ELECTRICAL ENGINEERING

EVALUATION SCHEME - B.TECH 4th YEAR

SEMESTER- VII

Sl. No.	Subject Codes	Subject	Periods			Evaluation Scheme				End Semester		Total	Credit
			L	T	P	CT	TA	Total	PS	TE	PE		
1	KHU701 /KHU702	HSMC -1 #/ HSMC-2 #	3	0	0	30	20	50		100		150	3
2	KEE07X	**Departmental Elective-IV**	**3**	**0**	**0**	**30**	**20**	**50**		**100**		**150**	**3**
3	KEE07X	**Departmental Elective-V**	**3**	**0**	**0**	**30**	**20**	**50**		**100**		**150**	**3**
4	KOE07X	Open Elective-II	3	0	0	30	20	50		100		150	3
5	KEE751	Industrial Automation & PLC Lab	0	0	2				25		25	50	1
6	KEE752	Mini Project or Internship Assessment*	0	0	2				50			50	1
7	KEE753	Project I	0	0	8				150			150	4
8		MOOCs (Essential for Hons. Degree)											
		TOTAL	**12**	**0**	**12**							**850**	**18**

*The Mini Project or internship (4 - 6 weeks) conducted during summer break after VI semester and will be assessed during VII semester.

Department Elective - IV	**Department Elective - V**
KEE070: Advanced Micro processors & Micro Controllers KEE071: Energy Conservation and Auditing KEE072: HVDC & AC Transmission KEE073: High Voltage Engineering KEE074: Power Quality and FACTS	KEE075: Electric drives KEE076: Power System dynamics and Control KEE077: Power System Protection KEE078: Deregulated Power System KEE079: Utilization of Electrical Energy & Electric Traction

SEMESTER- VIII

Sl. No.	Subject Codes	Subject	Periods			Evaluation Scheme				End Semester		Total	Credit
			L	T	P	CT	TA	Total	PS	TE	PE		
1	KHU801/ KHU802	HSMC-2#/HSMC-1#	3	0	0	30	20	50		100		150	3
2	KOE08X	Open Elective-III	3	0	0	30	20	50		100		150	3
3	KOE08X	Open Elective-IV	3	0	0	30	20	50		100		150	3
4	KEE851	Project II	0	0	18				100		300	400	9
5		MOOCs (Essential for Hons. Degree)											
		Total	**9**	**0**	**18**							**850**	**18**

INDUSTRIAL AUTOMATION & PLC LAB [L T P: 0 0 2]

List of Experiments: minimum 10 nos. of experiments to be performed from following sets,

A) Industrial Automation:

1. Study hardware and software platforms for DCS
2. Simulate analog and digital function blocks
3. Study, understand and perform experiments on timers and counters
4. Logic implementation for traffic Control Application
5. Logic implementation for Bottle Filling Application
6. Tune PID controller for heat exchanger using DCS
7. FBD for auto-clavable laboratory fermenter
8. Develop graphical user interface for the fermenter plant

B) PLC

1. Study hardware and software used in PLC
2. Implementation Logic Gates
3. Implementation of DOL Starter
4. Implementation of On-Delay Timer
5. Implementation of Off-Delay Timer
6. Implementation of Up-Down Counter
7. Implementation of PLC Arithmetic Instructions
8. Implementation of PID Controller

Note: - virtual lab links:

For Industrial Automation:

http://ial-coep.vlabs.ac.in/List%20of%20experiments.html?domain=Electrical%20Engineering

For PLC:

http://plc-coep.vlabs.ac.in/List%20of%20experiments.html?domain=Electrical%20Engineering

DEPARTMENT ELECTIVE – IV

[L T P: 3 0 0]

ADVANCED MICRO PROCESSORS & MICRO CONTROLLERS

Pre-requisites of course: Digital Electronics

	Course Outcomes:	Knowledge Level, KL
	Upon the completion of the course, the student will be able to:	
CO1	Explain the Architecture of 8086, memory segmentation and its mode.	K2
CO2	Describe the Instruction set of 8086, and develop various type of programs.	K2
CO3	Illustrate memory interfacing diagram , and explain various type of interfacing	k3
CO4	Illustrate various modes of processor.	K3
CO5	Explain the architecture of MSP430 and Develop GPIO controlling Program.	K2

UNIT1

8086 architecture-functional diagram, register organization, memory segmentation, programming model, memory address, physical memory organization, pins description, maximum mode and minimum mode signal descriptions.

