BTECH(Electrical)

SEM-V

ELECTRICAL MACHINE-1
GENERATION OF ELECTRICAL POWER
CONTROL SYSTEM
MICROPROCESSOR
ELECTRICAL ENGINEERING MATERIAL
ELECTROMAGNETIC FIELD THEORY

SEM-VI

POWER ELECTRONICS-I
ELECTRICAL MACHINE-II
NON-CONVENTIONAL ENERGY SOURCES
ELECTRICAL MEASUREMENT
STATIC PROTECTIVE RELAYS
TRANSMISSION & DISTRIBUTION

SEM-VII

EHV AC/DC TRANSMISSION
SWITCH GEAR AND PROTECTION
POWER SYSTEM ENGINEERING
POWER SYSTEM ANALYSIS
ELECTRIC DRIVES AND THEIR CONTROL
UTILIZATION OF ELECTRIC POWER INCLUDING TRACTION

SEM-VIII

Practical Training for 6 Month

a. Project
b. Seminar

1. BTEE351 ELECTRICAL MACHINES – I

1. **Electromechanical Energy conversion:** Basic principles of electro-mechanical energy conversion. Basic aspects and physical phenomena involved in energy conversion. Energy balance. Basic principles of operation of electric generators and motors.

2. **D.C. Machines:** Fundamentals of D.C. machine, construction, armature windings : ring and drum windings. Simple lap and wave windings. Chording, Equalizing, connections. Generated voltage.
3. **Armature Reaction:** Distribution of armature and field mmfs. Cross magnetizing and demagnetizing mmfs and their approximate estimation.
4. **Commutation:** Introduction to commutation, reactance voltage, resistance commutation, and interpoles.
5. **DC Generators:** Type of D.C. generators. No load and load characteristics of D.C. generators. Parallel operation.
6. **DC Motors:** Principles of operation, production of torque, back emf, torque-current and torque-speed characteristics of motors, Starting of motors. Speed control by variation of armature voltage, field current and Ward Leonard method. Electrical braking of D.C. motors. Losses and efficiency, direct and indirect tests, Swinburne's test, Hopkinson's test, Field test and retardation test, separation of losses, Rosenberg Generator.
7. **Cross Field Machines:** Basic principles of operation of metadyne and amplidyne and their applications.
8. **Transformers:** Constructional features, emf equation. No load and load conditions. No load current wave shapes. Ideal transformer. Equivalent circuit. Vector diagrams. O.C. and S.C. tests. Sumpner's back to back test. Efficiency. Voltage regulation. Effect of frequency. Parallel operation, auto-transformers, Switching currents in transformers, Separation of losses.
9. **Polyphase Transformers:** Single unit or bank of single-phase units, polyphase connections. Open delta and V connections. Phase conversion : 3 to 6 phase and 3 to 2 phase conversions. Effect of 3-phase winding connections on harmonics. 3-phase winding transformers, tertiary winding.

Text / References:

1. P.S. Bimbhra : Electrical Machinery
2. M.G. Say –Performance and Design of AC Machines
3. B.R. Gupta – Fundamentals of Electrical Machines, A New Age International Publishers
4. Nagrath & Kothari –Electrical Machines, TMH

GENERATION OF ELECTRICAL POWER

3L + IT **MM : 100**

Ex. Hr. : 3

1. **Method of bulk energy generation:** Introduction to thermal, hydel, nuclear and gas power plants with their layouts. Concept of co-generation. Impact of thermal, hydro and nuclear stations on environment.

2. **New Energy sources:** Elementary ideas of electric energy generation by wind, solar, tidal and geothermal energy. Open and closed cycle M.H.D. power generation.

3. **Load and Load curves:** Types of load, chronological load curves, load duration curve, energy load curve, mass curve Maximum demand, demand factor, load factor, capacity factor, utilization factor, diversity factor.

4. **Power plant economics:** Capital cost of plants, annual fixed and operating costs of plants, generation cost and depreciation. Effect of load factor on unit energy cost. Role of load diversity in power system economics. Off peak energy utilization. Energy cost reduction.

