DEPARTMENT OF EEE : : ANITS

(Proposed scheme under Autonomous w.e.f. 2015-16 admitted batch)

FOURTH YEAR FIRST SEMESTER

Code	Subject	Category	Instruction Periods per Week	Semester End Examination		Sessional Marks	Total Marks	Credits
				Duration (periods)	Marks			
EEE 411	**Open Elective-II**	OE	4	3	60	40	100	3
EEE 412	**Professional Elective-II**	PE	4	3	60	40	100	3
EEE 413	**Professional Elective-III**	PE	4	3	60	40	100	3
EEE 414	Power System Analysis	PC	4	3	60	40	100	3
EEE 415	Power Semiconductor Drives	PC	4	3	60	40	100	3
EEE 416	Power System Protection	PC	4	3	60	40	100	3
EEE 417	Power Electronics Laboratory	PC	3	3	50	50	100	2
EEE 418	Electrical Machines Laboratory-II	PC	3	3	50	50	100	2
EEE 419	Industrial Training *	IT	--	--	--	100	100	2
EEE 4110	Project Work	PW	6	--	--	60	60	4
	Total		**36**	**24**	**460**	**500**	**960**	**28**

OE-II: 1) Robotics (Mech) 2) Finite Element Analysis (Mech) 3) Introduction to VLSI system design (ECE) 4) Introduction to image processing / Computer Vision (ECE)

PE-II: 1) Electrical Drives & Traction 2) DCS 3) DSP 4) Power Quality & FACTS

PE-III: 1) Electrical and Hybrid Vehicles 2) Electrical Engineering Drawing 3) JAVA 4) HVDC

FOURTH YEAR SECOND SEMESTER

Code	Subject	Category	Instruction Periods per Week	Semester End Examination		Sessional Marks	Total Marks	Credits
				Duration (periods)	Marks			
EEE 421	Engineering Economics & Mgmt.	HS	4	3	60	40	100	3
EEE 422	**Professional Elective-IV**	PE	4	3	60	40	100	3
EEE 423	Energy Management & Control	PC	4	3	60	40	100	3
EEE 424	Power System Simulation Lab	PC	3	3	50	50	100	2
EEE 425	Control Systems Laboratory	PC	3	3	50	50	100	2
EEE 426	Project Work	PW	6	3	80	60	140	8
	MOOC’s	OE	---	---	---	---	100	2
	Total		**24**	**18**	**360**	**280**	**740**	**23**

PE-IV: 1) Non-Linear Systems; 2) Power System Reliability 3) Design of Electrical Machines 4) Process Control and Automation

FUNDAMENTALS OF ELECTRIC POWER UTILIZATION (Open Elective-II)	
EEE 411	**Credits : 3**
Instruction : 3 Periods & 1 Tut/Week	**Sessional Marks : 40**
End Exam : 3 Hours	**End Exam Marks : 60**

SYLLABUS

UNIT I: [12 Periods]

ELECTRIC DRIVES: Type of electric drives, choice of motor, starting and running characteristics, speed control, temperature rise, particular applications of electric drives, types of industrial loads, continuous, intermittent and variable loads, load equalization.

UNIT II: [12 Periods]

ELECTRIC HEATING: Advantages and methods of electric heating, resistance heating induction heating and dielectric heating.

ELECTRIC WELDING: Electric welding, resistance and arc welding, electric welding equipment, comparison between A.C. and D.C. Welding.

UNIT III: [12 Periods]

ILLUMINATION FUNDAMENTALS: Introduction, terms used in illumination, laws of illumination, polar curves, photometry, integrating sphere, sources of light.

VARIOUS ILLUMINATION METHODS: Discharge lamps, MV and SV lamps – comparison between tungsten filament lamps and fluorescent tubes, Basic principles of light control, Types and design of lighting and flood lighting.

UNIT IV: [12 Periods]

System of electric traction and track electrification. Review of existing electric traction systems in India. Special features of traction motor, methods of electric braking-plugging rheostatic braking and regenerative braking, problems on it.

UNIT V: [12 Periods]

Mechanics of train movement. Speed-time curves for different services – trapezoidal and quadrilateral speed time curves.

TEXT BOOKS:

1. Utilisation of Electric Energy – by E. Openshaw Taylor, Orient Longman.
2. Art & Science of Utilization of electrical Energy – by Partab, Dhanpat Rai & Sons.

REFERENCE BOOKS:

1. Utilization of Electrical Power including Electric drives and Electric traction – by N.V. Surya narayana, New Age International (P) Limited, Publishers, 1996.
2. Generation, Distribution and Utilization of electrical Energy – by C.L. Wadhwa, New Age International (P) Limited, Publishers, 1997.

ELECTRICAL DRIVES AND TRACTION (Professional Elective-II)	
EEE 412 (1)	Credits : 3
Instruction : 3 Periods & 1 Tut/Week	Sessional Marks : 40
End Exam : 3 Hours	End Exam Marks : 60

Course Outcomes: At the end of the course, students will be able to:

CO	BL	CO Statement
CO1	BL-3	**CLASSIFY** the electric drives and **ANALYZE** their stability
CO2	BL-3	**MODIFY** speed torque characteristics of three phase induction motors, d.c. motors and synchronous motors.
CO3	BL-3	**ANALYZE** in detail the starting of dc & ac motors.
CO4	BL-3	**ANALYZE** electric braking in detail employed to dc & ac motors.
CO5	BL-3	**DETERMINE** the specific energy consumption for a particular run and **EXPLAIN** the factors affecting it.