UNIT2

Instruction formats, addressing modes, instruction set of 8086, simple programs involves data transfer operation, arithmetic operation, logical operation, branch operation, machine control operation, string manipulations, stack and subroutine operations.

UNIT3

Memory interfacing to 8086. Interrupt structure of 8086, interrupt handling, vector interrupt table and interrupt Service routine. Interfacing programmable peripheral interface 8255, Timer IC 8253 and Interrupt controller 8259 to 8086.

UNIT4

Mode of operation of higher order processors: Real mode and protected mode, Real mode and protected mode memory addressing, access right byte, Memory paging, System descriptors, Multi-Tasking & TSS, Block Diagram 0f 80286, ARM Processor

UNIT5

MSP430 Microcontroller: block diagram, on-chip peripherals (analog and digital), and Register sets. Instruction set, instruction formats, addressing modes of MSP microcontroller. Memory Mapped Peripherals, programming System registers, I/O pin multiplexing, pull up/down registers, GPIO control. Interrupts and interrupt programming.

Text Book:

1. Ray, A.K. &Burchandi, K.m., “Advanced Microprocessors and Peripherals: Architeacture, Programming and Interfacing” Tata Mc.Graw Hill.
2. Renu Sing &B.P.Singh, “Advanced Microprocessors and Microcontrollers” New Age
3. International. 3. Krishna Kant,”Microprocessors and Microcontrollers” PHI Learning. 4. Brey, Barry B. “The INTEL Microprocessors” Pearson Education.
4. John H Davies, “MSP430 Microcontroller Basics” Newnes Publication.

Reference Book:

1. TI MSP430x5xx and MSP430x6xx Family User's Guide.

ENERGY CONSERVATION AND AUDITING

Pre-requisites of course: Basic Electrical Engineering, Power System-I & II

Course Outcomes:		Knowledge Level, KL
Upon the completion of the course, the student will be able to:		
CO1	Identify and assess the energy conservation/saving opportunities in different electric system and understand related legislations.	**K1**
CO2	Identify and assess the energy saving behavior of utilities through implementation of DSM and EMIS.	**K1**
CO3	Explain energy audit & management and to prepare energy audit report for different energy conservation instances.	**K2**
CO4	Illustrate the energy audit for Mechanical Utilities.	**K3**
CO5	Describe cost-effective measures towards improving energy efficiency and energy conservation by implementation of energy efficient technologies.	**K2**

UNIT-1: Energy Scenario: Classification of Energy, Indian energy scenario, Sectorial energy consumption (domestic, industrial and other sectors), energy needs of growing economy, energy intensity, long term energy scenario, energy pricing, energy security, energy conservation and its importance, energy strategy for the future.

Energy Conservation Act 2001 and related policies: Energy conservation Act 2001 and its features, notifications under the Act, Schemes of Bureau of Energy Efficiency (BEE) including Designated consumers, State Designated Agencies, Electricity Act 2003, Integrated energy policy, National action plan on climate change, ECBC code for Building Construction.

UNIT-2: Demand Side Management (DSM): Concept and Scope of Demand Side Management, Difference between Energy Efficiency and DSM, Evolution of Demand Side Management, DSM Strategy, Planning, Implementation and its application, Customer Acceptance & its implementation issues, National and International Experiences with DSM, UDAY scheme and other government initiatives for DISCOMs.