5. **Tariffs:** Objectives of tariffs. General tariff form. Flat demand rate, straight meter rate, block meter rate, two part tariffs, power factor dependent tariffs, three parts tariff. Spot (time differentiated) pricing.

6. **Power Factor Improvement:** Causes and effects of low power factor, advantages of power factor improvement, power factor improvement using shunt capacitors and synchronous condensers. Calculation of most economic power factor when (a) KW demand is constant (b) KVA demand is constant.

7. **Selection of Power Plant:** Comparative study of thermal, hydel, nuclear and gas power plants. Base load and peak load plants. Size of generating units, types of reserve and size of plant. Selection and location of power plants.

Text / References:

1. B. R. Gupta – Generation of Electrical Energy
2. Soni, Gupta and Bhatnagar – Generation of Electrical Power
3. S. L. Uppal – Electrical Power
4. M. V. Deshande – Elements of Electrical Power Station Design

3 BTEE 353 Control System

State variable characterisation of linear continuous - time and discrete - time systems, controllability, observability, stability; sampled data systems; Z transforms; non-linear systems; phase plane and describing function methods; calculus of variations; optimal control.

4 BTEE 354 Microprocessor Programming & Interfacing

Elements of digital electronics; PC organization; 80X86 as CPU : Instruction set register set, timing diagrams, modular assembly programming using procedures & macros, assembler, linker & loader concepts; concept of interrupts: hardware interrupts, software interrupts, BIOS and DOS interrupts; disk organization: boot sector, boot partition, root directory & FAT; memory interfacing & timing diagrams; I/O interfacing; programmable I/O devices such as 8255, 8253, 8259, etc.

ELECTRICAL ENGINEERING MATERIALS
2L+1T **M.M.: 100**
Ex. Hrs.: 3

1. **Conductor Materials:** Electrical, thermal and mechanical properties of conductive and resistive materials. Important characteristics and applications of specific conductor materials like copper, aluminium, AAC, ACSR, Silver, gold, platinum and tungsten, study of important resistance materials, carbon and nicrome, standard resistance materials. Soldering alloys.
2. **Super-conducting Materials:** Introduction, critical field and critical current density, type I and type II superconductors, intermediate state, penetration depth and thin films. Superconductivity at high frequencies, application of superconductivity. Advancements in super-conducting materials.
3. **Dielectric materials:** Dielectric behaviour of materials under static and dynamic field. Polarisation, induced and permanent dipole moments. Surface resistivity. Breakdown processes. Thermal properties. Electrical properties of important dielectric materials including plastics and ceramics, Ferro-electric and piezo-electric materials.
4. **Magnetic Materials:** Characteristics of Diamagnetic, paramagnetic, ferro-magnetic, ferrimagnetic and anti-ferromagnetic materials. Properties and applications of common non-retentive and retentive magnetic materials including various alloys, ferrites and powder cores. Eddy current and hysteresis losses, Curie point.
5. (a) **Semiconductor materials:** Electric properties of semi-conducting elements and compounds and their application. Zone refining and crystal growth.

   (b) **Miscellaneous Materials:** Important electronic properties of electron emitting materials, photosensitive materials and luminescent materials.

Text / References:

1. C.S. Indulkar & S. Thriuvengadam –An introduction to Electrical Engineering Materials, S. Chand.
2. S.P. Seth & P.V. Gupta –A Course in Electrical Engineering Materials, Dhanpat Rai & Sons.
3. B.D. Indu –Electrical Engineering Materials, Jain Brothers
4. A.J. Dekkar –Electrical Engineering Materials
5. R.M. Rose et al – Structure and Properties of Materials, Wiley Eastern Ltd.

BTEE356 ELECTROMAGNETIC FIELD THEORY

2L+IT MM: 100 Exam. Hrs. : 3

1. **Introduction:** Vector Relation in rectangular, cylindrical, spherical and general curvilinear coordinate system. Concept and physical interpretation of gradient, Divergence and curl, Green's Stoke's and Helmholz theorems.