Program Matrix

COs	Program Outcomes (POs)												PSOs	
	Domain Specific POs					Domain Independent POs								
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	-	-	-	-	-	-	-	-	-	1	-	-
CO2	3	3	1	-	-	-	-	-	-	-	-	1	-	-
CO3	3	2	-	-	-	-	-	-	-	-	-	1	-	-
CO4	3	3	-	-	-	-	-	-	-	-	-	1	-	-
CO5	3	-	-	-	-	-	-	-	-	-	-	1	-	-

JUSTIFICATION STATEMENT FOR CO-PO MAPPING			
COs	**POs**	**Level**	**Description**
CO1	PO1	3	The basics of electric drives using **basic sciences** & **fundamental engineering concepts** are discussed
CO1	PO2	3	The stability concepts were **discussed** in detail and henceforth the stability of electric drive is **analyzed** by using the same
CO2	PO2	3	The speed control techniques of electric motors are **analyzed** in detail.
CO2	PO3	1	The choice & **design** of appropriate circuit for obtaining a desired speed of an electric motor is **discussed.**
CO2	PO12	1	Recognize the need for complete analysis on speed control for better industrial application.
CO3	PO1	3	The starting techniques of electric motors are **discussed** in detail using **electrical engineering concepts**
CO3	PO2	2	The acceleration time & energy relations during starting are **analyzed** in detail for specific motor & load torques
CO3	PO12	1	Recognize the need for complete analysis of electrical starting for better industrial application.
CO4	PO1	3	The braking techniques of electric motors are discussed in detail using **electrical engineering concepts**

CO4	PO2	3	The energy relations during different electrical braking techniques & their dynamics are **analyzed** in detail.
CO4	PO12	1	Recognize the need for complete analysis of electrical braking for better industrial application.
CO5	PO1	3	The mechanics of electric traction are discussed in detail by electrical engineering concepts.

SYLLABUS

UNIT-I **[10 Periods]**

ELECTRIC DRIVE: Concept and classification of electric drives, four quadrant operation, types of loads, dynamics of motor load combination, steady-state and transient stability of drive.

UNIT-II **[15 Periods]**

CHARACTERISTICS OF MOTORS: Basic relations and characteristics and modified speed torque characteristics of D.C shunt and series motors, characteristics of 3- phase induction and synchronous motors and modification of their speed – torque characteristics

UNIT-III **[10 Periods]**

ELECTRIC STARTING: Effect of starting on power supply, motor and load, methods of starting, acceleration time, energy relations during starting, and methods to reduce energy loss during starting.

UNIT-IV **[10 Periods]**

ELECTRIC BRAKING: Types of braking, braking of D.C motors during lowering of loads, braking while stopping, braking of induction and synchronous motors, energy relations during braking.

UNIT-V **[15 Periods]**

ELECTRICAL TRACTION: General features and systems of traction electrification, traction motors, loco wheel arrangement and riding qualities, transmission of drive, traction motor control (series-parallel control), traction equipment and collection gear, train movement, speed-time curve and speed distance curve, specific energy consumption (sec) and factors affecting it.

Text Books:

1. S. K. PILLAI , “A First Course On Electric Drives”,2nd edition, 2004, wiley esastren ltd.
2. E. OPEN SHAW TAYLOR AND V.V.L. RAO ORIENTLONG man “Utilisation of electrical energy”, 2nd edition, 2004, Tata Mc Graw Hill Pub.

Reference Book:

1. H. PARTAB , “Modern Electric Traction”. 3rd edition, 2003, DHANPAT ROY & Co.
2. VEDAM SUBRAMANYAM , “ELECTRIC DRIVES” 4th edition,2006 TMH Pub.

DIGITAL CONTROL SYSTEMS (Professional Elective-II)	
EEE 412 (2)	**Credits : 3**
Instruction : 3 Periods & 1 Tut/Week	**Sessional Marks : 40**
End Exam : 3 Hours	**End Exam Marks : 60**

Course Outcomes:
At the end of the course student should be able to:

CO's Number	CO's Description
CO1	Able to understand the effects of sampling in performance
CO2	Able to represent sampled data system using difference equations, transfer function, block diagram
CO3	Able to understand and design discrete control system using transform techniques
CO4	Analyze discrete time systems using signal flow graph and state space analysis
CO5	Able to understand the stability of sampled data signals

Program Matrix

COs	Program Outcomes (POs)												PSOs	
	Domain Specific POs					Domain Independent POs								
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	0	2	0	0	0	0	0	0	0	0	0	0	-	-
CO2	0	0	3	2	0	0	0	0	0	0	0	0	-	-
CO3	0	0	0	3	0	0	0	2	1	0	0	0	-	-
CO4	0	3	0	0	0	0	0	2	1	0	0	0	-	-
CO5	0	3	2	0	0	0	0	0	1	0	0	0	-	-

UNIT-I:
SIGNAL CONVERSION AND PROCESSING: Introduction, block diagram representation of s/h device, mathematical modelling of the sampling process, finite-pulse width sampler, folding frequency. The sampling theorem, mathematical modelling of the sampling, ideal sampler, sample and hold devices, expressions of f*(s), s-plane properties of f*(s), zero-order hold, frequency-domain characteristics of zoh, first order hold, fractional hold device.

UNIT-II:
THE Z-TRANSFORM: The Z-Transform Definition, Relationship With Laplace Transform, Alternate Expression For F(Z), Evaluation Of Z-Transform, Relationship Between S-Plane And Z-Plane, Inverse Z-Transform, Non Uniqueness Of The Z-Transform, Defining Equations Of The Inverse Z-Transform, Theorems Of The Z-Transform, Limitations Of The Z-Transform.

UNIT-III:
TRANSFER FUNCTION, BLOCK DIAGRAMS & SIGNAL FLOW GRAPHS: Transfer functions, block diagrams, signal flow graphs, the pulse transfer function and z-transform function, systems with cascaded elements separated by a sampler & not separated by a sampler, pulse transform function of zoh and relation between g(s) and g(z), closed loop systems, characteristic equation, physical realizability.

UNIT-IV:
THE STATE VARIABLE TECHNIQUES: State equations of descrete systems with sample and hold devices, state transition equations, the recursive method, the z-transform method, state equations and

transfer function, characteristic equation, eigen values, eigen vectors, diagonalization of the ‘a’ matrix, jordan canonical form computing state transition matrix.

