NRI INSTITUTE OF TECHNOLOGY

(An Autonomous Institution Permanently Affiliated to JNTUK, Kakinada)
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POTHAVARAPPADU (V), (VIA) NUNNA, AGIRIPALLI (M), PIN – 521 212

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

COURSE STRUCTURE FOR FOURTH YEAR B.TECH PROGRAMME

IV YEAR I SEMESTER

Sl. No	Course Code	Title of the Course	Scheme of Instruction (Periods Per Week)				Scheme of Examination (Maximum Marks)			No. of Credits
			L	T	P	Total	CIA	SEA	Total	
1	18A4102401	Switch Gear and Protection	3	-	-	3	40	60	100	3
2	18A4102402	Power System Operation and Control	3	-	-	3	40	60	100	3
3	18A4102403	Digital Control Systems	3	-	-	3	40	60	100	3
4	18A4102511 18A4102512	**Professional Elective:** 1) Electrical Distribution Systems 2) Power Quality	3	-	-	3	40	60	100	3
5	18A4102521 18A4102522	**Professional Elective:** 1) HVDC Transmission 2) High Voltage Engineering	3	-	-	3	40	60	100	3
6	18A4104609 18A4104610 18A4104611	**OE-IV:** 1) Linear Integrated Circuit and Applications 2) Digital Image Processing 3) Wireless Communications	3	-	-	3	40	60	100	3
7	18A4102491	Power Systems Lab	-	-	3	3	40	60	100	1.5
8	18A4102492	Skill Oriented Course: Electrical Engineering Workshop	-	-	3	3	40	60	100	1.5
9	18A4100802	IPR & Patents	2	-	2	2	40	60	100	-
10	18A4102791	Term Paper	-	-	-	-	40	60	100	1
11	18A4102792	Technical Seminar	-	-	-	-	40	60	100	2
Total			**20**	**-**	**8**	**26**	**440**	**660**	**1100**	**24**

IV YEAR II SEMESTER

Sl. No	Course Code	Title of the Course	Scheme of Instruction (Periods Per Week)				Scheme of Examination (Maximum Marks)			No. of Credits
			L	T	P	Total	CIA	SEA	Total	
1	18A4202511	**Professional Elective:** 1) FACTS 2) Energy Audit, Conservation & Management	3	-	-	3	40	60	100	3
2	18A4202522	**Professional Elective:** 1) Power System Reforms 2) Special Electrical Machines	3	-	-	3	40	60	100	3
3		Project	-	-	3	3	140	60	200	8
Total			**6**	**-**	**3**	**9**	**200**	**180**	**400**	**14**

L - LECTURE T – TUTORIAL P - PRACTICAL CIA – Continuous Internal Assessment SEA – Semester End Assessment

SWITCH GEAR AND PROTECTION

Lecture – Tutorial:	3-1 Hours	**Internal Marks:**	40
Credits:	3	**External Marks:**	60

Prerequisites:

Concepts of Power Systems-I, Power Systems II and Microprocessors.

Course Objectives:

The Objectives of learning this Course are:

- To study the classification, operation and application of different types of electromagnetic protective relays.
- To explain the principle and operation of different types of static relays.
- To explain protective schemes, for generator and transformers.
- To impart knowledge of various protective schemes used for feeders and bus bars.
- To provide the basic principles and operation of various types of circuit breakers.
- To study different types of over voltages in a power system and principles of different protective schemes for insulation co–ordination.

Course Outcomes:

Upon successful completion of the course, the student will be able to:

CO1	Explain the working principle and constructional features of different types of electromagnetic protective relays
CO2	Compare different types of static relays with a view to application in the system.
CO3	Relate the acquired in depth knowledge of faults that is observed in high power generator and transformers and protective schemes used for all protections
CO4	Improve the ability to understand various types of protective schemes used for feeders and bus bar protection
CO5	Illustrate the principles of arc interruption for application to high voltage circuit breakers of air, oil, vacuum, SF6gas type
CO6	Explain different types of over voltages appearing in the system, including existing protective schemes

Contribution of Course Outcomes towards achievement of Program Outcomes
(1– Low, 2- Medium, 3 – High)

	PO a	**PO b**	**PO c**	**PO d**	**PO e**	**PO f**	**PO g**	**PO h**	**PO i**	**PO j**	**PO k**	**PO l**
CO1	-	-	3	-	3	-	-	-	-	-	-	-
CO2	-	3	-	-	3	-	-	-	-	-	-	-
CO3	-	3	2	-	-	-	-	-	-	-	-	-
CO4	-	2	2	-	2	-	-	-	-	-	-	-
CO5	2	1	-	-	-	-	-	-	-	-	-	-
CO6	-	-	-	-	2	-	-	2	-	-	-	-

UNIT I – PROTECTIVE RELAYING

ELECTROMAGNETIC RELAYS:

Protective Relaying Mechanism - Classification of Relays– Attraction Relays: Attracted Armature and Solenoid & Plunger Type - Balanced beam type attracted armature relay – Induction relays: Induction Disc, Watthour Meter and Induction Cup type – Torque equation

Applications of relays**:** Non- Directional Over Current Relays - Directional Over Current and Power Relays– Directional relays– Current, Percentage & Voltage Balance Differential Relays– Universal torque equation– Distance relays**:** Impedance, Reactance & Mho relays.

STATIC RELAYS:

Comparison of Static & Electromagnetic Relays – Basic Elements of Static Relay – Directional Static Overcurrent Relay – Static Differential Relay – Static Distance Relay – Microprocessor based Overcurrent Relay

UNIT II – ELECTRICAL APPARATUS PROTECTION

GENERATOR & TRANSFORMER PROTECTION:

Generators: Stator faults, Rotor faults and abnormal conditions – Differential & Merz Price Protection - Restricted, unrestricted earth fault, balanced earth fault, 100% earth fault and inter turn fault protection – Numerical examples on percentage winding protected.

Transformers**:** Transformer Faults **-** Percentage differential protection– Design of CT's ratio – Frame Leakage Protection - Buchholz relay protection–Numerical examples on CT ratios.

FEEDER & BUSBAR PROTECTION:

Protection of lines**:** Over current Protection schemes - Numerical examples - Carrier current and three zone distance relay using impedance relays.

Protection of bus bars: Circulating Current & Frame Leakage Protection.