Energy Monitoring and Targeting: Defining monitoring & targeting, elements of monitoring & targeting, data and information-analysis, techniques –energy consumption, production, cumulative sum of differences (CUSUM). Energy Management Information Systems (EMIS)

UNIT-3: Energy Audit: Aim of energy Audit, Strategies of Energy Audit, Energy management Team Consideration in implementing energy conservation Programme, Process flow diagram, Energy Audit report format, Benchmarking and Energy Performance, Instruments for energy audit, Economic analysis.

UNIT-4: System Audit of Mechanical Utilities: Pumps, types and application, unit's assessment, improvement option, parallel and series operating pump performance. Energy Saving in Pumps & Pumping Systems. Bloomers (Blowers) types & application, its performance assessment, series & parallel operation applications & advantages. Energy Saving in Blowers Compressors, types & applications, specific power consumption, compressed air system & economic of system changes. Energy Saving in Compressors & Compressed Air Systems Cooling towers, its types and performance assessment & limitations, water loss in cooling tower. Case studies related to Energy Audit & Management in Industries

UNIT-5: Energy Efficient Technology: Need for Energy Efficient Devices, Life Cycle Assessment, Comparison between simple pay-back and life cycle cost assessment, Energy Efficient Motors-motor losses and loss reduction techniques, determining and comparing motor efficiencies, motor efficiency testing standards, BIS specification for Energy Efficient Motors, efficiency as a function of load, Energy Efficient Lighting Sources-compact fluorescent lamp, light emitting diode, LED lamp, role of voltage on the efficiency of lighting system, Importance of Automatic power factor controllers, Variable Frequency Drives.

Reference Books:

1.Energy Conservation Guidebook,Dale R Patrick, Stephen W Fardo, 2nd Edition, CRCPress
2.Handbook of Energy Audits, Albert Thumann, 6th Edition, The Fairmont Press
3.Energy Management Handbook, W.C. Turner, John Wiley and Sons, A WileyInterscience publication
4.Carbon Capture and Sequestration: Integrating Technology, Monitoring, and Regulation edited byE J Wilson and D Gerard, Blackwell Publishing
5. Heating and Cooling of Buildings -Design for Efficiency, J. Krieder and A. Rabl, McGraw Hill Publication, 1994.

HVDC & AC TRANSMISSION

Pre-requisites of the course: Power System-I & II

Course Outcome No.	Statement	Knowledge Level, KL
CO1	Describe the comparison of EHVAC and HVDC transmission while understanding various issues related to transmission.	K1
CO2	Calculate and study the corona loss and its impacts. Cite examples of the causes of switching overvoltage, Ferro-resonance.	K3
CO3	Explain the generation and measurement circuits for impulse, high DC & AC voltages. While considering the design parameters evaluate the effect on the performance of the EHV lines.	K2
CO4	Classify the DC links and choice of converter configuration to investigate the impact of inductance on operation of converters and identify different control schemes as well as starting and stopping methods of DC links.	K4
CO5	Describe the converter faults, protections including MTDC types and applications .	K2

UNIT-I: EHV transmission, standard transmission voltage, comparison of EHV AC & DC transmission systems and their applications & limitations, surface voltage gradients in conductor, distribution of voltage gradients on sub-conductors, mechanical considerations of transmission lines, modern trends in EHV AC and DC transmission, UHVAC transmission system.

UNIT-II: EHV AC Transmission: Corona loss formulas, corona current, audible noise – generation and characteristics corona pulses their generation and properties, radio interference (RI) effects, over voltage due to switching, ferro-resonance, reduction of switching surges on EHV system, principle of half wave transmission.

UNIT-III: Extra High Voltage Testing: Characteristics and generation of impulse voltage, generation of high AC and DC voltages, measurement of high voltage by sphere gaps and potential dividers.