UNIT-V:

CONTROLLABILITY, OBSERVABILITY, STABILITY: Definition of controllability, theorem on controllability, definition of observability, theorem on observability, relationships between controllability and observability and transfer function, stability of linear digital control systems, definition & theorem, stability tests, bi-linear transformation method, jury’s stability test.

Text Books:

1. Digital control systems by b.c. Kuo, second edition, saunders college publication-1992.
2. Digital Control Systems By Ogata.
3. Digital Control Systems (Software & Hardware) By Laymount & Azzo.

DIGITAL SIGNAL PROCESSING (Professional Elective-II)	
EEE 412 (3)	Credits : 3
Instruction : 3 Periods & 1 Tut/Week	Sessional Marks : 40
End Exam : 3 Hours	End Exam Marks : 60

Course Outcomes:

By the end of the course, the student will be able to:	
CO1	Acquired knowledge on different types of signals and properties of systems..
CO2	Use Z - transforms and discrete time Fourier transforms to analyze a digital system.
CO3	Acquired knowledge on FFT for fast computation of DFT.
CO4	Ability to design and realize IIR using different techniques.
CO5	Ability to design and realize FIR using different techniques.

SYLLABUS

UNIT I [12 periods]

Introduction to Digital Signal Processing & Applications of Z-Transforms: Introduction to Digital Signal Processing: Discrete time signals & sequences, linear shift invariant systems, stability, and causality. Linear constant coefficient difference equations. Frequency domain representation of discrete time signals and systems. Review of Z-transforms, Applications of Z – transforms, solution of difference equations , Block diagram representation of linear constant-coefficient difference equations.

UNIT–II: [12 periods]

Discrete Fourier series and Discrete Fourier Transforms: Properties of discrete Fourier series, DFS representation of periodic sequences, Discrete Fourier transforms: Properties of DFT, linear convolution of sequences using DFT, Computation of DFT. Relation between Z–transform and DFS.

UNIT–III: [12 periods]

Fast Fourier Transforms: Frequency domain representation of discrete time signals and systems – Fast Fourier transforms (FFT) – Radix–2 decimation in time and decimation in frequency FFT Algorithms – Inverse FFT – and FFT for composite N.

UNIT IV: [12 periods]

IIR Digital Filter Design Techniques: Introduction, Analog low pass filter design, Butterworth and Chebyshev approximations, Frequency transformations, Design of HPF, Design of IIR Digital filters from analog filters, Bilinear Transformations method, Impulse invariance method. Realization of Digital filter: Direct form-I, Direct form-II, cascade form, Parallel form.

UNIT V: **[12 periods]**

FIR Digital Filter Design Techniques: Introduction, Fourier Series method to design digital filter, Design of FIR Digital Filters using Window Techniques, Frequency Sampling technique, Comparison of IIR & FIR filters.

TEXT BOOKS:

1. Digital Signal Processing, Principles, Algorithms, and Applications: John G. Proakis, Dimitris G. Manolakis, Pearson Education / PHI, 2007.
2. Digital Signal Processing – Alan V. Oppenheim, Ronald W. Schafer, PHI Ed., 2006
3. Digital Signal Processing – K Raja Rajeswari, I.K. International Publishing House.

Reference Books:

1. Digital Signal Processing: Andreas Antoniou, TATA McGraw Hill , 2006
2. Digital Signal Processing: MH Hayes, Schaum's Outlines, TATA McGraw Hill, 2007.
3. DSP Primer - C. Britton Rorabaugh, Tata McGraw Hill, 2005.
4. Fundamentals of Digital Signal Processing using Matlab – Robert J. Schilling, Sandra L. Harris,Thomson, 2007.

POWER QUALITY & FACTS (Professional Elective-II)	
EEE 412 (4)	**Credits: 3**
Instruction: 3 Periods & 1 Tut/Week	**Sessionals Marks:40**
End Exam: 3 Hours	**End Exam Marks:60**

Course Outcomes: At the end of the course the student will be able to:

CO1	Assess the severity of power quality problems in distribution system.
CO2	Analyze voltage and harmonic related power quality issues.
CO3	Analyze the effect of symmetrical and unsymmetrical faults on power system.
CO4	Identify configuration of FACTS controller and their application to improve power quality.

Program Matrix

COs	**Program Outcomes (POs)**												**PSOs**	
	Domain Specific POs					**Domain Independent POs**								
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	2	2	2	1	2	1	1	0	2	1	-	-
CO2	2	2	2	2	2	1	2	2	2	0	2	1	-	-
CO3	2	2	2	2	2	1	2	2	2	0	2	1	-	-
CO4	2	2	2	2	2	1	2	2	2	0	2	1	-	-

UNIT-I **[10 Periods]**

POWER QUALITY AN OVERVIEW

Introduction of the Power Quality (PQ) problem, Terms used in PQ: Voltage, Sag, Swell, Surges, Harmonics, over voltages, spikes, Voltage fluctuations, Transients, Interruption, overview of power quality phenomenon, Sources of PQ problems, Remedies to improve PQ, power quality monitoring.

UNIT-II **[12 Periods]**

VOLTAGE SAG-CHARACTRIZATION

Voltage sag - definition, causes of voltage sag, voltage sag magnitude- monitoring, theoretical calculations, voltage sag calculation in non-radial systems, meshed systems, voltage sag duration, Types of three phase unbalanced sags, phase angle jumps, magnitude and phase angle jumps for three phase unbalanced sags, load influence on voltage sags.

UNIT-III **[12 Periods]**

HARMONICS

Harmonic distortion, Voltage versus Current distortion, Harmonic indexes, Harmonic sources from commercial loads, Harmonic sources from industrial loads; Locating Harmonic sources, System response characteristics, effects of harmonic distortion.

UNIT-IV **[12 Periods]**

FACTS

Power flow in AC systems, need of FACTS controllers, relative importance of controllable parameters, basic types of facts controllers, shunt, series and combined shunt series controllers.

UNIT-V **[14 Periods]**

CUSTOM POWER DEVICES

Custom Power Devices - An Introduction: Overview of mitigation methods - from fault to trip, reducing the number of faults, reducing the fault clearing time, installing mitigation equipment, improving equipment immunity.

