DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING

Scheme and Syllabi of

M.E. (EEE)

Power Systems and Power Electronics

2014 - 2015

CHAITANYA BHARATHI INSTITUTE OF TECHNOLOGY

(Autonomous) (Affiliated to Osmania University)

Gandipet, Hyderabad-500075

VISION AND MISSION OF THE INSTITUTE

Vision:

- To be a centre of excellence in technical education and research.

Mission:

- To address the emerging needs through quality technical education and advanced research.

VISION AND MISSION OF THE DEPARTMENT

Vision:

- To be in forefront in assimilating cutting edge technologies in the field of Power & Electronics arena.

Mission:

- Imparting need based Engineering Education
- Extending the consultancy through Centre of Excellence with the support of public and private sector organizations
- Exposure to practical problems through Industry Institute interaction
- Solutions to practical problems through incubation center
- Complementing the engineering training through extra and co-curricular activities
- Taking technologies blended with ethics and morals to the society for sustainable growth to cater to the needs of the society.

<u>Programme Educational Objectives (PEO)</u>

Post graduates of the PS&PE programme

PEO1: Will excel in power system and power electronics area.

PEO2: Will become successful in executing software related applications.

PEO3: Will carry out research in new and applied technologies relevant to PS & PE.

PEO4: Will develop with professional ethics, effective communication skills, and knowledge of societal impacts of computing technologies.

<u>Programme Outcome (PO)</u>

POs describe what students are expected to know or be able to do by the time of Post Graduation from the program.

Post graduate students of PS&PE program will acquire ability to

PO1: apply knowledge of core subject which is derived ab initio in their four year UG program.

PO2: stimulate an idea which is thought provoking in formulating engineering requirement.

PO3: form a problem, analyze, diagnose and arrive for many solutions.

PO4: design (which is blended with simulation) prototype model which is a primitive.

PO5: use digital techniques, program skills & modern simulation tools necessary for soft computing methods.

PO6: fulfill the aphorism “Think locally act Globally” in order to cater to the needs of society such as Cultural and Environmental issues.

PO7: maintain the knowledge levels on par with contemporary competencies.

PO8: comprehend the professional, ethical, legal, security and social responsibilities.

PO9: aware that education is possession that cannot be isolated from the individual throughout their life.

PO10: communicate cogently with people from all walks of life.

PO11: demonstrate the capability and knowledge to modify the problem formulation and methods of solution based on the results to arrive at acceptable outcome, independently.

CHAITANYA BHARATHI INSTITUTE OF TECHNOLOGY

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Scheme of Instruction & Examination

M.E. (Power Systems & Power Electronics) Four-Semester Course (Full-Time) 2014-15

S. No	Subject	Periods Per Week		Semester Exam Duration(Hrs.)	Max. Marks		Credits
		L	D/P		Semester Exam	Sessional	
SEMESTER-I							
1	Core	4	-	3	75	25	3
2	Core	4	-	3	75	25	3
3	Core/Elective	4	-	3	75	25	3
4	Core/Elective	4	-	3	75	25	3
5	Core/Elective	4	-	3	75	25	3
6	Elective	4	-	3	75	25	3
7	Lab-1	-	3	-	-	50	2
8	Seminar-I	-	3	-	-	50	2
	Total	**24**	**06**		**450**	**250**	**22**
SEMESTER-II							
1	Core	4	-	3	75	25	3
2	Core	4	-	3	75	25	3
3	Core/Elective	4	-	3	75	25	3
4	Core/Elective	4	-	3	75	25	3
5	Core/Elective	4	-	3	75	25	3
6	Elective	4	-	3	75	25	3
7	Lab-2	-	3	-	-	50	2
8	Seminar-II	-	3	-	-	50	2
	Total	**24**	**06**		**450**	**250**	**22**
SEMESTER-III							
1	Project Seminar	-	**6**	-	-	100	**4**
SEMESTER-IV							
1	Dissertation	-	**-**	Viva-Voce	Grade	-	**16**

M.E (Power System and Power Electronics)

List of theory and practical subjects

Sl.No	Code No	Core subjects
1	EE5101	Power Semi-Conductor Devices Circuits
2	EE5102	Distribution System Planning and Automation
3	EE5103	Advanced Computer Methods in Power Systems
4	EE5104	Power System Stability
5	EE5105	Advanced Electric Drives
6	EE5106	HVDC & FACTS
		Practicals
7	EE5107	Power systems Lab
8	EE5108	Power Electronics Lab
9	EE5109	Seminar-I
10	EE5110	Seminar- II
11	EE5111	Project seminar
12	EE9101	Dissertation
		Elective Subjects
13	EE6101	Machine Modeling and Analysis
14	EE6102	Modern Control Theory
15	EE6103	Advanced Power System Protection
16	EE6104	Real Time Applications in Power Systems
17	EE6105	Deregulation of Power Systems
18	EE6106	Soft computing techniques to power systems
19	EE6107	Renewable Energy Sources
20	EE6108	Reliability Modeling in Power Systems
21	EE6109	Power Quality Engineering
22	EE6110	Energy Management
23	EE6111	Advanced Microprocessors Systems
24	EE6112	Digital Control Systems

EE5101 Power Semi-Conductor Devices & Circuits (Core)

Instruction	:	4 Periods / Week
Duration of Semester Examination	:	3 Hours
Semester Examination	:	75 Marks
Sessional	:	25 Marks

The objective of the course is to:

- *Understand switching characteristics of Power Electronics based equipment and principles of operation of converters and inverters*
- *Study the operational principles of resonant converters and get familiarity with different types of switching power supplies.*

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

- *Apply knowledge of switching characteristics of Power Electronics based equipment and principles of operation of converters and inverters*
- *Acquire concepts of the operational principles of resonant converters and apply to different types of switching power supplies.*

UNIT I

Switching Characteristics: Power MOSFETs and IGBTs, Limitations and Safe Operating Areas (SOAs), Latching in IGBTs. Thyristors-Converter & Inverter grade, GTO, RCT, and MCT.

UNIT II

Switch Mode D.C-D.C Converters: Step-down converter (Buck), Step-up converter (Boost), Buck-Boost converter, Control of D.C-D.C converters, Cuk converter

UNIT III

Switch Mode D.C-A.C Inverters: Pulse width modulated switching schemes, Sinusoidal PWM and Square wave PWM of Single phase Inverters and Three phase Voltage source Inverters, Effect of Blanking time on output voltage in PWM Inverters.

UNIT IV

Resonant Converters: Classification, Basic resonant circuit concepts, Load resonant, Resonant switch converters, Resonant D.C Link Inverters with Zero Voltage Switching, High frequency Link Integral half-Cycle converters.

UNIT V

Power Supply Applications: Overview of switching power supplies, DC-AC converters with electrical isolation, Electrical isolation in the feed back loop, Fly-back converters forward converters, Push pull converters, Full bridge converters, Power supply protection, Applications.

