Course Structure For B. Tech. In Electrical Engineering

- **The following Course Structure has already been approved by AC**

Semester – I

CODE	COURSE NAME	L	T	P	CR	CH
MS 101:	Mathematics I	3	1	0	4	4
PH 101:	Physics I	2	1	1	4	5
CH 101 :	Chemistry	2	1	1	4	5
EL 101:	Basic Electrical Engineering	2	1	1	4	5
ME 101:	Engineering Graphics	1	0	2	3	5
ME 103	Workshop Practice	0	0	2	2	4
Humanities Elective:						
EG 101	Communicative English	3	0	0	3	3
SO 101	Sociology					
BM 101	Elementary Economics					
	Total	13	4	7	24	31

Semester – II

CODE	COURSE NAME	L	T	P	CR	CH
MS 103	Mathematics – II	3	1	0	4	4
PH 102	Physics – II	2	1	1	4	5
ME 102	Engineering Mechanics	3	1	0	4	4
EL 102	Basic Electronics	3	1	1	5	6
CO 101	Introductory Computing	2	1	0	3	3
CO 102	Computing Laboratory	0	0	2	2	4
Science Elective:						
BT 101	Elements of Modern Biology	3	0	0	3	3
ES 101	Environmental Science					
CH 102	Introductory Material Science					
	Total	16	5	4	25	29

Semester – III

CODE	COURSE NAME	L	T	P	CR	CH
MS 201	Mathematics – III	2	1	0	3	3
EE 201	Network Theory	2	1	0	3	3
EE 202	Network Laboratory	0	0	2	2	4
EL 201	Switching Circuits & Digital Logic	2	1	1	4	5
EL 203	Analog Electronic Devices& Circuits	2	1	1	4	5
EL 204	Signals and Systems	2	1	0	3	3
CO 212	Computer Architecture and Organization	3	1	1	5	5
	Total	13	6	5	24	28

Semester – IV

CODE	COURSE NAME	L	T	P	CR	CH
EE 203	Measurement and Instrumentation	3	0	1	4	5
EE 204	Electrical Machines -I	3	0	0	3	3
EE 205	Electrical Machines Laboratory -I	0	0	2	2	4
EL 205	Integrated Circuit	3	0	1	4	5
EL 206	Principles of Communication	3	0	1	4	5
EL 208	Engineering Electromagnetics	3	0	0	3	3
CO 221	Data Structures and Object Oriented Programming	3	0	1	4	5
	Total	18	0	6	24	30

Semester – V

CODE	COURSE NAME	L	T	P	CR	CH
EE 301	Power Systems-I	3	0	2	5	7
EE 302	Electrical Machines -II	3	0	0	3	3
EE 303	Electrical Machines Laboratory -II	0	0	2	2	4
EL 302	Microprocessors and Interfacing	2	0	2	4	6
EL 303	Digital Signal Processing	3	0	1	4	5
EL 304	Control System Engineering	3	0	1	4	5
BM 321	Fundamental of Management	3	0	0	3	3
	Total	17	0	8	25	33

Semester – VI

CODE	COURSE NAME	L	T	P	CR	CH
EE 304	Power Systems-II	3	0	2	5	7
EE 305	Advanced control System Engineering	3	0	1	4	5
EE 306	Power Electronics and Drives	3	0	0	3	3
EE 307	Power Electronics and Drives Lab	0	0	2	2	4
BM 322	Social Responsibility and Professional Ethics in Engineering	3	0	0	3	3
	EE Elective – I	3	0	0	3	3
	Open Elective – I*	3	0	0	3	3
	Total	18	0	5	23	28

Electives for Semester- VI

EE 308	Nonconventional Energy sources
EE 309	Utilization and Conservation of Electrical Energy
EE 310	Embedded systems

* Open Elective: Any course of level 400 and above offered in the University and recommended by the department.

Semester – VII¥

CODE	COURSE NAME	L	T	P	CR	CH
EE 401	Computer aided Power System analysis	3	0	2	5	7
	EE Elective – II	3	0	0	3	3
	EE Elective – III	3	0	0	3	3
	Open Elective – II	3	0	0	3	3
EE 402	Industrial Summer Training #	-	-	-	2	-
EE 403	Project I	0	0	6	6	12
	Total	12	0	8	22	28

¥ The 7th semester will start a month later than usual and therefore be shorted by a month. To compensate for it there shall be 4 class hours per week for a 3 credit course.

Industrial Summer Training: Training of 12 weeks duration carried out during the summer break after the 6th semester. The report will be submitted in the 7 semester.

Semester – VIII

CODE	COURSE NAME	L	T	P	CR	CH
	EE Elective – IV	3	0	0	3	3
	Open Elective – III	3	0	0	3	3
EE 404	Project – II	0	0	12	12	24
	Total	6	0	12	18	30

EE Electives for Semester VII and VIII:

CODE	COURSE NAME
EE 405	Industrial automation Systems
EE 407	Advanced power electronics and Drives
EE 408	High Voltage Engineering
EE 409	Industrial Drives and Control
EE 411	Power system interconnection and control
EL 426	Fuzzy Logic and Neural Networks

EE courses of Semester IV:

EE 203: MEASUREMENT AND INSTRUMENTATION 3 0 1 4 5

Aim: To acquaint the students with the knowledge of various electrical measuring instruments and their practices.
Objectives:

- *To learn the characteristics of a measurement system.*
- *To learnt the use of transducers for various purposes.*
- *To learn the techniques for measurement of resistance, inductance and capacitance, and power.*
- *To learn how to display and record measured data.*

This course includes the topics:

UNIT I: Introduction to Measurement and Instrumentation: Elements of a Generalized Measurement System – Classification of Instrument – Performance Characteristics of Instrumentation System: Static and Dynamic Characteristics – Types of Errors and Error Analysis.

UNIT II: Transducers: Transducer and its Classification – Measurement of electrical and non- electrical quantities – Characteristics and Choice of Transducer.

UNIT III: Instrument transformers: Current Transformer – Potential Transformer – Testing of Instrument Transformers – Power measurement using Instrument Transformers.

UNIT IV: Measurement:

Measurement of Power and Energy: Types of Wattmeter – Dynamometer type wattmeter – Induction type wattmeter – Comparison between Dynamometer type and Induction type Wattmeters – Measurement of power in Single-phase and Three-phase circuits – Single Phase Induction Type Energy Meter – Measurement of Volt-Ampere hours – Testing methods – Measurement of KVA.

Measurement of resistance: Measurement of Low, Medium and High Resistance – Measurement of Earth Resistance.

Potentiometers: DC potentiometers – Volt Ratio Box – AC potentiometers – Types of AC potentiometers – Application of DC and AC potentiometers.

AC Bridges: Inductance measurement by Maxwell's bridge, Maxwell Wien bridge, Anderson bridge, Hay's bridge, Owen Bridge – Capacitance measurement using De Sauty's bridge and Schering bridge – Mutual inductance measurement by Heaviside Mutual Inductance bridge, Carey Foster bridge, Campbell's bridge.

Magnetic measurements: Introduction to Magnetic measurements – Types of tests – Measurement of Flux Density, Magnetising Force – Determination of B-H curve and Hysteresis loop – AC testing of magnetic materials – Iron loss curve – Methods of Iron loss measurement: Wattmeter method, Bridge method.

Smart Measuring Devices: Smart voltmeter, ammeter, energy meter.

UNIT V: Data recording and representation: Cathode Ray Oscilloscope: Cathode Ray Tube, Focusing device, Block Diagram, Basic Circuitry, Types of Sweep, Lissajous Patterns – Recorders: Strip chart Recorder, X-Y Recorder – DMM.