Utility-Customer Interface, Introduction to CP devices: Network Reconfiguring Devices, Load Compensation and Voltage Regulation using DSTATCOM, Protecting Sensitive loads using DVR, Unified Power Quality Conditioner (UPQC).

TEXT BOOKS:

1. Math H J Bollen, "Understanding Power Quality Problems", IEEE Press, Standard Publishers Distributors, 1st edition, 2001.
2. Narain G. Hingorani, Laszlo Gyugyi, "Understanding FACTS–Concepts and Technology of Flexible AC Transmission Systems", Wiley India publications, 2011.
3. Arindham Ghosh, Gerard Ledwich, Kluwer, "Power Quality Enhancement Using Custom Power Devices", Academic Publishers, 1st edition, 2002.

ELECTRICAL AND HYBRID VEHICLES (Professional Elective-III)	
EEE 413 (1)	**Credits: 3**
Instruction: 3 Periods & 1 Tut/Week	**Sessionals Marks:40**
End Exam: 3 Hours	**End Exam Marks:60**

Course Outcomes: At the end of the course the student will be able to:

CO	BL	CO Statement
CO1	BL-3	**Associate** with the history of hybrid vehicles and physics involved in the conventional vehicle movement to **Calculate** the total tractive force required for vehicle motion.
CO2	BL-3	**Classify** various types of hybrid vehicle configurations to **interpret** their compatibility in specific applications.
CO3	BL-4	**Identify** specific configuration of electric vehicle, electric drive machine and power converter as per the requirement to **Analyze** the performance of system design.
CO4	BL-3	**Distinguish** the features and suitability of energy storage devices to **Relate** them as per the requirement.
CO5	BL-4	**Compare** various energy management strategies to **Select** them appropriately in specific EHV/EV controller design.

Program Matrix

COs	Program Outcomes (POs)												PSOs	
	Domain Specific POs					Domain Independent POs								
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	3	1	-	-	-	-	-	-	-	-	1	-	-
CO2	2	3	1	-	-	-	-	-	-	-	-	1	-	-
CO3	2	3	2	-	2	-	-	-	-	-	-	1	-	2
CO4	2	3	1	-	2	-	-	-	-	-	-	1	-	1
CO5	2	2	2	-	1	-	-	-	-	-	-	1		1

JUSTIFICATION STATEMENT FOR CO-PO MAPPING			
COs	**POs**	**Level**	**Description**
CO1	PO1	2	Tractive effort for vehicle movement is calculated with the fundamental knowledge of basic engineering physics and mathematics.
CO1	PO2	3	Based on the different types of vehicle resistance calculation, formulate the tractive effort force equation and analyze the results in terms of vehicle speed.
CO1	PO3	1	Calculate the design parameters of vehicles with the knowledge of different resistance and force calculations.
CO1	PO12	1	Recognize the need of history of vehicles and vehicle dynamic calculations, in order to be compatible enough for vehicle designing and manufacturing sector.
CO2	PO1	2	The fundamental knowledge of basic engineering mathematics, engineering physics and electrical engineering is utilized for hybrid vehicle design and power flow control.

CO2	PO2	3	Based on the knowledge of hybrid vehicle types and their individual configuration and application, power flow structure is analyzed and efficiency is calculated.
CO2	PO3	1	The classification and basic configuration knowledge of hybrid vehicles are utilized for designing hybrid vehicle configuration based on the source availability and applicability.
CO2	PO12	1	Recognize the need of basic hybrid vehicle design and classification, in order to be compatible enough for hybrid vehicle manufacturing requirement.
CO3	PO1	2	With the knowledge of fundamental electrical engineering and engineering physics, specific configuration of electric vehicle from various types, is selected.
CO3	PO2	3	In reference to electric vehicle configurations, mathematical design of power electronic converters, dc drives, ac drives are formulated and their performance parameters are analyzed.
CO3	PO3	2	Design parameters and control methods of various electric vehicle components such as DC-DC converters, DC-AC Inverters, DC drives, AC drives are calculated based on their individual operational analysis.
CO3	PO5	1	Using MATLAB software the performance specifications of power electronic converters and machine drives are analyzed for a given electric vehicle design.
CO3	PO12	1	Recognize the need of electric vehicle classification and individual component design, in order to be compatible enough for electric vehicle manufacturing requirement.
CO3	PSO1	2	With the knowledge of power electronic converters and dc/ac drives applicability in electric vehicles, as per the requirement and availability, electric vehicle designs are analyzed.
CO4	PO1	2	The fundamental knowledge of basic engineering science, engineering mathematics are utilized for analyzing energy storage elements such as batteries, fuel cell, flywheel and ultracapacitor.
CO4	PO2	3	With knowledge of mathematical designs for energy storage devices such as fuel cell, flywheel and ultracapacitor, their application criteria in vehicle design are formulated and performance parameters are analyzed.
CO4	PO3	1	Novel electric vehicle designs are analyzed with renewable energy source based storage elements.
CO4	PO5	2	Using MATLAB software energy storage devices such as fuel cell are analyzed with their mathematical model to decide performance specifications.
CO4	PO12	1	Recognize the need of different energy storage design for hybrid/electric vehicle, in order to be compatible enough for their design and manufacturing requirement.
CO4	PSO2	1	With the knowledge of energy storage elements, their applicability with different switching devices and drives, as per the requirement and availability, electric vehicle designs are analyzed.
CO5	PO1	2	With the fundamental knowledge of basic engineering physics and engineering mathematics, control strategies such as fuzzy logic and design constraints for hybrid/battery vehicles are realized.
CO5	PO2	2	With knowledge of different energy management strategies, their application criteria in specific vehicle design are formulated and their performance aspects are analyzed.
CO5	PO3	2	With knowledge on energy management strategies and case studies, design considerations for specific vehicle configurations are formulated.
CO5	PO5	1	Using MATLAB software, management strategy tool such as fuzzy logic

			controller is developed to design control system for vehicles.
CO5	PO12	1	Control technique for drives in electric vehicle application is formulated with the knowledge of energy management strategies.