Text Books:

1. Mohan, Undeland, Robbins, '*Power Electronics'*, John Wiley.
2. Rashid M.H, '*Power Electronics'*, Prentice Hall of India.

Suggested Reading:

1. Sen P.C, '*Power Electronics',* Tata McGraw Hill Pvt. Ltd., New Delhi.
2. Singh M.D and Khanchandani K.B, '*Power Electronics'*, Tata McGraw Hill.

EE5102 Distribution System Planning and Automation (Core)

Instruction	:	4 Periods / Week
Duration of Semester Examination	:	3 Hours
Semester Examination	:	75 Marks
Sessional	:	25 Marks

The objective of the course is to:

- *Understand electric distribution system planning aspects*
- *Understand role and functioning of sub-transmission and distribution sub-stations*
- *Study the aspects of feeder analysis and improvement of voltage levels with special reference to primary and secondary distribution systems*
- *Understand distribution automation covering SCADA, CIS, GIS, AMR*

After completion of this course, the student

- *Able to know different planning models in the distribution system planning and will have knowledge of role and functioning of sub-transmission and distribution sub-stations*
- *Capable of doing the primary feeder and secondary feeder voltage drop and power loss calculations*
- *Competent to calculate the reactive power requirements of distribution system*
- *Acquire knowledge of different aspects of Distribution automation*

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 & 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, Application curves, Interpretation of the Percentage Voltage drop formula.

UNIT III

Primary Feeders: Types of primary feeders, Primary feeder loading, Tie lines, Design of radial primary feeders, Voltage drop calculations by ABCD 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.

Text Books:

1. Gonen Turan, ‘Electric Power Distribution System Engineering’, CRC Press.
2. A.S. Pabla, ‘Electric Power Distribution’, Tata McGraw Hill.

Suggested Reading:

1. William.Kersting, ‘Distribution System Modelling & Analysis ‘, CRC Press.
2. V. Kamaraju, ‘Electrical Power Distribution systems’, Tata McGraw Hill.

EE5103 Advanced Computer Methods in Power Systems (Core)

Instruction	:	4 Periods / week
Duration of Semester Examination	:	3 Hours
Semester Examination	:	75 Marks
Sessional	:	25 Marks

The objective of the course is to:

- *Understand the importance of power flow studies in power systems and study different methods to conduct power flow studies*
- *Study related mathematical modelling aspects required for power flow studies*
- *Study SC studies and its importance power systems*

After completion of this course, the student:

- *Will have knowledge to draw network graphs, formulate bus incidence matrices form the graphs and bus impedance matrix*
- *Acquire knowledge in three-phase network elements and transformation matrices*
- *Will have knowledge to calculate power flows and short circuit calculations for different types of faults*

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, Construction of Primitive network element, Network Matrix Formation of Y Bus.

UNIT II

Formulation of Z-Bus: Matrix representation of power systems, Triangularization, Gaussian elimination method, LU, LDU, Crowds and Cholesky factorization, Algorithm for formation of Z-Bus matrix, Modification of bus impedance matrix for changes in the network, Addition of branch and link.

UNIT III

Load Flow Studies-I: Concepts of load flow, Classification of buses, Representation of fixed tap setting and on load tap changing transformers, Load flow solution using Gauss-Seidel & Newton-Raphson methods, Treatment of voltage controlled buses, Acceleration factors.

UNIT IV

Load Flow Studies-II: Decoupled and fast decoupled method, Flow chart and comparison of different methods, Numerical analysis, Distribution Load Flow Methods

UNIT V

Short Circuit Studies: Review of Z_{Bus} calculations, Basic assumption in short circuit studies, Short circuit calculations using Z_{Bus}-System representation, Short circuit calculations for balanced three phase network using ZBUS, Fault impedance and admittance matrices for 3-phase to ground and line to ground faults.

Text Books:

1. Stagg & El-Abiad, ‘Computer methods in Power System Analysis’, Tata McGraw Hill, 1968.
2. Kusic Gearge L, ‘Computer Aided Power System Analysis’, - Prentice Hall, 1986.
3. M.A.Pai, ‘Computer techniques in Power System Analysis’, Tata McGraw Hill, 2006.

Suggested Reading

1. L.P. Singh, ‘Advanced Power System Analysis and Dynamics’, New Age International Publishers.
2. As Abhijit Chakrabarti, Sunita Halder, ‘Power System Analysis: Operation and Control’ Prentice Hall India.

EE5104 Power Systems Stability (Core)

Instruction	:	4 Periods / Week
Duration of Semester Examination	:	3 Hours
Semester Examination	:	75 Marks
Sessional	:	25 Marks

The objective of the course is to:

- *Understand modelling aspects of power system components to carryout stability studies.*
- *Study and analyse the Low Frequency Oscillations phenomena in power system and design of damping controls to damp low frequency oscillations*
- *Study the phenomena of Sub-synchronous Resonance (SSR) in series-compensated*

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

- *Have knowledge to carry out power system stability studies and voltage stability studies through appropriate modelling of power system components.*
- *Acquire knowledge in Low Frequency Oscillations phenomena in power systems and design of damping controls (supplementary excitation controls) to damp low frequency oscillations.*
- *Acquire knowledge in analyzing the causes for occurrence of Sub-Synchronous Resonance (SSR) in series compensated power system and to design SSR damping controls.*

UNIT I

Synchronous Machine modeling: The Synchronous machine, Park's transformation, Flux linkage equations, Voltage equations, Current formulation of state space equations, 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

Steady state stability: Basic concept of stability,Types of stability, Stability criteria for single and multi-machine systems.

Transient stability: The swing equation for single and multi-machine system, Basic assumptions, Different methods of solution of swing equation, Determination of critical time and critical angle,.

Voltage Stability: Concept of voltage stability, Characteristics of network, Generator and load, for voltage stability, Voltage stability and angular stability in power systems, Factors contributing and affecting voltage stability / collapse, Prevention of voltage collapse, Voltage stability static indices, Reactive power - voltage control, 'P-V' curves and 'Q-V' curves, Power Flow analysis for voltage stability, Voltage critical and angle critical for a two bus system.

UNIT III

IEEE Excitation, Turbine and Governor models and Facts controls: IEEE Excitation System Models - 1, 2, 3. Hydraulic Power and Governor Models, Models for steam turbine, Improvement of Transient stability- SVC, SSSC & UPFC.

UNIT IV

Low Frequency Oscillations: Low frequency oscillation and supplementary 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.

UNIT V

Sub-Synchronous Resonance (SSR): Sub-Synchronous Resonance and Sub Synchronous oscillations in series compensated transmission system, Turbine-Generator torsional Characteristics, Torsional interaction with power system controls, Sub-Synchronous resonance damping schemes.

Text Books:

1. Yao-Nan-Yu, '*Power System Dynamics',* Academic Press.
2. Prabha Kundur, '*Power System Stability & Control',* Tata McGraw Hill Edition.
3. KR Padiyar, '*FACTS Controllers in Power Transmission & Distribution',* New Age International Publishers.