Measurement And Instrumentation Laboratory

Experiments to be performed:

1. Measurement of Three-phase power and Power Factor.
2. Calibration of Single Phase Energy Meter.
3. Calibration of Current Transformer.
4. Measurement of Resistance using Wheatstone Bridge.
5. Measurement of Resistance by the Voltmeter-Ammeter Method.
6. Measurement of Resistance using Kelvin's Double Bridge.
7. Study of DC Potentiometer.
8. Measurement of Inductance using Maxwell's Bridge.
9. Measurement of Capacitance using Schering Bridge.
10. To measure Self Inductance of two coils, Mutual Inductance between these and the Coefficient of Coupling.
11. Study of the characteristics of Pressure Transducer
12. Study of Input-Output characteristics of LVDT

TEXT BOOKS

1. A.K. Sawhney, A Course in Electrical & Electronics Measurement and Instrumentation, Dhanpat Rai, 2012.
2. D. Helfrick and W. D. Cooper, Modern Electronic Instrumentation and Measuring Techniques, Pearson Education, 2009.

REFERENCE BOOKS

1. B. E. Jones, Instrumentation, Measurement, and Feedback, Tata McGraw-Hill.
2. C. F. Coombs, Electronic Instruments Handbook, McGraw-Hill.
3. Vijay K. Varadan, K. J. Vinoy, S. Gopalakrishnan, Smart Material Systems and MEMS: Design and Development Methodologies, Wiley Publications.

EE 204: ELECTRICAL MACHINES-I 3 0 0 3 3

Aim: *To acquaint students with the theory and principles of electromagnetism and electromechanical energy conversion devices and systems.*

Objectives:

- *To learn the basic principle, construction and working of DC Generator and DC motor.*
- *Learning the characteristics and applications of DC Generators and DC Motors.*
- *To learn the basic speed control techniques of DC motors.*
- *Learning the Transformer theory and practices including routine tests, its efficiency and regulation. etc.*
- *Learning in detail the constructional features and working principle of Three Phase Induction Motors along with its equivalent circuits, performance curves and applications.*

The course includes the topics:

UNIT I: DC Generator: Working principle of DC generator; Constructional features; Armature winding – different types of windings; Details of Lap and Wave windings; Dummy coil; Equalizer rings; Types of DC generators – shunt, series and compound; EMF equation; Armature reaction; Inter poles and Compensating Windings; Commutation; Characteristic curves of DC Generators; Parallel operations of DC generators; Losses and Efficiency; Voltage regulation; Applications.

UNIT II: DC Motors: Working principle of DC motor; Back EMF; Torque equation; Condition for maximum torque; Armature reaction and commutation; Types of DC motors – shunt, series and compound; Characteristics and applications of DC motors; Losses and Efficiency; Speed regulation; Electric braking; Methods of Speed Control; DC motors Starters; Grading of Starting Resistance, Testing of D.C. machines – Brake test; Swinburne’s test; Hopkinson’s test; Retardation test; Choice of motors for different duties.

UNIT III: Transformer: Working principle; Construction – Shell type and Core type; EMF equation; Transformation ratio; Ideal transformer; Winding resistance and Magnetic leakage reactance; Phasor diagrams; Impedance ratio; Shifting Impedance;

Equivalent circuit; Voltage regulation; Testing of transformers – Polarity test, O.C and S.C tests; Sumpner test; Losses and efficiency; Condition for maximum efficiency; All-day efficiency; Construction, Types and Working of Autotransformer; Saving of copper; Equivalent circuit; Advantages and disadvantages; 3 phase transformer connections – Y-Y, Δ-Δ,Y-Δ and Δ-Y connections; Open Delta connection; Scott connection; Applications; 3-ph to 6-ph conversion – double star, double delta and diametrical connections; Parallel operation – conditions for parallel operation and load sharing; Transformer cooling.

UNIT IV: Three-phase Induction Motors: Construction of squirrel-cage and phase-wound motor; Production of rotating magnetic field; Principle of operation; Slip and rotor current frequency; Rotor torque; Starting torque; Condition for maximum torque; Torque under running conditions; Torque-slip and Torque-speed characteristics; Speed regulation; Speed control; Power factor; Power flow diagram; Equivalent circuit; Performance curves; Starting methods; Rating; No-load and block rotor tests; Circle diagram - construction; Double cage induction motor; Induction generator; Induction regulator; Cogging and crawling; Applications.

TEXT BOOKS

1. Nagrath & Kothari, Electrical Machines, TMH, 2010, 4th edition.
2. A.S Langsdrof, Theory of A.C Machinery, TMH, 2004, 2nd edition.
3. Ashfaq Husain, Electric Machines, Dhanpat Rai, 2012.

REFERENCE BOOKS

1. *I. L. Kosow – Electrical Machinery and Transformers – Prentice – Hall of India Pvt. Ltd.,2nd edition, 2010.*
2. *Stephen Chapman – Electric Machinery Fundamentals – McGraw-Hill, 2003, 4th edition.*

EE 205: ELECTRICAL MACHINES LAB – I 0 0 2 2 4

Experiment No. 1: Open circuit characteristic of DC shunt generator. Determination of critical field resistance and critical speed.

Experiment No. 2: Load test on DC shunt motor. Determination of characteristics.

Experiment No. 3: Speed control of DC shunt motor by field and armature control.

Experiment No. 4: Load test on DC series motor. Determination of characteristics.

Experiment No. 5: Hopkinson's test on DC shunt machines. Predetermination of efficiency.

Experiment No. 6: Swinburne's test and speed control of DC shunt motor. Predetermination of efficiencies.

Experiment No. 7: Retardation test on DC shunt motor. Determination of losses at rated speed.

Experiment No. 8: O.C. & S.C. tests on single phase transformer.

EE courses of Semester V:

EE 301: POWER SYSTEMS – I 3 0 2 5 7

Aim: *To give students a well-grounded understanding of the fundamentals of electrical power systems and the role of electrical power engineering profession.*

Objectives:

- *To study the fundamental concepts of structure of electrical power systems with regard to generation, transmission and distribution.*
- *To know the Basics of load classification and characteristics.*
- *To understand the electrical and mechanical design of overhead transmission line and overhead insulators.*
- *Learning the representation, classification and performance of overhead transmission lines.*
- *Learning the construction, classification and grading of insulated cables.*

The course includes the topics:

UNIT I: Fundamentals of Power System: Importance of Electrical Energy; Sources of Electrical Energy; Function & growth of Electric Power Systems; Typical AC Power Supply Scheme; Per Unit System; Load Characteristics; Load Curves; Important Terms & Factors; Types of Load; Interconnected Grid System; Cost of Electrical Energy – Expression; Tariff – Desirable Characteristics & Types.

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UNIT II: Generating stations: Steam Power Station – Schematic arrangement, Choice of site, Equipments; Hydroelectric Power Station – Schematic arrangement, Choice of site, Constituents; Diesel Power Station; Nuclear Power Station; Gas Turbine Power Plant; Comparison.