SYLLABUS

UNIT-I **[10 Periods]**

Conventional Vehicles: Basics of vehicle performance, vehicle power source characterization, transmission characteristics, mathematical models to describe vehicle performance.

Introduction to Hybrid Electric Vehicles: History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies.

UNIT-II **[10 Periods]**

Hybrid Electric Drive-trains: Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis.

UNIT-III **[12 Periods]**

Electric Drive-trains: Basic concept of electric traction, introduction to various electric drive train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis. Electric Propulsion unit: Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives, configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance Motor drives, drive system efficiency.

UNIT-IV **[12 Periods]**

Energy Storage: Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Super Capacitor based energy storage and its analysis, Flywheel based energy storage and its analysis, Hybridization of different energy storage devices. Sizing the drive system: Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology, Communications, supporting subsystems.

UNIT-V **[12 Periods]**

Energy Management Strategies: Introduction to energy management strategies used in hybrid and electric vehicles, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy management strategies. Case Studies: Design of a Hybrid Electric Vehicle (HEV), Design of a Battery Electric Vehicle (BEV).

Text / References:

1. C. Mi, M. A. Masrur and D. W. Gao, "Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives", John Wiley & Sons, 2011.
2. S. Onori, L. Serrao and G. Rizzoni, "Hybrid Electric Vehicles: Energy Management Strategies", Springer, 2015.
3. M. Ehsani, Y. Gao, S. E. Gay and A. Emadi, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design", CRC Press, 2004.
4. T. Denton, "Electric and Hybrid Vehicles", Routledge, 2016.

ELECTRICAL ENGINEERING DRAWING (Professional Elective-III)	
EEE 413 (2)	**Credits : 3**
Instruction : 3 Periods & 1 Tut/Week	**Sessional Marks : 40**
End Exam : 3 Hours	**End Exam Marks : 60**

SYLLABUS

UNIT: I **[12 Periods]**

Different views of different types of nuts and bolts including foundation bolts with threads. Different types of welded joints, riveted joints, keys and cotters. Different types of solid and flexible couplings Pulleys flat and V-belt drive and gears used in Electrical Machine Drive. Knifes switches: Single, Double and Triple pole types, Main Switches, Energy meters.

UNIT: II **[12 Periods]**

Pin insulators, Sackless Insulators and Disc type Insulators for L.T. and H.T. Lines. String Insulators and Guard Ring for String Insulators. Cable supports and Holders. Sketches of C.T., P.T. and other Relays with feeders and distributors.

UNIT: III **[12 Periods]**

Development of Machine Winding:D.C. pole windings. D.C. Lap winding/Single and Double layer. D.C. wave winding: Single and Double layer. Placing of carbon brushes on the commutator segments showing the direction of current.

UNIT: IV **[14 Periods]**

Free Hand Sketches: Different Industrial Electrical symbols. Pole of Machine: Different views. Armature of D.C. Machine: Different views. Commutator of D. C. Machine: Different views. D.C. Machine brush and brush holder. Single-phase Transformer. Three-phase transformer. Cross arms and their arrangement with various Insulators. Different types of poles and Towers with feeders and Distributors and Lightning Arrestors. Stay Arrangement and guard wires arrangement for roads and rail lines crossing. Battery Charging Circuit with Battery.

UNIT: V **[10 Periods]**

Earthing - different types

Text Book:

1. Electrical Engineering Drawing by G.B. Bharadwajan.
2. Electrical Engineering Drawing by Dargon.
3. Electrical Engineering Drawing by Narang.
4. Electrical Engineering Drawing by Surjit Singh.

JAVA
(Professional Elective-III)

EEE 413 (3)	**Credits : 3**
Instruction : 3 Periods & 1 Tut/Week	**Sessional Marks : 40**
End Exam : 3 Hours	**End Exam Marks : 60**

Pre-requisites: Object oriented concepts, C++ programming

Course Outcomes:

By the end of the course, the student will be able to:	
CO1	Understand the concept of OOP as well as the purpose and usage principles of inheritance, polymorphism, and encapsulation.
CO2	Understand classes, objects, members of a class and the relationships among them needed for a specific problem.
CO3	Design and develop programs using packages and interfaces.
CO4	Develop the mechanism of exceptional handling and multithread
CO5	Implements the concept of event handling and GUI interface using Java swings

Program Matrix

COs	Program Outcomes (POs)												PSOs	
	Domain Specific POs					Domain Independent POs								
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	3	3	3	3	3	3	3	3		3	2	3	2
CO2	2	3	3	3	3	3	3	3	3		3	2	3	2
CO3	3	3		2	3	3	3	3	3		3	3	2	2
CO4	3	3	3	1	3	3	3	3	3		3	3	3	3

SYLLABUS

UNIT I: [12 Periods]

Introduction: OOP Principles, Encapsulation, Inheritance and Polymorphism, data types, variables, declaring variables, scope and life time of variables, arrays, operators, control statements, type conversion and casting.

UNIT II: [12 Periods]

Classes and Objects : Concepts of classes and objects, class fundamentals Declaring objects, introducing methods, constructors, usage of static with data and methods, access control, this key word, garbage collection, overloading methods and constructors, parameter passing – call by value, recursion..

UNIT III: [12 Periods]

Inheritance: Basic concepts, member access rules, usage of super key word, types of inheritance, method overriding, abstract classes, dynamic method dispatch, final keyword.
Packages and Interfaces : Defining, Creating and Accessing a Package, Understanding CLASSPATH, importing packages, differences between classes and interfaces, defining an interface, implementing interface, applying interfaces, variables in interface and extending interfaces.

UNIT IV: **[12 Periods]**

Exception Handling and Multithreading : Concepts of Exception handling, types of exceptions, usage of try, catch, throw, throws and finally keywords, Built-in exceptions, creating own exception sub classes, Concepts of Multithreading, differences between process and thread, thread life cycle, creating multiple threads using Thread class, Runnable interface, Synchronization, thread priorities, inter thread communication, deadlocks.

