pheripherals, memory, Addressing modes, assembly programming using C2xx DSP instruction set.

UNIT-III

GPIO functionality: Pin multiplexing (MUX) and GPIO Overview, multiplexing and GPIO control registers. **Interrupts on the TMS320LF2407:** Introduction, Interrupt Hierarchy and its Control Registers.

UNIT-IV

ADC: Overview, Operation and programming modes. **Event managers**: Overview, Interrupts, Timers, Compare Units, Capture units and QEP circuitry PWM Signal Generation with Event Managers.

UNIT-V

Programmable Logic Controller (PLC) Basics: Definitions and history of PLCs – Advantages and disadvantage of PLC – overall PLC Systems, CPUs and Programmer/ Monitors – Programming procedures – programming equipment – Programming formats Ladder diagrams, Basic PLC programming and Basic PLC functions: Programming on / off inputs to produce on / off outputs, PLC programming examples.

Suggested Reading:

1. Kenneth J.Ayala, The Micro Controllers - Architecture, Programming & Applications, Penram International Publishing (India).
2. Hamid A Toliyat, DSP based Electromechanical Motion Control, Steven Campbell 2004, CRC Press.
3. John W. Webb and Roland A. Reis, Programmable Logic Controllers, Prentice Hall India Ltd., Fifth edition, 2003.

EE 3201

Distribution System Planning and Automation

(Core PS)

Instruction	**:** 3 Hours/Week
Duration of Univ. Examination	**:** 3 Hours
SEE	**:** 70 Marks
CIE	**:** 30 Marks

Course Objectives:

- Introduce various advancements in the distribution systems.
- Understand sub transmission, Primary and Secondary systems.
- Analyze the importance of capacitors in distribution systems.
- Introduce distribution automation, SCADA and their components.

Course Outcomes:

The students will be able to:

- Distinguish characteristics of distribution systems from transmission systems.
- Study the types of sub-transmission systems, primary systems and secondary systems.
- Be familiar with control functions of Distribution Automation, Consumer Information Service, Geographical Information System and Automatic Meter Reading.

UNIT-I

Distribution System Planning: Introduction, Distribution system Planning: Factors effecting planning, Present techniques, Planning models, Planning in the future, Future nature of distribution planning, Role of computer in Distribution planning. Load characteristics and Load models – Wye connected loads, Delta connected loads.

UNIT-II

Sub Transmission lines and Substations: Types of sub – transmission, Distribution substation, bus schemes, substation location, rating of substation, calculation of voltage drops with primary feeders, Derivation of the K constant, Interpretation of the Percentage Voltage drop formula.

UNIT-III

Primary Feeders: Types ofprimary feeders, Primary feeder loading, Tie-lines, Distribution feeder exit – rectangular and radial type development, Design of radial primary feeders – Voltage drop calculations by A,B,C,D constants, Uniformly distributed load, Non uniformly distributed load. Distribution Feeder Analysis – the ladder Iterative technique.

UNIT-IV

Secondary Feeders: Secondary voltage levels, present design practice, Secondary Banking, Economic design of secondaries, Total annual cost equation, Voltage drop and Power loss calculations. Distribution system voltage regulation: Quality of services, voltage control, Application of capacitors in Distribution system.

UNIT-V

Distribution Automation: Distribution Automation, Project planning, Definitions, Communication, Sensors, Supervisory Control and Data Acquisition Systems (SCADA), Consumer Information Service (CIS), Geographical Information System (GIS), Automatic Meter Reading (AMR), Automation system.

Suggested Reading:

1. Turan Gonen, *Electric Power Distribution System Engineering*, CRC Press, Second Edition 2007
2. William.Kersting, *Distribution Modelling & Analysis* – CRC Press – third edition - 2002
3. A.S. Pabla, *Electric Power Distribution*, Tata McGraw Hill, Fifth Edition, 2005.

EE3202

Advanced Computer Methods in Power Systems

(Core PS)

Instruction	**:** 3 Hours/Week
Duration of Univ. Examination	**:** 3 Hours
SEE	**:** 70 Marks
CIE	**:** 30 Marks

Objectives:

- To understand the necessity of mathematical modeling and use of computer methods
- To be familiar with models used for analysis of load flows and short circuit studies
- To adopt various optimal methods of computations for large systems
- To model different types of loads

Outcomes:

- The student will be able to model the power system using computer aided methods different types of analysis.
- The student will be able to perform load flows and short circuit studies using Y_{BUS} and Z_{BUS} matrices.
- The student will be able to utilize optimal ordering and Factorization for efficient computations
- The student will be able to perform modeling of various loads like induction motors and synchronous motors

UNIT-I

Graph Theory : Network graph – Incidence matrices – Element node incidence matrix – Bus incidence matrix –Branch path incidence matrix – Basic and Augmented cut set incidence matrices – Basic and augmented branch incidence matrices - Basic and Augmented loop incidence matrices – Primitive network – Formation of Y Bus, YBR & Z loop by singular transformation.

UNIT-II

Z Bus formation: Matrix representation of power systems, Triangularization, Gaussian elimination method, LU, LDU factorization, Table of factors, Optimal ordering. Algorithm for formation of Z Bus matrix. Concept of branch and link addition – modification of bus impedance matrix for changes in the network, Z bus – sparse vector method.

UNIT-III

Load flow studies: Concepts of load flow – classification of buses, Representation of fixed tap setting and on load tap changing transformers, Power System Loads-Basic Load Modeling concepts, Modeling of induction and synchronous motors**.** Load flow solution using Gauss-Seidel, Newton-Raphson methods – Treatment of voltage controlled buses – Acceleration factors, Decoupled and Fast decoupled method, Flow chart and comparison of different methods.

UNIT-IV

Modifications in Z bus matrix : Representation and performance equation of 3 phase network elements – Three phase network elements with balanced and unbalanced excitation – Transformation matrices –Symmetrical and Clarke's components – Algorithm for formation of three phase bus impedance matrix – Modification of three phase Z bus changes in network.

UNIT-V

Short circuit studies: Basic assumption in short circuit studies - System representation – General equations for short circuit study in phase variables and Symmetrical components for fault current and node voltage – Short circuit calculations for balanced three phase network using Z bus – Fault impedance and admittance matrices – Analysis of 3 phase, line to ground and double line to ground faults – Flow chart for short circuit study. Short circuit studies using Table of Factors.

Suggested Reading:

1. Stagg & El-Abiad. *Computer methods in Power System Analysis*, Tata McGraw Hill, 1968.
2. Kusic George L, *Computer Aided Power System Analysis*, Prentice Hall, 1986.
3. M.A.Pai ,*Computer techniques in Power System Analysis*, Tata McGraw Hill, 2006.
4. PrabhaKundur, *Power System Stability & Control*, Tata McGraw Hill edition, 2006.

EE 3203

Advanced Synchronous Machine Theory

(Core PS)

Instruction	**:** 3 Hours/Week
Duration of Univ. Examination	**:** 3 Hours
SEE	**:** 70 Marks
CIE	**:** 30 Marks

Course Objectives :

- Utilize the reference frame theory to model, analyze, and design AC machine drives, and understand advanced electromechanical systems
- Carry out DC machines and drives modelling and dynamic performance analysis, and conduct DC machine drive designs and design optimization
- Understand and use induction machine transformation theory for modelling, analysis, and design of high-performance induction machine drives
- Understand and use synchronous machine transformation theory for modelling, analysis, and design of high-performance synchronous machine drives
- Observe, measure, and record dynamic performance of DC and AC machines and their drives

Course outcomes:

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

- Utilize the reference frame theory to develop the mathematical model for a synchronous machine to use in stability computations and to developed State space formation of synchronous machine equations a) using current as state variable and b) using flux linkages as state variable.
- Understand and use synchronous machine phasor diagram models from the initial conditions and available data;
- Understand and use linear models of synchronous machine modelling, analysis, and design and to understand and use simplified linear models of synchronous machine modelling, analysis, and design.
- Understand and use synchronous machine excitation system models and to developed State space formation of excitation systems of synchronous machine equations.

UNIT-I

The Synchronous machine - Park's transformation – Flux linkage equations – Voltage equations - Formulation of state space equations- Current formulation – Per-unit conversion – Normalizing voltage and torque equations – Torque and power – Equivalent circuits of synchronous machine – Flux linkage state space model

– Treatment of saturation Synchronous machine connected to infinite bus – Current , Voltage and flux linkage models.

UNIT-II

Sub-transient and transient reactances and time constants – Simplified models of the synchronous machine – Steady state equations and phasor diagrams – Machine connected to infinite bus with local load at machine terminals – Determining steady state conditions.

UNIT-III

Linear models of the synchronous machine – Linearization of the generator state space current, voltage and flux linkage models.

UNIT-IV

Linearization of the load equation for the one machine problem –Simplified linear models – Effect of loading – State space representation of simplified model.

UNIT-V

Representation of excitation systems, Different models of excitation systems – IEEE, 1, 2 & 3 systems – Representation of loads. State-space representation of the excitation system-simplified linear model, complete linear model.