UNIT III: Mechanical & Electrical Design of Overhead Lines:

Mechanical design: Main components of Overhead Lines; Conductor Materials; Line Supports; Insulators; Types of Insulators; String Efficiency; Corona; Factors affecting Corona; Methods of Reducing Corona Effect; Radio Interference; Sag in Overhead Lines; Calculation of Sag

Electrical design: Constants of a Transmission Line; Resistance of a Transmission Line; Skin effect; Flux Linkages; Inductance of Overhead Lines; Transposition of Power Lines; Concept of self-GMD and mutual GMD; Skin and Proximity Effect; Charging Current; Effect on Regulation of the Transmission Line; Shunt Compensation; Electric Potential; Capacitance of Overhead Lines; Effect of Earth on the Capacitance of Conductors; Voltage distribution; Capacitance grading; Static Shielding

UNIT IV: Supply systems & Performance of Transmission Lines:

Supply systems: D.C. and A.C. Transmission; Advantages of High Transmission Voltage; Various Systems of Power Transmission; Comparison of Conductor Materials; Elements of a Transmission Line; Requirements of satisfactory electric supply

Performance of Transmission Lines: Representation of Transmission Lines; Classification of overhead Transmission Lines; Short Transmission Lines; Medium Transmission Lines; End Condenser method; Nominal T-Method; Nominal π-Method; Long Transmission Lines; ABCD constants; Ferranti effect; Incident, Reflected and Refracted Waves; Surge Impedance and SIL of Long Lines; Wave Length and Velocity of Propagation of Waves.

UNIT V: Distribution System: Classification of Distribution Systems; D.C. Distribution; Types of D.C. Distributors; 2-wire & 3-wire D.C. System; A.C. Distribution; A.C. Distribution Calculations; Overhead versus Underground System; Connection Schemes of Distribution System; Requirements of a Distribution System.

Power Systems Laboratory – I

Experiments to be performed:

1. Experiment setup to study the performance of a long transmission line under no load

and under light load condition.
2. Experiment kit to study the performance of a long transmission line under load at different power factors.
3. Experiment kit to find out the ABCD and hybrid parameters of given transmission model.
4. Experiment kit to study the performance characteristics of a typical dc distribution system (radial configuration).
5. To measure:
(a) Direct axis and quadrature axis reactance of synchronous machine.
(b) Direct axis and quadrature axis subtransient reactance of synchronous machine.
6. Condition Monitoring of Distribution Transformer
   i. Oil Testing: Determine the strength of the given transformer oil.
   ii. Partial Discharge Testing: Determine the partial discharge level of the given distribution transformer as a function of voltage.

TEXT BOOKS

1. C. L.Wadhwa, Electrical Power System ,New Age Intl. (P) Ltd., 2005, 4th edition.
2. Nagrath & Kothari, Power System Engineering, TMH, 2008, 2nd edition.
3. V.K.Mehta & Rohit Mehta, Principles of Power System, S. Chand, 2005, 4th edition.

REFERENCE BOOKS:

1. *John J Grainger, William D Stevenson – Power system Analysis – TMH Companies, 1994.*
2. *A.R. Bergen and V. Vittal – Power System Analysis – Pearson Education Inc., 1999.*
3. *O. I. Elgerd – Electrical Energy System Theory – TMH, 2001, 2nd Edition.*

EE 302 ELECTRICAL MACHINES – II 3 0 0 3 3

Aim: *To acquaint students with the theory and principles of Synchronous machines, Single phase induction motors and special purpose motors.*

Objective:

- *To study the principle of construction and working of Synchronous Generator and Synchronous Motor.*
- *To learn the Parallel operation of alternators and their Synchronizing procedure.*
- *To learn the effect of change of Excitation on Synchronous Generator and Synchronous Motor.*
- *Learning the theory, Equivalent circuit, Starting methods and types of three phase Induction Motors.*
- *To study different types of Special purpose motors.*

The topics included in this course are:

UNIT I: Synchronous Generator: Construction and principle of operation; Armature winding and winding factors; EMF equation; Armature reaction; Armature leakage reactance; Synchronous reactance and impedance; Phasor diagrams; Voltage regulation; Synchronous impedance method; Ampere-turn method; Zero power factor characteristics; Potier Triangle; Power flow equation; Short Circuit Ratio (SCR); Two-reactance concept; Salient pole synchronous generator; Power angle characteristics; Parallel operation of alternators; Synchronizing procedure; Synchronising power; Alternators connected to infinite busbars; Effect of change of excitation and mechanical input; Generator capability curve; Hunting.

UNIT II: Synchronous motor: Construction and principle of operation; Damper winding; Equivalent circuit and phasor diagram; Different torques in a synchronous motor; Power flow equation; Effect of variation of field excitation and load; Mechanical Power; V-curve and O-curve; Hunting; Power factor; Synchronous condenser; Application.

UNIT III: Single phase motor: Single phase induction motor; Double field revolving theory; Rotating magnetic field from two phase supply; Equivalent circuit; Starting methods and types of single phase motors; Split phase induction motor; Capacitor-start motor; Capacitor-start capacitor-run motor; shaded-pole motor; Universal motor; Single-phase repulsion motor; Repulsion-start induction-run motor; Repulsion-induction motor; Schrage motor.

UNIT IV: Special purpose motors: Single phase synchronous motor; Reluctance motor; Hysteresis motor; Servomotors – AC & DC; Stepper motors; Dual Fed Induction Motor (DFIM).

TEXT BOOKS

1. Nagrath & Kothari, Electrical Machines, TMH, 2010, 4th edition.
2. A.S Langsdrof, Theory of A.C Machinery, TMH, 2004, 2nd edition.
3. Ashfaq Husain, Electric Machines, Dhanpat Rai, 2012.

REFERENCE BOOKS

1. *I. L. Kosow – Electrical Machinery and Transformers – Prentice – Hall of India Pvt. Ltd.,2nd edition, 2010.*
2. *Stephen Chapman – Electric Machinery Fundamentals – McGraw-Hill, 2003, 4th edition.*

EE 303 ELECTRICAL MACHINES LAB – II 0 0 2 2 4

Experiments to be performed:

Experiment No. 1: Load test on single phase transformer

Experiment No. 2: Parallel operation of Single phase Transformers

Experiment No. 3: Sumpner's back-to-back test on a pair of single phase transformers

Experiment No. 4: No-load & Blocked rotor tests on three phase Induction motor

Experiment No. 5: Speed control and load test on 3 phase slip ring induction motor

Experiment No. 6: Load test of a three-phase alternator

Experiment No. 7: Regulation of a three –phase alternator by synchronous impedance (emf) & Ampere-turn (mmf) methods

Experiment No. 8: V and Inverted V curves of a three—phase synchronous motor

EE Courses of Semester VI

EE 304 POWER SYSTEMS – II 3 0 2 5 7

Aim: *To provide the student a firm foundation in the fields of Power System Transients, Power System Analysis and Switchgear and Protection.*

Objectives:

- *To learn the fundamental concepts of transients of power systems.*
- *Theory of balanced and unbalanced faults.*
- *To be able to perform fault analysis on power systems.*
- *To acquire the basic concepts of stability.*
- *To learn about the various components of static substation and concept of neutral grounding.*
- *Study of overvoltage phenomena, overvoltage protection and insulation coordination.*

The topics included in this course are:

Unit 1: Power System Transients and Fault Analysis:

Power System Transients: Types of System Transients; Lightning phenomena; Switching surges; Travelling Waves; Shape and Specification of Travelling waves; Attenuation and Distortion of Traveling Waves; Attenuation due to Corona; Behavior of Traveling Waves at a Line Transition; Reflection and Refraction Coefficients; Termination of lines with different types of conditions; Construction of Bewley Lattice Diagram.

Fault Analysis: Sequence components of 3-ph system; Types of Fault; Symmetrical Fault Analysis; Unsymmetrical Fault Analysis; Types and Location of Reactors.