UNIT III – ARC QUENCHING IN CIRCUIT BREAKERS

ARC PHENOMENON:

Arc Quenching: Formation, Maintenance & Extinction – AC & DC Circuit Breaking - Restriking Voltage and Recovery voltages– Restriking phenomenon - RRRV– Average and Max. RRRV– Current chopping and Resistance switching

CIRCUIT BREAKERS:

Description and operation of Air Blast– Air Break, Vacuum, SF6 and Double break Oil circuit breakers– Miniature Circuit Breaker(MCB)

UNIT IV –OVER VOLTAGE PROTECTION & NEUTRAL GROUNDING

OVER VOLTAGE PROTECTION:

Causes of over voltages: Lightning, Switching, Insulation Failure & Arcing Grounds

- Protection against Direct & Indirect lightning Strokes: Ground Wires, Protector Tubes and Horn gap - Rod Gap - Multi gap - Expulsion type - Valve type - Metal oxide lightning arresters – Surge Absorbers – Insulation coordination– BIL– impulse ratio–Standard impulse test wave– volt-time characteristics

NEUTRAL GROUNDING:

Grounded and ungrounded neutral systems–Effects of ungrounded neutral on system performance– Methods of neutral grounding**:** Solid Earthing, Resistance Earthing, Resonant Earthing, Voltage Transformer Earthing and Earthing Transformer.

TEXT BOOKS:

1. A course in Electrical Power systems, J.B. Gupta, Kataria Publications.
2. Power System Protection and Switchgear by Badari Ram and D.N Viswakarma, TMH Publications
3. Power system protection- Static Relays with microprocessor applications by T.S.MadhavaRao, TMH.

REFERENCE BOOKS:

1. Fundamentals of Power System Protection by Paithankar and S.R.Bhide, PHI, 2003.
2. Art & Science of Protective Relaying – by C R Mason, Wiley Eastern Ltd.
3. Protection and Switch Gear by Bhavesh Bhalja, R.P. Maheshwari, Nilesh G. Chothani, Oxford University Press, 2013

E-RESOURCES:

1. https://nptel.ac.in/courses/108/101/108101039/
2. https://nptel.ac.in/courses/108/105/108105104/
3. https://www.coursera.org/lecture/electric-power-systems/system-design-switching-circuit-breakers-0MMaF

POWER SYSTEM OPERATION AND CONTROL

Lecture – Tutorial:	4 – 1	**Internal Marks:**	40
Credits:	3	**External Marks:**	60

Course Objectives:

- To understand optimal dispatch of generation with and without losses.
- To study the optimal scheduling of hydro thermal systems.
- To study the optimal unit commitment problem.
- To study the load frequency control for single area system with and without
- controllers
- .To study the load frequency control for two area system with and without controllers
- To understand the reactive power control and compensation of transmission lines.

Course Outcomes:

Upon successful completion of the course, the student will be able to:

CO1	Able to compute optimal scheduling of Generators.
CO2	Able to understand hydrothermal scheduling.
CO3	Understand the unit commitment problem.
CO4	Able to understand importance of the frequency.
CO5	Understand importance of PID controllers in single area and two area systems.
CO6	Will understand reactive power control and compensation for transmission line.

Contribution of Course Outcomes towards achievement of Program Outcomes (1– Low, 2- Medium, 3 – High)

	PO a	PO b	PO c	PO d	PO e	PO f	PO g	PO h	PO i	PO j	PO k	PO l
CO1	3	2	2					3	2			
CO2	3	2	3					2	2			
CO3	3	2	2					2	2			
CO4	3	2	2					3	2			
CO5	3	2	3									
CO6	3	2	2									

UNIT I

Economic Operation of Power Systems

Optimal operation of generators in thermal power stations, heat rate curve, cost curve, incremental fuel and production costs, input-output characteristics of steam unit, optimum generation allocation with line losses neglected. Optimum generation allocation including the effect of transmission line losses, loss coefficients, general transmission line loss formula.

UNIT II

Hydrothermal Scheduling

Optimal scheduling of hydrothermal system, hydroelectric power plant models,

types of scheduling problems, short term hydrothermal scheduling problem.

UNIT III

Load Frequency Control

Modeling of speed governing system, steam turbine, hydro turbine and generator. Necessity of keeping frequency constant, definitions of control area, single area control, block diagram representation of an isolated power system, steady state analysis, dynamic response, proportional plus integral control of single area and its block diagram representation, steady state response. Load frequency control of 2- area system, tie-line bias control, comparison between load frequency control and economic dispatch control.

UNIT IV

Reactive Power Control

Overview of reactive power control, reactive power compensation in transmission systems, advantages and disadvantages of different types of compensating equipment for transmission systems, load compensation, specifications of load compensator, uncompensated and compensated transmission lines, shunt and series compensation.

Text books:

1. Electric Energy systems Theory – by O.I.Elgerd, Tata McGraw–hill Publishing Company Ltd., Second edition.
2. Modern Power System Analysis – by I.J.Nagrath&D.P.Kothari Tata McGraw Hill Publishing Company Ltd, 2nd edition.

References:

1. Power System Analysis and Design by J.Duncan Glover and M.S.Sarma., Thompson, 3rdEdition.
2. Power System Analysis by Grainger and Stevenson, Tata McGraw Hill.
3. Power System Analysis by HadiSaadat – TMH Edition.
4. Power System stability & control, PrabhaKundur,TMH

E-Resources:

1. http://nptel.ac.in/courses.php
2. http://jntuk-coeerd.in/
3. https://ocw.mit.edu/courses/electrical-engineering- /

DIGITAL CONTROL SYSTEMS

Lecture – Tutorial:	4 – 1	**Internal Marks:**	40
Credits:	3	**External Marks:**	60

Course Objectives:

- To understand the concepts of digital control systems and assemble various components associated with it. Advantages compared to the analog type.
- The theory of *z*–transformations and application for the mathematical analysis of digital control systems
- To represent the discrete–time systems in state–space model and evaluation of state transition matrix,
- To examine the stability of the system using different tests
- To study the conventional method of analyzing digital control systems in the w–plane.
- The design of state feedback control by the pole placement method.