Suggested Reading:

1. P.M.Anderson & A.A.Foud, *Power System Control & Stability,* Iowa State University Press, U.S.A. (1977), reprint 2005.
2. Kimbark, E.W., *Power System Stability,* Vol. III, Dover, New York, 1968.
3. Yao-Nan-Yu, *Power System Dynamics, Academic Press,* 1983.

EE3204

Power Systems Stability

(Core PS)

Instruction	**:** 3 Hours/Week
Duration of Univ. Examination	**:** 3 Hours
SEE	**:** 70 Marks
CIE	**:** 30 Marks

Course Objectives:

- To gain knowledge about the dynamic mechanisms behind angle and voltage stability problems in electric power systems, including physical phenomena and modeling issues.
- To examine the effects of excitation systems on stability.
- To understand sub synchronous oscillations and damping schemes
- To understand Voltage stability, means to improve it.
- To become familiar with concepts of dynamic stability

Course Outcomes:

- The student will be able to analyze the performance of single machine and multi machine systems under transient, steady state and dynamic conditions.
- The student will be able to design supplementary excitation systems, stabilizers for improving stability
- The student will be able to analyze sub synchronous oscillations and understand various damping schemes to reduce these oscillations
- The student will be able to understand voltage stability and methods of enhancing it.
- The student will be able to understand dynamic stability concepts using Transient Energy Function Analysis and Extended Equal Area Criterion

UNIT-I

Stability Concepts: Basic concept of stability-Types of stability – Stability criteria for single and multi-machine systems –Synchronous machine representation for stability studies – Swing equation for single and multi-machine system – Basic assumptions–Different methods of solution of swing equation–Solution by indirect methods–Runge-Kutta method – Determination of critical time and critical angle.

UNIT-II

Excitation models: Hydraulic power and governor models – IEEE standard models – Models for steam turbine – Various Excitation systems, Effect of Excitation systems on Stability.

UNIT-III

Low frequency oscillation and supply controls: Transfer function of low frequency oscillation studies – Improving system damping with supplementary excitation – Design of supplementary excitation system – State equation for single machine system – Improving system model with governor control.

UNIT-IV

Sub Synchronous oscillations: Turbine generator torsional characteristics, Torsional interaction with power system controls. Sub Synchronous resonance. Damping schemes.

UNIT-V

Concept of voltage stability – Characteristics of network, generator and load for voltage stability – Methods of enhancing stability, Transient stability analysis using Transient Energy Function Analysis, Extended Equal Area Criterion – Basics.

Suggested Reading:

1. Yao-Nan-Yu, *Power System Dynamics*, Academic Press, 1983.
2. PrabhaKundur, *Power System Stability & Control*, Tata McGraw Hill edition, 2006.
3. KR Padiyar, *FACTS Controllers in Power Transmission & Distribution* New AGE International Publishers First edition 2007.
4. Stagg and Elabiad, *Computer Methods in Power systems* - McGraw Hill., 1968.
5. John Machowski, JanuszBialek, Jim Bumby, Power System Dynamics: Stability and Control, Wiley.

EE3205

Real Time Applications in Power Systems

(Core PS)

Instruction	**:** 3 Hours/Week
Duration of Univ. Examination	**:** 3 Hours
SEE	**:** 70 Marks
CIE	**:** 30 Marks

Course Objectives:

To prepare the students to understand

- The concept of state estimation and also the solution techniques of the state estimation problem.
- The methodology for detection and identification of bad data from the available measurements in the Energy control centre.
- The concepts of power system security and methods for analyzing the system security.
- The need of computer control of power system and necessity of different softwares available in Energy control centre.

Course Outcomes:

The students will be

- Able to estimate the state of given power system using WLS method for the available measurements in the energy control centre.
- Able to choose suitable state estimation solution technique for a given power system network.
- Able to detect and identification of bad data for the set of measurements available in the energy control centre.
- Able to analyze the security of a given power system using different methods.
- Able to understand the need of the computer control of power system and also the significance of different software's available in the energy control centre.

UNIT- I

State Estimation: Introduction, Power system state estimation, Types of measurements, Linear weighted least square (WLS) estimation theory, DC Load flow based WLS state estimation, Linearised model of WLS state estimation of Non-linear AC power systems, sequential and non-sequential methods to process measurements, typical results of state estimation on an Ac network.

UNIT-II

Types of State Estimation: State estimation by conventional WLS (normal equations), orthogonal decomposition and its algorithm, hybrid method. Tracking of state estimation, Dynamic state estimation.

UNIT-III

Advanced Topics in State Estimation: Detection and identification of bad measurements, estimation of quantities not being measured, Network observability and pseudo-measurements, observability by graphical technique and triangularisation approach, Optimal meter placement, Application of power system state estimation.

UNIT- IV

Power System Security Analysis: Concept of security, Security analysis and monitoring, factors affecting power system security, detection of network problems, an overview of security analysis, contingency analysis for generator and line outages by interactive linear power flow (ILPF) method, network sensitivity factors. Contingency selection

UNIT-V

Computer control of Power Systems: Need for real-time and computer control of power systems, operating states of a power system, Supervisory control and Data acquisition system (SCADA), implementation considerations, energy control centers, software requirements for implementing the above functions.

Suggested Reading:

1. Allen J. Wood and Bruce Woolen berg: Power System Generation, Operation and Control, John Wiley and Sons, 1996.
2. John J. Grainger and William D Stevenson Jr.: Power System Analysis, McGraw Hill ISE, 1994.
3. E. Hands chin: Real-time control of electrical power systems, Elsevier Pub. Co, 1988
4. IEEE Proc. July 1974, Special Issue on Computer Control of Power Systems

EE3206

Advanced Power System Protection

(Core PS)

Instruction	**:** 3 Hours/Week
Duration of Univ. Examination	**:** 3 Hours
SEE	**:** 70 Marks
CIE	**:** 30 Marks

Course Objectives:

- To understand the necessity and operation and applications of various static relays
- To understand the various protection schemes for Generation, transmission and in distribution system.
- To be familiar with digital protection and relaying algorithms.

Course Outcomes:

The students will be able to:

- Apply the scheme of protection using static relay to power system (distribution system and transmission line).
- Realize the complex relay characteristics with static relays.
- Understand the principle of operation of Differential relay and application of digital protection for various equipments in generation, transmission and distribution.

UNIT-I

Static relays – Concept of level detectors – Time delay circuits – Filters – Thyristors -Triggering circuits and DC power supplies. Comparators and static relay characteristics: Relays as comparators –Amplitude and Phase comparison schemes – General equation for comparators for different types of relays – Static comparators – Coincidence circuits – Phase splitting methods–Hall effect comparators – Operating principles

UNIT-II

Static relay hardware: Operating principles: Static time current relays directional units based on phase and amplitude comparison–Distance relays – Quadrilateral relay – Elliptical relay – Relay response – Principle of R-X diagram – Convention for superposing relay and system characteristics – Power swings, Loss of synchronism and its effect on distance relays.

UNIT-III

Differential relays. Generator and transformer differential protection. Digital protection scheme based upon second harmonic current induced in the rotor field circuit.

UNIT-IV

Digital Protection: Developments in computer relaying-mathematical basis for protective relaying algorithms, Fourier Transforms – Discrete Fourier transforms-Wavelet transforms. Digital protection EHV/ UHV transmission line based upon traveling wave phenomena Switched schemes – Auto-reclosing – Single and multi-shot auto reclosing – Single pole and three pole auto reclosing.

UNIT-V

Pilot wire and carrier protection: Circulating current scheme – Balanced Voltage scheme -Translay scheme – Half wave comparison scheme – Phase comparison carrier current protection –carrier transfer scheme – carrier blocking scheme.

Suggested Reading:

1. Badriram and Viswakarma D.N., *Power System Protection and Switchgear* — Tata McGraw Hill, 2004.
2. L.P.Singh, *Digital Protection*, Wiley Eastern Ltd., 1994.
3. Warrington A.R. Van C, *Protective Relays* ,Vol I & II Chapman & Hall, London and John Wiley & Sons, (1977), reprint,2010 .
4. Mason C.R. *The art and science of Protective Relaying,* Wiley & Sons, 1956.

EE3211

Advanced Power System Operation and Control

(Elective to PS)

Instruction	**:** 3 Hours/Week
Duration of Univ. Examination	**:** 3 Hours
SEE	**:** 70 Marks
CIE	**:** 30 Marks

Course Objectives:

- To understand the economics of power system operation using thermal units.
- To analyze the economics of hydro-thermal units.
- To become familiar with multi area load frequency control and application of optimal control to LFC.
- To gain knowledge of the approaches used for load forecasting techniques.

Course Outcomes:

- The student will be able to develop generation dispatching schemes for thermal units, shared generators and scheduling between areas.
- The student will be able to develop economic generating schedules for combined hydro-thermal units using dynamic programming method.
- The student will be able to apply optimal control to load frequency control of multi area system.
- The student will be able to analyze various methods of Load Forecasting.