Suggested Reading:

1. Stagg and El-Abiad, '*Computer Methods in Power systems',* McGraw Hill.
2. P.M. Anderson and A A Foud, '*Power System Control and Stability'*, IEEE Press.

EE5105 Advanced Electric Drives (Core)

Instruction	:	4 Periods per week
Duration of Semester Examination	:	3 Hours
Semester Examination	:	75 Marks
Sessional	:	25 Marks

The objective of the course is to:

- *Understand the principles of commutation in converters and study the performance, stability and control aspects of DC motors and Induction motors.*
- *Understand the microprocessor based control of electric drives*
- *Study the working principles and control aspects of special motors: Brushless DC motor, Switched Reluctance Motor drives.*

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

- *Apply the principles of commutation in converters and study the performance, stability and control aspects of DC motors and Induction motors.*
- *Acquire the knowledge of microprocessor based control of electric drives*
- *Have knowledge of the principles and control aspects of special motors: Brushless DC motor, Switched Reluctance Motor drives*

UNIT-I

Review of Power Converters: Commutation in Thyristor power converters, Principle of natural commutation and forced commutation, Discontinuous conduction in converters, DC choppers, Force commutated inverters, Frequency conversion.

Introduction to Motor Drives: Motor drive components, Power Converters-controllers, Procedure for computation of dc motor response, General considerations, Evaluation of a dc drive performance

UNIT II

DC Motor Control: Forced commutation schemes to improve the performance of the drives, Steady-State Analysis of the Three-Phase Converter Controlled DC Drive, Steady-state analysis of chopper, Controlled dc motor drive, Dynamic simulation of the speed-controlled dc motor drive and its flow chart, State space model and digital simulation of dc motors.

UNIT III

Induction Motor Control: Basic Steady-Slate Performance Equations and its performance of Induction Motor, Dynamic simulation of induction motor drive and its flow chart, Steady state performance characteristics of the slip-energy-recovery-controlled induction motor drive and its flow chart, Closed-loop control of the slip-energy recovery controlled induction motor drive for torque and speed regulation, Steady-State Performance of current source inverter fed induction motor drive, Closed loop current source inverter fed induction motor drive for speed control, Frequency-Controlled Induction Motor Drives, Constant V/Hz control, Constant slip speed control, Constant air gap flux control.

UNIT IV

Microprocessors in the Control of Electrical Drives: Applications of microprocessors in variable speed drives (Block Diagram and Flowchart Approach only), DC motor speed control using microprocessor, Induction motor speed control, Synchronous motor speed control, Stepper Motor Control.

UNIT V

Brushless DC Motor and Switched Reluctance Motor Drives: Switched reluctance motor drive construction, Working principle, Normalized torque-speed characteristics, Speed Control Schemes, Control schemes.

Brushless DC Motor construction: Working principle, Torque-speed characteristics, Speed Control Schemes, Control Schemes.

Text Books:

1. Vedam Subramanyam, 'Thyristor Control of Electric Drives', Tata McGraw Hill Publishing Co., New Delhi.
2. S.B.Dewan, G.R.Slemon, A.Straughen, 'Power Semi Conductor Drives', Wiley Interscience.
3. B.K.Bose, 'Power Electronics and AC Drives', Prentice Hall.

Suggested Reading:

1. R. Krishnan, ' Electric Motor Drive: Modeling, Analysis and Control' Prentice Hall of India

EE5106 HVDC & FACTS (Core)

Instruction	:	4 Periods / Week
Duration of Semester Examination	:	3 Hours
Semester Examination	:	75 Marks
Sessional	:	25 Marks

The objective of the course is to:

- *Understand operating principles of HVDC systems and control aspects.*
- *Understand concepts and control aspects of FACTS devices.*

After completion of this course, the student:

- *Will acquire the knowledge to compare AC and HVDC systems in terms of power transmission and stability.*
- *Will acquire knowledge in improving the stability of the power system by applying FACTS controllers.*

UNIT-1:
Comparison of AC and DC transmission system: , Applications of DC Transmission, Types of DC links, Analysis of HVDC converters, Pulse number, analysis with and without overlap, Equivalent circuit of Rectifier and Inverter, Converter bridge characteristics.

UNIT-2:
HVDC system control: Principles of dc link control, Starting and stopping of dc link, Power control, Harmonics & filters, Introduction and generation of harmonics, Types of ac filters, Power flow analysis in ac/dc systems, General modeling of dc links, Solutions of ac- dc power flow.

UNIT-3:
Flexible AC Transmission Systems (FACTS): Concept of FACTS, Flow of power in an AC system, Dynamic stability consideration, Basic types of FACTS controllers.

UNIT-4:
Static shunt compensators: SVC & STATCOM, Objectives of shunt compensation, Methods of controllable VAr generation, Switching converter type VAr generators, Basic operating principle and control approaches.

UNIT-5:
Static series compensators: GCSC, TSSC, TCSC & SSSC, Objectives of series compensator, Variable impedance type series compensators, Basic operating control schemes, Power angle characteristics, Control range and VA rating, External control, Combined compensators.

Text Books:

1. K.R. Padiyar, 'HVDC Power Transmission System', New Age Intl. Co.
2. N.G. Hingorani and L.Gyugyi: 'Understanding FACTS', Standard Publishers, Distributors, New Delhi.

Suggested Books:

1. Arrillaga J., '*High Voltage Direct Current Transmission',* Peter Peregrinus Ltd., London..

EE5107 Power Systems Lab

Instruction	:	3 Periods / Week
Internal Marks	:	50 Marks

Course Objectives:

- *To Simulate and compare the various aspects economic load dispatch and load flows..*
- *To Simulate and observe the stability studies of transient and steady state*
- *To simulate and observe behavior of a system during the Short circuit*
- *4. To Conduct experiments on a given system to know performance when subjected to various faults*
- *To Conduct experiments on different types of relays*

Course Outcomes:

The student will be able to

- *1. validate the adaptability of economic load dispatch and load flow for a given situation by simulation results.*
- *2. Design a controller for FACTS application by simulation*
- *Demonstrate the effects of different sequence reactances of a synchronous machine by experimentation.*
- *Acquainted with the characteristics of different relays by experimentation*
- *Know how to use the simulation software to design a real time power system .*

LIST OF EXPERIMENTS

PART A : Simulation

1. Load frequency Control of Single & Two Area System.
2. Economic dispatch in power systems
3. Formation of Z-bus matrix using Building Algorithm.
4. Load Flow Studies using Gauss-Seidel and Newton Raphson method
5. Transient Stability Studies for different faults
6. Short Circuit Analysis
7. Applications of FACTS controllers
8. Distribution load flow studies

Part B: Hardware

1. To measure negative sequence and zero sequence reactance of synchronous machine.
2. To measure direct axis and quadrature axis reactances of synchronous machine
3. To study the single line to ground fault
4. To study line to line fault
5. To study three-phase fault
6. To study microprocessor based over current relay characteristics
7. To study percentage differential relay characteristics
8. To study over voltage relay
9. To study under voltage relay
10. To measure positive and zero sequence reactance's of three-phase transformer