Consideration for Design of EHV Lines: Design factors under steady state limits, EHV line insulation design based upon transient over voltages. Effects of pollution on performance of EHV lines.

UNIT-IV:EHV DC Transmission – I: Types of dc links, converter station, choice of converter configuration and pulse number, effect of source inductance on operation of converters, working principle and characteristics of a 6 pulse converter with two & three valve conduction mode, three valve conduction mode and three and four valve conduction mode, Principle of DC link control, converter controls characteristics, firing angle control, current and excitation angle control, power control, starting and stopping of DC link.

UNIT-V:EHV DC Transmission – II: Converter faults, protection against over currents and over voltages, smoothing reactors, generation of harmonics, AC and DC filters, Multi Terminal DC systems (MTDC): Types, control, protection and applications.

Text Books:

1. R. D. Begamudre, “Extra High Voltage AC Transmission Engineering” Wiley Eastern.
2. K. R. Padiyar, “HVDC Power Transmission Systems: Technology and System Reactions” New AgeInternational.
3. J. Arrillaga, “High Voltage Direct Current Transmission” IFFE Power Engineering Series 6, Peter Peregrinus Ltd, London.
4. M. S. Naidu & V. Kamaraju, “High Voltage Engineering” Tata Mc Graw Hill.

Reference Books:

5. M. H. Rashid,“Power Electronics: Circuits, Devices and Applications” Prentice Hall of India.
6. S. Rao, “EHV AC and HVDC Transmission Engineering and Practice” Khanna Publisher.
7. “EPRI, Transmission Line Reference Book, 345 KV and above” Electric Power Research Institute. PaloAlto, California, 1982.

HIGH VOLTAGE ENGINEERING

Pre-requisites of course: Power System-I and II

Course Outcomes:		Knowledge Level, KL
Upon the completion of the course, the student will be able to:		
CO1	Describe conduction and breakdown phenomenon in gases, liquid dielectrics and solid dielectrics.	K1
CO2	Explain generation of high voltages and currents	K2
CO3	Explain measurement techniques for high voltages and currents	K2
CO4	Describe overvoltage phenomenon and insulation coordination in electric power systems.	K2
	Describe non-destructive testing of materials and electric apparatus andhigh-voltage testing of electric apparatus	K2

UNIT-I: Conduction and Breakdown in Gases:

Gases as Insulating Media, Collision Process, Ionization Processes, Townsend's Current Growth Equation, Current Growth in the Presence of Secondary Processes, Townsend's Criterion for Breakdown, Experimental Determination of Coefficients α and γ, Breakdown in Electronegative Gases, Time Lags for Breakdown, Streamer Theory of Breakdown in Gases, Paschen's Law, Breakdown in Non-Uniform Fields and Corona Discharges.

Conduction and Breakdown in Liquid Dielectrics:Liquids as Insulators, Pure Liquids and Commercial Liquids, Conduction and Breakdown in Pure Liquids, Conduction and Breakdown in Commercial Liquids.

Breakdown in Solid Dielectrics:Introduction, Intrinsic Breakdown, Electromechanical Breakdown, Thermal Breakdown.

UNIT-II: Generation of High Voltages and Currents:

Generation of high direct current voltages, generation of high alternating voltages, generation of impulse voltages, generation of impulse currents, tripping and control of impulse generators.

UNIT –III: Measurement of High Voltages and Currents:

Measurement of high direct current voltages, measurement of high alternating and impulse voltages, measurement of high direct, alternating and impulse currents, Cathode Ray Oscillographs for impulse voltage and current measurements.

UNIT-IV: Overvoltage Phenomenon and Insulation Coordination in Electric Power Systems

National Causes for Overvoltages - Lightning Phenomenon, Overvoltage due to Switching Surges, System Faults and Other Abnormal, Principles of Insulation Coordination on High Voltage and Extra High Voltage Power Systems.