UNIT-I

Generation Base Power Setting: Economic dispatch of generation with line losses - Classical method to calculate loss coefficients – Loss coefficients calculation using Y bus and sparse matrix techniques Execution of the economic dispatch utilizing the load flow Jacobian and economic dispatch – Economic dispatch using shared generators – Economic exchange of power between areas.

UNIT-II

Combined Operation of Hydro-Thermal Plants: Dynamic programming method – Kirchmayer's method of co-ordination equations - Decomposition technique for Hydro–thermal schedules.

UNIT-III

ALFC of Multi-Control Area System (Pool Operation): The two Area system - Block diagram representation of a two Area system - Static and dynamic response of a two Area system - Tie-line bias control for two Area and multi area systems - Steady state instabilities - Negative damping - Effect of change of E’ - Factors causing changes in E’. Inclusion of AVR loop.

UNIT-IV

AGC using Kalman methods: Dynamic model in state variable form, Application of optimal control to LFC – Optimal control index - Optimal control trajectories – Application of optimal control to Two Area system for LFC.

UNIT-V

Load Forecasting Technique: methodology –Estimation of average and trend terms– Estimation of periodic components–Estimation of y(k): Time series approach- Estimation of stochastic component: Kalman filters approach–Long term load predictions– Reactive load forecast.

Suggested Reading:

1. Kusic George L - Computer Aided Power System Analysis,- Prentice Hall, 1986.
2. P.S.R. Murty, Power System Operation and Control - Tata McGraw Hill, 1984.
3. OlleLElgerd, Electric Energy System Theory - Tata McGraw Hill, 1982.
4. D.P. Kothari, l.J. Nagrath, Modern Power System Analysis, Tata McGraw Hill, 3rd Edition, 2004.

EE3212

Power Quality Engineering

(Elective to PS & PES)

Instruction	**:** 3 Hours/Week
Duration of Univ. Examination	**:** 3 Hours
SEE	**:** 70 Marks
CIE	**:** 30 Marks

Course Objectives:

- The student able to learn and understand the importance of power quality, different power quality issues and their effects in power system network.

Course Outcomes:

The students will be able to:

- Understand the significance of power quality study and identify various power quality disturbances.
- Analyze the effects of power quality problems like voltage sags, Harmonics and transients on various equipment.
- Mitigate Harmonic and voltage sags.

UNIT-I

Introduction: Power Quality (PQ),PQ problems , Sags, Swells, Transients, Harmonics, Interruptions, Flicker ,Voltage fluctuations, Notch.Transient Overvoltages – Sources of Transient Over voltages.

Wiring and Grounding: Resources, Definitions, Reasons for Grounding, Typical wiring and grounding problems, Solutions to wiring and grounding problems.

UNIT-II

Voltage Sag Analysis: Voltage sag characteristics - Methodology for computation of voltage sag magnitude and occurrence — Accuracy of sag analysis — Duration & frequency of sags — Faults behind transformers — Effect of pre-fault voltage — Simple examples — Voltage dip problems, fast assessment methods for voltage sags in distribution systems.

UNIT-III

PQ Consideration in Industrial Power Systems: Adjustable speed drive (ASD) systems and applications — Sources of power system harmonics — Mitigation of harmonics — Characterization of voltage sags experienced by three-phase ASD systems — Types of sags and phase angle jumps — Effects of momentary voltage dips on the operation of induction and synchronous motors .

UNIT-IV

Harmonics: Harmonic distortion, Voltage versus current distortion, Harmonics versus Transients, Harmonic Indices, Harmonic sources from commercial loads, Harmonic sources from industrial loads, Locating Harmonic sources, System response characteristics, Effects of Harmonic distortion, Inter harmonics, Devices for controlling harmonic distortion.

UNIT-V

Power quality monitoring – Monitoring considerations, Historical Perspective of PQ Measuring Instruments, PQ measurement equipment, Assessment of PQ measurement data, Application of intelligent systems, PQ monitoring standards

Suggested Reading:

- Math H.J. Bollen, *Understanding Power Quality Problems*, IEEE Press, 1999.
- Roger C.Dugan,MarkF.McGranaghan, Surya Santoso, H.WayneBeaty, *Electrical Power Systems Quality,* Second Edition,Tata McGraw-Hill Edition.
- C.Sankaran, *Power Quality*, CRC Press, 2002.

EE3213

Power System Deregulation

(Elective to PS)

Instruction	**:** 3 Hours/Week
Duration of Univ. Examination	**:** 3 Hours
SEE	**:** 70 Marks
CIE	**:** 30 Marks

Course Objectives:

- Understand the new dimensions associated with operation of deregulated power systems.
- Introduction to the power sector market, trading and bidding strategies.
- Apply the concept of deregulation and ATC.
- Understand the electricity power business and technical issues in a deregulated power system in both Indian and world scenario.

Course Outcomes:

The students will be able to:

- Understand the role of various entities in the deregulated environment..
- Calculate Available Transmission Capability using various methodologies.
- Explore issues like congestion management, Transmission pricing, Ancillary Services Management.

UNIT-I

Overview of Key Issues in Electric Utilities: Introduction – Restructuring models – Independent system operator (ISO) – Power Exchange - Market operations – Market Power – Stranded costs – Transmission Pricing – Congestion Pricing .

UNIT-II

OASIS: Open Access Same-Time Information System**:** Structure of OASIS - Posting of Information – Transfer capability on OASIS – Definitions Transfer Capability Issues – ATC – TTC – TRM – CBM calculations – Methodologies to calculate ATC, Biding strategies.

UNIT-III

Electricity Pricing: Introduction – Electricity Price Volatility Electricity Price Indexes – Challenges to Electricity Pricing – Construction of Forward Price Curves – Short-term Price Forecasting.

UNIT-IV

Power system operation in a competitive environment: Introduction – Operational Planning Activities of ISO- the ISO in Pool Markets – The ISO in Bilateral Markets – Operational Planning Activities of a Genco, Congestion management.

UNIT-V

Ancillary Services Management: Introduction – Reactive Power as an Ancillary Service – a review – Synchronous Generators as Ancillary Service Providers.

Suggested Reading:

1. Kankar Bhattacharya, Math H.J. Bollen, JaapE.Daalder, 'Operation of Restructured Power System' Kluwer Academic Publisher – 2001
2. Mohammad Shahidehpour, and Muwaffaqalomoush, - "Restructured Electrical Power systems" Marcel Dekker, Inc. 2001
3. Loi Lei Lai; "Power system Restructuring and Deregulation", John Wiley & Sons Ltd., England.

EE3214

High Voltage Engineering

(Elective to PS)

Instruction	**:** 3 Hours/Week
Duration of Univ. Examination	**:** 3 Hours
SEE	**:** 70 Marks
CIE	**:** 30 Marks

Course Objectives:

- To understand the concepts of Conduction and Breakdown of Gaseous Insulating Materials.
- To make the students understand the Generation, Measurement and Testing of High Voltage DC, AC & impulse Currents.

Course Outcomes:

The students will be able to:

- Explain the fundamentals of conduction and breakdown in various solid, liquid and gaseous insulating materials.
- Able to design the circuits used in high voltage AC, DC generation, measurement and testing.
- Able to understand the significance of standard impulse wave shapes and radio interference measurement,

UNIT-I

Conduction and Breakdown of Gaseous Insulating Materials: Ionization processes and current growth -- Townsend's criterion for breakdown - Breakdown in electronegative gases - Time lags for breakdown - Paschen's law - Corona discharges - Breakdown in non-uniform fields - Practical considerations for selecting gases for insulation purposes.

UNIT-II

Conduction and Breakdown in Liquid and Solid Dielectrics: Various mechanisms of breakdown in liquid dielectrics - Liquid dielectrics used in practice- Various processes - Breakdown in solid dielectrics- Solid dielectrics used in practice.

UNIT-III

Generation of High Voltages and Currents: Generation of high D.C voltages using voltage multiplier circuits - Van de Graff generator. Generation of high alternating voltages using cascade transformers- Production of high frequency A.C high voltages

- Standard impulse wave shapes - Marx circuit - Generation of switching surges - Impulse current generation - Tripping and control of impulse generators.

UNIT-IV

Measurement of High Voltages and Currents: High D.C voltage measurement techniques - Methods of measurement for power frequency A.C voltages - Sphere gap measurement technique - Potential divider or impulse voltage measurements - Measurement of high D.C, A.C and Impulse currents - Use of CRC for impulse voltage and current measurements.

UNIT-V

High Voltage Testing: Tests on insulators - testing on bushings - Testing of isolators and circuit breakers -Cable testing of transformers Surge diverter testing - Radio interference measurement - Use of I.S.S. for testing.

Suggested Reading:

1. M.S. Naidu and V. Kamaraju, *High Voltage Engineering,* Tata McGraw Hill, 1982.
2. E. Kuffel and M. Abdullah, *High Voltage Engineering,* Pergamon Press, 1970.