Course Outcomes:

Upon successful completion of the course, the student will be able to:

CO1	Explain advantages of discrete time control systems and the "know how" of various associated accessories
CO2	Evaluate mathematical analysis of discrete systems (Z-transforms)
CO3	Represent the discrete–time systems in state–space model and evaluation of state transition matrix.
CO4	Stability criterion for digital systems and methods adopted for testing the same are explained.
CO5	Explain conventional method of analyzing digital control systems in the w–plane
CO6	Design of state feedback control by "the pole placement method."

Contribution of Course Outcomes towards achievement of Program Outcomes (1– Low, 2- Medium, 3 – High)

	PO a	PO b	PO c	PO d	PO e	PO f	PO g	PO h	PO i	PO j	PO k	PO l
CO1	3	2	2					3	2			
CO2	3	2	3					2	2			
CO3	3	2	2					2	2			
CO4	3	2	2					3	2			
CO5	2	2	1					2	2			
CO6	2	2	1					2	2			

UNIT I

INTRODUCTION AND SIGNAL PROCESSING : Introduction to analog and digital control systems – Advantages of digital systems – Typical examples – Continuous and Discrete Time Signals – Sample and hold devices – Sampling theorem and data reconstruction – Frequency domain characteristics of zero order hold.

Z–TRANSFORMATIONS: z–Transforms – Theorems – Finding inverse z–transforms – Formulation of difference equations and solving – Block diagram representation – Pulse transfer functions and finding open loop and closed loop responses

UNIT II

STATE SPACE ANALYSIS AND THE CONCEPTS OF CONTROLLABILITY AND OBSERVABILITY:

State space representation of discrete time systems – Solving Discrete Time state space equations – State transition matrix and its properties .problems

Discretization of continuous time state equations – Concepts of controllability and observability – Tests(without proof). problems

UNIT III

STABILITY ANALYSIS: Mapping between the s–Plane and the z–Plane – Primary strips and Complementary strips .

STABILITY CRITERION – Modified Routh's stability criterion and Jury's stability test.

problems

UNIT IV

DESIGN OF DISCRETE–TIME CONTROL SYSTEMS BY CONVENTIONAL METHODS: Transient and steady state specifications – Design using frequency response in the w–plane for lag and lead compensators – Root locus technique in the z–plane.

STATE FEEDBACK CONTROLLERS : state feedback controller through pole placement – Necessary and sufficient conditions – Ackerman's formula.

Text books:

1. Discrete–Time Control systems – K. Ogata, Pearson Education/PHI, 2nd Edition.
2. Digital Control and State Variable Methods by M.Gopal, TMH, 4th Edition.

References:

1. Digital Control Systems, Kuo, Oxford University Press, 2nd Edition, 2003.

E-Resources:

1. http://nptel.ac.in/courses.php
2. http://jntuk-coeerd.in/
3. https://ocw.mit.edu/courses/electrical-engineering- /

ELECTRICAL DISTRIBUTION SYSTEMS

Lecture – Tutorial:	4 – 1	**Internal Marks:**	40
Credits:	3	**External Marks:**	60

Course Objectives:

- To understand the concepts of digital control systems and assemble various components associated with it. Advantages compared to the analog type.
- The theory of z–transformations and application for the mathematical analysis of digital control systems
- To represent the discrete–time systems in state–space model and evaluation of state transition matrix,
- To examine the stability of the system using different tests
- To study the conventional method of analyzing digital control systems in the w–plane.
- The design of state feedback control by the pole placement method.

Course Outcomes:

Upon successful completion of the course, the student will be able to:

CO1	Explain advantages of discrete time control systems and the "know how" of various associated accessories
CO2	Evaluate mathematical analysis of discrete systems (Z-transforms)
CO3	Represent the discrete–time systems in state–space model and evaluation of state transition matrix.
CO4	Stability criterion for digital systems and methods adopted for testing the same are explained.
CO5	Explain conventional method of analyzing digital control systems in the w–plane
CO6	Design of state feedback control by "the pole placement method."

Contribution of Course Outcomes towards achievement of Program Outcomes
(1– Low, 2- Medium, 3 – High)

	PO a	PO b	PO c	PO d	PO e	PO f	PO g	PO h	PO i	PO j	PO k	PO l
CO1	3	2	2					3	2			
CO2	3	2	3					2	2			
CO3	3	2	2					2	2			
CO4	3	2	2					3	2			
CO5	2	2	1					2	2			
CO6	2	2	1					2	2			

UNIT I

General Concepts

Introduction to distribution systems, Load modeling and characteristics – Coincidence factor – Contribution factor loss factor – Relationship between the

load factor and loss factor – Classification of loads (Residential, commercial, Agricultural and Industrial).

Substations

Location of substations**:** Rating of distribution substation – Service area with'n'primary feeders – Benefits and methods of optimal location of substations.

UNIT II

Distribution Feeders

Design Considerations of distribution feeders**:** Radial and loop types of primary feeders – Voltage levels – Feeder loading – Basic design practice of the secondary distribution system.

System Analysis

Voltage drop and power–loss calculations**:** Derivation for voltage drop and power loss in lines – Uniformly distributed loads and non-uniformly distributed loads – Numerical problems - Three phase balanced primary lines.

UNIT III

Protection

Objectives of distribution system protection – Types of common faults and procedure for fault calculations for distribution system – Protective devices**:** Principle of operation of fuses – Circuit reclosures – Line sectionalizes and circuit breakers.

Coordination

Coordination of protective devices**:** General coordination procedure –Various types of coordinated operation of protective devices - Residual Current Circuit Breaker

UNIT IV

Compensation for Power Factor Improvement

Capacitive compensation for powerfactor control – Different types of power capacitors – shunt and series capacitors – Effect of shunt capacitors (Fixed and switched) – Power factor correction – Capacitor allocation – Economic justification – Procedure to determine the best capacitor location – Numerical problems.

Voltage Control

Voltage Control**:** Equipment for voltage control – Effect of series capacitors – Effect of AVB/AVR – Line drop compensation – Numerical problems.