2. **Electrostatics:** Electric field vectors-electric field intensity, flux density & polarization. Electric field due to various charge configurations. The potential functions and displacement vector. Gauss's law. Poisson's and Laplace's equation and their solution. Uniqueness theorem. Continuity equation. Capacitance and electrostatics energy. Field determination by method of images, boundary conditions. Field mappings and concept of field cells.

3. **Magnetostatics:** Magnetic field vector, Magnetic field intensity, flux density & magnetization. Bio-Savart's law, Ampere's law, Magnetic scalar and vector potential, self & mutual inductance, Energy stored in magnetic field, Boundary conditions, Analogy between electric and magnetic field, Field mappings and concept of field cells.

4. **Time varying fields:** Faraday's law, Displacement currents and equation of continuity. Maxwell's equations, Uniform plane wave in free space, dielectrics and conductors, skin effect sinusoidal time variations, reflections, refraction and polarization of UPW, standing wave ratio. Pointing vector and power considerations.

5. **Radiation & transmission:** Retarded Potentials and concepts of radiation, Radiation from small current element. Transmission line parameters, Calculation of resistance, capacitance & inductances.

6. **EMI & EMC:** Introduction to Electromagnetic interference and Electromagnetic compatibility, EMI coupling modes, Methods of eliminating interference, shielding, grounding, conducted EMI, EMI testing: emission testing, susceptibility testing.

Recommended Books:

1. David K. Cheng – Field and Wave Electromagnetic, 2nd Ed., Wesley Pub. Co.
2. Griffith –Introduction to Electrodynamics, 2nd Edition, Prentice Hall of India
3. J.D. Kraus, Electromagnetic, 5th, McGraw Hill Book Co.
4. P. Loprrain, D.R. Corson – Electromagnetic Field & Waves, Willey Eastern Ltd.
5. V.V. Sarwate –Electromagnetic Field and Waves, Willey Eastern Ltd.
6. The Feynman Lectures on Physics, Vol. –II, Narosa Publishing House
7. J.K. Kraus –Applied Electromagnetic, 5th Ed.

BTEE361 – POWER ELECTRONICS – I

2L+IT **MM : 100** **Exam. Hrs. : 3**

1. **Semiconductor power devices:** Characteristics of Power Diodes. Power Transistor, Triac, Diac and UJT.

2. **SCR:** Construction and characteristics, specification and ratings, pulse transformer, optical isolators, methods of turn on R, RC, UIT relaxation oscillator, blocking oscillator and flipflop firing. Rating extension by series and parallel connections, string efficiency. Protection of SCR: Protection against over voltage, over current, dv/dt, di/dt, switching surges, over heating, Gate protection.

3. **Converters:** Half wave converters for single, two, three, six phase. Single phase and three phase full wave converter with R, RL, and RLE loads. Performance factors for line commutated converters. Firing circuits for line commutated converters. Inversion operation. Semi converters, dual converter. Effect of source impedance. Microprocessor based firing scheme for three-phase fully controlled bridge converter.

4. **Choppers:** Principle of chopper operation. Control strategies. Step up/down Copper. Chopper configuration. Chopper commutation. AC Chopper. Source filter. Multiphase Chopper. Chopper firing circuit.

Recommended Books:

1. M. H. Rashid: Power Electronics, Circuit Devices and Applications, PHI, 1988
2. V. Subrahmanyam: Power Electronics, New Age Inc. Publishers, New Delhi, 1996
3. P. C. Sen: Power Electronics, Tata McGraw Hill 1987
4. C. W. Lander: Power Electronics, 2nd Ed. McGraw Hill 1987
5. P.S. Bimbhra: Power Electronics, 2nd Ed. Khanna Publishers, 1998
6. M.D. singh and K.B. Khanchandani: Power Electronics, TMH, 1998

BTEE362 ELECTRICAL MACHINES – II

3L +IT **MM: 100**

Exam. Hrs. : 3

1. **Introduction:** General equation of inducted emf. Effect of distribution, chording and skewing on induced emf. Armature emf. Armature and field mmfs – Effect of power factor and magnitudes of current on armature mmf. Harmonics caused by winding, distribution and saturation, Rotating fields.