Unit 2: Steady State Stability Analysis and Voltage Control:

Steady State Stability Analysis: Power Flow; Swing Equation; Equal Area Criterion; Critical Clearing Angle.

Voltage Control: Importance of Voltage Control; Location of Voltage Control Equipment; Methods of Voltage Control; Power Circle Diagram.

Unit 3: Circuit Breakers and Relays:

Circuit breakers: Operating Principles; Arc Phenomenon; Arc Interruption Theories; DC & AC circuit breaking; Arc voltage & current waveforms; Restriking & Recovery voltages; Current Zero Pause; Current Chopping; Classification of Circuit Breakers; Air, Oil, Vacuum & SF_6 Breaker: Working and Types; Problems of Current Interruption; Ratings & Testing of circuit breakers, Miniature Circuit Breaker (MCB).

Protective relays: Operating Principles; Terminology; Functional characteristics of Protective relays; Classification; The Universal Relay Torque Equation; Induction Type Over Current relays; Distance relays; Differential relays; Translay relays; Feeder, Generator & Transformer Protection; Carrier Current Protection; Comparators; Static relays; Linear Couplers; Example with block/ power and overvoltage circuit diagrams and operation.

Unit 4: Insulation co-ordination and Power system Protection:

Insulation co-ordination: Introduction to Insulation Coordination; Volt-time curve; Over-voltage Protection; Terminology; BIL & factors affecting it; Ground & Counterpoise Wires.

Power system Protection: Voltage Surge; Causes of Over-voltage; Mechanism of Lightning Discharge; Different Types of Lightning Arresters & Surge Absorbers; Types of Fault in Alternators; Differential Protection of Alternators; Protection Systems for Transformers; Buchholz Relay; Earth Fault Protection of Transformers; Circulating-Current Scheme; Protection of Busbars & Lines; Co-ordination of System Equipment; Classification of substation; Interconnection of substations; Necessity, Function & Arrangement of substation equipment; Layout diagram- single line diagram with different bus-bar arrangements; Current limiting reactors: Types and construction; Substation Grounding.

Power Systems Laboratory – II
Experiments to be performed:

1. To determine direct and sub transient axis reactance (x_d) and quadrature axis reactance (x_q) of a salient pole alternator.
2. To determine negative and zero sequence reactance of an alternator.
3. To determine fault current for L-G, L-L, L-L-G and L-L-L faults at the terminals of an alternator at very low excitation.
4. To study the IDMT over current relay and determine the time current characteristics.
5. To study percentage differential relay, Impedance, MHO and Reactance type distance relays.
6. To determine location of fault in a cable using cable fault locator.
7. To study Ferranti effect and voltage distribution in H.V. long transmission line using transmission line model.
8. To obtain steady state, transient and sub-transient short circuit currents in an alternator.

TEXT BOOKS
1. C. L.Wadhwa, Electrical Power System, New Age Intl. (P) Ltd., 2005, 4th edition.
2. N.V. Ramana – Power System Analysis – Pearson Education India, 2010, 1st edition.
3. Nagrath& Kothari, Power System Engineering, TMH, 2008, 2nd edition.

REFERENCE BOOKS
1. *John J Grainger, William D Stevenson – Power system Analysis – TMH Companies, 1994.*
2. *P.M.Anderson – Power System Protection – McGraw Hill, 1999*
3. *P.Kundur – Power System Stability and Control – McGraw Hill Inc, New York.*, 1994.

EE 305 ADVANCED CONTROL SYSTEM ENGINEERING

3 0 1 4 5

Aim: *To impart the UG students the knowhow of advanced control techniques*

Objectives:

- *Learning the design of lag, lead, and lag-lead compensators.*
- *Learning about describing functions for non-linear systems and their analysis.*
- *To learn phase plane analysis and techniques.*
- *To learn about discrete control systems*
- *To learn about state space analysis of control systems*
- *To study about the Liapunov techniques for control system analysis.*

The topics included in this course are:

UNIT I: Compensation techniques: Preliminary design specifications in time and frequency domains; gain compensation; load compensation, lag compensation; lag- lead compensation; design.

UNIT II: Nonlinear control systems: Introduction to nonlinear systems; describing functions of common non linarites; nonlinear control systems; describing function analysis of nonlinear control systems.

UNIT III: Phase- Plane Analysis: Introduction; methods of constructing phase-plane trajectories; time information and solutions from phase-plane trajectories; singular points; phase-plane analysis of linear and nonlinear control systems.

UNIT IV : Discrete time systems: Introduction to discrete time systems; Mathematical modeling of sampling process; data reconstruction; Z-transform; inverse Z-transformation; solving difference equation by the Z-transform method; pulse transfer function; sampled signal flow graph; stability analysis; Jury stability test; Time response of discrete systems.

UNIT V: State Space Analysis of control systems: Concepts of space; state variables and state models; canonical forms; state space representation of linear systems; state transition matrix; state- space representation of discrete- time systems; solution of linear time-invariant and discrete time state equations.

UNIT VI: Stability Analysis by Lyapunov's second method: Definition of stability in the sense of Lyapunov; the second method of Lyapunov; stability analysis of linear systems; estimating the transient response behavior of dynamic systems; Controllability and observability; stability analysis of nonlinear systems.

Advanced Control System Engineering Laboratory:

The laboratory experiments covered will include the following topics:

- Programming and computation in MATLAB and SCILAB.
- Design of control systems and their simulation using software tools.
- Implementation of algorithms for multivariable systems for pole placement, observer design, stability computations, factorizations, solutions of Lyapunov and Ricatti equations, realizations, balancing.
- Use of algorithms for multivariable time series modeling.

References for lab:

1. A. Antoulas (Ed) "Mathematical systems theory" Springer Verlag 1991.
2. C. T. Chen "Linear system theory and design", 3rd Edition. Oxford 1999.
3. K. N. Sigmon and T. A. Davis, "MATLAB primer 6th edition", CRC Press 2001.

TEXT BOOKS

1. I.J. Nagrath, M. Gopal, "Control System Engineering" New Age International Publishers. 2008
2. K. Ogata, "Discrete-Time Control Systems", Prentice Hall, 2nd Edition 2012

REFERENCE BOOKS

1*) B.C. Kuo, "Digital Control System", Oxford University Press. 1992*
2) James A. Cadzow, Hinrich R. Martens, "Discrete-time and computer control systems", Prentice-Hall, 1970

EE 306: POWER ELECTRONICS AND DRIVES 3 0 0 3 3

Aim: The course discusses introductory topics in power electronics and drives for the UG level students of electrical engineering

Objectives:

- *To learn the operation of different power electronic devices.*
- *To study about different power electronic converters – ac-dc converters, dc-ac converters, dc-dc converters, ac voltage controllers.*
- *To study power electronic drives – dc motor drives and ac motor drives and their control techniques.*

The topics included in this course are:

UNIT I: Introduction to Power Semiconductor Devices:

Power Diodes – General Purpose, Fast Recovery, Schottky Diode; BJT, MOSFET, SCR, SCS, SUS, UJT, DIAC, TRIAC, GTO, IGBT and their V-I characteristics; SCR: Operating Principle, Gate Characteristics, Two-Transistor model, di/dt and dv/dt Protection, Firing circuits, series and parallel operation, rating, selection; Thyristor Triggering techniques; Thyristor Commutation techniques; Snubber circuits.

UNIT II: AC-DC Converters (Rectifier):

Diode rectifiers; 1-ϕ and 3-ϕ semi, half-wave, dual and full-wave controlled rectifiers with R and RL loads; freewheeling diode; detailed derivation of rms, average value, harmonic factor, THD, crest factor; half wave and full wave controlled rectifiers; Effect of Source impedance.