Text books:

1. "Electric Power Distribution system, Engineering" – by TuranGonen,

References:

1. Electrical Distribution Systems by Dale R.Patrick and Stephen W.Fardo, CRC press
2. Electric Power Distribution – by A.S. Pabla, Tata McGraw–hill Publishing company, 4th edition, 1997.
3. Electrical Power Distribution Systems by V.Kamaraju, Right Publishers

E-Resources:

1. http://nptel.ac.in/courses.php
2. http://jntuk-coeerd.in/
3. https://ocw.mit.edu/courses/electrical-engineering- /

HVDC TRANSMISSION

Lecture – Tutorial:	4 – 1	**Internal Marks:**	40
Credits:	3	**External Marks:**	60

Course Objectives:

- To Understand basic concepts of HVDC Transmission.
- To analyze the converter configuration.
- To Know the control of converter and HVDC Transmission.
- To Understand the significance of reactive power control and AC/DC load flow.
- To Know different converter faults, protection and effect of harmonics.
- To leave low pass and high pass filters.

Course Outcomes:

Upon successful completion of the course, the student will be able to:

CO1	Learn different types of HVDC levels.
CO2	Learn Basic Concepts of HVDC Transmission.
CO3	Know the operation of converters.
CO4	Acquire control concept of reactive power control and AC/DC load flow.
CO5	Understand converter faults, protection and harmonic effects.
CO6	Design low pass and high pass filters.

Contribution of Course Outcomes towards achievement of Program Outcomes
(1– Low, 2- Medium, 3 – High)

	PO a	**PO b**	**PO c**	**PO d**	**PO e**	**PO f**	**PO g**	**PO h**	**PO i**	**PO j**	**PO k**	**PO l**
CO1	3	2						3				
CO2	3	2						3	2			
CO3	3	2						3	2			
CO4	3	2						3	2			
CO5	3	2						3	2			
CO6	3	2						3	2			

UNIT I

Basic Concepts: Economics & Terminal equipment of HVDC transmission systems: Types of HVDC Links – Apparatus required for HVDC Systems – Comparison of AC &DC Transmission, Application of DC Transmission System – Planning & Modern trends in D.C. Transmission.

Analysis of HVDC Converters: Choice of converter configuration – analysis of Graetz – characteristics of 6 pulse & 12 pulse converters.

UNIT II

Converter & HVDC System Control: Principle of DC Link Control – Converters Control Characteristics – Firing angle control – Current and extinction angle control – Effect of source inductance on the system - Starting and stopping of DC link - Power Control.

Reactive Power Control in HVDC: Reactive Power Requirements in steady state-Conventional control strategies-Alternate control strategies, sources of reactive power-AC Filters – shunt capacitors-synchronous condensers.

UNIT III
Power Flow Analysis In AC/DC Systems: Modeling of DC Links- -Solution of DC load flow –solution of AC-DC Power flow-Simultaneous method-Sequential method. **Converter Fault & Protection**: Converter faults – Protection against over current and over voltage in converter station – surge arresters –smoothing reactors – DC breakers – Audible noise-corona effects on DC lines-Radio interference.
UNIT IV
Harmonics: Generation of Harmonics –Characteristics harmonics, Non-Characteristics harmonics, adverse effects of harmonics – Calculation of voltage & Current harmonics – Effect of Pulse number on harmonics. **Filters:** Types of AC filters, Design of Single tuned filters –Design of High pass filters.
Text books:
1.HVDC Power Transmission Systems: Technology and system Interactions – by K.R.Padiyar,New Age International (P) Limited, and Publishers. 2.HVDC Transmission by S.Kamakshaiah and V.Kamaraju-Tata McGraw–Hill
References:
1. HVDC Transmission – J.Arrillaga. 2. Direct Current Transmission – by E.W.Kimbark, John Wiley & Sons. 3. Power Transmission by Direct Current – by E.Uhlmann, B.S.Publications.
E-Resources:
1. http://nptel.ac.in/courses.php 2. http://jntuk-coeerd.in/ 3. https://ocw.mit.edu/courses/electrical-engineering- /

HIGH VOLTAGE ENGINEERING

Lecture – Tutorial:	4 – 1	**Internal Marks:**	40
Credits:	3	**External Marks:**	60

Course Objectives:

- To understand electric field distribution and computation in different configuration of electrode systems.
- To understand HV breakdown phenomena in gases, liquids and solids dielectrics.
- To acquaint with the generating principle of operation and design of HVDC, AC and Impulse voltages and currents.
- To understand various techniques of AC, DC and Impulse measurement of high voltages and currents.
- To understand the insulating characteristics of dielectric materials.
- To understand the various testing techniques of HV equipments.

Course Outcomes:

Upon successful completion of the course, the student will be able to:

CO1	To be acquainted with the performance of high voltages with regard to different configurations of electrode systems.
CO2	To be able to understand theory of breakdown and withstand phenomena of all types of dielectric materials.
CO3	To acquaint with the techniques of generation of AC,DC and Impulse voltages.
CO4	To be able to apply knowledge for measurement of high voltage and high current AC,DC and Impulse.
CO5	To be in a position to measure dielectric property of material used for HV equipment.
CO6	To know the techniques of testing various equipment's used in HV engineering.

Contribution of Course Outcomes towards achievement of Program Outcomes
(1– Low, 2- Medium, 3 – High)

	PO a	**PO b**	**PO c**	**PO d**	**PO e**	**PO f**	**PO g**	**PO h**	**PO i**	**PO j**	**PO k**	**PO l**
CO1	3	2						3				
CO2	3	2						3				
CO3	3	2						3				
CO4	3	2							2			
CO5	3	2							2			
CO6	3	2							2			

UNIT I

Introduction to High Voltage Technology

Electric Field Stresses – Uniform and non–uniform field configuration of electrodes – Estimation and control of electric Stress – Numerical methods for electric field computation.

Break down phenomenon in gaseous, liquid and solid insulation

Gases as insulating media – Collision process – Ionization process – Townsend's criteria of breakdown in gases – Paschen's law – Liquid as Insulator – Pure and

commercial liquids – Breakdown in pure and commercial liquid – Intrinsic breakdown – Electromechanical breakdown – Thermal breakdown –Breakdown of solid dielectrics.

UNIT II

Generation of High voltages and High currents

Generation of high DC voltages – Generation of high alternating voltages – Generation of impulse voltages and currents – Tripping and control of impulse generators.

UNIT III

Measurement of high voltages and High currents

Measurement of high AC, DC and Impulse voltages – Voltages and measurement of high currents – Direct, alternating and Impulse.

Non–destructive testing of material and electrical apparatus

Measurement of DC resistivity – Measurement of dielectric constant and loss factor – Partial discharge measurements.