UNIT V: **[12 Periods]**

Event Handling: Events, Event sources, Event classes, Event Listeners, Delegation event Applets and swings: Applets – Concepts of Applets, differences between applets and applications, life cycle of an applet, types of applets, creating applets, passing parameters to applets, graphics class model, handling mouse and keyboard events, Adapter classes.

Swings – JApplet, JFrame and JComponent, Icons and Labels, text fields, buttons –The JButton class, Check boxes, Radio buttons, Combo boxes, Tabbed Panes, Scroll Panes, Trees, andTables.

Text Books:

1. The Complete Reference Java J2SE 5th Edition, Herbert Schildt, TMH Publishing Company Ltd, New Delhi.
2. "Learn Object Oriented Programming Using Java: An UML Treatment using Live Examples from Science and Engineering," Dr. N.B. Venkateswarlu, Dr. E.V. Prasad, S Chand, New Delhi.
3. Big Java 2nd Edition, Cay Horstmann, John Wiley and Sons.

Reference Books:

1. Java How to Program, Sixth Edition, H.M.Dietel and P.J.Dietel, Pearson Education/PHI
2. Core Java 2, Vol 1, Fundamentals, Cay.S.Horstmann and Gary Cornell, Seventh Edition, Pearson Education.
3. Core Java 2, Vol 2, Advanced Features, Cay.S.Horstmann and Gary Cornell, Seventh Edition, Pearson Education.
4. Beginning in Java 2, Iver Horton, Wrox Publications. 5. Java, Somasundaram, Jaico.

HVDC (Professional Elective-III)	
EEE 413 (4)	**Credits: 3**
Instruction: 3 Periods & 1 Tut/Week	**Sessionals Marks:40**
End Exam: 3 Hours	**End Exam Marks:60**

Course Outcomes: At the end of the course the student will be able to:

CO	BL	CO Statement
CO1	BL-2	**Differentiate** HVAC and HVDC transmission systems and to **summarize** different types of HVDC links.
CO2	BL-3	**Apply** 6-pulse, 12-pulse converter to **Determine** the equivalent circuit of HVDC converter.
CO3	BL-5	**Analyze** the Converter control characteristics to **Design** firing angle control for HVDC system.
CO4	BL-4	**Analyze** different types of faults and protection schemes used in HVDC system and to **Compute** the filter parameters to eliminate the harmonics.
CO5	BL-4	**Explain** the needs of FACTS controllers in power systems and to **Classify** different FACTS controllers.

Program Matrix

COs	Program Outcomes (POs)												PSOs	
	Domain Specific POs					Domain Independent POs								
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	2	-	2	-	-	-	-	-	-	2	2	-
CO2	2	3	2	-	2	-	-	-	-	-	-	2	3	-
CO3	2	3	3	-	2	-	-	-	-	-	-	2	3	-
CO4	2	3	3	-	2	-	-	-	-	-	-	2	3	-
CO5	2	2	3	-	-	-	-	-	-	-	-	2	3	-

JUSTIFICATION STATEMENT FOR CO-PO MAPPING			
COs	**POs**	**Level**	**Description**
CO1	PO1	2	Students can be able to apply knowledge of engineering fundamentals to understand principles of HVDC transmission.
CO1	PO2	2	Students will analyze problems related to HVDC links.
CO1	PO3	2	Students will identify various cost effective measures and design HVDC system components using Modern trends in HVDC system.
CO1	PO5	2	Student can able to apply power tools to find the Equipment ratings in HVDC transmission.
CO1	PO12	2	Knowledge of HVDC links and planning of HVDC transmission will be helpful to the students for technological change.
CO1	PSO1	2	Design the modern power system components and also solve the advances power system problems in the area of power system specialization modern trends in DC transmission and power handling capabilities of HVDC lines.
CO2	PO1	2	Develop the 6 and 12 pulse output voltage with the knowledge of fundamentals of basic electrical engineering and mathematics.

CO2	PO2	3	Student will able to analysis complex problem related to 6 pulse and 12 pulse convertes.
CO2	PO3	2	Student will able to design complex HVDC converter equations.
CO2	PO5	2	Student can able to apply power tools to implement equivalent circuit of HVDC transmission.
CO2	PO12	2	Knowledge of 12 pulse converters of HVDC transmission will be helpful to the students for technological change.
CO2	PSO1	3	Develop equivalent HVDC circuit in the area of power system specialization with the knowledge of converter configuration.
CO3	PO1	2	Analysis converter characteristics with the knowledge of fundamentals of basic electrical engineering and mathematics.
CO3	PO2	3	Student will able to analysis complex equations related to HVDC converter control.
CO3	PO3	3	Student will able to design complex HVDC converter and higher order controls.
CO3	PO5	2	Using ETAP/MATLAB software's the firing angle is generated for DC power flow control.
CO3	PO12	2	Knowledge of firing angle control of HVDC transmission will be helpful to the students for technological change.
CO3	PSO1	3	HVDC power transmission can be regulated in different conductions and power flow is maintained using higher level control.
CO4	PO1	2	Students can be able to apply knowledge of engineering fundamentals classify converter faults and its protection.
CO4	PO2	3	Students will analyze problems related to protective filters for harmonic reduction.
CO4	PO3	3	Students will identify various cost effective measures and design HVDC system filter components.
CO4	PO5	2	Student can able to apply power tools to find the DC and AC filter ratings in HVDC transmission.
CO4	PO12	2	Knowledge of harmonics and filter design is helpful to the students for technological change.
CO4	PSO1	3	Design the modern power system filter components and also solve the advances power system problems in the area of power system specialization.
CO5	PO1	2	Students can be able to apply knowledge of engineering fundamentals classify various FACTS devices.
CO5	PO2	2	Students will analyze problems related to controllable parameters used in FACTS system.
CO5	PO3	3	Students will identify various cost effective measures and design FACTS device for various applications.
CO5	PO12	2	Knowledge of FACTS controllers is helpful to the students for technological change.
CO5	PSO1	3	Design of FACTS devices are useful to improve the power quality in modern power system.