UNIT III: DC-AC Converters (Inverter) and DC-DC Converters (Chopper):

Concepts of switched mode inverters; PWM switching; Series and parallel inverters;1-ϕ and 3-ϕ half bridge and full bridge inverter with R and RL loads; 120° & 180° degree conduction; harmonics reduction; Current source inverter; McMurrey-Bedford inverter; Zero current switching (ZCS); Zero voltage Switching (ZVS); Introduction of resonant inverters. Principle of chopper operation; step-up and step-down choppers; classification; commutation in chopper circuits; Jones chopper; Morgan chopper; switched-mode voltage regulators and its topologies.

UNIT IV: AC Voltage Controllers and Power Supplies:

AC Voltage Controllers: Principles of ON-OFF Control and Phase Control; 1-ϕ and 3-ϕ controllers; Transformer Tap Changer; PWM controlled AC voltage controller; 1-ϕ and 3-ϕ Cycloconverters.

Power Supplies: DC and AC Power Supplies – Types; UPS; Power factor conditioning.

UNIT V: Power Electronic Drives:

Introduction; Classification; DC motor drives: speed-torque characteristics of shunt, series, PMDC motors, dynamic models, speed and position control methods; AC motor drives: d-q model of induction motor, constant flux speed control structure, vector control model, vector control structure.

TEXT BOOKS

1. N. Mohan: "Power Electronics- Converters, Applications and Design", 3/e, John Wiley & Sons, 2003.
2. G. K. Dubey, "Fundamentals of Electrical Drives", Narosa Publising House 2nd Edition, 2001

REFERENCE BOOKS

1. M.H. Rashid, "Power Electronics, Circuits Devices and Application", Pearson, 3rd Edition, 2004.
2. B. K. Bose, "Modern Power Electronics and AC Drives", Pearson Education, 2002.

EE 307: POWER ELECTRONICS AND DRIVES LABORATORY
0 0 2 2 4

Experiments to be performed:

Expt. No. 1: To study operation and performance of diode rectifier with LC filters.
Expt. No. 2: Study the operation of a SCR half controlled rectifier with R load, R-L load.
Expt. No. 3: Study the operation of a SCR full controlled rectifier with R load, R-L load.
Expt. No. 4: To study the operation of voltage source inverter.
Expt. No. 5: To study the operation of current source inverter.
Expt. No. 6: To study the operation of a thyristor controlled dc drive: 1-Phase and 3-phase.
Expt. No. 7: To study the operation of an IGBT based quadrant drive for PMDC Motor control.
Expt. No. 8: To study the closed loop control of DC motor using three phase fed four quadrant Chopper drive.
Expt. No 9: To study the speed control of a synchronous motor using V/f drive.
Expt. No 10: To study the speed control of a single phase induction motor.
Expt. No 11: Modeling and simulation of electric drives using MATLAB/PSIM software.

Texts/References

1. O. P. Arora, "Power Electronics Laboratory: Theory, Practice & Organization", Narosa Publishing House, 1/e, 2007.
2. Bose B.K., "Power Electronics and Variable Frequency Drives - Technology and Applications", IEEE Press, Standard Publisher Distributors, 2001.

Electives for Semester VI

EE 308: NON-CONVENTIONAL ENERGY SOURCES 3-0-0-3-3

Aim: *An undergraduate student taking this course will have foundation knowledge of various forms of non-conventional/renewable energy sources*

Objective:

- *To learn about the sources of renewable energy*
- *To learn about the solar energy and their utilization*
- *To learn about wind energy and its applications*
- *To learn about fuel cells, biomass, geothermal energy, MHD generation and ocean thermal energy*
- *To learn about hybrid renewable energy sources and technology.*

This course includes:

UNIT I: Introduction to Non-conventional energy sources: Primary and secondary energy sources, limitations to primary sources, Indian Energy Scene, Conventional and non-conventional energy sources, Prospects of renewable energy sources, MNRE and various schemes for promotion of Renewable Energy utilization.

UNIT II: Solar Energy and its utilization: Solar constant, Solar Radiation-measurements, data, average solar radiation and solar radiation at tilted surfaces, solar energy collectors, Principle of conversion of solar energy, flat plate collectors and concentrating collectors, advantages and disadvantages, selective absorber coatings, Solar ponds and solar parks, applications of solar energy. Photovoltaic Energy Conversion Photovoltaic effect, equivalent circuit & V-I characteristics of PV cell, types of solar cell & their characteristics, effect of temperature, light intensity, cell-area & series resistance on PV cell, solar cell array & module and their configurations, specifications of PV module, PV system & their components, isolated & grid connected PV systems.

UNIT III: Wind Energy: Wind energy conversion – principle, Basic components of a WECS, Classification of WEC, Types of wind machines-horizontal and vertical axis wind turbines, aerodynamics of wind-machines, Performance of wind-machines, Wind energy generation systems, grid connected wind turbine, wind farms, site selection.

UNIT IV: Geothermal and Ocean Thermal Energy Sources: Sources and use of geo-thermal energy, geo-thermal power plants, advantages and disadvantages of geothermal energy over other forms of energy sources. Tidal power, components of tidal power plants, generation of tidal power, estimation of energy & power, site requirements, advantages and limitations, ocean thermal energy conversion (OTEC)- open cycle and closed cycle, site selection, prospects of tidal and ocean thermal energy in India, Small scale Hydroelectric (mini and microhydel) – classification, advantages and limitations of small scale hydro-electric plants.

UNIT V: Hybrid Energy sources: Introduction, Bio-mass conversion technologies, bio-gas generations, classifications of bio-gas plants, selection of site for bio-gas plant, utilization of bio-gas, thermal gasification of bio-mass. Fuel Cells -Introduction, energy conversion principles, classification of fuel cells, Conversion efficiency of fuel cells, applications of fuel cells. Need for Hybrid Systems, Range and type of Hybrid systems, Case studies of Diesel-PV, Wind-PV, Microhydel–PV, Biomass-Diesel systems, electric and hybrid electric vehicles

TEXT BOOKS

1.) G.D. Rai, “Non-Conventional Energy Sources”, Khanna Publications, 1st Edition 2011
2.) B.K.Khan, “Non-Conventional Energy Resources”, Tata McGraw-Hill Education. 2006

REFERENCE BOOKS

1.) L.E. Ferris and D. Infield , “Renewable Energy in Power Systems”, Wiley, 1st Edition, 2008,
2.) M.R. Patel, “Wind and Solar Power System, Design, Analysis and Operation”, CRC Press, 2nd Edition 2006,
3.) IEEE and IET journals on Renewable Energy Technologies.

EE 309: UTILIZATION & CONSERVATION OF ELECTRICAL ENERGY

3 0 0 3 3

Aim: *To acquaint students with the practical application of utilization of electrical energy and imparting them the knowledge of the principles of electrical energy conservation.*

Objective:

- *To study the principle of construction and working of Electric Heating Furnaces*
- *To learn the classification and apparatus of Electric Welding.*
- *To learn the principles and control systems of Electric Traction.*
- *Learning the sizing, duration and modes of Energy Storage Systems..*
- *To study the principles of Electrical energy losses and energy audit.*

Unit 1: Illumination and Energy Storage

Illumination: Review of laws of illumination, luminous efficacy, lighting sources and their use in domestic, street and industrial lighting, energy considerations, photometry.

Energy Storage: Size & Duration of storage, Modes of energy storage: mechanical, electrical, magnetic, thermal & chemical, Comparison of the different systems.