UNIT IV

High voltage testing of electrical apparatus

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. High Voltage Engineering: Fundamentals by E.Kuffel, W.S.Zaengl, J.Kuffel by Elsevier, 2nd Edition.
2. High Voltage Engineering and Technology by Ryan, IET Publishers.

References:

1. High Voltage Engineering by M.S.Naidu and V. Kamaraju – TMH Publications, 3rd Edition
2. High Voltage Engineering by C.L.Wadhwa, New Age Internationals (P) Limited, 1997.
3. High Voltage Insulation Engineering by RavindraArora, Wolfgang Mosch, New Age International (P)Limited,1995.

E-Resources:

1. http://nptel.ac.in/courses.php
2. http://jntuk-coeerd.in/
3. https://ocw.mit.edu/courses/electrical-engineering- /

LINEAR INTEGRATED CIRCUIT APPLICATIONS

Lecture – Tutorial:	4 – 1	**Internal Marks:**	40
Credits:	3	**External Marks:**	60

Course Objectives:

- To understand the basic operation &performance parameters of differential amplifiers.
- To understand & learn the measuring techniques & performance parameters of OP-AMP
- To learn the linear and non-linear applications of operational amplifiers.
- To understand the analysis & design of different types of active filters using OP-AMP
- To learn the internal structure, operation and applications of different ICs

Course Outcomes:

Upon successful completion of the course, the student will be able to:

CO1	Design Differential amplifier circuits and gains knowledge in OP-AMPs
CO2	Understand and gains knowledge in various applications of OP-AMPS
CO3	Analyze amplifiers and active filters using Op-amp.
CO4	Design amplifiers and active filters using Op-amp.
CO5	Understand thoroughly the operational amplifiers with linear integrated circuits.
CO6	Understand the structure of commercially available Analog & Digital converters

Contribution of Course Outcomes towards achievement of Program Outcomes
(1– Low, 2- Medium, 3 – High)

	PO a	**PO b**	**PO c**	**PO d**	**PO e**	**PO f**	**PO g**	**PO h**	**PO i**	**PO j**	**PO k**	**PO l**
CO1	3	2	-	-	-	-	-	-	-	-	-	-
CO2	-	3	2	-	-	2	-	-	-	-	-	-
CO3	2	-	-	3	-	-	-	-	-	-	-	2
CO4	-	2	-	2	-	-	-	-	-	-	-	-
CO5	2	-	3	-	-	-	-	-	-	-	-	2
CO6	3	2	-	-	-	-	-	-	-	-	-	-

UNIT I

Integrated Circuits

Introduction, Differential Amplifier- DC and AC analysis of Dual input Balanced output Configuration, Properties of other differential amplifier configuration (Dual Input Unbalanced Output, Single Ended Input – Balanced/ Unbalanced Output)

Characteristics of op-amps and Integrated Circuits

Characteristics of OP-Amps, Integrated circuits-Types, Classification, Package Types and temperature ranges, Power supplies, Op-amp Block Diagram, ideal and practical

Op-amp specifications, 741 op-amp & its features

UNIT II

Op-Amp parameters

Input & Out put off set voltages & currents, slew rates, CMRR, PSRR, drift, Frequency Compensation technique

Applications of op-amps

Inverting and Non-inverting amplifier, Integrator, Differentiator, Difference amplifier, Instrumentation amplifier, AC amplifier, V to I, I to V converters, Comparators, Multivibrators, Triangular and Square wave generators, Log amplifiers, Anti log amplifiers, Precision rectifiers

UNIT III

Active Filters

Introduction to Butter worth filters – 1st order, 2nd order, LPF - 1st order, 2nd order HPF - 1st order, 2nd order BPF, BRF , all pass filters

Timers and Phase Locked Loops

Introduction to 555 timer, functional diagram, Monostable operation and applications, Astable operation and applications, Schmitt Trigger, PLL - introduction, block schematic, principles

UNIT IV

Digital to analog and Analog to digital Converters

Introduction, basic DAC techniques Weighted resistor DAC, R-2R ladder DAC Inverted R-2R DAC, Different types of ADCs - parallel comparator type ADC, Counter type ADC, successive approximation ADC , Dual slope ADC DAC and ADC Specifications

Text books:

1. Linear Integrated Circuits – D. Roy Chowdhury, New Age International (p) Ltd, 2nd Edition,2003.
2. Op-Amps & Linear ICs - Ramakanth A. Gayakwad, PHI,1987

References:

1. Design with Operational Amplifiers & Analog Integrated Circuits - Sergio Franco, McGraw Hill, 1988.
2. Operational Amplifiers & Linear Integrated Circuits–R.F.Coughlin & Fredrick Driscoll, PHI, 6th Edition.
3. Micro Electronics – Millman, McGraw Hill,1988.
4. Operational Amplifiers – C.G. Clayton, Butterworth & Company Publ. Ltd./ Elsevier, 1971.

E-Resources:

1. http://nptel.ac.in/courses.php
2. http://jntuk-coeerd.in/
3. https://ocw.mit.edu/courses/electrical-engineering- /

IPR & Patents

Lecture – Tutorial:	2-0	Internal Marks:	40
Credits:	0	External Marks:	60

Course Objectives:

- To know the importance of Intellectual property rights, which plays a vital role in advanced Technical and Scientific disciplines.
- Imparting IPR protections and regulations for further advancement, so that the students can familiarize with the latest developments.

Course Outcomes:

- IPR Laws and patents pave the way for innovative ideas which are instrumental for inventions to seek Patents.
- Student get an insight on Copyrights, Patents and Software patents which are instrumental for further advancements.