EE3215

Reactive Power Control and Voltage Stability

(Elective to PS)

Instruction	: 3 Hours/Week
Duration of Univ. Examination	: 3 Hours
SEE	: 70 Marks
CIE	: 30 Marks

Course Objectives:

Course Outcomes:

UNIT-I

Concepts of power in AC transmission systems – reactive loss characteristics – operation of transmission lines under no-load, heavy load conditions – Voltage regulation relations with reactive power – line loadability – governing effects on reactive power flow – reactive power transient stability – reactive power requirements for control – system MVAR mismatch – constraints, effects and practical aspects of reactive power flow problems.

UNIT-II

Reactive power and voltage collapse - Voltage stability - classification, analysis and modelling of voltage collapse – basic aspects of voltage stability, security and transient voltage stability – Power transfer at voltage stability limit – different expressions and relations between reactive power and system stability - loading of a transmission system at voltage stability.

UNIT-III

Voltage stability indicators – P-V and Q-V curves – criteria of voltage stability – different voltage stability indicators – voltage stability indicators – singular value decomposition – expressions for investigate the voltage security – voltage stability evaluation – factors effecting voltage stability – voltage stability relations with off-nominal tap ratios and source to load reactances – Power system security analysis – computation of voltage stability limits – contingency analysis.

UNIT-IV

Voltage control and improvement of voltage stability – role and modelling of transformers – OLTC tap settings, effects and practical aspects on voltage stability – methods of improving voltage stability – series compensation – optimal load shedding – facts devices – advantages of fact devices.

UNIT-V

Advanced topics in voltage stability: On - Line Voltage Stability Monitoring - Feasibility of online collaborative voltage stability control of power systems - A Fast Calculation Static Voltage Stability Index Based on Wide Area Measurement System - Improving Voltage Stability by Reactive Power Reserve Management.

Suggested Readings:

1. An introduction to reactive power control and voltage stability in power transmission systems - AbhijitChakrabarti, D.P Kothari, A.K. Mukhopadhyay, Abhinandan De – PHI – 2010.
2. Research Papers:
    a. Line Voltage Stability Monitoring - IEEE transactions on power systems, vol. 15, no. 4, November 2000.
    b. Improving Voltage Stability by Reactive Power Reserve Management - Feng Dong, Badrul H. Chowdhury, Mariesa L. Crow, LeventAcar, IEEE transactions on power systems, vol. 20, no. 1, February 2005.
    c. Feasibility of online collaborative voltage stability control of power systems -W. Du, Z. Chen, H.F. Wang, R. Dunn - IET Gener. Transm. Distrib., 2009, Vol. 3, Issue. 2, pp. 216–224.
    d. A Fast Calculation Static Voltage Stability Index Based on Wide Area Measurement System - TianjiaoPu, Zhao Zhang, Ting Yu , Wei Han, And Lei Dong – 2014.

EE3216

Artificial Neural Networks

(Elective to PS)

Instruction	**:** 3 Hours/Week
Duration of Univ. Examination	**:** 3 Hours
SEE	**:** 70 Marks
CIE	**:** 30 Marks

Course Objectives:

Course Outcomes:

UNIT-I

Neural and Fuzzy Intelligence: Fuzziness as multi-valence - Bivalent paradoxes as fuzzy midpoints - Sets as points in cubes - Subset hood and probability- The dynamical system approach to machine intelligence - Brain as a dynamical system - Neural networks as trainable dynamical system - Intelligent behaviour as adaptive model free estimation - Generalization and creativity - Learning as change- Rules vs. principles - Symbolic vs. numeric processing - Structured numerical estimators.

UNIT-II

Neural Network Theory: Neurons as functions - Signal monotonicity Biological activities and signals - Neuron fields - Neuronal dynamic systems - Common signal functions - Pulse coded signal functions- Additional neuron dynamics - Additive neural feedback - Additive activation models - Bivalent BAM theorem - Hopfield model.

UNIT-III

Synaptic Dynamics: Unsupervised learning - Learning laws - Probability spaces and random processes - Signal Hebbian learning- Competitive learning - Differential Hebbian learning - Supervised learning - The perceptions - LMS algorithm - Back propagation algorithm - AVQ algorithm - Global stability of feedback neural networks.

UNIT-IV

Fuzzy Logic: Fuzzy sets and systems - Geometry of fuzzy sets - Fuzzy entropy theorem- Entropy subset - Hood theorem - Fuzzy and neural function estimators - FAM system architecture - Uncertainty and estimation - Types of uncertainty -

Measure of fuzziness - Classical measures of uncertainty – Measures of dissonance - Confusion and non- specificity. Fuzzy logic structure - Knowledge base defuzzification - Fuzzy logic in control - Pattern recognition - Planning and Diagnosis.

UNIT-V

Fuzzy Logic and ANN Application: Application to load forecasting - Load flow, Fault detection and Unit commitments - LF control - Economic dispatch.

Suggested Reading:

1. Bart Kusko, *Neural Networks and Fuzzy System* - Prentice Hall of India, 1994.
2. B.Yegnanarayana, *Artificial Neural Networks*,PHI Learning,1994.

EE3303

Industrial Electronic Systems

(Core PES)

Instruction	**:** 3 Hours/Week
Duration of Univ. Examination	**:** 3 Hours
SEE	**:** 70 Marks
CIE	**:** 30 Marks

Course Objectives:

- To prepare the students as per Industry standard tools to analyze design and develop the Industrial Electronics based systems.
- To provide the students the deeper knowledge in the area related with Industrial Electronics as well as the Automation.
- To develop the ability to exhibit creative skills to comprehend, analyze, design and implement solutions for problems in Industrial applications.

Course Outcomes:

On successful completion of program

- The student will acquire the knowledge of various types of power supply systems like UPS, power conditioners switched mode supplies.
- The student will acquire deeper knowledge in the area related with Industrial Electronics as well as the Automation in automatic welding system.
- The student will be able to apply innovative skills to model design and develop various control systems for Industrial applications.
- The student will be able to design analyze various types of switched mode power supplies for different types of renewable energy generation topologies and for various electrical applications.
- The student will be analyze, design and develop reactive power compensation techniques in Arc furnace.

UNIT-I

Power Supplies: UPS- Offline, Online & Hybrid types of UPS, Parallel redundancy, Dual redundancy, AC Power conditioner- power supply noise-servo system – servo controlled voltage stabilizer- AC generator voltage regulator– Constant voltage transformer SMPS -Fly back, feed forward, Push pull and Bridge types.

UNIT-II

Automatic Welding System: Physical Description of a wheel welding system - Sequence of operations – Sequence initiation –Interval triggering and gating circuit - Interval stepping circuit –Interval time counter –Heat -cool counter –Weld power circuit.

UNIT-III

Closed loop Industrial Systems: Thermistor control of quench oil temperature Proportional mode pressure control system Strip tension controller – Edge guide control for a strip recorder –Control of relative humidity in a textile moisturizing process. Closed loop industrial systems warehouse humidity controller.

UNIT-IV

High Frequency Heating: Merits of Induction Heating–Applications of Induction Heating–High Frequency Power Source for Induction Heating–Principle of Dielectric Heating–Theory of Dielectric Heating–Dielectric Properties of a few typical materials–Electrodes used in Dielectric Heating–Method of Coupling of Electrodes to the R.F. Generator–Thermal Losses in Dielectric Heating–Applications of Dielectric Heating.

UNIT-V

Reactive Compensation in Electric Arc Furnace: The arc Furnace an Electrical Load – Flicker and Principles of its compensation Thyristor controlled compensators –Saturable Reactor Compensator.

Suggested Reading:

1. Maloney Timothy. J, *IndustrialSolidState Electronics*, Prentice Hall International, 1986.
2. Krishna Kant, *Computer Based Industrial Control*, Prentice Hall of India, 1997.
3. G.K. Mithal, Dr. Maneesha Gupta, Industrial and Power Electronics, Khanna Publishers, 2007.
4. M.D Singh &Kanchandani.K.B., *Power Electronics,* Tata McGraw Hill.,1998.
5. P.C Sen, *Modern Power Electronics,* S.Chand& Co.

EE3305

Advanced Topics in Power Electronics

(Core PES)

Instruction	: 3 Hours/Week
Duration of Univ. Examination	: 3 Hours
SEE	: 70 Marks
CIE	: 30 Marks

Course Objectives:

Course Outcomes:

UNIT-I

Introduction to switches - Advanced Silicon devices - Silicon HV thyristors, MCT, BRT &EST. SiC devices - diodes, thyristors, JFETs & IGBTs. Gallium nitrate devices - Diodes, MOSFETs.

UNIT -II

Pulse Width Modulated Rectifiers: Properties of ideal rectifier, realization of near ideal rectifier, control of the current waveform, single phase and three-phase converter systems incorporating ideal rectifiers and design examples. Non-linear phenomena in switched mode power converters: Bifurcation and Chaos.

UNIT-III

Control of DC-DC converters- State space modeling of Buck, Boost, Buck-Boost, Cuk Fly back, Forward, Push-Pull, Half & Full-bridge converters. Closed loop voltage regulations using state feedback controllers**.**

Soft-switching DC - DC Converters: zero-voltage-switching converters, zero-current switching converters, Multi-resonant converters and Load resonant converters.