UNIT-V: Non-Destructive Testing of Materials and Electrical Apparatus

Measurement of dielectric constant and loss factor, partial discharge measurements

High Voltage Testing: Testing of insulators and bushings, testing of isolators and circuit breakers, testing of cables, testing of transformers, testing of surge arresters, radio interference measurements.

Text Books:

1. M. S. Naidu and V. Kamaraju, "High Voltage Engineering, Tata Mc-Graw Hill.
2. C. L. Wadhwa, "High Voltage Engineering", Wiley Eastern Ltd.

Reference Books:

1. E. Kuffel and W. S. Zacngal, High Voltage Engineering", Pergamon Press.
2. M. P. Chaurasia , "High Voltage Engineering", Khanna Publishers
3. R. S. Jha, "High Voltage Engineering", DhanpatRai& sons
4. M. Khalifa,' High Voltage Engineering Theory and Practice,' Marcel Dekker.
5. Subir Ray,' An Introduction to High Voltage Engineering' Prentice Hall of India

POWER QUALITY AND FACTS

Pre-requisites of the course: Power System-I & II

Course Outcome		Knowledge Level
Upon the completion of the course, the student will be able to:		
CO1	Classify the power quality issues in electrical distribution network	K2
CO2	Describe the sources of voltage sag and protective devices including voltage regulators, active series compensator and UPS.	K1
CO3	Describe the different phenomenon causing electrical transients and devices for over voltage protection.	K2
CO4	Explain the working and application of different type of FACT devices like SSC, SVC, TSC, SSS, TCSC, UPFC.	K2
CO5	Explain the causes of harmonics, its effect on motor ,capacitor, cables and mitigation techniques.	K2

Unit-I: Introduction to Power Quality:
Terms and definitions of transients, Long duration Voltage Variations: under Voltage, Under Voltage and Sustained Interruptions; Short Duration Voltage Variations: interruption, Sag, Swell; Voltage Imbalance; Notching D C offset, waveform distortion; voltage fluctuation; power frequency variations.

Unit-II: Voltage Sag:
Sources of voltage sag: motor starting, arc furnace, fault clearing etc; estimating voltage sag performance and principle of its protection; solutions at end user level- Isolation Transformer, Voltage Regulator, Static UPS, Rotary UPS, and Active Series Compensator.

Unit-III: Electrical Transients:
Sources of Transient Over voltages- Atmospheric and switching transients- motor starting transients, pf correction capacitor switching transients, ups switching transients, neutral voltage swing etc; devices for over voltage protection.

Unit-IV: FACT Systems:
Introduction – Terms & Definition, Fact Controllers, Type of FACT devices i.e. SSC, SVC, TSC, SSSC, TCSC, UPFC Basic relationship for power flow control.

Unit- V: Harmonics:
Causes of harmonics; current and voltage harmonics: measurement of harmonics; effects of harmonics on – Transformers, AC Motors, Capacitor Banks, Cables, and Communication Lines etc., Harmonic Mitigation Techniques.

Text Books:

1. Roger C Dugan, McGrahan, Santoso&Beaty, “Electrical Power System Quality” McGraw Hill
2. Arindam Ghosh & Gerard Ledwich, “Power Quality Enhancement Using Custom Power Devices” Kluwer Academic Publishers
3. C. Sankaran, “Power Quality” CRC Press.
4. S. Sivanagaraju& S. Satyanarayana, “Electric Power Transmission and Distribution” Pearson Education
5. Narain G. Hingorani& Laszlo Gyugyi “Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems” Wiley

DEPARTMENT ELECTIVE – V

[L T P: 3 0 0]

ELECTRIC DRIVES

Pre-requisites of the course: Power Electronics, Electrical Machines-I & II

Course Outcome		Knowledge Level
Upon the completion of the course, the student will be able to:		
CO1	Describe the operation of electric drives and its classification.	**K1**
CO2	Explain the electric drive stability and selection of motor power rating.	**K2**
CO3	Illustrate electric braking and its dynamics.	**K3**
CO4	Describe the types of DC drives and its control.	**K2**
CO5	Describe the types of AC drives and its control.	**K2**

UNIT-I: Fundamentals of Electric Drive:
Electric Drives and its parts, advantages of electric drives, Classification of electric drives, Speed-torque conventions and multi-quadrant operations, Constant torque and constant power operation, Types of load, Load torque: components, nature and classification.