Note: At least **5** experiments should be conducted from **each part.**

EE5108 Power Electronics Lab

Instruction	:	3 Periods / Week
Internal Marks	:	50 Marks

Course Objectives:

- *To Simulate and compare the characteristics of Inverter .*
- *To Simulate and compare the characteristics of converters*
- *To simulate and observe the various speed control methods of IM*
- *To Conduct experiments on various converters and inverters and observe the differences*
- *To Conduct experiments on different types of speed control techniques of IM and to observe the adaptability for the given situation.*

Course Outcomes:

The student will be able to

- *Analyze the performance of converters and inverters by simulation results.*
- *2. Design a control circuit with different orientations of devices by simulation*
- *Demonstrate the effects of different loads on various converters and inverters by experimentation.*
- *Acquainted with the different speed control techniques of IM*
- *Know how to use the simulation software to design and fabricate different power electronic circuits.*

LIST OF EXPERIMENTS:

Part A: Simulation

1. Single phase and Three phase IGBT inverters.
2. PWM in inverters.
3. Buck and Buck-Boost converter.
4. Resonant converter.
5. V/f control of three phase induction motor.
6. Three phase AC voltage controller.
7. Performance of three phase controlled rectifier with source inductance.
8. Reactive power compensation using FACTS controllers.

Part B: Hardware

1. Three phase Mc-Murray Bed-Ford inverter.
2. Three phase IGBT inverter.
3. Closed loop control of permanent magnet DC drive.
4. Single phase dual converter.
5. Three phase controlled rectifier with R & RL-Loads.
6. Three phase half controlled rectifier with R & RL-Loads.
7. Three phase step down Cyclo-Converter.
8. Speed control of SRIM using static Kramer’s system.

Note: At least **5** experiments should be conducted from **each part**.

EE5109 SEMINAR – I
&
EE5110 SEMINAR – II

The student has to give a seminar during the first semester evaluated by a committee consists of Head of the Department, Program co-ordinator and two faculty members. The topic for the seminar will be chosen by the student relevant to power electronics or power systems. The student has to submit an abstract on the topic prior to the presentation and a detailed report during his presentation. The seminar activity is also helping the students to improve communication skills, clarity in explanation, orderly preparation and discussions for clarifications etc. the seminar is evaluated for **50 marks.** No external examination for seminar.

EE5111 PROJECT SEMINAR

During the third semester, student will deliver a seminar on the progress of the project, which is evaluated by the committee. The main objective of project seminar is to prepare the students for the project to be executed in 4th semester .The student will take up project work at the beginning of the third semester, and it stretches till the end of the forth semester. The project work is carried out for one academic year / two semesters (i.e. 3rd and 4th semesters). The seminar shall be evaluated by the Departmental Review Committee consists of Head of the Department, Programme co-ordinator and Supervisor for **50 marks**. No external examination for Project seminar.

EE9101 DISSERTATION

During the fourth semester, student will deliver seminar, evaluate the preparedness, sufficiency of the work carried out, results etc. On satisfactory recommendation by the Departmental Review Committee, student will prepare the report as per the guidelines issued report to department. The award of the project is done through grades (Excellent/ Very Good/ Good/ Satisfactory/ Unsatisfactory).

EE6101 Machine Modeling and Analysis (Elective)

Instruction	:	4 Periods / Week
Duration of Semester Examination	:	3 Hours
Semester Examination	:	75 Marks
Sessional	:	25 Marks

The objective of the course is to Understand:

- *the concepts of reference frame theory and basic principles to carryout machine analysis*
- *the modelling aspects of Synchronous Machine, DC Machine, and Induction Machine and study the dynamic performance aspects.*

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

- *Apply the concepts of reference frame theory to carryout machine analysis*
- *Have the knowledge to carry out modeling aspects of Synchronous Machine, DC Machine, and Induction Machine and study the dynamic performance aspects.*

UNIT I

Basic Principles for Electric Machine Analysis: Magnetically coupled circuits, Electro-mechanical energy conversion, Basic Two pole DC Machine, Primitive 2 axis machine, Voltage and Current relationship, Torque equation.

UNIT II

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 III

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 IV

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 V

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.

Text Books

1. C.V. Jones, *“Unified Theory of Electrical Machines”* Butterworths Publishers.
2. P.S. Bhimbra, “*Generalized Theory of Electrical Machines”*, Khanna publishers.

Suggested Reading:

1. Paul C. Krause, Oleg Wasynczuk, Scott D.Sudhoff, “*Analysis of Electric Machinery and drive systems*” John Wiley and Sons.

2. J. Meisel, “*Principles of Electromechanical Energy Conversion” McGraw Hill.*

With effect from the academic year 2014-2015

EE6102 Modern Control Theory (Elective)

Instruction	:	4 Periods / week
Duration of Semester Examination	:	3 Hours
Semester Examination	:	75 Marks
Sessional	:	25 Marks

The objective of the course is to:

- *Understand state space representation of systems and study controllability, and observability aspects.*
- *Understand the problem formulation of non-linear systems and Study the performance.*
- *Understand different types of adaptive control systems and its application aspects.*

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

- *Acquire knowledge to represent the system in state space form and analyze controllability and observability aspects*
- *Have knowledge in problem formulation of non-linear systems and analyze performance.*
- *Acquire knowledge pertaining to Adaptive control systems and applications.*

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 feed back.

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 functional, 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 theory.

Text Books:

1. IJ Nagarath , M.Gopal *Control Systems Engineering* , New Age International Publishess, Wiley Eastern Ltd.
2. Ogata K, ‘*Modern Control Engineering’*, Prentice Hall.

Suggested Reading:

1. Donald E Kirk, ‘Optimal control theory - An introduction , Dover Publications.
2. Karl J Astrom Bjron wittenmark, ‘Adaptive control’, Pearson Education

EE6103 Advanced Power System Protection (Elective)

Instruction	:	4 Periods / Week
Duration of Semester Examination	:	3 Hours
Semester Examination	:	75 Marks
Sessional	:	25 Marks

The objective of the course is to:

- *Study the operating principles and application aspects of static relays*
- *Learn different types of differential relays and its application to power systems*
- *Understand the protection philosophy of Generator, Motor, and transformers*
- *Disseminate with the general principles of pilot protection and travelling wave relays.*

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

- *Comprehend the basic components of static relays and their characteristics*
- *Acquaint with the characteristics and application of different protection schemes*
- *Know various types of pilot protection schemes, their adaptability and basic principle of travelling wave relays.*

UNIT I

Static relays: Advantages and disadvantages, Comparators, Amplitude and Phase comparison schemes, Duality between Amplitude and phase comparators, General equation for comparators for different types of relays, Static comparators, Coincidence circuits, Phase splitting methods, Hall effect comparators, Operating principles, Use of level detectors, Time delay circuits, Filters, Thyristors, Triggering circuits and DC power supplies.