UNIT-IV

Advance converter topologies - Multi level converters - Cascaded H-Bridge, Diode clamped, NPC, Flying capacitor. Modular Multi-level converters(MMC), Multi-Input DC-DC Converters, Multi pulse PWM current source converters, Interleaved converters, Z-Source converters.

UNIT-V

Control Design Techniques for Power Electronic Systems- Modeling of systems, Digital Controller Design, Optimal and Robust controller Design.

Suggested Reading:

1. Andrzej M Trzynadlowski, ‘Introduction to Modern Power Electronics, John Wiley and sons. Inc, New York, 1998
2. L. Umanand, ‘Power Electronics Essentials &Applications’, Wiley publishing Company, 1st Edition, 2014
1. 3 B. JayantBalinga, 'Advanced High Voltage Power Device Concepts', Springer New York 2011. ISBN 978-1-4614-0268-8
3. BIN Wu, 'High Power Converters and AC Drives', IEEE press Wiley Interscience, a John wiley & sons Inc. publication 2006

EE3306

Static Control of Electric Drives

(Core PES)

Instruction	**:** 3 Hours/Week
Duration of Univ. Examination	**:** 3 Hours
SEE	**:** 70 Marks
CIE	**:** 30 Marks

Course Objectives:

- To understand the operation and performance characteristics of various converters such as Semi Converters, Full converters, Dual converters and choppers for control of separately exited and self excited DC Motors.
- To understand the control of Induction motor drives using scalar control, Vector control and Direct torque control.
- To understand the control of special machines such as BLDC, PMSM, Stepper motor and SRM

Course Outcomes:

After the completion of this course, the students shall be able to:

- Identify Analyze and Design suitable control technique to achieve efficient performance of the Induction motor and synchronous motor drives for specific application.
- Model existing and new control Techniques for control of AC drives under Transient and Steady state conditions.
- Analyze and Design Power converters and control techniques for control of special machines.

UNIT-I

DC Motor Control: Operation of Single phase and Three phase Full converter and Semi converter fed dc motors, Speed torque characteristics, Performance characteristics, Dual converter drives, Analysis of four quadrant chopper fed dc drive, Dynamic & Regenerative braking, Closed loop control of phase control and chopper dc drive.

UNIT-II

Scalar Control: Stator voltage control, Static rotor resistance control, Slip power recovery schemes, Closed loop control, VSI & CSI fed Induction motor drives, Analysis of stepped and PWM waveform, Harmonic equivalent circuit and motor performance.

UNIT-III

Vector Control: DC drive analogy, Equivalent circuit and Principle of Vector control, Direct vector control – Flux & Torque processor using Terminal voltages and Induced emf, Indirect vector control – Flow chart and Implementation.

UNIT-IV

Principle of Sensor less vector control: Principle of Space vector Pulse width modulation & control, Direct torque and Flux control - Torque expression with Stator and Rotor fluxes - Control strategy of DTC.

UNIT-V

Brushless D.C Motor: Unipolar and Bipolar Brushless D.C motors, Applications, Stepper Motors — Variable reluctance and Permanent magnet stepper motors — Characteristcs & Drive circuits, Switched reluctance motor.

Suggested Reading:

1. R.Krishnan, *Electric Motor Drives*, Prentice Hall of India Pvt. Ltd., New Delhi, 2002.
2. G.K.Dubey, *Fundamentals of Electrical Drives,* Narosa Publishing House, New Delhi, 1999.
3. W.Shepard, L.N.Hulley and D.T.W.Liang, *Power Electronics and Motor Control*, Cambridge University Press, 1995.
4. B.K.Bose, *Modern Power Electronics and A.C. Drives,* Prentice Hall, 2002.

EE3001

Power Electronic Applications to Power Systems

(Common Electives for IDC, PS & PES)

Instruction	**:** 3 Hours/Week
Duration of Univ. Examination	**:** 3 Hours
SEE	**:** 70 Marks
CIE	**:** 30 Marks

Course Objectives:

- To understand the issues involved in existing Power Transmission system
- To be familiar with the Techniques to overcome the problems associated with AC Power Transmission system
- To Understanding the control of active and reactive power control using Power electronic converters

Course Outcomes:

- The student will be able to know the application of FACTS devices in Power Transmission system.
- The student will be able to Study and apply the power transmission schemes – HVDC Transmission
- The student will be able to implement the control circuits based on the Controlling parameters of HVDC system

UNIT - I

Facts concepts: Reactive power control in electrical power transmission, principles of conventional reactive power compensators. Introduction to FACTS, flow of power in AC parallel paths, meshed systems, basic types of FACTS controllers, definitions of FACTS controllers, brief description of FACTS controllers.

UNIT - II

Static shunt and series compensators: Shunt compensation - objectives of shunt compensation, methods of controllable VAR generation, static VAR compensators - SVC, STATCOM, SVC and STATCOM comparison. Series compensation - objectives of series compensation, thyristor switched series capacitors (TCSC), static series synchronous compensator (SSSC), power angle characteristics, and basic operating control schemes.

UNIT -III

Combined compensators: Unified power flow controller (UPFC) - Introduction, operating principle, independent real and reactive power flow controller and control structure. Interline power flow controller (IPFC), Introduction to Active power filtering, Concepts relating to Reactive power compensation and harmonic current compensation using Active power filters.

UNIT-IV

Hvdc transmission: HVDC Transmission system: Introduction, comparison of AC and DC systems, applications of DC transmission, types of DClinks, Layout of HVDC Converter station and various equipments. HVDC Converters, analysis of bridge converters with and without overlap, inverter operation, equivalent circuit representation of rectifier and inverter configurations

UNIT-V

Control of HVDC system: Principles of control, desired features of control, converter control characteristics, power reversal, Ignition angle control, current and extinction angle control. Harmonics-introduction, generation, ac filters and dc filters.

Introduction to multiterminal DC systems and applications, comparison of series and parallel MTDC systems.

Suggested Reading:

1. Song, Y.H. and Allan T. Johns, 'Flexible AC Transmission Systems (FACTS)', Institution of Electrical Engineers Press, London, 1999.
2. Hingorani ,L.Gyugyi, 'Concepts and Technology of Flexible AC Transmission System', IEEE Press New York, 2000 ISBN –078033 4588.
3. Padiyar, K.R., 'HVDC transmission systems', Wiley Eastern Ltd., 2010.
4. Mohan Mathur R. and Rajiv K.Varma , 'Thyristor - based FACTS controllers for Electrical transmission systems', IEEE press, Wiley Inter science , 2002.
5. Padiyar K.R., 'FACTS controllers for Transmission and Distribution systems' New Age International Publishers, 1st Edition, 2007.
6. Enrique Acha, Claudio R.Fuerte-Esqivel, Hugo Ambriz-Perez, Cesar Angeles-Camacho 'FACTS –Modeling and simulation in Power Networks' John Wiley & Sons, 2002.

EE3002

Renewable Energy Sources

(Common Electives for IDC, PS & PES)

Instruction	**:** 3 Hours/Week
Duration of Univ. Examination	**:** 3 Hours
SEE	**:** 70 Marks
CIE	**:** 30 Marks

Course Objectives:

- To understand the concepts and Importance of renewable energy sources such as solar, wind, biomass, tidal power.
- To make the students understand the advantages and disadvantages of different renewable energy sources

Course Outcomes:

The students will be able to:

- To understand the basic principle of operations of renewable energy sources.
- To understand the applications of renewable energy sources.
- To understand the technology processes of renewable energy sources.

UNIT-I

Review of Conventional and Non-Conventional energy sources - Need for non-conventional energy sources Types of Non- conventional energy sources - Fuel Cells - Principle of operation with special reference to H2 °2 Cell - Classification and Block diagram of fuel cell systems - Ion exchange membrane cell - Molten carbonate cells - Solid oxide electrolyte cells - Regenerative system- Regenerative Fuel Cell - Advantages and disadvantages of Fuel Cells — Polarization - Conversion efficiency and Applications of Fuel Cells.

UNIT-II

Solar energy - Solar radiation and its measurements - Solar Energy collectors -Solar Energy storage systems - Solar Pond - Application of Solar Pond - Applications of solar energy.

UNIT-III

Wind energy- Principles of wind energy conversion systems - Nature of wind - Power in the Wind-Basic components of WECS -Classification of WECS -Site selection considerations -Advantages and disadvantages of WECS -Wind energy collectors -

Wind electric generating and control systems - Applications of Wind energy - Environmental aspects.

UNIT-IV

Energy from the Oceans - Ocean Thermal Electric Conversion (OTEC) methods - Principles of tidal power generation -Advantages and limitations of tidal power generation -Ocean waves - Wave energy conversion devices -Advantages and disadvantages of wave energy - Geo-thermal Energy - Types of Geo-thermal Energy Systems - Applications of Geo-thermal Energy.