UNIT-II: Dynamics of Electric Drive:

Dynamics of motor-load combination, Steady state stability of Electric Drive, Transient stability of electric Drive

Selection of Motor Power rating: Thermal model of motor for heating and cooling, classes of motor duty, determination of motor power rating for continuous duty, short time duty and intermittent duty., Load equalization.

UNIT-III: Electric Braking:

Purpose and types of electric braking, braking of dc, three phase induction and synchronous motors

Dynamics During Starting and Braking: Calculation of acceleration time and energy loss during starting of dc shunt and three phase induction motors, methods of reducing energy loss during starting. Energy relations during braking, dynamics during braking.

UNIT-IV: Power Electronic Control of DC Drives:

Single phase and three phase controlled converter fed separately excited dc motor drives (continuous conduction only), dual converter fed separately excited dc motor drive, rectifier control of dc series motor. Supply harmonics, power factor and ripples in motor current Chopper control of separately excited dc motor and dc series motor.

UNIT-V: Power Electronic Control of AC Drives:

Three Phase induction Motor Drive: Static Voltage control scheme, static frequency control scheme (VSI, CSI, and cyclo – converter based) static rotor resistance and slip power recovery control schemes.

Three Phase Synchronous motor: Self controlled scheme

Special Drives: Switched Reluctance motor, Brushless dc motor. Selection of motor for particular applications

Text Books:

1. G.K. Dubey, “Fundamentals of Electric Drives”, Narosa publishing House.
2. S.K.Pillai, “A First Course on Electric Drives”, New Age International.

Reference Books:

1 M.Chilkin, “Electric Drives”,Mir Publishers, Moscow.
2 Mohammed A. El-Sharkawi, “Fundamentals of Electric Drives”, Thomson Asia, Pvt. Ltd. Singapore.
3 N.K. De and Prashant K.Sen, “Electric Drives”, Prentice Hall of India Ltd.
4 V.Subrahmanyam, “Electric Drives: Concepts and Applications”, Tata McGraw Hill.

POWER SYSTEM DYNAMICS AND CONTROL

Pre Requisite- Electrical Machines-II, Power System-I, Power System-II, Control Systems

Course Outcome		Knowledge Level
Upon the completion of the course, the student will be able to:		
CO1	Explain the fundamental dynamic behavior and controls of power systems to perform basic stability analysis.	**K2**
CO2	Describe modeling of Synchronous Machine and per unit quantities-Equivalent circuits.	**K2**
CO3	Describe modeling of main power system components, such as synchronous machines, excitation systems and calculation of Initial conditions	**K2**
CO4	Illustrate Small signal analysis, synchronizing and damping torque analysis.	**K3**
CO5	Explain the concept of Power System Stabilizers, Structure & tuning and dynamic compensator analysis.	**K2**

UNIT- I: Basic Concepts: Power system stability states of operation and system security, system dynamics, problems system model analysis of steady State stability and transient stability, simplified representation of Excitation control.

UNIT- II: Modeling of Synchronous Machine: Synchronous machine, Park's Transformation-analysis of steady state performance, per unit quantities-Equivalent circuits of synchronous machine determination of parameters of equivalent circuits.

UNIT- III: Excitation System: Excitation system modeling-excitation systems block Diagram – system representation by state equations, Dynamics of a synchronous generator connected to infinite bus, system model Synchronous machine model-stator equations rotor equations, Synchronous machine model with field circuit, one equivalent damper winding on q axis, calculation of Initial conditions.