Unit 2: Electric Heating and Electric Welding

Electric Heating: Advantages, Classification, Resistance Heating, Furnaces, Requirements and Design of heating elements, Temperature control, Electric arc furnaces, Direct & Indirect, Construction & Operation, Electrodes & Power Supply, High Frequency Heating, Induction Heating, Working principle, Power & High frequency Heating, Choice of Frequency, Core type & Coreless Furnaces, Skin Effect & Pinch effect, High Frequency Supply, Advantages & Disadvantages, Dielectric Heating, Working principle, Choice of Voltage and Frequency, Advantages & Applications.

Electric Welding: Classifications, Resistance Welding Spot, Butt, Seam. Arc welding types, electrode used, power sources and control circuits, Atomic hydrogen welding, Modern development.

Unit 3: Electric Traction and Drive

Traction Drive, Requirements for traction application, Consideration for motor selection. Control of Traction Motors, Starting, speed control and braking, energy consideration, rectifier system and power electronic control, OHE, current collection, feeding and distribution system, Electric cars, Choice of system voltage and frequency, the Indian scenario, Types of train services, Train movements and energy consumption, energy consumption curves, Tractive effort, Adhesion, Train resistance, Power supply arrangements, Substation equipment.

Unit 4: Electrical Losses, Conversion and Audit

Electrical Losses & Energy Conversion: Electrical transmission, distribution & utilization losses, Classification, Reduction of losses, Benefits of electrical energy conservation, Energy conservation in lighting, electric furnaces, electric drive, traction systems, use of energy efficient equipment.

Electrical Energy Audit: Introduction, benefits, procedure for energy audit, Instruments for energy audit, Methodology, Case study.

TEXT BOOKS

1. H. Pratab, Art and Science of Utilization of Electrical Energy, Dhanpat Rai& Sons, 1992.
2. N.V. Suryanarayan, Utilization of Electric power, Wiley Eastern Ltd, 1994

REFERENCE BOOKS

1. *E.O.Taylor, Utilisation of Electric Energy, Orient Blackswan Pvt. Ltd., 1984.*
2. *Er. R.K.Rajput, Utilisation of Electrical Power, Firewall Media, 2006.*

EE 310: EMBEDDED SYSTEMS 3 0 0 3 3

Aim: *To acquaint students with the concepts and broad scopes of embedded systems and imparting them the knowledge to design and develop practical systems.*

Objective:

- *To give sufficient background for undertaking embedded system design*
- *To introduce students to the embedded systems, its hardware and software.*
- *To explain programming concepts*
- *To explain real time operating systems*
- *To learn the design and development of practical systems.*

The topics included in this course are:

UNIT I: The Typical Embedded System: Embedded Systems vs General Computing Systems, History of Embedded Systems, Classification, Major Application Areas, Purpose, Core of the Embedded System, Memory, Sensors and Actuators, Communication Interface, Embedded Firmware, Other System Components, PCB and Passive Components, Characteristics and Quality Attributes of Embedded System, Application and Domain Specific Embedded Systems

UNIT II: Embedded Hardware Design and Hardware Software Co-Design: Analog and Digital Electronic Components, VLSI and Integrated Circuit Design, Electronic Design Automation (EDA) Tools, Embedded Firmware Design Approaches, Embedded Firmware Development Languages, Programming in Embedded 'C', Fundamental issues in Hardware Software Co-Design, Computational models in Embedded Design, Introduction to Unified Modeling Language (UML), Hardware Software Trade-offs.

UNIT III: Real Time Operating System (RTOS) based Embedded System Design: Operating System Basics, Types of Operating Systems, Tasks, Process and Threads, Multiprocessing and Multitasking, Task Scheduling, Threads, Processes and Scheduling: Putting them altogether, Task Communication, Task Synchronisation, Device Drivers, How to choose an RTOS.

UNIT IV: Design and Development of Embedded Systems: Introduction to Embedded System Design with VxWorks and MicroC/OS-II (μCOS-II) RTOS, Integration and Testing of Embedded Hardware and Firmware, Board Power up, Integrated Development Environment (IDE), Types of files generated on cross-compilation, Disassembler/Decompiler, Simulators, Emulators & Debugging, Target Hardware Debugging, Boundary Scan, Product Enclosure Design Tools and Development Techniques, Embedded Product Development Life Cycle (EDLC), Objectives of EDLC, Different Phases of EDLC, EDLC Approaches, Modeling the EDLC.

UNIT V: Trends in the Embedded Industry: Processor Trends in Embedded System, Embedded OS Trends, Development Language Trends, Open standards, Frameworks and Alliances, Bottlenecks.

TEXT BOOKS

1. K.V.Shibu, "Introduction to Embedded Systems", Tata McGraw Hill Education Private Limited, New Delhi, 1st edition, 2009.
2. Lyla B. Das, "Embedded systems: An Integrated Approach", Pearson Education, 1st edition, 2013

REFERENCE BOOKS

1. *Kirk Zurell, "C Programming for Embedded Systems", CMP Books, 1st edition 2000.*
2. *Michael Barr, "Programming Embedded Systems in C and C++, O'Reilly, 1st edition 1999.*
3. *Jack Ganssle, "The Art of Designing Embedded Systems", Newnes, 2000.*

EE courses of Semester VII

EE 401: COMPUTER AIDED POWER SYSTEMS ANALYSIS 3 0 2 5 7

Aim: *To acquaint the students with the knowledge of performing load flow studies, fault analysis and voltage stability analysis in power systems.*

Objectives:

- *To learn the Z-bus and Y-bus formulation.*
- *Learning to perform AC power flow analysis.*
- *To perform fault calculations and contingency analysis.*
- *To learn the concepts of steady state and Transient analysis.*

The topics included in this course are:

UNIT I: Formulation of Network matrix: Primitive network, bus incidence matrix, formation of Y-bus by singular transformation, networks with mutually coupled elements, formation of Z-bus by matrix inversion, formation of Z-bus using the building algorithm – addition of a tree branch p to reference bus, addition of a link between buses p and q, addition of a link between bus p and reference bus .

UNIT II: AC Power Flow Analysis: Introduction, Modeling of Power System Components, Power Flow Equations, Power Flow Solution Algorithms, Gauss Seidel Load Flow Method, Newton Raphson Load Flow Method, Fast Decoupled Load Flow Method And DC Load Flow Method, AC-DC System Power Flow Analysis - Sequential and Simultaneous Solution Algorithms, Overview of SCADA system.

UNIT III: Fault Calculation: Fault calculation using Z-bus and Y-bus, Symmetrical and Asymmetrical Faults, Short Circuit Analysis of Large Power Systems using Z-bus, Analysis of Open Circuit faults.

UNIT IV: Stability Analysis: Classification of Power System Stability, Classical Model of Synchronous Machines and Excitation System, Automatic regulation, Transient Stability Analysis of

Multi-Machine Systems, Power-angle curve, Steady-state and transient Stabilities, Equal area criterion, Calculation of power-angle curves for fault and post – fault conditions for various types of fault, effect of reclosing, Small Signal Stability Analysis using Classical Model, Basic Concepts of Voltage Stability Analysis, Factors affecting stability.

UNIT V: Reactive Power Compensation and Control: Methods of voltage control, power flow in a transmission line, VAR compensation, reactive power injection and control, receiving-end and sending-end power circle diagrams, universal power circle diagram, load compensation – power factor correction, improving voltage regulation and balancing of load, passive compensators, Flexible AC Transmission (FACTS) devices, classification, series, shunt and series-shunt controllers.