Upon successful completion of the course, the student will be able to:

CO1	To know the importance of Intellectual property rights
CO2	To know the importance which plays a vital role in advanced Technical disciplines.
CO3	To know the importance which plays a vital role in advanced Scientific disciplines.
CO4	Imparting IPR protections
CO5	Imparting IPR regulations for further advancement
CO6	Familiar with latest developments

Contribution of Course Outcomes towards achievement of Program Outcomes
(1– Low, 2- Medium, 3 – High)

	PO a	PO b	PO c	PO d	PO e	PO f	PO g	PO h	PO i	PO j	PO k	PO l
CO1	3	2						3				
CO2	3	2						3	2			
CO3	3	2						3	2			
CO4	3	2						3	2			
CO5	3	2						3	2			
CO6	3	2						3	2			

UNIT I

Introduction to Intellectual Property Rights (IPR) Concept of Property - Introduction to IPR – International Instruments and IPR - WIPO - TRIPS – WTO -Laws Relating to IPR - IPR Tool Kit - Protection and Regulation - Copyrights and Neighboring Rights – Industrial Property – Patents - Agencies for IPR Registration – Traditional Knowledge –Emerging Areas of IPR - Layout Designs and Integrated Circuits – Use and Misuse of Intellectual Property Rights.

UNIT II

Copyrights and Neighboring Rights Introduction to Copyrights – Principles of

Copyright Protection – Law Relating to Copyrights - Subject Matters of Copyright – Copyright Ownership – Transfer and Duration – Right to Prepare Derivative Works –Rights of Distribution – Rights of Performers – Copyright Registration – Limitations – Infringement of Copyright – Relief and Remedy – Case Law - Semiconductor Chip Protection Act.

UNIT III

Patents Introduction to Patents - Laws Relating to Patents in India – Patent Requirements – Product Patent and Process Patent - Patent Search - Patent Registration and Granting of Patent - Exclusive Rights – Limitations - Ownership and Transfer — Revocation of Patent – Patent Appellate Board - Infringement of Patent – Compulsory Licensing — Patent Cooperation Treaty – New developments in Patents – Software Protection and Computer related Innovations.

UNIT IV

Trademarks Introduction to Trademarks – Laws Relating to Trademarks – Functions of Trademark – Distinction between Trademark and Property Mark – Marks Covered under Trademark Law - Trade Mark Registration – Trade Mark Maintenance – Transfer of rights - Deceptive Similarities - Likelihood of Confusion - Dilution of Ownership – Trademarks Claims and Infringement – Remedies – Passing Off Action.

Text books:

1.Intellectual Property Rights (Patents & Cyber Law), Dr. A. Srinivas. Oxford University Press, New Delhi.
2. Deborah E.Bouchoux: Intellectual Property, Cengage Learning, New Delhi.

References:

1. PrabhuddhaGanguli: Intellectual Property Rights, Tata Mc-Graw –Hill, New Delhi
2. Richard Stim: Intellectual Property, Cengage Learning, New Delhi.
3. Kompal Bansal &Parishit Bansal Fundamentals of IPR for Engineers, B. S. Publications (Press).
4. Cyber Law - Texts & Cases, South-Western's Special Topics Collections.
5. R.Radha Krishnan, S.Balasubramanian: Intellectual Property Rights, Excel Books. New Delhi.
6. M.Ashok Kumar and MohdIqbal Ali: Intellectual Property Rights, Serials Pub.

E-Resources:

1. http://nptel.ac.in/courses.php
2. http://jntuk-coeerd.in/
3. https://ocw.mit.edu/courses/electrical-engineering- /

POWER SYSTEMS LAB

Lecture – Tutorial:	3-0	**Internal Marks:**	40
Credits:	1.5	**External Marks:**	60

List of experiments

The following experiments are compulsory

1. Sequence impedances of 3 phase Transformer.
2. Sequence impedances of 3 phase Alternator by Direct method.
3. ABCD parameters of Transmission line.
4. Dielectric strength of Transformer oil.
5. Calibration of Tong Tester.
6. Load flow studies using Gauss-seidel method
7. Load flow studies using N-R method.
8. Load frequency control without feedback control
9. Load frequency control with feedback control
10. Economic load dispatch without losses

The following experiments are done beyond the syllabus

1. Economic load dispatch without losses
2. Sequence impedances of 3 phase Alternator by Fault Analysis.

Skill Oriented Course: ELECTRICAL ENGINEERING WORKSHOP

Lecture – Tutorial:	3-0	**Internal Marks:**	40
Credits:	1.5	**External Marks:**	60

List of experiments

Any TEN of the following Experiments are to be conducted

1. Study of various Electrical Symbols and Tools.
2. One-Way and Two-Way Control.
3. GODOWN Wiring.
4. Wiring of Power Distribution Arrangement using 1-Φ MCB distribution board with ELCB, Main Switch and Energy Meter for calculating Power and Power Factor.
5. Hospital Wiring.
6. Tube Light Wiring.
7. Troubleshooting of Electrical Equipments (Tube Light and Fan).
8. Measurement of Voltage, Current and Power in DC Circuit.
9. CRO, Function Generator and Power Supply.
10. Resistors, Capacitors and Digital Multimeters.
11. Moving Coil, Moving Iron, Electro Dynamo and Induction Type Meters.
12. Assembling Electrical Components on Bread-Board.
13. V-I Characteristics of LED.
14. Measurement of Earth Resistance.
15. Identification of various semi conductor devices.

FLEXIBLE ALTERNATING CURRENT TRANSMISSION SYSTEMS

Lecture – Tutorial:	4 – 2	Internal Marks:	40
Credits:	3	External Marks:	60

Course Objectives:

- To learn the basics of power flow control in transmission lines using FACTS controllers
- To explain operation and control of voltage source converter.
- To understand compensation methods to improve stability and reduce power oscillations of a power system.
- To learn the method of shunt compensation using static VAR compensators.
- To learn the methods of compensation using series compensators
- To explain operation of Unified Power Flow Controller (UPFC).

Course Outcomes:

Upon successful completion of the course, the student will be able to:

CO1	Understand power flow control in transmission lines using FACTS controllers
CO2	Explain operation and control of voltage source converter
CO3	Analyze compensation methods to improve stability and reduce power oscillations in the transmission lines.
CO4	Explain the method of shunt compensation using static VAR compensators.
CO5	Understand the methods of compensations using series compensators.
CO6	Explain operation of Unified Power Flow Controller (UPFC).