UNIT-V

Energy from Biomass - Biomass conversion technologies / processes - Photosynthesis - Photosynthetic efficiency - Biogas generation - Selection of site for Biogas plant - Classification of Biogas plants - Details of commonly used Biogas plants in India - Advantages and disadvantages of Biogas generation -Thermal gasification of biomass -Biomass gasifiers.

Suggested Reading:

1. Rai G.D, *Non-Conventional Sources of Energy,* Khandala Publishers, New Delhi, 1999.
2. M.M.El-Wakil, *Power Plant Technology.* McGraw Hill, 1984.

EE3003

Electric and Hybrid Electrical Vehicles

(Common Electives for IDC, PS & PES)

Instruction	: 3 Hours/Week
Duration of Univ. Examination	: 3 Hours
SEE	: 70 Marks
CIE	: 30 Marks

Course objectives:

- To understand the basics of electric and hybrid electric vehicles and their working
- To understand the basics of batteries and their role for electric/hybrid vehicle applications
- To obtain the knowledge of various types of electric/hybrid vehicles
- To understand the real time challenges in the implementation of this technology

Course outcomes:

- Basics of electric and hybrid electric vehicles are studied both conceptually and mathematically so that clear understanding from bacis physics is achieved
- Knowledge of battery behavior for electric vehicle application is obtained
- Different types of Electric/Hybrid vehicles technologies available and their applications are studied
- Challenges in implementing electric/hybrid vehicle technology is understood by looking into various charging topologies and their impact on distribution systems.

UNIT-I

Introduction to Electric Vehicles: Sustainable Transportation - EV System - EV Advantages - Vehicle Mechanics - Performance of EVs - Electric Vehicle drivetrain - EV Transmission Configurations and components-Tractive Effort in Normal Driving - Energy Consumption - EV Market - Types of Electric Vehicle in Use Today - Electric Vehicles for the Future.

UNIT-II

Electric Vehicle Modelling - Consideration of Rolling Resistance - Transmission Efficiency - Consideration of Vehicle Mass - Tractive Effort - Modelling Vehicle Acceleration - Modelling Electric Vehicle Range -Aerodynamic Considerations - Ideal Gearbox Steady State Model - EV Motor Sizing - General Issues in Design.

UNIT-III

Introduction to electric vehicle batteries - electric vehicle battery efficiency - electric vehicle battery capacity - electric vehicle battery charging - electric vehicle battery fast charging - electric vehicle battery discharging - electric vehicle battery performance – testing.

UNIT-IV

Hybrid Electric Vehicles - HEV Fundamentals -Architectures of HEVs-Interdisciplinary Nature of HEVs - State of the Art of HEVs - Advantages and Disadvantages - Challenges and Key Technology of HEVs - Concept of Hybridization of the Automobile-Plug-in Hybrid Electric Vehicles - Design and Control Principles of Plug-In Hybrid Electric Vehicles - Fuel Cell Hybrid Electric Drive Train Design - HEV Applications for Military Vehicles.

UNIT-V

Advanced topics - Battery Charger Topologies, Charging Power Levels, and Infrastructure for Plug-In Electric and Hybrid Vehicles - The Impact of Plug-in Hybrid Electric Vehicles on Distribution Networks – Sizing Ultra capacitors for Hybrid Electric Vehicles.

Suggested Reading:

1. Modern Electric, Hybrid Electric and Fuel Cell Vehicles – Fundamentals, Theory and Design – MehrdadEhsani, UiminGao and Ali Emadi - Second Edition - CRC Press, 2010.
2. Electric Vehicle Technology Explained - James Larminie, John Lowry - John Wiley & Sons Ltd, - 2003.
3. Electric Vehicle Battery Systems - SandeepDhameja – Newnes - New Delhi – 2002.
4. Hybrid electric Vehicles Principles and applications With practical perspectives - Chris Mi, Dearborn - M. AbulMasrur, David WenzhongGao - A John Wiley & Sons, Ltd., - 2011.
5. Electric & Hybrid Vehicles – Design Fundamentals -IqbalHussain, Second Edition, CRC Press, 2011.
6. Research Papers:
    a. The Impact of Plug-in Hybrid Electric Vehicles on Distribution Networks: a Review and Outlook - Robert C. Green II, Lingfeng Wang and MansoorAlam - 2010 IEEE.
    b. Sizing Ultracapacitors For Hybrid Electric Vehicles - H. Douglas P Pillay - 2005 IEEE.
    c. Review of Battery Charger Topologies, Charging Power Levels, and Infrastructure for Plug-In Electric and Hybrid Vehicles - Murat Yilmaz, and Philip T. Krein, - IEEE transactions on power electronics, vol. 28, no. 5, may 2013.

EE 3004

Modern Control Theory

(Common Electives for IDC, PS & PES)

Instruction	**:** 3 Hours/Week
Duration of Univ. Examination	**:** 3 Hours
SEE	**:** 70 Marks
CIE	**:** 30 Marks

Course Objectives:

- To provide the fundamentals required to model a control system in state space and check it's controllability and observability.
- To educate the students about non-linear systems behavior and the methods to determine their stability.
- To make then students thorough with Liapunov stability analysis.
- To familiarise the students with the concept of optimal control and how to determine optimum for functional using calculus of variations.
- To introduce the concept of Adaptive control and explain how to design a Model Reference Adaptive System.

Course Outcomes:

- Able to model any control system in state space.
- Able to understand the behavior of non linear system and methods of determining stability.
- Able to determine stability of non linear system using Liapunov method.
- Able to formulate optimal control problem and determine optimum of functionals.
- Able to understand and design adaptive control problem.

UNIT-I

Review of state variable representation of systems - Controllability and Observability –Model control of single input – single output systems (SISO), Controllable and Observable companion forms – Effect of state feedback on Controllability and Observability, Pole placement by state feedback.

UNIT-II

Classification of Non-linearities: Phenomenon exhibited by the nonlinearities – Limit cycles – Jump resonance ,Sub-harmonic oscillations – Phase plane analysis – Singular points – Construction of phase plane trajectories – Isocline method – Delta method – Measurement of time on phase plane trajectories.

UNIT-III

Concept and definition of stability - Lyapunov stability - Lyapunov's first and second methods - Stability of linear time invariant systems by Lyapunov's second method - Generation of Lyapunov functions- Variable gradient method - Krasooviski's method.

UNIT-IV

Formulation of optimal control problems - Calculus of variations – Fundamental concepts –Functionals – Variation of functionals – Fundamental theorem of calculus of variations - Boundary conditions – Constrained minimization – Dynamic programming – Hamilton Principle of optimality, Jacobi Bellman equation – Potryagins minimum principle.

UNIT-V

Introduction to adaptive control, types of adaptive control systems. Design of model reference adaptive control systems using M/T rule and Lyapunov stability theorem.

Suggested Reading:

1. I.J Nagarath , M.Gopal *Control Systems Engineering*, fifth edition , New Age International Publishers, 1984 Wiley Eastern Ltd.
2. Ogata K, *Modern Control Engineering*, Prentice Hall, 1997.
3. Donald E Kirk, optimal control thery An introduction
4. Karl J AstromBjronwihenmark, *Adaptive control* second edition – Pearson education.

EE3005

Reliability Engineering

(Common Electives for IDC, PS & PES)

Instruction	**:** 3 Periods / Week
Duration of Univ. Examination	**:** 3 Hours
SEE	**:** 70 Marks
CIE	**:** 30 Marks

Course Objectives:

- To comprehend the basics of probability distributions & reliability models.
- To model systems with series-parallel block diagrams and state-space diagrams and to understand time dependent and limiting state probabilities using Markov models.
- To understand multi-mode failures of electrical & electronic circuits and their effect on reliability & availability.
- To understand reliability & availability models for generation, transmission and distribution systems and evaluate critical indices.