2. **Induction motors:** Construction, basic principles, flux and mmf waves, induction motor as a transformer. Equivalent circuits., Circle diagram. Calculation of performance. Torque-slip curves. Effect of rotor resistance. Cogging crawling. Starting, speed control and braking of induction motors. Losses and efficiency. Testing. Induction Generator. Induction regulator. Single – phase induction motor. Revolving field theory. Starting methods.

3. **Synchronous machines:** Construction, Basic principles, Flux and EMF waves. Theory of cylindrical rotor and salient pole machines. Two reactance theory. O.C. and S.C and Zero power factor characteristics. Potier triangle and ASA method of finding regulation. V-curves, O-curves, and power angle characteristics. Parallel operation. Synchronizing. Hunting and its prevention. Starting of synchronous motors. Single phase synchronous motor. Single phase series and repulsion motor.

Recommended Books:

1. Dr. P.S. Bimbhra –Electrical Machinery
2. H. Cotton –Advanced Electrical Techniques
3. M.G. Say –Performance and Design of A.C. machines
4. I.J. Nagrath and D.P. Kothari: Electrical Machines

BTEE363 – NON-CONVENTIONAL ENERGY SOURCES

2L+IT **MM: 100** **Exam. Hrs. : 3**

1. **Introduction:** Energy crisis; demand and generation gap; energy management systems, alternative resources of energy & their utilization.

2. **Solar energy:** Principles, scope and applications, solar radiation, its measurement & prediction, flat plate collectors-design & theory, solar water heating, solar dryers, solar stills, solar cooling and refrigeration. Solar cells, thermal storage, street lighting, solar power generation.

3. **Wind energy:** Wind energy potential measurement, suitable sites, aero-foil design, and windmill and wind electrical generator.

4. **Geothermal energy:** Hot spring and steam ejection, site selection, power plant, advanced concepts.
5. Mini & Micro hydro-plants
6. Tidal energy.

Recommended Books

1. S.P. Sukhatme –Solar Energy
2. Duffie & Beckman –Solar Engineering of Thermal Processes
3. Dr. A. N. Mathur –Non-conventional Resources of Energy
4. B.R. Gupta –Generation of Electrical Energy

BTEE364 ELECTRICAL MEASUREMENTS

3L+1T **M.M.: 100**

Ex. Hrs.: 3

1. **Measuring instruments:**
   (a) Principle of operation, construction, torque equation, scale shapes uses and errors in moving coil, moving iron, electro-dynamic and induction instruments for the measurement of voltage, current and power. Errors in wattmeter and their compensation. Single phase and poly phase induction type energy meters. Energy meter errors, adjustment and testing.
   (b) Principle and working of Cathode Ray Oscilloscope and C.R.O. probes. D' Arsonval, Vibration and Ballistic galvanometers. Dynamic equation of motion and its solution for various. Relative Damping, logarithmic decrement and galvanometer sensitivities.
   (c) Theory and construction of Meggar, frequency meter and synchronoscopes.
2. **Potentiometers:** Theory of operation and construction of D.C. and A.C. potentiometers (polar and coordinate type). Their standardization and applications.
3. **Measurement of Resistance:** Methods of measurement of medium, low and high resistances. Loss of charge method. Measurement of earth resistance and soil resistivity.
4. **A.C. Bridges:** Generalized treatment of four-arm a.c. bridges. Sources and detectors. Maxwell's Inductance and capacitance bridges, Hay's bridge, Anderson Bridge, Heaviside mutual inductance bridge, Schering bridge, De sauty bridge and Wein's bridge. Sources of errors and their minimization in bridge measurement. Screens and Wagner earth device.
5. **Polyphase metering:** Blondel's theorem for n-phase, p-wire system. Measurement of power and reactive KVA in 3-phase balanced and unbalanced systems.
6. **Instrument Transformers:** Theory and construction of current and potential transformers. Ratio and phase angle errors and their minimization. Effects of variation of power factor, secondary burden and frequency on errors. Testing of CTs and PTs.
7. **Magnetic Measurements:** Determination of B-H curve and hysteric loop of ring and bar specimens. Measurement and separation of looses.