UNIT II

Static relay hardware: Operating principles, Static time current relays, Differential relays, Distance relays, Quadrilateral relay, Elliptical relay, Relay response, Principle of R-X diagram, Effect of arc resistance, source impedance and line length on the performance of distance relay, Power swings, Loss of synchronism and its effect on distance relays

UNIT III

Generator and motor protection: Generator protection against short circuits using differential relays against inter-phase fault, Combined split-phase and overall differential relays, Protection against stator open circuits, Rotor and Stator overheating, Loss of excitation protection, Field & ground fault protection, Digital protection scheme based upon second harmonic current induced in the rotor field circuit.

UNIT IV

Transformer differential protection: Effect of magnetizing inrush currents, Grounding transformers, Bus zone protection with differential relays, 3-zone protection using distance relays, 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, Digital protection of EHV/ UHV transmission line based upon traveling wave phenomena.

Text Books:

1. Badriram and Viswakarma D.N., '*Power System Protection and Switchgear',* Tata McGraw Hill.
2. Madhavarao T.S., '*Power System Protection Static relays with microprocessor applications'*, Tata McGraw Hill.
3. A.T. Johns and S.K. Salman, '*Digital protection for power systems',* IEE series.
4. Stanley H Horowitz, A.G. Phadke, '*Power system relaying'*, 4th Edition, Wiley publications

Suggested Reading:

1. Warrington A.R. Van C, '*Protective Relays',* Vol I & II Chapman & Hall, John Wiley & Sons.
2. Bhuvanesh A OZA, Nirmal kumar C. Nair, Rashesh P Mehta, Vijay H.M., '*Power system protection and Switchgear'*, Tata McGraw Hill.
3. J. Lewis Blackburn, Thomas J Domin, '*Protective relaying Principles and Applications'*, CRC press.
4. L.P. Singh, '*Digital Protection: Protective Relaying from Electromechanical to Microprocesso*r', John Wiley & Sons.

EE6104 Real Time Applications in Power Systems (Elective)

Instruction	:	4 Periods / Week
Duration of Semester Examination	:	3 Hours
Semester Examination	:	75 Marks
Sessional	:	25 Marks

The objective of the course is to:

- *Understand the need for real-time control of power systems and importance of state estimation in real time operation of power system.*
- *Understand the importance of contingency analysis at planning stage for secured operation of power system.*
- *Understand the concept of operation of power system in de-regulated environment and familiarize with the salient features of Electricity Act 2003 and Indian Electricity Grid code.*

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

- *Acquire knowledge in differentiating between conventional power flow studies and State Estimation, and the importance of State Estimation in Energy control centres.*
- *Acquire knowledge in studying the importance of contingency analysis at planning stage for secured operation of power system.*
- *Acquire knowledge to study the operation of power system in de-regulated environment and grasp the salient features of Electricity Act 2003 and Indian Electricity Grid Code.*

UNIT I

SCADA / EMS: Need for real-time and computer control of power systems, Operating states of power system, Supervisory Control and Data Acquisition (SCADA), Implementation considerations in Energy Control centers, Functional aspects of Energy Management System, Software requirements for implementing the above functions.

UNIT II

State Estimation Techniques: Definition of State Estimation, Difference between Load Flow and State Estimation, Types of measurements, Data acquisition, Role of a state estimator, Rationale of state estimation, Method of least squares for state estimation, Estimation of power system state variables by the Weighted Least Square Estimation (WLSE) technique, Pseudo-measurement**s, S**tatistical errors and bad data recognition, Power system state estimator in noisy environment, Composition of the Jacobian matrix H and the measurement vector Z, Observability in State Estimation, Application of Power System State Estimation, Role of Phasor Measurement Units (PMU).

UNIT III

Contingency Analysis Techniques: Security in a power system, Approximations in contingency analysis, Simulation of addition and removal of multiple lines in a power system, Simulation of tie lines in inter connected power systems, Network reduction for contingency analysis, Contingency analysis and approximate power flow method for simulating contingencies.

UNIT IV:

Power System Security: Introduction. Challenges for secure operation, Methods of enhancing security, Reliability criterion, Enhancement of stability controls, On-line dynamic security assessment, Management of system reliability, Future trends in dynamic security assessment, Real time monitoring and control.

UNIT V:

Introduction to Power System Deregulation: Operation of vertically integrated power systems, Models and examples of deregulated operation, New operation and planning policies, Generation scheduling, Independent power producers, Cogeneration, Power wheeling, Salient features of Electricity Act 2003 and Indian Electricity Grid Code.

Text Books:

1. Allen J Wood and Bruce F. Wollenberg, 'Power Generation, operation and control', John Wiley &Sons.
2. T.K.Nagsarkar, M.S.Sukhija, Power system analysis, Oxford publications
3. Prabha Kundur, Power system stability and control, Tata McGraw /Hill Edition.

Suggested Reading:

1. J.Arrillaga, C.P.Arnold, 'Computer modeling of electric power systems', John Wiley.
2. L.P. Singh, 'Advanced Power System Analysis and Dynamics', Wiley eastern Ltd.
3. C.W. Taylor, 'Power System Voltage Stability', McGraw Hill.
4. Lai L.L, 'Power system restructuring and deregulation', John Wiley & sons.
5. Edmund Handschin (Editor), 'Real Time Control of Electric Power Systems', Elsevier Publishing Co.

With effect from the academic year 2014-2015

EE 6105 Deregulation of Power Systems (Elective)

Instruction	:	4 Periods / Week
Duration of Semester Examination	:	3 Hours
Semester Examination	:	75 Marks
Sessional	:	25 Marks

The objective of the course is to:

- *Understand open access and operation of power system in deregulated and competitive environment and give thrust to operation and planning policies, generation scheduling etc.*
- *Understand the transmission pricing methodologies and congestion management*
- *Understand different aspects of managing ancillary services*

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

- *Have knowledge in analyzing the operation of power system in de-regulated and competitive environment*
- *Acquire knowledge in operation and planning policies, generation scheduling etc.*
- *Have knowledge of transmission pricing methodologies, congestion management and manage different aspects of ancillary services*

UNIT 1

Introduction to Power System Deregulation : Operation of vertically integrated power systems, Models and examples of deregulated operation, New operation and planning policies, Generation scheduling, Independent power producers, Cogeneration, Optimal dispatch based on offers and bids, Unit commitment, Power wheeling.

UNIT 2

Power system operation in competitive environment: Power system operation in competitive environment, Introduction, Operational planning activities of iso, The iso in pool markets, The iso in bilateral markets, Ooperational planning activities of a genco, Allocation of spinning reserve, Transmission planning under uncertainty, Demand side bidding, pricing schemes.

UNIT 3

Transmission Pricing and congestion Management: Transmission pricing and congestion Management, Introduction, Transmission cost allocation methods, Postage Stamp Rate Method, Contract path Method, MW-Mile Method, MVA-Mile method, Unused Transmission Capacity Method, Comparison of cost allocation methods.