Course Outcomes:

- Able to relate the probability concepts and distributions in reliability engineering studies
- Able to draw reliability logic diagram and state-space diagram of engineering systems to evaluate reliability and availability
- Able to apply multi-mode failures in electrical and electronic circuits
- Able to evaluate various reliability indices related to generation, transmission and distribution systems

Unit-I

Discrete & Continuous random variables – Binomial, Exponential & Weibull distributions – Causes of failure – Failure rate & Failure density – Bath tub curve – Reliability & MTTF – Maintainability & Availability – MTBF & MTTR - Reliability block diagram – Series & Parallel systems – Conditional probability - Minimal Cut-set & Tie-set methods

Unit-II

Continuous Markov models – State space diagram - Reliability models of single unit, two unit & standby systems – Reliability & Availability models with repair – Frequency of failures – State transition matrix and estimation of MTTF

Unit-III

Multi-mode failures - Short circuit & open circuit failures - Resistors & capacitors in series & parallel - Diodes & MOSFETs in series & parallel - Quad system - Reliability Prediction - MIL standards - Parts count technique - Parts stress technique - Reliability, Availability and MTTF evaluation of Power electronic circuits & Drive systems

Unit-IV

Outage definitions – Markov model of Generating plant with identical and non-identical units – Capacity outage probability table – Cumulative frequency – LOLE & LOEE – Composite Generation & Transmission systems - Radial configuration – Conditional probability approach

Unit-V

Customer oriented, load oriented & energy oriented indices of distribution system – Application to radial systems – Effects of lateral distributer protection, disconnects, protection failures & transferring loads – Parallel & Mesh networks – Dual transformer feeder – Approximate, Network reduction & FMEA methods

Suggested Reading:

1. Roy Billinton, R.N. Allan, 'Reliability Evaluation of Engineering Systems', Springer International Edition, Plenum Press, New York, 1992
2. E. Balaguruswamy, 'Reliability Engineering', Tata McGraw Hill Education Pvt. Ltd., 2012
3. Charles E. Ebeling, 'An Introduction to Reliability and Maintainability Engineering', McGraw Hill International Edition, 1997
4. L. Umanand, 'Power Electronics: Essentials & Applications', Wiley, 2009
5. Roy Billinton, R.N. Allan, 'Reliability Evaluation of Power Systems', Springer, 1st Edition, Plenum Press, New York , 1996

EE3006

Optimization Methods

(Common Electives for IDC, PS & PES)

Instruction	**:** 3 Hours/Week
Duration of Univ. Examination	**:** 3 Hours
SEE	**:** 70 Marks
CIE	**:** 30 Marks

Course Objectives:

- To understand the concepts of single variable and multivariable optimization with and without constraints
- To make the students understand about linear and non linear optimization problems.
- To make the students understand about Evolutionary computational techniques

Course Outcomes:

The students will be able to:

- Formulate optimization problems.
- Solve single, multivariable methods with and without constraints.
- Solve evolutionary and advanced optimization methods.

UNIT-I

Classical Optimization techniques: Introduction to optimization and design optimization, optimum design problem formulation, Single variable optimization- Multivariable optimization with and without constraints – Multi variable optimization with inequality constraints – Solution by Lagrangian multipliers - Kuhn-Tucker conditions.

UNIT-II

Linear Programming: Formulation and standard form of LP problem, Basic definitions and theorems – Solution of a system of linear simultaneous equations – simplex method and its algorithm – Revised simplex method – Big-M method – Duality in LP and primal dual relations – Dual simplex method.

UNIT-III

Non Linear Programming: One dimensional minimization methods – Introduction – Elimination methods – Unrestricted search, Exhaustive search, Dichotomous search, Fibonacci methods. Unconstrained optimization techniques- Univariate and Powell's pattern search method, steepest descent method.

UNIT-IV

Evolutionary computations: Introduction – Genetic algorithms – Terminologies and operations of GA – Advanced operators and techniques in GA – Introduction to particle swarm optimization and Ant colony optimization.

UNIT-V

Advanced topics in optimization: Fast Multi-swarm Optimization for Dynamic Optimization, Reliability-Based Optimization Using Evolutionary Algorithms, Ant Colony Optimization for Mixed-Variable Optimization Problems, Bacterial Foraging Global Optimization Algorithm.

Suggested Reading:

1. Engineering Optimization, Theory and Practice - Singiresu S. Rao, S. S. Rao – Fourth edition – New Age Internationals – 2009.
2. Introduction to Optimum design, Jasbir S. Arora, - Third Edition – Elsevier – 2013.
3. Optimization methods for Engineers, N.V.S. Raju – PHI – 2014.
4. Introduction to Genetic Algorithms, S.N.Sivanandam, S.N Deepa – Spinger – 2013.
5. Reliability-Based Optimization Using Evolutionary Algorithms: IEEE transactions on evolutionary computation, vol. 13, no. 5, October 2009.
6. Ant Colony Optimization for Mixed-Variable Optimization Problems: IEEE Transactions on evolutionary computation, vol. 18, no. 4, august 2014.

EE3007

Advanced Microprocessors

(Common Electives for IDC, PS & PES)

Instruction	**:** 3 Hours/Week
Duration of Univ. Examination	**:** 3 Hours
SEE	**:** 70 Marks
CIE	**:** 30 Marks

Course Objectives:

Course Outcomes:

UNIT-I

Review of Basic I/O Interfaces: Programmable Interval Timer 8253 - Programmable peripheral Interlace 8255 — Programmable Interrupt Controller 8259 Microprocessor 8085 applications.

UNIT-II

8086 Architecture: CPU Architecture Machine language instructions - Instruction execution — Timing.

UNIT-III

Assembler Language Programming: Incorporating Data Transfer -Branch Arithmetic -Loop -NOP and HLT - Flag manipulation, Logical Shift and Rotate Instructions — Directives and Operators.

UNIT-IV

Modular Programming: Linking and Relocation -Stacks - Procedures - Interrupts and Interrupt Routines. Byte and String Manipulation: String instruction - REP Prefix -Text Editor - Table translation.

UNIT-V

8087 Numeric Data Processor: NDP -Data types -Processor architecture -Instruction set.

Suggested Reading:

1. Liu, Gibson, Microcomputer Systems The 8086/8088 Family, Prentice Hall India, 1986.

2. Ghosh, Sridhar, 0000-8085 introduction to Microprocessors, Prentice HallIndia, 1991.

EE3008

Artificial Intelligence & Expert Systems
(Common Electives for IDC, PS & PES)

Instruction	**:** 3 Hours/Week
Duration of Univ. Examination	**:** 3 Hours
SEE	**:** 70 Marks
CIE	**:** 30 Marks

Course Objectives:

- To understand the concepts of Artificial Intelligence techniques.
- To make the students understand about Reliability, availability model of Power Systems and markov modeling of Power Plants. with identical and non-identical units.

Outcomes

The students will be able to

- Understand the meaning of discrete and continuous random variables and their significance, causes of failures of a system.
- Acquire the knowledge of different distribution functions and their applications.
- Able to develop reliability block diagrams and evaluation of reliability of different systems.

UNIT-I

Artificial Intelligence: Definition and Study of AI Techniques - Problems and problem space, Al Characteristics — Heuristics - Forward and backward reasoning - Problem trees - Problem graph- Hill climbing - Search method - Problems reduction - Constraint satisfaction means and analysis - Game playing - Minimax algorithms Alphabetic heuristics.

UNIT-II

Computer vision: Perception - Early processing - Representation and recognition at senses Guzman’s algorithms of spurting objects in a scene - Waltz algorithm.

UNIT-III

Natural Language understanding problems - Syntactic analysis - Semantic analysis - Augmented transition networks.

UNIT-IV

Knowledge representation (Logic) - Representing facts in logic predicate logic — Resolution — Unification - Question answering - Mathematical theorem providing knowledge representation (structured) - Declarative representation - Semantic nets - Procedural representation.

UNIT-V

Learning: Learning as Induction - Failure drive earning - Learning by teaching - Learning through examples (Winston's program) - Skill acquisition.

Suggested Reading:

1. Elarine Rich, *Artificial Intelligence,* McGraw Hill, 1985.
2. K.L.Nilson, *Principles of Artificial Intelligence,* Tiago Pub Company, Palo Alto, C.A, 1980.
3. P.H.Winston, *The Psychology of Computer vision*, McGraw Hill, 1975

EE3009

Programmable Logic Controllers
(Common Electives for IDC, PS & PES)

Instruction	**:** 3 Hours/Week
Duration of Univ. Examination	**:** 3 Hours
SEE	**:** 70 Marks
CIE	**:** 30 Marks

Objectives:

- To provide the knowledge of different components used in PLCs such as processor, input/output devices and programmer monitors
- To make the students thorough with ladder programming of PLC.
- To train them how to use timer, counter, register, arithmetic and different conversion systems.
- To give awareness about application of different PLC features in Process control industry.
- To explain the students about different data handling functions of PLC

Outcomes:

- Will be able to understand different components of PLC.
- Will be able to construct ladder diagrams for different industry applications.
- Will be able to deal with applications like timer/counter, registers etc.
- Will be able to understand the utility of different features of PLC in process industry.
- Will be able to use data handling function in PLC programming.

UNIT-I

PLC Basics: Definition and History of PLC - PLC advantages and disadvantages - Over all PLC Systems - CPUs and Programmer Monitors - PLC input and output models - Printing PLC Information- Programming Procedures - Programming Equipment - Programming Formats- Proper Construction of PLC Diagrams - Devices to which PLC input and output modules are connected - Input on/off switching devices - Input analog devices - Output analog on/off devices and output analog devices.

UNIT-II

Basic PLC Programming: Programming on/off inputs to produce on/off outputs - PLC input instructions - Outputs - Operational procedures - Contact and coil input/output programming examples - Relation of digital gate logic contact / coil logic - PLC programming and conversion examples - Creating ladder diagrams from process control descriptions - Sequence listings - Large process ladder diagram constructions.

UNIT-III

Basic PLC Functions: General Characteristics of Registers - Module addressing - Holding registers - Input registers - output registers - PLC timer functions - examples of timer functions. Industrial applications - PLC counter functions.