UNIT- IV: Analysis of Single Machine System: Small signal analysis with block diagram – Representation Characteristic equation and application of Routh Hurwitz criterion, synchronizing and damping torque analysis-small signal model, State equations.

UNIT – V: Application of Power System Stabilizers: Basic concepts in applying PSS, Control signals, Structure and tuning of PSS, Washout circuit , Dynamic compensator analysis of single machine infinite bus system with and without PSS.

TEXT BOOKS:

1. K. R. PADIYAR," Power system dynamics "- B.S. Publications.
2. P.M. Anderson and A. A. Fouad, "Power system control and stability", IEEE Press

REFERENCE:

3. R. Ramanujam, "Power Systems Dynamics"- PHI Publications.

POWER SYSTEM PROTECTION

Pre-requisites of the course: Power System-I, Power System-II

Course Outcome		Knowledge Level
Upon the completion of the course, the student will be able to:		
CO1	Describe the relays and different protective schemes.	**K1**
CO2	Explain Relay types and its application.	**K2**
CO3	Describe types of faults and protection scheme for major components of power system.	**K2**
CO4	Describe the circuit breaker operation, testing and types.	**K2**
CO5	Explain the electronic relay, microprocessor and computer based protection schemes.	**K2**

Unit-I: Protection Scheme
Need for Protective systems, Evolution of protective relays - Zones of protection - Primary and Back -up Protection - Essential qualities of Protection - Classification of Protective schemes -Automatic reclosing – current transformer for Protection - potential transformer - summation transformer -phase – sequence current - segregating network

Unit-II: Relays:
Electromagnetic, attracted and induction type relays, thermal relay, gas actuated relay, design considerations of electromagnetic relay. Relay Application and Characteristics: Amplitude and phase comparators, over current relays, directional relays, distance relays, differential relay Static Relays: Comparison with electromagnetic relay, classification and their description, over current relays, directional relay, distance relays, differential relay.

Unit-III: Protection of Components
Types & detection of faults and their effects, alternator protection scheme (stator, rotor, reverse power protection etc.) - Power transformer protection (external and internal faults protection), generator-transformer unit protection scheme, bus bar protection - Transmission line protection (current/time grading, distance), Pilot relaying schemes, power line carrier protection.

Unit-IV: Circuit Breaking
Properties of arc, arc extinction theories, re-striking voltage transient, current chopping, resistance switching, capacitive current interruption, short line interruption, circuit breaker ratings. Testing of Circuit Breaker: Classification, testing station and equipment, testing procedure, direct and indirect testing, selection of circuit breakers. constructional features and operation of Bulk Oil, Minimum Oil, Air Blast, SF6, Vacuum and d. c. circuit breakers.

UNIT V- Modern Trends in Protection
Electronic relays - static relays functional circuits: comparators, level detectors, logic and training circuits, microprocessor and computer based protection schemes - software development for protection, security and reliability.

Text Books:
1. S. S. Rao, “Switchgear and Protection”, Khanna Publishers.
2. B. Ravindranath and M. Chander, Power system Protection and Switchgear, Wiley Eastern Ltd.
3. B. Ram and D. N. Vishwakarma, “Power System Protection and Switchgear”, Mc Graw Hill

DEREGULATED POWER SYSTEM

Pre-requisites of the course: Power System-I & II

Course Outcome		Knowledge Level
Upon the completion of the course, the student will be able to:		
CO1	Describe the deregulation, unbundling of electric utilities and its benefits.	**K1**
CO2	Explain the operational planning activities of independent system operator in pool & bilateral markets and describe competitive bidding.	**K2**
CO3	Explain the open access of transmission line and management of security & congestion in deregulation.	**K2**
CO4	Describe the different types of Electric traction, system of track electrification and its related mechanics	**K2**
CO5	Illustrate the Reliability Analysis of Generation, transmission and distribution and the regulation of the market.	**K3**

UNIT-I: Deregulation, Reconfiguring Power systems, unbundling of electric utilities, Background to deregulation and the current situation around the world, benefits from a competitive electricity market after effects of deregulation

UNIT-II: Role of the independent system operator, Operational planning activities of ISO: ISO in Pool markets, ISO in Bilateral markets, Operational planning activities of a GENCO: Genco in Pool and Bilateral markets, market participation issues, competitive bidding.