Text /References:

1. A.K. Sawhney: Electrical and Electronic Measurements and Measuring Instruments, Dhanpat Rai & Sons.
2. E.W. Golding: Electrical Measurements

BTEE484 STATIC PROTECTIVE RELAYS

3L+IT MM: 100 Exam. Hrs. : 3

1. **INTRODUCTION:** Basic for static relay development, classification of static relays, microprocessor based relays, Digital protection, advantages of digital protection. Basic protection scheme using microcomputer.

2. **STATIC RELAY COMPONENTS:** Semi conductor devices, static switching, logic circuits and relay logic. Integrated circuits, transducers and interface devices, replica impedances, time delay devices, sequence filters, voltage regulators.

3. **STATIC COMPARATORS:** Single input multi-input comparators. Amplitude comparator – integrating, instantaneous and sampling techniques; phase comparators – Vector product & coincidence techniques. Direct phase comparison, phase splitting technique, integrating phase comparison. Duality of amplitude and phase comparison.

4. **STATIC RELAYS:** Over current relays, directional over current relays using Hall crystal, rectifier bridge, instantaneous since comparator. Distance relay, impendence. Reactance, admittance, offset mho, trapezoidal and elliptical characteristics. Differential relays.

5. **SCHEMES OF PROTECTION:** Static switching scheme of distance relays. Polyphase distance relays. Static differential protection for generators, transformer and Bus zone. Static protection for motors, single-phase preventer.

6. **MODERN TRENDS IN POWER SYSTEM PROTECTION**: Auto recolsing, frequency relay-under frequency, over frequency and rate of change of frequency relay, static ultra high speed directional comparison line protection, reliability-dependability, security, redundancy, factors affecting the performance of relays, design reliability of complete protection schemes; improving technical reliability; routine tests, type tests ad reliability tests of relays.

RECOMMENDED BOOKS:

1. TMS Rao – Static Relays
2. M. Chander – Switchgear protection
3. S.S. Rao – Switchgear and protection

BTEE482 TRANSMISSION & DISTRIBUTION

3L + IT MM: 100 Exam. Hrs. : 3

1. **Supply systems:** Basic Network of power systems. Effect of system voltage on size of conductor and losses, comparison of dc 2-wire, dc –3 wire, 1 –phase ac and 3 phase (3 wire and 4 wire) ac systems, transmission voltages.

2. **Distribution automation:** Types of primary & secondary distribution system, voltage drop, Kelvin's law, Lamp flicker. Distribution automation, project planning, communication, sensors, supervisory control and data acquisition, consumer information service, introduction to automation systems.

3. **Insulators:** Pin, shackle, suspension, post and strain insulators, bushing, voltage distribution over an insulator string, grading and methods of improving string efficiency, pollution flashover.

4. **Mechanical features of overhead lines:** Different types of conductor materials with special reference to their mechanical properties. Line support, cross arms and stays, spacing and arrangement of conductors. Conductors' vibration and its prevention, sag tension, calculation for various conditions. Sag templates. Conductor erection and stringing.

5. **Parameters of transmission lines:** Resistance inductance and capacitance of overhead lines. Effect of earth. Line transposition. Geometric mean radius and distance. Inductance and capacitance of line with symmetrical and unsymmetrical spacing. Inductance and capacitance of double circuit lines. Skin and proximity effects.

6. **Performance of transmission lines:** Steady state analysis short, medium and long lines. Generalized ABCD line constant. Receiving end & sending end power circle diagrams. Ferranti effect. Interference with communication circuits.

7. **CORONA:** Electric stress between parallel conductors. Disruptive critical voltage and visual critical voltage. Calculation for 3-phase overhead line corona power loss. Factors affecting corona. Effect of corona.