UNIT 4

Ancillary services management: Ancillary services management- introduction, Reactive power as an ancillary service, A review, Synchronous generators as ancillary service providers.

UNIT 5

Open access same-time information system: Oasis, Open access same-time information system, Structure of oasis, Pooling of information, Transfer capability on oasis, Definitions transfer capability issues, atc, ttc, trm, cbm calculations, Methodologies to calculate atc.

Text Books:

1. Lai, L.L. (ed.), ‘Power System restructuring and deregulation’, John Wiley and Sons Ltd.
2. Bhattacharya, K., Bollen, M.H.J., and Daalder, J.E., ‘Operation of Restructured Power Systems’, Kluwer Academic Publishers.

Suggested Books:

1. Ilic, M., Galiana, F., and Fink, L., 'Power System restructuring Engineering and Economics', Kluwer Academic Publishers.
2. Md Shahidephpour and Alomoush, 'Restructured Electrical Power Systems', Marcel Deccar Inc.

EE 6106 SOFT COMPUTING TECHNIQUES TO POWER SYSTEMS

(Elective)

Instruction	:	4 Periods / Week
Duration of Semester Examination	:	3 Hours
Semester Examination	:	75 Marks
Sessional	:	25 Marks

The objective of the course is to:

- *Understand basics of advanced optimization algorithms: ANN, FUZZY, Genetic, Particle Swarm Optimization, Ant Colony search algorithms*
- *Understand the techniques to apply advanced optimization algorithms to power system problems: Reactive power planning, Distribution network expansion, optimal power flow, loss minimization etc.*

After completion of this course, the student:

- *Able to understand different selection mechanisms in genetic algorithm*
- *Acquire knowledge of discrete PSO, hybrid PSO etc*
- *Capable of applying ant colony search algorithm to an optimization problem*
- *Competent to have the knowledge of key operators in differential evolution*

UNIT- I

ANN: Difference between Artificial Neuron and Biological Neuron, Activation functions, Single layer and Multi layer ANN, Error Calculation, Training of Neural Network, Learning rate, Learning Algorithms, LMS algorithm, Back propagation algorithm, AVQ algorithm.

UNIT- II

Fuzzy Logic: Basic concept of Fuzzy logic, Membership Function, Fuzzy Set Operations and its properties, Fuzzy relations, Fuzzy graphs, Fuzzy analysis, Fuzzy Quantifiers, Fuzzy Inference, Rule based system, Defuzzification methods.

UNIT –III

Fundamentals of Genetic Algorithms: Introduction to GAs, Encoding, Fitness Function, Premature Convergence, Basic Operators, Selection, Tournament Selection, Truncation Selection, Linear Ranking Selection, Exponential Ranking Selection, Elitist Selection, Proportional Selection, Crossover, Mutation

UNIT- IV

Fundamentals of Particle Swarm Optimization Techniques : Introduction, Basic Particle Swarm Optimization, Background of Particle Swarm Optimization, Original PSO, Variations of Particle Swarm Optimization, Discrete PSO, PSO for MINLPs, Constriction Factor Approach (CFA), Hybrid PSO (HPSO), Lbest Model

UNIT- V

Applications to Power Systems: Distribution Network Expansion, Dynamic Planning of Distribution System Expansion, Reactive Power Planning, Optimal Power Flow Under Contingent Condition with Line Capacity Limit, Optimal Power Flow for Loss Minimization etc.

Text Books:

1. Kwang Y. Lee and Mohamed A. El-Sharkawi, 'Modern heuristic optimization techniques', IEEE press, Wiley-Interscience Publication
2. Soliman, Soliman Abdel-Hady, Mantawy, Abdel-Aal Hassan, 'Modern Optimization Techniques with Applications in Electric Power Systems', Springer publications

3. Simon haykin, 'Neural Networks: A comprehensive foundation', Pearson Education.
4. Zimmermann.H.J, 'Fuzzy Set Theory and Its Applications', Kluwer Academic Publishers

Suggested Reading:

1. S.N.Sivanandam, S.N.Deepa, 'Principles of soft computing techniques', Wiley publications.
2. Kalyanmoy Deb , " Multi-objective optimization using evolutionary algorithms" ,Wiley publications.
3. S.Rajsekaram, G.A.Vijayalakshmi Pai, 'Neural Networks, Fuzzy Logic and Genetic Algorithms - Synthesis & Applications', Practice Hall India.

EE6107 Renewable Energy Sources (Elective)

Instruction	:	4 Periods / Week
Duration of Semester Examination	:	3 Hours
Semester Examination	:	75 Marks
Sessional	:	25 Marks

The objective of the course is to:

- *Understand the working principles and implementation aspects of different types of non-conventional energy sources Solar, Wind, Bio-mass and ocean energy sources.*
- *Study the advantages, environmental issues and necessity of going in for non-conventional energy sources.*

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

- *Have the knowledge in working principles and implementation aspects of different types of non-conventional energy sources Solar, Wind, Bio-mass and ocean energy sources.*
- *Acquire in depth knowledge pertaining to non-conventional energy sources and associated environmental issues, advantages.*

UNIT 1

Principles of Renewable Energy: Introduction, Energy & Sustainable Development, Scientific Principles of RE, Technical Implications, Social Implications, Types of Energy Resources, Basics of Thermal Energy, Hydel Energy, Nuclear Energy, Solar Energy, Wind Energy, Tidal Energy, Geothermal Energy, Ocean Energy, Indian & Global Energy Resources, Environmental Aspects of Energy, Energy Chain, Cost Effectiveness.

UNIT 2

Solar Energy: Introduction, Basics of Solar Radiation, Solar Collectors, Classification, Salient Features, Solar Energy Storage, Solar Pond, Solar Water Heater, Solar Furnace, Solar Refrigeration & Cooling System, Solar Cooker, Solar Thermal Power Plants, Solar PV System, Solar Cell Fundamentals, Solar Cell Characteristics, Materials for Solar Cells, Standalone System, Grid Interactive Solar PV System, Hybrid Solar PV System, Design of Solar PV System for Home Lighting.

UNIT 3

Wind Energy: Introduction, Wind Flow, Power in the Wind, Types of Wind Turbines, Wind Turbine Sizing and System Design, Energy Derived from Wind Turbine, Estimation of required Wind Turbine Power Rating, Social & Environmental Considerations

Wave Energy: Introduction to Wave energy, Power, Wave energy devices.

UNIT-4

Geo Thermal Energy: Introduction, Resources of Geo thermal energy, Geo thermal Power Plants, Comparison with conventional power plants, Advantages & Disadvantages, Potential of Geo thermal energy in India.

Ocean Thermal Energy: Introduction, Working principle of OTEC, Status of OTEC plants, Merits & De-merits,

UNIT-5

Hydrogen Energy: Introduction, Hydrogen as a source of renewable energy, Production of Hydrogen, Hydrogen powered vehicles & storages, Hydrogen as a fuel and safety issues.