UNIT-III: Power wheeling, Transmission open access, pricing of power transactions, security management in deregulated environment, and congestion management in deregulation

UNIT-IV: General description of some ancillary services, ancillary services management in various countries, and reactive power management in some deregulated electricity markets.

UNIT-V: RELIABILITY ANALYSIS*:* Interruption criterion, stochastic components, component models, Calculation methods, Network model: stochastic networks, series and parallel connections, minimum cut sets, reliability cost. Generation, transmission and distribution reliability, Reliability and deregulation: conflict, reliability analysis, effects on the actual reliability, regulation of the market.

Text Books:

1. K. Bhattacharya, MHT Bollen and J.C Doolder, “Operation of Restructured Power Systems”, Kluwer Academic Publishers, USA, 2001.
2. Lei Lee Lai, “Power System restructuring and deregulation”, John Wiley and Sons, UK. 2001.
3. Fred I Denny and David E. Dismukes, “Power System Operations and Electricity Markets”, CRC Press, LLC, 2002.

UTILIZATION OF ELECTRICAL ENERGY & ELECTRIC TRACTION

Pre-requisites of the course: Basic Electrical Engineering, Electrical Machines-I & II

Course Outcome		Knowledge Level
Upon the completion of the course, the student will be able to:		
CO1	Describe the methods of electric heating and their advantages.	**K1**
CO2	Explain the types of Electric welding and the principle of Electro-deposition, laws of electrolysis and its applications	**K2**
CO3	Explain the laws of illumination and explain the principle of refrigeration and air-conditioning.	**K2**
CO4	Describe the different types of Electric traction, system of track electrification and its related mechanics	**K2**
CO5	Describe the salient features of traction drive and concept of energy saving using power electronic control of AC and DC drives	**K2**

Unit-I: Electric Heating: Advantages and methods of electric heating, Resistance heating, Electric arc heating, Induction heating and Dielectric heating

Unit-II: Electric Welding: Electric Arc Welding Electric Resistance Welding Electronic welding controls Electrolyte Process: Principles of electro deposition, Laws of electrolysis, and applications of electrolysis

Unit-III: Illumination: Various definitions, Laws of illumination, requirements of good lighting Design of indoor lighting and outdoor lighting systems Refrigeration and Air Conditioning: Refrigeration systems, domestic refrigerator, water cooler Types of air conditioning, Window air conditioner

Unit-IV: Electric Traction – I: Types of electric traction, Review of existing electric traction systems in India, systems of track electrification Traction mechanics- types of services, speed time curve and its simplification, average and schedule speeds Tractive effort, specific energy consumption, mechanics of train movement, coefficient of adhesion and its influence

Unit-V: Electric Traction – II: Salient features of traction drives Series – parallel control of dc traction drives (bridge transition) and energy saving Power Electronic control of dc and ac traction drives Diesel electric traction.

Text Books:

1. H. Partab, "Art and Science of Electrical Energy" Dhanpat Rai & Sons.

2. J.B. Gupta, "Utilization of Electric Power and Electric Traction", Kataria & Sons publishers, Delhi, IX Edtion, 2004.

3. C.L. Wadhwa, "Generation, Distribution and Utilization of electrical Energy", New Age International (P) Limited Publishers, 3rd Edition, 2010.

Reference Books:

1. H. Partab, " Modern Electric Traction" Dhanpat Rai & Sons.

2. G.K. Dubey, "Fundamentals of Electric Drives" Narosa Publishing House.