8. **Underground cables:** Conductor, insulating, sheathing and armouring materials. Types of cables. Insulation resistance and capacitance calculation. Reduction of maximum stresses. Causes of breakdown, idea about oil filled and gas filled cables. Thermal rating of cable.

9. **Travelling waves:** Travelling waves on transmission lines. Wave equation, specification of travelling waves, Reflection and refraction of travelling waves, Typical cases of line terminations.

Recommended Books:

1. A.S. Pabla: Electric Power Distribution
2. B.R. Gupta: Power System Analysis & Design
3. Soni, Gupta and Bhatnagar: A course in Electrical Power
4. C.L. Wadhwa: Electrical Power Systems
5. Nagrath Kothari: Modern Power System Analysis
6. J.J. Grainger & W.D. Stevenson: Power System Analysis

BTEE481 **EHV AC/DC TRANSMISSION**

3L+IT **MM: 100** **Exam. Hrs. : 3**

1. **EHV AC TRANSMISSION:** Need of EHV transmission lines, power handling capacity and surge impedance loading. Problems of EHV transmission, bundled conductors geometric mean radius of bundle, properties of bundle conductors. Electrostatic fields of EHV lines and their effects, corona effects: Corona loss, audio and radio noise.

2. **LOAD FREQUENCY CONTROL:** Introduction to control of active and reactive power flow, trubin sped governing system. Speed governing characteristic of generating unit and parallel operation of generations. Element of load frequency control. Flat frequency, flat tie line and tie line load bias control. Automatic generation control (description of block diagram only)

3. **VOLTAGE CONTROL:** No load receiving end voltage and reactive power generation. Methods of voltage control. Synchronous phase modifier, shunt capacitors and reactors, saturable reactors, Thynstorised static VAR compensators.

4. **FACTS**: Introduction to FACTS controllers.

5. **HVDC TRANSMISSION:** Types of DC links, advantages and disadvantages of HVDC transmission. Basic scheme and equipment of converter station. Ground return. Basic principles of DC link control and basic converter control characteristics. Introduction to multi-terminal HVDC systems. Application of HVDC transmission.

RECOMMENDED BOOKS:

1. R.D. Begamudre – EHV AC Transmission Engineering.
2. K.R. Padiyar – HVDC Power Transmission system
3. J.J. Grainger and W.D. Stevenson – Power System Analysis
4. B.R. Gupta – Generation of Electrical Engineering
5. K.R. Padiyar – Flexible AC transmission systems – A status review, Summer School on "Recent Advances in Power Electronics". August 10-21, 1998, IISc Bangalore, Page 10.1 to 10.16.

BTEE372 – SWITCH GEAR & PROTECTION

3L+IT **MM: 100** **Exam. Hrs. : 3**

1. **Introduction:** Causes and consequences of dangerous currents; fault, overloads and switching over currents. Basic idea of an over current relay as a level detector. Selectively discrimination, sensitivity, reliability of relay. Fastness of operation. Upper and lower limits for the time of relay operation. Current grading. Time

grading. Time grading and inverse time operation. Primary and backup protection. Pick up and reset values.

2. **Construction and operation of relay:** Construction and operation of electromagnetic over current and directional relays. Directional element to be realized from rectifier bridge circuits. Connection of directional element and their operating characteristics. Directional relay connections 30 Deg., 60 Deg. and 90 Deg. connections. Directional Earth fault relay. Directional Relay Connections 30 Deg., 60 Deg., and 90 Deg. connections. Directional Earth fault relay.

3. **Distance protection of transmission lines:** Construction and characteristics of impedance relay, C.T. and P.T. connection for performance. Reactance and mho relay characteristics. Transmission line protection.

4. **Carrier current protection of transmission lines:** Basic apparatus used for power line carrier system. Principle of operation of directional comparison and phase comparison carrier protection, carrier assisted distance protection.