SYLLABUS

UNIT-I **[10 Periods]**

HVDC TRANSMISSION

General considerations, comparison of AC and DC transmission, applications of DC transmission, types of DC links, converter station and terminal equipment, planning for HVDC transmission, modern trends in DC transmission, power handling capabilities of HVDC lines.

UNIT-II **[12 Periods]**

STATIC POWER CONVERTRES

Basic AC/DC conversion principles, static converter configuration, 3-pulse, 6-pulse and 12-pulse converters, commutation process, rectifier and inverter operation, equivalent circuit for converter, special features of converter transformers.

UNIT-III **[12 Periods]**

CONTROL OF HVDC CONVERTERS AND SYSTEMS

Converter control characteristics, system control hierarchy, current and extinction angle, firing angle control, higher level controllers, DC power flow control.

UNIT-IV **[14 Periods]**

CONVERTRES FAULTS AND PROTECTION

converter faults, protection against over currents and over voltages in a converter station, surge arresters, smoothing reactors, corona effects, dc line insulators, transient over voltages in DC line, protection of DC line, DC breakers.

Harmonics in HVDC Systems: Harmonics in HVDC systems, harmonic elimination, AC and DC filters.

UNIT-V **[12 Periods]**

FACTS

Power flow in AC systems, need of FACTS controllers, relative importance of controllable parameters, basic types of facts controllers, shunt, series and combined shunt series controllers.

TEXT BOOKS:

1. R. Padiyar, “HVDC Power Transmission Systems”, New Age International Publishers, 2nd edition, 2013.
2. Narain G. Hingorani, Laszlo Gyugyi, “Understanding FACTS–Concepts and Technology of Flexible AC Transmission Systems”, Wiley India publications 2011.

POWER SYTEM ANALYSIS

EEE 414	Credits: 3
Instruction: 3 Periods & 1 Tut/Week	Sessionals Marks:40
End Exam: 3 Hours	End Exam Marks:60

Course Outcomes: At the end of the course the student will be able to:

CO	BL	CO Statement
CO1	BL-3	**Apply** per unit calculations to **Develop** reactance diagram for a given single line diagram.
CO2	BL-3	**Apply** Gauss-Seidel, Newton-Raphson and Fast Decoupled methods to **Compute** different parameters of the load flow problem.
CO3	BL-4	**Analyze** symmetrical and unsymmetrical faults to **Compute** fault current of the given single line diagram.
CO4	BL-4	**Analyze** the steady state and transient stability on single machine connected to infinite bus system to **Determine** steady state and transient stability limit.

Program Matrix

COs	Program Outcomes (POs)												PSOs	
	Domain Specific POs					Domain Independent POs								
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	3	1	-	-	-	-	-	-	-	-	1	2	-
CO2	2	3	2	-	2	-	-	-	-	-	-	1	3	-
CO3	2	3	2	-	2	-	-	-	-	-	-	1	3	-
CO4	2	3	2	-	2	-	-	-	-	-	-	1	3	-

JUSTIFICATION STATEMENT FOR CO-PO MAPPING			
COs	**POs**	**Level**	**Description**
CO1	PO1	2	Per unit values are calculated with the knowledge of fundamentals of basic electrical engineering and mathematics.
CO1	PO2	3	Based on the per unit values, formulate the impedance diagram and analyze it and develop the reactance diagram.
CO1	PO3	1	Calculate the ratings/design parameters of the various electrical equipment's with the knowledge of per unit calculations.
CO1	PO12	1	Recognize the need of per unit calculations for solving the advanced power system problems in the area of power system specialization.
CO1	PSO1	2	Design the modern power system components and also solve the advances power system problems in the area of power system specialization using per unit calculations.
CO2	PO1	2	Develop the bus admittance matrix with the knowledge of fundamentals of basic electrical engineering and mathematics.
CO2	PO2	3	Calculate voltage magnitude, phase angles, real power flows, reactive power flow, and line losses and analyze the single line diagram using different load flow methods with help of bus admittance matrix.
CO2	PO3	2	Design power system components through simulation software's with the knowledge of load flow parameters like voltage magnitude, phase angles, real power flows, reactive power flow, and line losses.

CO2	PO5	2	Using ETAP/MATLAB software's the load flow parameters like voltage magnitude, phase angles, real power flows, reactive power flow, and line losses are calculated and analyzed for the given single line diagram.
CO2	PO12	2	Recognize the need of load flow calculation for solving the advanced power system problems in the area of power system specialization.
CO2	PSO1	3	Solve the advanced power system problems like congestion management, optimal power flow etc in the area of power system specialization with the knowledge of load flow studies.
CO3	PO1	2	Form the bus impedance matrix with the knowledge of fundamentals of basic electrical engineering and mathematics.
CO3	PO2	3	For the given electrical network using bus impedance matrix and the knowledge of basic electrical circuit theorems fault currents are calculated and also the same is analyzed for symmetrical and unsymmetrical type of faults.
CO3	PO3	2	Ratings/design parameters of the Circuit Breaker and fault limiting reactors are calculated based on the analysis of different types of faults.
CO3	PO5	2	Using ETAP/MATLAB software's the symmetrical and unsymmetrical faults are calculated and analyzed for the given single line diagram.
CO3	PO12	1	Recognize the need of fault current calculations for design of protective equipment and security aspects of power system.
CO3	PSO1	3	Solve the advanced power system problems like contingency analysis, power system security, state estimation etc. with the knowledge of fault calculations.
CO4	PO1	2	Derive the swing equation and as well as concept equal area criteria with the knowledge of basic electrical engineering and mathematics.
CO4	PO2	3	With the knowledge of swing equation/equal area criteria, the steady state and transient stability are analyzed under different disturbances for the single machine connected to infinite bus system.
CO4	PO3	2	Design the rating of the Circuit breakers with calculations of transient stability parameters like critical clearing angle and critical clearing time.
CO4	PO5	2	Using MATLAB software's the transient stability parameters like critical clearing angle and critical clearing time are calculated and analyzed for the given single line diagram.
CO4	PO12	1	Recognize the need of transient stability analysis to design the modern protective equipment under different disturbances.
CO4	PSO1	3	Calculate voltage, frequency and rotor angle stability for a multi-machine system with the knowledge of transient stability analysis.