Bio-Gas Energy: Introduction, Photo synthesis, Aerobic & Anaerobic processes, Classification of Bio-Gas plants, Location of Bio-Gas plant, Size of Bio-Gas plant, Biomass gasification, Power Generation from Liquid Waste, Biomass Energy Program in INDIA.

Text Book:

1. John Twidell & Tony Weir: Renewable Energy Resources, Taylor & Francis.
2. G.S.Sawhney: Non – Conventional Energy Resources, PHI Learning Pvt. Ltd.

Suggested Reading:

1. Chetan Singh Solanki: Renewable Energy Technologies – A Practical Guide for Beginners, PHI Learning Pvt. Ltd.
2. Ashok V.Desai: Non – Conventional Energy, New Age International, United Nations University Tokyo.

EE 6108 Reliability Modeling in Power Systems (Elective)

Instruction	:	4 Periods / week
Duration of Semester Examination	:	3 Hours
Semester Examination	:	75 Marks
Sessional	:	25 Marks

The objective of the course is to:

- *Understand the basic principles of reliability as applied to power systems*
- *Understand the concepts and evaluation procedures of generator capacity reserves, operating reserves*
- *Study the reliability evaluation of Generation, Transmission and Distribution through appropriate mathematical models.*

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

- *Have the knowledge of principles of reliability applied to power systems*
- *Have the knowledge to carryout evaluation procedures of generator capacity reserves, operating reserves*
- *Acquire knowledge to formulate mathematical models for reliability evaluation of Generation, Transmission and Distribution*

UNIT I

Introduction: The Concept of reliability, Reliability Indices, Power System reliability, Component Reliability, Non-repairable components, Hazard Models, System Reliability, Network methods, Logic Diagrams, Monotonic Structures.

UNIT II

Generating Capacity Reserve Evaluation: Planning for reliability, Outage definitions, Construction of reliability models, Probability of capacity deficiency, Loss of load method, Loss of energy method, Frequency and duration method, Two level representation of the daily load, Merging the generation and load models, Multilevel representation of the daily load, Comparison of the reliability indices, Generation expansion planning.

UNIT III

Operating Reserve Evaluation: General concepts, PJM method, Outage replacement rate, Generation model, Unit commitment risk, Modified PJM method, Area risk curves, Modelling rapid start units, Modelling hot reserve units, Unit commitment risk, Security function approach, Security function model, Response risk, Evaluation techniques, Effect of distributing spinning reserve, Effect of Hydro electric units, Interconnected systems

UNIT IV

Generation and Transmission Systems: Introduction, Radial configurations, Conditional probability approach, Network configurations, State selection, Systems and load point indices, Application to practical systems, Data requirements for composite system reliability evaluation concepts, Deterministic data, Stochastic data, Independent outages, Dependent outages, Common mode outages, Station originated outages.

UNIT V

Distribution Systems: Introduction, Basic evaluation techniques, State space diagrams, Approximate methods, Network reduction method, Failure modes and effects analysis, Temporary and transient failures, Concepts, Evaluation techniques, Common mode failures, Evaluation techniques, Sensitivity analysis, Total loss of continuity(TLOC), Partial loss of Continuity(PLOC), PLOC criteria, Extended load, Duration curve, Effect of transferable loads, General concepts, Evaluation techniques, Economic considerations

Text Books:

1. Roy Billiton, Ronold N.Allan, 'Reliability Evaluation of Power Systems', Plenum press, springer International Edition
2. E.Balaguruswamy, 'Reliability Engineering'.

Suggested Books:

1. Endrenyi, 'Reliability Modeling in Electrical Power Systems', John Wiley & Sons.

With effect from the academic year 2014-2015

EE 6109 Power Quality Engineering (Elective)

Instruction	:	4 Periods / week
Duration of Semester Examination	:	3 Hours
Semester Examination	:	75 Marks
Sessional	:	25 Marks

The objective of the course is to:

- *Understand the theoretical concepts and standards of Power Quality, and methods to calculate and analyse voltage sag in distribution systems.*
- *Understand P-Q issues and sources in Industrial systems and its mitigation*
- *Understand the presence and sources of harmonics in industrial and commercial loads and devices for controlling and mitigating.*

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

- *Have the knowledge of theoretical concepts and standards of Power Quality and issues in industrial systems*
- *Have the knowledge to calculate and analyze voltage sag in distribution systems*
- *Acquire knowledge in identifying sources of harmonics and its mitigation in industrial and commercial loads systems*

UNIT I

Introduction: Power Quality (PQ), PQ problems, Sags, Swells, Transients, Harmonics, Interruptions, Flicker, Voltage fluctuations, Notch. PQ Issues, Assessing PQ: Remedies, Customer side of meter, Utility side of the meter, 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.

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

Transient Over-voltages: Sources of Transient Over-voltages, Wiring and Grounding, Resources, Definitions, Reasons for Grounding, Typical wiring and grounding problems, Solutions to wiring and grounding problems.

Text Book

1. C.Sankaran, ‘Power Quality’, CRC Press.

Suggested Reading:

1. Math H.J. Bollen, ‘*Understanding Power Quality Problems’*, IEEE Press.
2. Roger C.Dugan, Mark F.McGranaghan, Surya Santoso, H.Wayne Beaty, ‘*Electrical Power Systems Quality’*, Tata McGraw-Hill,

EE 6110 Energy Management (Elective)

Instruction	:	4 Periods / week
Duration of Semester Examination	:	3 Hours
Semester Examination	:	75 Marks
Sessional	:	25 Marks

The objective of the course is to:

- *Understand the general principles of energy management and functions of energy manager.*
- *Understand the objective and types of Energy Audit and Energy Conservation aspects with reference to EC Act 2001 and Electricity Act 2003.*
- *Understand the methods to improve energy efficiency of industrial equipment by conducting energy audits and suitable methods for energy conservation in domestic and industrial sectors.*
- *Understand simple methods in Energy Management and benefits in using energy efficient equipment.*

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

- *Acquire knowledge of Energy management principles and the evolution EC Act 2001 & 2003.*
- *Acquainted with energy auditing, energy conservation and energy efficient systems.*

UNIT 1

Essentials of Energy Management: Introduction, Energy Conservation & its need, Energy Management techniques, Importance of Energy Management, Managing the Energy Consumption, Environmental Aspects, Alternate sources of Energy, Energy Efficiency, Energy Scenario in India, National Institutions promoting Energy Conservation.

UNIT 2

Energy Auditing: Introduction, Need for Energy Audit, Types of Energy Audit, Energy Audit Methodology, Process Flow Diagram, Energy Audit Reporting Format, Bench marking & Energy performance, Matching Energy usage to requirement, Energy Audit Instruments, Energy Efficiency, Energy Audit Case Studies.