5. **Protection of synchronous generators and transformers:** Faults in stator winding of alternators, differential protection. Effect of resistance in the star point earthling. Single and multiple ground faults on the rotor. Protection against excitation failure and prime mover failure. Negative sequence protection. Differential protection of generator transformer unit. Differential protection of 3-phase transformers; effect of magnetizing inrush currents, methods for minimizing the effects. Buchholtz protection. CT connections.

6. **Bus bar protection:** Frame leakage and circulating current protection.

7. **Circuit breakers:** Electric arc, arc characteristics, theories of current interruption, energy balance and recovery rate theory, transient recovery voltage in simple three phase circuits, rate of rise of restricting voltage, resistance switching, current chopping, interruption of capacitive currents. Circuit breaker ratings. Practical systems of arc quenching in air and oil. Construction and operation of bulk oil, minimum oil and air blast circuit breakers. Recent trends in HV circuit breakers, sulpher hexa fluoride, vacuum circuit breakers, principle of DC circuit breaking, testing of circuit breakers.

Recommended Books:

1. M. Chander: Switchgear Protection
2. S.S. Rao: Switchgear & Protection
3. T.M.S. Rao: Static Relays

BTEE373 POWER SYSTEM ENGINEERING

2L+IT MM: 100 Exam. Hrs. : 3

1. **Economic operation of power systems:** Input –output curves, heat rate and incremental rate curves of generating units. Economic distribution of load between generating units within a plant. Economic distribution of load between power stations, transmission loss equation. Unit commitment and dynamic programming method. Introduction to power system security.

2. **Power system stability:** Power angle equations and power angle curves under steady. State and transient conditions. Rotor dynamics and swing equation (solution of swing equation not included). Steady state, dynamic and transient stability. Synchronizing power coefficient, and stability limits. Introductory explanation of equal area criterion and its application. Critical clearing angle and critical cleaning time of circuit breaker use of auto-reclosing circuit breakers. Factors affecting stability and methods to improve stability.

3. **Excitation systems:** Types of excitation systems. D.C. excitation system, automatic voltage regulator, use of amplidyne and magnetic amplifier. A.C. excitation systems: Shunt excitation system, separate excitation system and brush less excitation system. Solid –state automatic voltage regulator (description of block diagram only).

4. **Interconnected power systems:** Reserve capacity of power station, spinning and maintenance reserves. Advantages and problems of interconnected power systems. Power system interconnection in India.

5. **Voltage control:** Tap changing transformer, phase angle control and phase shifting transformers. Series compensation of transmission lines, Location and Protection of series capacitors, advantages and problems.

Recommended Books

1. I. J. Nagrath and D. P. Kothari: Power System Engineering
2. J.J. Grainger and W.D. Stevenson: Power System Analysis
3. B.R. Gupta: Generation of Electrical Energy
4. C.L. Wadhwa: Electrical Power Systems
5. C.M. Arora: Power System Engineering

BTEE374 POWER SYSTEM ANALYSIS

2l+IT **MM: 100** **Exam. Hrs. : 3**

1. Percent and Per unit quantities. Single line diagram for a balanced 3-phase system.

2. **Symmetrical fault analysis:** Transient in R-L Circuit. Symmetrical and asymmetrical short circuit currents in synchronous generator. Equivalent circuits of synchronous machine under sub transient, transient and steady state conditions. Analysis of three phase faults.

3. **Symmetrical components:** Fortescue theorem, symmetrical component transformation. Phase shift in star-delta transformer. Sequence impedances of

synchronous machine, transformers and transmission lines. Zero sequence networks of transformers and transmission lines. Construction of sequence networks of a power system.

4. **Unsymmetrical fault analysis:** Signal line to ground, line-to-line and double line to ground faults, connection of sequence networks under fault conditions. Analysis of unsymmetrical faults using symmetrical components.

5. **Load flow analysis:** Static load flow equations (SLFE). System variables. Solution of SLFE. Bus admittance matrix. Bus classification. Load flow problems. Gauss Seidel, Newton Raphson, decoupled and fast decoupled methods for load flow analysis. Comparison of methods.