Contribution of Course Outcomes towards achievement of Program Outcomes (1– Low, 2- Medium, 3 – High)

	PO a	PO b	PO c	PO d	PO e	PO f	PO g	PO h	PO i	PO j	PO k	PO l
CO1	3	2						1				
CO2	2	2	1					2	1			
CO3	3	2	1						1			
CO4	3	2	1					2	2			
CO5	2	2						2	2			
CO6	2	2	1					2	2			

UNIT I

Introduction to FACTS:

Power flow in an AC System – Loading capability limits –stability considerations – Basic types of FACTS controllers – Benefits from FACTS controllers

Voltage source and Current source converters

Concept of voltage source converter (VSC) – Single phase bridge converter – Three–phase full wave bridge converter – Transformer Connections for 12-Pulse Operation, 24 and48-PulseOperation – Current source converter – Thyristor based converters, CurrentSourced Converter with Turn off Devices –Comparison of current source converter with voltage source converter.

UNIT II

Shunt Compensators–1

Objectives of shunt compensation – Mid–point voltage regulation for line segmentation – End of line voltage support to prevent voltage instability – Improvement of transient stability – Power oscillation damping.

UNIT III

Shunt Compensators–2

Thyristor Switched Capacitor (TSC)–Thyristor Switched Capacitor – Thyristor Switched Reactor (TSC–TCR). Static VAR compensator (SVC) and Static Compensator (STATCOM): The regulation and slope transfer function and dynamic performance – Transient stability enhancement and power oscillation damping– Operating point control and summary of compensation control.

UNIT IV

Series Compensators

Static series compensators: Concept of series capacitive compensation – Improvement of transient stability – Power oscillation damping – Functional requirements. GTO thyristor-controlled Series Capacitor (GSC) – Thyristor Switched Series Capacitor (TSSC) and Thyristor Controlled Series Capacitor (TCSC).

Combined Controllers

Schematic and basic operating principles of Unified Power Flow Controller (UPFC). – Application on transmission lines.

Text books:

1. "Understanding FACTS" N.G.Hingorani and L.Guygi

References:

1. "Flexible ac transmission system (FACTS)" Edited by Yong Hue Song and Allan T Johns, Institution of Electrical Engineers, London.
2. Thyristor-based FACTS Controllers for Electrical Transmission Systems, by R.MohanMathur and Rajiv k.Varma, Wiley

E-Resources:

1. http://nptel.ac.in/courses.php
2. http://jntuk-coeerd.in/
3. https://ocw.mit.edu/courses/electrical-engineering- /

ENERGY AUDIT, CONSERVATION & MANAGEMENT

Lecture – Tutorial:	4 – 2	**Internal Marks:**	40
Credits:	3	**External Marks:**	60

Course Objectives:

- To understand energy efficiency, scope, conservation and technologies.
- To design energy efficient lighting systems.
- To Estimate/calculate power factor of systems and propose suitable compensation techniques.
- To understand energy conservation in HVAC systems
- To understand Economic Aspects and Financial Analysis
- To calculate life cycle costing analysis and return on investment on energy efficient technologies

Course Outcomes:

Upon successful completion of the course, the student will be able to:

CO1	Explain energy efficiency, conservation and various technologies.
CO2	Design energy efficient lighting systems
CO3	Power factor of systems and propose suitable compensation techniques , audit instruments
CO4	Explain energy conservation in HVAC systems
CO5	Explain economic aspects and financial analysis
CO6	Calculate life cycle costing analysis and return on investment on energy efficient technologies

Contribution of Course Outcomes towards achievement of Program Outcomes (1– Low, 2- Medium, 3 – High)

	PO a	PO b	PO c	PO d	PO e	PO f	PO g	PO h	PO i	PO j	PO k	PO l
CO1	3	2						1				
CO2	2	2	1					2	1			
CO3	3	2	1						1			
CO4	3	2	1					1	2			
CO5	2	2										
CO6	2	2										

UNIT I

BASIC PRINCIPLES OF ENERGY AUDIT AND MANAGEMENT :Energy audit – Definitions – Concept – Types of audit – Energy index – Cost index – Pie charts – Sankey diagrams – Load profiles – Energy conservation schemes and energy saving potential – Numerical problems – Principles of energy management – Initiating, planning, controlling, promoting, monitoring, reporting – Energy manager – Qualities and functions – Language – Questionnaire – Check list for top management

UNIT II

LIGHTING: Modification of existing systems – Replacement of existing systems – Priorities: Definition of terms and units – Luminous efficiency – Polar curve – Calculation of illumination level – Illumination of inclined surface to beam.

POWER FACTOR AND ENERGY INSTRUMENTS :Power factor – Methods of improvement – Location of capacitors Numerical problems. Energy Instruments – Watt–hour meter – Data loggers – Thermocouples – Pyrometers – Lux meters – Tong testers – Power analyzer

UNIT III

Space Heating and Ventilation :Ventilation – Air–Conditioning (HVAC) and Water Heating: Introduction – Heating of buildings – Transfer of Heat–Space heating methods. Energy conservation methods

Economic Aspects and Financial Analysis: Understanding energy cost - Economics Analysis – Depreciation Methods – Time value of money, – Rate of return – Present worth method – Replacement analysis – Life cycle costing analysis

UNIT IV

COMPUTATION OF ECONOMIC ASPECTS: Need of investment, appraisal and criteria - Calculation of simple payback period–Return on investment – Net present value – Internal rate of return – numerical examples – Power factor correction – Lighting – Applications of life cycle costing analysis – Return on investment – Numerical examples.

Text books:

1. Hand Book of Energy Audit by Sonal Desai- Tata McGraw hill
2. Energy efficient electric motors by John .C. Andreas, Marcel Dekker Inc Ltd–2nd edition, 1995

References:

1. Energy Management By W.R. Murphy & G. Mckay Butter Worth, Elsevier Publications. 2012
2. Electric Energy Utilization And Conservation By S C Tripathy, Tata Mcgraw Hill Publishing Company Ltd. New Delhi.
3. Energy Management By Paul O' Callaghan, Mc–Graw Hill Book Company–1st Edition, 1998.
4. Energy Management Hand Book By W.C.Turner, John Wiley And Sons.
5. Energy Management And Conservation –K V Sharma And P.venkataseshaiah-I K International Publishing House Pvt.Ltd,2011.
6. Http://Www.Energymanagertraining.Com/Download/Gazette_Of_Indiapartiiseci37_25-08-2010.Pdf

E-Resources:

1. http://nptel.ac.in/courses.php
2. http://jntuk-coeerd.in/
3. https://ocw.mit.edu/courses/electrical-engineering- /

SPECIAL ELECTRICAL MACHINES

Lecture – Tutorial:	4 – 2	**Internal Marks:**	40
Credits:	3	**External Marks:**	60

Course Objectives:

- To explain theory of operation and control of switched reluctance motor.
- To explain the performance and control of stepper motors, and their applications.
- To describe the operation and characteristics of permanent magnet dc motor.
- To distinguish between brush dc motor and brush less dc motor.
- To explain the theory of travelling magnetic field
- To explain the applications of linear motors.