UNIT 3

Energy Conservation: Introduction, Energy Conservation Act, Practical aspects for Energy Conservation in Domestic Sector, Energy Conservation opportunities in HVAC Systems, Energy Conservation at Macro Level, Demand Side Management, Benefits of DSM, DSM Implementation Strategy, Electricity Pricing.

UNIT 4

Energy Efficiency: Introduction, Industrial Energy Efficiency, Energy Saving Potential in Industries, Boiler, Furnace, Heat Exchanger, Electrical Drives, Pumps, Fans & Blowers, Energy Conservation in Agriculture Sector, Energy Efficient Motors, BIS Specifications for Energy Efficient Motors.

UNIT 5

Application of Technology in Energy Management: Introduction, Power Cables, Amorphous Core Transformer, Intelligent Power factor Controller, Maximum Demand Controller, Soft Starter, Variable Frequency Drives, Energy Management Systems, Industrial Power Management System.

Text Books:

1. W.R.Murphy & G.Mckay: Energy Management Butter worth Heinemann Publications.
2. Umesh Rathore: Energy Management S.K. Kataria & Sons.

Suggested Reading:

1. K.V.Sharma, P.Venkataseshaiah: Energy Management and Conservation IK International Publishing House Pvt. Ltd.
2. Turner W.C.: Energy Management Handbook.

EE 6111 Advanced Microprocessor Systems (Elective)

Instruction	:	4 Periods / week
Duration of Semester Examination	:	3 Hours
Semester Examination	:	75 Marks
Sessional	:	25 Marks

The objective of the course is to:

- *Understand Architecture features and function of 8086, 80386, 80486, Pentium, Motorola 68000 microprocessors.*
- *Understand features of MIPS, AMD, 68020, 68030 and 68040 Microprocessors*
- *Understand the features of RISC, Dec Alpha AXP and Sun SPARC*

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

- *Have knowledge of Architecture features and function of 8086, 80386, 80486, Pentium, Motorola 68000 microprocessors.*
- *Have knowledge of features of MIPS, AMD, 68020, 68030 and 68040 Microprocessors*
- *Acquire knowledge of functional features of RISC, Dec Alpha AXP and Sun SPARC*
- *To get knowledge on Pentium , Pentium pro Pentium II Pentium III features of Pentium series microprocessors*

UNIT I

8086 Microprocessor: Architecture, Segmented Memory, Addressing Modes, Instruction Set, 8086 Assembly Language Programming, 8087 Numerical Data Processor Architectural details, Data types, Floating point Operations, 8087 Instructions.

UNIT II

Architectural details of 80386 Microprocessor: Special registers, Memory management, Operation in protected mode and virtual 80386 mode, Memory paging mechanism, Special instructions of 80386, Architectural details of 80486, Special registers, Additional instructions, Comparison of 80386 and 80486 processors.

UNIT III

Introduction to Pentium Processor: Architectural features, Comparison with the workstations, Branch prediction logic, Cache structure, Special Pentium Registers, Memory management, Virtual mode of operation, Comparison with the previous processors, Features of Pentium-II, Pentium-III and Pentium Pro-processors.

UNIT IV

RISC Microprocessors, RISC Vs CISC, RISC Properties, DEC Alpha AXP Architecture, Power PC, Architecture, Programming Model, Data Types, Addressing Modes, Instruction Set, Sun SPARC, Architecture, Data Types, Instruction Sets, Features of MIPS, AMD Microprocessors.

UNIT V

Motorola Microprocessors, 68000 Microprocessor, Architecture, Registers, Addressing Modes, Features of 68020- 68030- 68040 Microprocessors.

Text Books:

1. Barry B Brey, ‘Intel Microprocessors: 8086/88, 80186/188, 80286, 80386, 80486, Pentium, Pentium – II, Pentium – III and Pentium – IV, Architecture, Programming & Interfacing’, Pearson Education.
2. Badri Ram, ‘Advanced Microprocessors and Interfacing’, Tata McGraw Hill.

Suggested Books:

1. A.K. Ray & K.M. Bhurchandi,, 'Advanced Microprocessors & Peripherals, Architecture, Programming & Interfacing', Tata McGraw Hill.
2. Daniel Tabak, 'Advanced Microprocessors', McGraw Hill.

EE 6112 Digital Control Systems (Elective)

Instruction	:	4 Periods / week
Duration of Semester Examination	:	3 Hours
Semester Examination	:	75 Marks
Sessional	:	25 Marks

The objective of the course is to:

- *Understand the concepts of Z-transforms, System representation in state space form and analyze stability, controllability, observability aspects.*
- *Study the design methodology of Discrete time control systems through conventional methods.*
- *Understand the importance of pole placement and design of state feedback controllers.*
- *Understand the concepts and features of adaptive controls and State Estimation through Kalman filters*

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

- *Acquire knowledge Acquire knowledge on Z-transforms, and represent system in state space form to analyze stability, controllability, observability aspects*
- *Acquire knowledge to design discrete time control systems through conventional methods*
- *Have knowledge of pole placement and design of state feedback controllers*
- *Acquire knowledge of Adaptive controls and State Estimation through Kalman filter*

UNIT I

Review of Z-Transforms: Introduction, Linear difference equations, Pulse response, Z-transforms, Theorems of Z-Transforms, Inverse Z-transforms, Modified Z-Transforms, Z-Transform method for solving difference equations, Pulse transforms function, Block diagram analysis of sampled data systems, Mapping between s-plane and z-plan, Primary strips and Complementary Strips.

UNIT II

State Space Analysis : State Space Representation of discrete time systems, Pulse Transfer Function, Matrix solving discrete time state space equations, State transition matrix and it's Properties, Methods for Computation of State Transition Matrix, Discretization of continuous time state - space equations.

UNIT III

Controllability and Observability: Concepts of Controllability and Observability, Tests for controllability and Observability, Duality between Controllability and Observability, Controllability and Observability conditions for Pulse Transfer Function. Stability Analysis (Discrete), Stability Analysis of closed loop systems in the Z-Plane,Jury stability test, Stability Analysis by use of the Bilinear Transformation and Routh Stability criterion, Stability analysis using Liapunov theorems.

UNIT IV

Design of Discrete Time Control System by Conventional Methods: Design of digital control based on the frequency response method, Bilinear Transformation and Design procedure in the w-plane, Lead, Lag and Lead-Lag compensators and digital PID controllers, Design of digital control through deadbeat response method.

UNIT V

State Feedback Controllers and Observers(Discrete): Design of state feedback controller through pole placement, Necessary and sufficient conditions, Ackerman's formula, State Observers, Full order and Reduced order observers, Min/Max principle, Linear Quadratic Regulators, Kalman filters, State estimation through Kalman filters, Introduction to adaptive controls.

Text Book:

1. K. Ogata , 'Discrete-Time Control systems', Pearson Education/PHI.
2. M.Gopal , 'Digital Control and State Variable Methods ' , Tata McGraw Hill

Suggested Reading:

1. Kuo B.C., 'Digital Control Systems,' Oxford University Press.
2. M. Gopal, 'Digital Control Engineering',