Recommended Books:

1. J.J. Grainger, William, D. Stevenson Jr. –Power System Analysis
2. C.L. Wadhwa –Electrical Power Systems
3. Nagrath and Kothari –Power system Engineering

BTEE375 ELECTRIC DRIVES AND THEIR CONTROL

3L+IT MM: 100 Exam. Hrs. : 3

1. **Characteristics of electric motors:** Characteristic of dc motors, three phase induction motors and synchronous motors.

2. **Dynamics of electric drives:** Fundamental torque equations, speed torque conventions and multi-quadrant operation, equivalent values of drive parameters, components of load torques, nature and classification of load torques, calculation of time and energy loss in transient operations, steady state stability, load equalization.

3. **Control of DC drives:** Basic machine equation, operating modes: motoring, and breaking modes. Schemes for dc motor speed control single-phase drive, three phase drive, chopper drive, close loop control, phase-locked-loop control and microcomputer control. Braking operation of rectifier controlled and chopper controlled dc drives.

4. **Control of AC drives:** Induction motor drives: Basic principle of operation, stator voltage control, rotor voltage control, frequency control, voltage and frequency control, current control, voltage, current and frequency control, Close-loop control, Synchronous motor drive: Cylindrical rotor, salient pole, reluctance, permanent magnet and switch reluctance motors Close loop control of synchronous motors. Brushless DC and AC drives.

Recommended Books:

1. G.K. Dubey :Fundamentals of Electrical Drives, Narosa Publishing House, New Delhi, 1995

2. V. Subrahmanyam: Thyristor Control of Electric Drives, Tata McGraw Hill, New Delhi, 1988
3. V. Subrahmanyam: Electric Drives –Concepts and Applications, Tata McGraw Hill, New Delhi
4. S.K. Pillai: A first Course on Electrical Drives, Wiley Eastern Limited, India
5. B. K. Bose: Power Electronics and A.C. Drives, Prentice Hall

BTEE376 UTILIZATION OF ELECTRIC POWER INCLUDING TRACTION
3l+IT MM: 100 Exam. Hrs. : 3

1. **Electrical heating & welding:** Different methods of electric heating. Principle of high frequency induction and di-electric heating. Construction, operation, performance and applications of arc furnace and induction furnace. Classification of electric welding Electric arc welding. Electric supply for arc welding: welding transformers. Resistance welding.

2. **Electric drives:** Characteristics of load, Reviews of starting and running characteristics of various D.C. A.C. industrial motors. Relative study of efficiency, power factor, size and costs. Starting and speed control of motors. Electric braking, plugging, Rheostatic braking, regenerative braking. Behaviour of motor during starting, acceleration, braking and reversing operations. Speed time relations, Load equalization. Use of flywheels. Determination of motor rating for intermittent loads. Drives for machine tools, lift and cranes, paper mills, printing machinery, rolling for intermittent. Loads.

3. **Electric Traction:** Systems of electric traction, power supply systems for track electrification – comparison and application of different systems.

4. **Traction Methods:** Types of services, speed time and speed distance curves, average and schedule speed. Tractive effort. Estimation of power and energy requirements: specific energy consumption, Mechanics of train movement. Co-efficient of adhesion, Adhesive weight, effective weight.

5. **Traction motor control:** D.C. and A.C. traction motors, special requirements of selection of type. Speed torque /current characteristics. Various methods of starting and speed control and D.C. A.C. drives used in traction. Series parallel starting. Shunt and bridge transition, drum and contacted type controllers. Metadyne control. Multiple unit control, Master controllers. Methods of electric braking of traction motors.

6. **Means of supplying power and train lighting:** Sub-station equipment and layout. Feeding and distribution systems. Overhead equipment, current collection, gear, negative boosters. System of train lighting, special requirements, methods of obtaining unidirectional polarity and constant output voltage.

Recommended Books:

1. H. Pratap –Art & Science of Utilization of Electric
2. H. Pratap –Modern Electric Traction
3. C.L. Wadhwa –Utilization of Electric Traction Electric Power
4. G.K. Dubey –Electric Drives
5. Vedam and Subrahmanyam –Concept & Application of Electric Drives