COMPUTER AIDED POWER SYSTEMS ANALYSIS LABORATORY

1. Formulation of Z-bus & Y-bus matrix in MATLAB.
2. Implementation of Gauss Seidel Load Flow Method in MATLAB.
3. Implementation of Newton Raphson Load Flow Method in MATLAB.
4. Fault calculation using Z-bus and Y-bus in MATLAB.
5. Modelling of Synchronous Machines and Excitation System.

TEXT BOOKS

1. George Kusic, "Computer-Aided Power Systems Analysis" CRC Press, 2nd Edition, 2008
2. Ramasamy Natarajan, "Computer-Aided Power System Analysis", CRC Press, 2002
3. G.W.Stagg and A.H.El-Abiad, "Computer Methods in Power System Analysis", McGraw Hill 1968.

REFERENCE BOOKS

1. *A.R. Bergen and Vijay Vittal, "Power Systems Analysis", Pearson Education Asia, 2001.*
2. *J.J. Grainger and W.D. Stevenson, "Power System Analysis", McGraw-Hill, New York, 1994.*
3. *N. G. Hingorani and L. Gyugyi, "Understanding FACTS", Wiley 2000.*

EE courses of Semester VIII: Electives and Project

Elective Courses for VII and VIII Semesters

EE 405: INDUSTRIAL AUTOMATION SYSTEMS 3-0-0-3-3

Aim: *To impart the undergraduate students taking this course an overview of the instrumentation automation system.*

Objectives:

- *To study about sensors and measurement systems used in an industry*
- *To learn about measurement techniques involved in measurement of Temperature, pressure, level, flow, displacement and speed, humidity, pH level.*
- *To learn basics of process control and P-I-D controllers*
- *To study about Actuators and Pneumatic Control Systems*
- *To study PLCs and Relay Ladder Logic and the Fieldbus Communication Protocol*

The topics included in this course are:

UNIT I: Introduction to Industrial Automation and Control: Architecture of Industrial Automation Systems.

UNIT II: Introduction to sensors and measurement systems: Temperature measurement, Pressure measurement, Force measurement, Displacement and speed measurement, Flow measurement techniques, Measurement of level, humidity, pH, E-nose.

UNIT III: Introduction to Process Control: Proportional, Integral and Differential controllers, Limitations of controllers, PID Controller, Controller Tuning, Implementation of PID controllers. Cascade Control, Split Range Control.

UNIT IV: Introduction to Actuators and Control Systems: Flow Control Valves Principles, Components and Symbols, Pumps and Motors, Proportional and Servo Valves Pneumatic Control Systems – System Components, Pneumatic Control Systems Controllers and Integrated Control Systems.

UNIT V: Networking of Sensors, Actuators and Controllers: Introduction to Sequence Control, PLCs and Relay Ladder Logic, Fieldbus, Fieldbus Communication Protocol.

TEXT BOOKS

1. E O Doeblin and D N Manik, "Measurement Systems: Applications and Design", Tata McGraw Hill, 5th Edition, 2003.
2. D. Patranabis, "Industrial Instrumentation" McGraw Hill, 2nd Edition, 2001.
3. A. K. Sawhney, "A Course in Electrical, Electronic Measurement and Instrumentation", Dhanpat Rai Publication. 2012

REFERENCE BOOKS

1. *D. Helfric and W. D. Cooper, "Modern Electronic Instrumentation and Measurement Techniques", PHI, Revised Edition, 1990.*
2. *K. Ogata "Modern Control Engineering", Prentice Hall of India, 5th Edition, 2005.*

EE 407: ADVANCED POWER ELECTRONICS AND DRIVES 3-0-0-3-3

Aim: *The course discusses advanced topics in power electronics and drives for the UG level students of electrical engineering*

Objectives:

- *To study the power electronic converters for drive systems*
- *To study the modeling of DC machines*
- *To study the control of DC motor drives- phase and chopper control techniques*
- *To study the control of Induction motor drives*
- *To study the PMSM and BLDC motor drives and their control techniques*
- *To learn about expert systems, Fuzzy logic and Neural Networks for control of power electronic drives.*

The topics included in this course are:

UNIT I: Power Electronic Converters for Drives: Development of Power Electronic converters and its application to drive technology, control of amplitude, converters for ac variable frequency drives, switch applications technology.

UNIT II: Modeling of DC Machines and Controlled DC Motor Drives:

Modeling of DC Machines: Theory of Operation, Induced emf, Equivalent circuit and Electromagnetic Torque, State space modeling, block diagram and transfer functions, field excitation- separately excited, shunt excited and series excited compound machine and PMDC machine, measurement of motor constants.

Controlled DC Motor Drives: Principle of dc motor speed control, phase controlled converters, steady state analysis of three phase converter controlled dc motor drive, two quadrant and four quadrant operation of dc motor drives, Harmonics and associated problems. Principle of operation of chopper, four quadrant chopper circuit, steady state analysis of chopper controlled dc motor drive, pulsating torques, closed loop operation.

UNIT III: Controlled Induction Motor Drives: Introduction, Stator voltage control, slip-energy recovery scheme. Static frequency changers, Voltage source inverters, VSI driven Induction motor, Constant V/f control, Constant slip-speed control, air-gap-flux control, Torque pulsations and harmonics, CS Induction motor drives.

UNIT IV: Permanent Magnet, Synchronous and Brushless dc motor drives: Synchronous machines with PM, vector control of PMSM, control strategies, speed-controller design, sensorless control, PMBDCM-modeling, half-wave PMBDCM drives, sensorless control of PMBDCM drives, torque smoothing, design of speed controllers.

UNIT V: Expert system, Fuzzy logic and Neural Networks in Power Electronics and Drives: Expert systems- principles, knowledge, methodology and application in power electronics and drives, Fuzzy logic- Principle, control, modeling and estimation, design methodology and control implementation, application, Neural Network Principles, design methodology and implementation, application in power electronics and drives.

TEXT BOOKS

1. B.K. Bose, “Power Electronics and Variable Frequency Drives – Technology and Applications”, IEEE Press, Standard Publisher Distributors, 2001.
2. R. Krishnan, “Electric Motor Drives- Modeling, Analysis and Control”, 2001 Pearson Education

REFERENCE BOOKS

1. G.K. Dubey, S.R. Doradla, A. Joshi and R.M.K. Sinha, "Thyristorised Power Controllers", New Age International Private Limited., 2008.
2. M. Rashid, "Power Electronics- Circuits, Devices and Applications", 3rd Ed., Pearson Education, 2008.
3. N. Mohan, T.M. Underland and W.P. Robbins, "Power Electronics - Converters, Applications and Design", 3rd Ed., Wiley India. 2008.

EE 408: HIGH VOLTAGE ENGINEERING 3 0 0 3 3

Aim: *To impart students with the knowledge of theory and applications of High Voltage Engineering.*

Objective:

- *To study the principle of conduction and breakdown in insulating mediums.*
- *To learn the phenomenon of lightening overvoltage.*
- *To learn the theory of principle and components of High Voltage Generation.*
- *Learning the theory of High Voltage Measurement.*
- *To study different types High Voltage Testing equipments and Laboratory.*

The topics included in this course are:

UNIT I: Conduction and Breakdown in Gases, Liquids and Solid Dielectrics

Conduction and Breakdown in Gases: Desirable properties of gas and insulating medium, Townsend's current growth equations, Townsend's criterion for breakdown, Electronegative gases and their breakdown, Streamer theory, Baschen' s law.