UNIT-IV

Intermediate Functions: PLC Arithmetic functions - PLC additions and subtractions - The PLC repetitive clock - PLC Multiplications, Division and Square Root - PLC trigonometric and log functions - Other PLC arithmetic functions - PLC number comparison functions. PLC basic comparison functions and applications - Numbering systems and number conversion functions - PLC conversion between decimal and BCD-Hexadecimals numbering systems.

UNIT-V

Data Handling Functions: The PLC skip and master control relay functions - Jump functions - Jump with non return - Jump with return. PLC data move Systems - The PLC functions and applications. PLC functions working with bits - PLC digital bit functions and applications - PLC sequence functions - PLC matrix functions.

Suggested Reading:

1. John W. Weff, Ronald A. Reis, *Programmable Logic Controllers,* Prentice Hall of India Private Limited, Fifth edition, 2003.

EE3010

Digital Signal Processing
(Common Electives for IDC, PS & PES)

Instruction	**:** 3 Hours/Week
Duration of Univ. Examination	**:** 3 Hours
SEE	**:** 70 Marks
CIE	**:** 30 Marks

Course objectives:

- To gain knowledge about discrete time signal and systems; their representation, operations and properties.
- To understand the importance of frequency domain representation of discrete time signals and calculating DTFT, DFT and FFT.
- To learn to represent discrete time signals and systems in Z-domain and finding solution of difference equations using z-transform.
- To design IIR and FIR filters.
- To familiarize with the digital signal processor TMS320C5X

Course Outcomes:

At the end of the course students will be able to

- Produce discrete time signals and analyze them and determine discrete time system output for the given discrete time input signals.
- Determine frequency domain representation DTFT, DFT and FFT.
- Use z-transforms effectively in the analysis and solutions of discrete time systems.
- Design IIR and FIR filters.
- Explain the architecture, memory and peripherals of Digital Signal Processor.

UNIT-I

Introduction to Digital Signal Processing: Discrete time signals & sequences - Linear shift Invariant systems - Stability and causality- Linear constant coefficient difference equations - Frequency domain representation of discrete time signals and systems.

UNIT-II

Discrete Fourier Series: Properties of Discrete Fourier Series - DFS representation of periodic sequences - Discrete Fourier Transforms- Properties of DFT - Linear convolution of sequences using DFT - Computation of DFT - Fast Fourier Transforms (FFT) - Radix-2 decimation in time and decimation in frequency FFT Algorithms inverse FFT.

UNIT-III

Applications of Z-Transforms: Solution of difference equations of digital filters - System function - Stability criterion - Frequency response of stable systems - Realization of digital filters - Direct, Canonic, Cascade & Parallel forms.

UNIT-IV

IIR Digital Filters: Analog filter approximations - Butterworth and Chebyshev - Design of IIR Digital filters from analog filters - Bilinear transformation method - Step & Impulse invariance techniques - Spectral Transformations.

FIR Digital Filters: Characteristics of FIR Digital Filters - Frequency response - Design of FIR filters using Window Techniques.

UNIT-V

Introduction to digital signal processors: TMS320C5X architecture – CALU, ARAU, PLU, MMR, on chip memory, on chip peripherals, Digital signal processing applications.

Suggested Reading:

1. Proakis & Manolakis, Digital Signal Processing Principles, P Pub. 1994.
2. Sahivahanam, Valtavaraj & Gnanapariya, Digital Sign Processing, TMGH Pub. 2001.
3. Oppenheim &Sehaffter, Digital Signal Processing, PHI Pub.
4. S.K.Mitra, Digital Signal Processing, TMH, 1996.

EE3011

Smart Grid Technology
(Common Electives for IDC, PS & PES)

Instruction	: 3 Hours/Week
Duration of Univ. Examination	: 3 Hours
SEE	: 70 Marks
CIE	: 30 Marks

Course Objectives:

- To introduce the concept of smart grid , difference between conventional grid and smart grid
- To introduce the main components of smart grid
- To introduce microgrids and grid integration issues of renewable energy sources
- To introduce the load frequency control concepts in microgrid

Course Outcomes:

A student who successfully fulfills the course requirements will be able to

- Understand advantages of smart grid system
- Know the key challenges for smart grid
- Understand the importance of data centers in the operation of smart grids.
- Understand importance of electric vehicles and grid integration issues

UNIT-I

Introduction to Smart Grid: Working definitions of Smart Grid and Associated Concepts – Smart Grid Functions-comparison of Power Grid and Smart Grid-New Technologies for Smart Grid – Advantages – Present development and International policies in Smart Grid, Indian Smart Grid. Key Challenges for Smart Grid. Components and Architecture of Smart Grid-Description.

UNIT-II

DC Distribution and Smart Grid: AC Vs DC sources-Benefits of and drives of DC power delivery systems – Powering equipment and appliances with DC-Data centers and information technology loads equipment and appliances with DC-Data centers and information technology loads – Future neighbourhood- Potential future work and research.

UNIT-III

Smart Grid Architecture:

UNIT-IV

Smart Grid Communications and Measurement Technology: Communication and Measurement – Monitoring, Phasor Measurement Unit (PMU), Smart Meters, Wide area measurement System (WAMS).

UNIT-V

Renewable Energy and Storage: Introduction to Renewable Energy Technologies-Micro grids-Storage Technologies-Electric Vehicles and plug-in hybrids-Environmental impact and Climate Change-Economic Issues. Grid integration issues of renewable energy sources.

UNIT-VI

Smart Power Grid System Control: Load Frequency Control (LFC) in Micro Grid System – Voltage Control in Micro Grid System, Reactive Power Control in Smart Grid.

TEXT BOOKS

1. Stuart Borlase, Smart Grids, Infrastructure, Technology and Solutions, CRC Press, 2013.
2. A.G. Phadke and J.S. Thorp, “Synchronized Phasor Measurements and their Application”, Springer Edition, 2010.
3. Iqbal Hussein, “Electric and Hybrid Vehicle: Design fundamentals”, CRC Press, 2003.
4. Gil Masters, Reneable and Efficient Electric Power System, Wiley-IEEE Press, 2004.
5. Fereidoon P. Sioshansi, “Smart Grid: Integrating Renewable, Distributed & Efficient Energy”, Academic Press, 2012.
6. Jean Claude Sabonnadiere, Nouredine Hadjsaid, “Smart Grids”. Wiley-ISTE, IEEE Press, May 2012.

ME2001

Engineering Research Methodology
(Common Electives for IDC, PS & PES)

Instruction	**:** 3 Hours/Week
Duration of Univ. Examination	**:** 3 Hours
SEE	**:** 70 Marks
CIE	**:** 30 Marks

Course Objectives:

- Introduction to philosophy of research.
- Understand process to formulate research questions / idea
- Understand process of planning of research time, resource
- Understand different statistical analysis methods
- Develop thesis and report writing.

Course Outcomes:

- Acquire knowledge and formulate research problems (task) and develop a sufficiently coherent research design
- Assess the appropriateness of different kinds of research designs
- Knowledge on qualitative, quantitative and mixed methods of research, as well as relevant ethical and philosophical considerations
- Develop independent thinking for critically analyzing research reports

UNIT-I

Research Methodology: Objectives and Motivation of research – Types of Research– Research approaches – Significance of Research – Research Methods versus Methodology– Research and scientific method– Importance of research methodology – Research process – Criteria of good research – Problems encountered by Researchers in India – benefits to society in general.

Defining Research problem: Definition of research Problem– Problem formulation – Necessity of Defining the Problem – Techniques involved in defining a problem

UNIT-II

Literature survey: Importance of Literature survey– Sources of information – Assessment of Quality of journals and articles – Information through internet.

Literature Review: Need of Review – Guidelines for Review – Record of Research Review.

UNIT-III

Research Design: Meaning of research Design – Need of research design – Features of a good design– Important concepts relating to Research Design – Different research designs- Basic Principles of experimental designs - Developing a Research plan – Design of experimental set-up – Use of standards and codes

UNIT-IV

Exploration of data: Analysis of data– Role of statistics for data analysis – Functions of statistics – Estimation of population parameters – Parametric Vs Non parametric methods – Descriptive statistics- Point of central tendency – Measures of variability – Inferential statistics – estimation – Hypothesis testing – Use of statistical software.

Data Analysis: Deterministic and random data – Uncertainty analysis- Tests for significance – Chi-square test – Student's 't' test – Regression modeling – ANOVA-F test – Time series analysis – Autocorrelation and Autoregressive modeling.

UNIT-V

Research Report Writing: Format of research report – Style of writing report – Reference/ Bibliography / Webiliography – Technical paper writing – Journal report writing. Research Proposal Preparation: Writing a research Proposal and research Report – Writing a Research Grant proposal.

Suggested Reading:

1. C.R.Kothari, *Research methodology, Methods & technique*, New age international publishers, 2004.
2. R.Ganesan, *Research Methodology for Engineers* ,MJP Publishers: Chennai,2011.
3. DR.VijayUpagade and Dr.AravindShende; *Research Methodology*; S.Chand& Company Ltd. New Delhi;2004
4. P.Ramdass and A.WilsonAruni; Research and Writing across the disciplines; MJP Publishers; Chennai 2009