Course Outcomes:

Upon successful completion of the course, the student will be able to:

CO1	To explain theory of operation and control of switched reluctance motor.
CO2	To explain the performance and control of stepper motors, and their applications
CO3	To describe the operation and characteristics of permanent magnet dc motor.
CO4	To distinguish between brush dc motor and brush less dc motor.
CO5	To explain the theory of travelling magnetic field
CO6	To explain the applications of linear motors.

Contribution of Course Outcomes towards achievement of Program Outcomes
(1– Low, 2- Medium, 3 – High)

	PO a	**PO b**	**PO c**	**PO d**	**PO e**	**PO f**	**PO g**	**PO h**	**PO i**	**PO j**	**PO k**	**PO l**
CO1	3	2						3				
CO2	3	2						3	2			
CO3	3	2						3	2			
CO4	3	2						3	2			
CO5	3	2						3	2			
CO6	3	2						3	2			

UNIT I

Permanent magnet materials and PMDC motors Introduction-classification of permanent magnet materials used in electrical machines-minor hysteresis loop and recoil line-Stator frames of conventional dc machines-Development of electronically commutated dc motor from conventional dc motor-Permanent-magnet materials and characteristics-B-H loop and demagnetization characteristics-Temperature effects: reversible and irreversible losses-high temperature effects-Mechanical properties, handling and magnetization-Application of permanent magnets in motors-power density-severity of operation duty.

UNIT II

Stepper Motors Classification of stepper motors – Hybrid and Variable Reluctance Motor (VRM) - Construction and principle of hybid type synchronous stepper motor –

Different configuration for switching the phase windings control circuits for stepper motors – Open loop and closed loop control of 2-phase hybrid stepping motor. Construction and principle of operation of Variable Reluctance Motor (VRM) – Single stack and multiple stack – Open loop control of 3- phase VR Stepper Motor-Applications.

UNIT III

Switched Reluctance Motors Construction – Comparison of conventional and switched reluctance motors – Design of stator and rotor pole arcs – Torque producing principle and torque expression – Different converter configurations for SRM – Drive and power circuits for SRM – Position sensing of rotor – Applications of SRM.
Square Wave Permanent Magnet Brushless :DC Motor Types of constructions – Surface mounted and interior type permanent magnet – Principle of operation of BLDC motor– Torque speed characteristics – Performance and efficiency

UNIT IV

Construction– principle of operation–Double sided LIM from rotating type Induction Motor – Schematic of LIM drive for traction – Development of one sided LIM with back ironequivalent circuit of LIM.

Text books:

1. Special electrical Machines, K.VenkataRatnam, University press, 2009, New Delhi.

References:

1. Brushless Permanent magnet and reluctance motor drives, Clarenden press, T.J.E. Miller, 1989, Oxford

E-Resources:

1. http://nptel.ac.in/courses.php
2. http://jntuk-coeerd.in/
3. https://ocw.mit.edu/courses/electrical-engineering- /

POWER SYSTEM REFORMS

Lecture – Tutorial:	4 – 2	**Internal Marks:**	40
Credits:	3	**External Marks:**	60

Course Objectives:

- To study fundamentals of power system deregulation and restructuring.
- To study available transfer capability.
- To study congestion management
- To study various electricity pricing methods.
- To study operation of power system in deregulated environment.
- To study importance of Ancillary services management.

Course Outcomes:

Upon successful completion of the course, the student will be able to:

CO1	To study fundamentals of power system deregulation and restructuring
CO2	To study available transfer capability.
CO3	To study congestion management
CO4	To study various electricity pricing methods.
CO5	To study operation of power system in deregulated environment
CO6	To study importance of Ancillary services management.

Contribution of Course Outcomes towards achievement of Program Outcomes
(1– Low, 2- Medium, 3 – High)

	PO a	**PO b**	**PO c**	**PO d**	**PO e**	**PO f**	**PO g**	**PO h**	**PO i**	**PO j**	**PO k**	**PO l**
CO1	3	2						3				
CO2	3	2						3	2			
CO3	3	2						3				
CO4	3	2						3				
CO5	3	2						3				
CO6	3	2						3	2			

UNIT I

Over view of key issues in electric utilities Introduction – Restructuring models – Independent system operator (ISO) – Power Exchange – Market operations – Market Power – Standard cost – Transmission Pricing – Congestion Pricing – Management of Inter zonal/Intra zonal Congestion.
Available Transfer Capability (ATC) Structure of OASIS – Processing of Information – Transfer capability on OASIS – Definitions Transfer Capability Issues – ATC – TTC – TRM – CBM calculations – Methodologies to calculate ATC.

UNIT II

Congestion Management Introduction to congestion management – Methods to relieve congestion

UNIT III

Electricity Pricing: Introduction – Electricity price volatility electricity price indexes – Challenges to electricity pricing – Construction of forward price curves – Short–time

price forecasting.

UNIT IV

Power system operation in competitive environment: Introduction – Operational planning activities of ISO – The ISO in pool markets – The ISO in bilateral markets – Operational planning activities of a GENCO.
Ancillary Services Management: Introduction – Reactive power as an ancillary service – A review – Synchronous generators as ancillary service providers.

Text books:

1.Kankar Bhattacharya, Math H.J. Boller, JaapE.Daalder, 'Operation of Restructured Power System' Kluver Academic Publisher – 2001.

2. Mohammad Shahidehpour, and Muwaffaqalomoush, – "Restructured electrical Power systems" Marcel Dekker, Inc. 2001

References:

1. Loi Lei Lai; "Power system Restructuring and Deregulation", Jhon Wiley & Sons Ltd., England.
2. Electrical Power Distribution Case studies from Distribution reform, upgrades and Management (DRUM) Program, by USAID/India, TMH

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1. http://nptel.ac.in/courses.php
2. http://jntuk-coeerd.in/
3. https://ocw.mit.edu/courses/electrical-engineering- /