Conduction and Breakdown of Liquid Dielectrics: Pure and commercial liquids, origin and purification, breakdown of commercial liquids, Transformer oil- composition, properties and deterioration: Inhibitor.

Breakdown of Solid Dielectrics: Different types of breakdown, measurement of intrinsic strength, partial discharge.

UNIT II: Lightning over-voltage and High-voltage Generation

Lightning over-voltage: Measuring instruments, Magnetic surge crest ammeter, Kyldonograph, Fulchronograph, Oscillograph, Protective devices, surge absorbers, ground and counterpoise wires, lighting arresters, switching over voltages- origin, wave shape and magnitudes, protective devices.

High-voltage Generation: Alternating voltage: transformers in cascade, single units, high frequency transformers, direct voltage: Voltage multipliers and cascade circuits using rectifiers, electrostatic machines, voltage stabilization, transient voltage, impulse generator, analysis of the basic circuits, standard impulse wave-shape, multi-stage circuits, wave shape control, triggering, general construction, synchronization with oscilloscope.

UNIT III: High-voltage Measurement and Testing

High-voltage Measurement: Measurement of high direct, alternating (rms and peak) and impulse voltage and currents. Uniform field electrodes, measurement of dielectric constant and loss factor, Schering bridge, Wagner earth discharge and measurement.

High-voltage Testing: Low-frequency tests, impulse tests, test circuits, control gear, testing of overhead line insulators, cables and transformer oil.

UNIT IV: High-voltage Equipment

High-voltage Equipment's Design and classification: Bushings: classification, construction and application, Grading, Breakdown of bushings, design and constructional features of high-voltage resistors, High-voltage capacitors, guard rings and shields.

TEXT BOOKS

1. Naidu, M. S., and Karmaju, V., "High Voltage Engineering", Tata Mc Grow Hill, 5th Edition 2013.
2. Kuffel E., W.S. Zaengl, Kuffel J, "High Voltage Engineering", Newness, 2nd edition, 2000
3. Chourasia, M. P., "High Voltage Engineering", Khanna publishers. 1972

REFERENCE BOOKS

1. *Jha R.S., 'High Voltage Engineering', Dhanpat Rai & Sons.*
2. *Rind D., 'High Voltage Laboratory Technics" PHI.*

EE 409: INDUSTRIAL DRIVES AND CONTROL 3 0 0 3 3

AIM: *To learn about the various electric drives and their control at industry level.*

OBJECTIVES:

- *To study the electric drives*
- *To learn about selection of electric drives based on rating.*
- *To learn about the various dc motor drives and their control techniques*
- *To learn about the various industrial motor drives and their control techniques*
- *To learn about synchronous motor drives and brushless dc motor drives*
- *To learn about industrial applications of electric drives*

The topics included in this course are:

UNIT I: Introduction to Electrical Drives:
Electrical drives, advantages of electrical drives, parts of electrical drives, choice of electrical drives, torque equation, speed torque convention and multiquadrant operation-drive parameters, nature and classification of load torques, steady state stability, load equalization, modes of operation, speed control, closed loop control of drives-current limiting control, torque control- speed control, thermal model of motor for heating and cooling, classes of motor duty, determination of motor rating, continuous duty, short time duty, intermittent periodic duty.

UNIT II: DC motor drives: dc motors types – self and separately excited motors, series motor, shunt motor, compound motor, universal motor, starting, braking, speed control, controlled rectifier fed dc drives, single phase half and fully controlled rectifier of dc separately excited motor, three phase control, rectifier control of dc series motor, control of fractional hp motors, chopper controlled dc motor drives, harmonics power factor and ripple in motor current.

UNIT III: AC motor drives: Single phase and three phase induction motor drives, starting, braking, transient analysis, speed control, pole changing, stator voltage control, variable frequency control from voltage sources, voltage source inverter (VSI) control, cyclo-converter control, current source inverter (CSI) control. Operation from fixed frequency supply, variable speed drives, self-controlled synchronous motor drive employing load commutated Thyristor inverter, permanent magnet ac motor drives.
UNIT IV: Brushless dc motor (BLDC) and Stepper motor drives: BLDC motor drives for servo applications, low cost BLDC motor drives, applications, stepper motors, switched reluctance motor drives.

UNIT V: Industrial applications: Steel mills, paper mills, cement mills, textile mills, sugar mills, electric traction, and machine tool applications.

TEXT BOOKS
1. R. Krishnan, “Electric Motor Drives, Modeling, Analysis and Control”, Prentice Hall 2001.
2. G.K. Dubey, “Fundamentals of Electrical Drives”, Narosa Publications, 2nd Edition, 2001.

REFERENCE BOOKS
1. S.K. Pillai, “A first Course in Electric Drives” New age International Publications. 2nd Edition, 2009 (Indian Reprint).

2. *M.H. Rashid, "Power Electronics, Circuits Devices and Application", Pearson, 3rd Edition, 2004.*
3. *Werner Leonhard, "Control of Electrical Drives, Springer" Springer, 3rd Edition, 2013.*

EE 411: POWER SYSTEM INTERCONNECTION AND CONTROL
3-0-0-3-3

Aim: *To acquaint the students the knowledge of planning, operation and control of power system.*

Objective:

- *To learn the economics of dispatch of electrical power.*
- *To learn the methods of forecasting electric load and scheduling thermal units.*
- *To learn how hydro and thermal units are scheduled to meet the load demand.*
- *To study the interconnection of power systems and the basics of load frequency control.*
- *To study the basics of reactive power management.*

The topics included in this course are:

UNIT I: Economic Load Dispatch

Economic Load Dispatch: Economic dispatch problem and system constrains, λ-iteration method, gradient method, economic dispatch neglecting losses, optimum load dispatch including transmission losses, cost curves, base point and participation factors, transmission loss co-ordination, penalty factors, B-matrix loss formula and its derivation, calculation of B coefficients by approximate method, exact transmission loss formula.

UNIT II: Load forecasting and Unit Commitment:

Important factors for load forecast, types of forecasting, forecasting methods, need for unit commitment, comparison with economic load dispatch, constraints in unit commitment, unit commitment solution methods, reliability considerations, Patton's security function, security constrained optimal unit commitment, start-up considerations, optimal load flow solution by Dommel and Tinney's method.

UNIT III: Hydro Thermal Scheduling

Scheduling of hydro units, hydroelectric plant models, long range and short range hydro scheduling, solution of short term hydro thermal scheduling problem, Lambda-Gamma iteration method, gradient approach, hydro units in series i.e. hydraulically coupled units, pumped storage hydro plants, dynamic programming solution to multiple hydro plant problem.

UNIT IV: System Interconnection and Control

Types of inter connection, advantages of interconnection, philosophy of real and reactive power control, necessity of maintaining frequency constant, ALFC, alternator (generator) model, load model, prime-mover model, governor model, tie-line model, control area concept, single area load frequency control system, integral or supplementary control, two areas connected by a tie line, power frequency control of the tie line, load frequency and economic load dispatch control, automatic voltage regulators, automatic excitation control.

TEXT BOOKS

1. C. L. Wadhwa, "Electrical Power System", New Age International, New Delhi. 4th edition 2005.
2. S. Sivanagaraju, "Power System Operation and Control", Pearson. 4th edition 2009.

REFERENCE BOOKS

1. *Wood and Wolenberg, "Power Generation, Operation, and Control", Wiley. 2nd edition, 2005.*
2. *Abhijit Chakrabarti & Sunita Halder, "Power System Analysis and Control", PHI. 3rd edition, 2010.*