SYLLABUS

UNIT-I [8 Periods]

PER UNIT SYSTEM OF REPRESENTATION

Single line diagram, per unit system, per unit impedance of a 3-winding transformer, per unit impedance and reactance diagram of a power system.

UNIT-II [14 Periods]

POWER FLOW ANALYSIS

Formulation of bus admittance matrix, classification of buses, power flow problem, Gauss-Seidel Method, Newton-Raphson method, Decoupled & Fast decoupled method of solving power flow problem.

UNIT-III [12 Periods]

SYMMETRICAL FAULT ANALYSIS

Formulation of bus impedance matrix, 3-phase short circuit currents and reactances of a synchronous machine, methods of calculating symmetrical fault currents, selection of circuit-breakers, fault limiting reactors.

UNIT-IV [12 Periods]

UN-SYMMETRICAL FAULT ANALYSIS

Symmetrical components, 3-phase power in terms of symmetrical components, sequence impedances and sequence networks, phase shift in delta/star Transformers.
Unsymmetrical faults –L-G, L-L, L-L-G on an unloaded alternator.

UNIT-V [14 Periods]

POWER SYSTEM STABILITY

Concepts of stability (steady state and transient), swing equation, steady state stability limit, equal area criterion, critical clearing angle and time for transient stability, step by step method of solution, methods of improving transient stability.

TEXT BOOKS:

1. Hadi Sadat, "Power System Analysis", TMC Publications, 3rd edition, 2010.
2. John J. Grainger & William D. Stevenson, Jr.," Elements of Power System Analysis, TMH Publications, 2014.
3. I.G. Nagrath & D.P. Kothari, "Modern Power System Analysis", TMH Publications, 4th edition, 2011.

RFERENCE BOOKS:

1. B. M. Weedy & B. Cory, "Electric Power Systems", Wiley Publications, 4th edition, 2012.
2. J. Duncan Glover, M.S.Sarma & Thomas J. Overbye, " Power System Analysis &Design Systems", CLI Private Ltd.,2012.

POWER SEMICONDUCTOR DRIVES	
EEE 415	**Credits: 3**
Instruction: 3 Periods & 1 Tut/Week	**Sessionals Marks:40**
End Exam: 3 Hours	**End Exam Marks:60**

Course Outcomes: At the end of the course the student will be able to:

CO	BL	CO Statement
CO1	BL-3	**Discuss** the operation and characteristics of single phase and three phase controlled rectifiers fed to D.C motors to **Calculate** the values of output voltage, speed and torque for a given D.C drive.
CO2	BL-3	**Illustrate** braking techniques and **Explain** the four quadrant operation fed Dual converter. **Calculate** the values of output voltage, speed and torque in motoring and braking modes.
CO3	BL-4	**Demonstrate** the operation and speed –torque characteristics of Choppers fed D.C motors to **Select** a drive based on mechanical characteristics for a particular drive application.
CO4	BL-3	**Classify** induction motor speed control methods connected to A.C Voltage controller, Cycloconverter, VSI and CSI to **Examine** their use in specific applications.
CO5	BL-3	**Describe** the operation and speed –torque characteristics of Separate control & self control of synchronous motors using VSI, CSI and Cycloconverter. **Examine** the possible combinations of converter fed motors.

Program Matrix

COs	Program Outcomes (POs)												PSOs	
	Domain Specific Pos					Non-Domain Independent Pos								
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	3	1	-	2	-	-	-	-	-	-	1	-	2
CO2	2	3	1	-	2	-	-	-	-	-	-	1	-	2
CO3	2	3	1	-	2	-	-	-	-	-	-	1	-	2
CO4	2	3	1	-	2	-	-	-	-	-	-	1	-	2
CO5	2	3	-		-	-	-	-	-	-	-	1	-	2

JUSTIFICATION STATEMENT FOR CO-PO MAPPING			
COs	**POs**	**Level**	**Description**
CO1	PO1	2	Single Phase & three phase half wave, semi and fully controlled converters fed D.C motors operation and speed-torque characteristics are discussed with the knowledge of basic engineering sciences and fundamental engineering.
CO1	PO2	3	Speed & torque expressions of DC motor are calculated based on converter output parameters for a particular load.
CO1	PO3	1	Design a single phase & three phase rectifier circuits connected to D.C drive for a given application.
CO1	PO5	2	Using MATLAB software the performance characteristics of D.C motor fed from rectifier circuits are analyzed.
CO1	PO12	1	Recognize the need of DC drives by using rectifier configuration design as per the requirement, since DC drives are mostly used in industrial applications.
CO1	PSO2	2	With the knowledge of various DC drives operation and characteristics, their design for industrial and research sectors are analyzed.
CO2	PO1	2	The fundamental knowledge of basic engineering mathematics and electrical

			engineering is used to Illustrate braking techniques and four quadrant operations fed Dual converter.
CO2	PO2	3	Based on the knowledge of braking technique circuits, speed & torque parameters are analyzed and their values are calculated.
CO2	PO3	1	Various modes of operations such as motoring, breaking and plugging is utilized for designing dual converter fed dc motors.
CO2	PO5	2	Using MATLAB software, specifications of dual converter are analyzed.
CO2	PO12	1	Recognize the need of braking techniques, in order to be compatible enough for high power drive application based industries.
CO2	PSO2	2	With the knowledge of dual converter operation and characteristics, able to design and analyze the dc drives in industries.
CO3	PO1	2	The fundamental knowledge of basic engineering mathematics, engineering physics and electrical engineering is utilized for demonstrating the operation and speed –torque characteristics of Choppers fed D.C motors.
CO3	PO2	3	In reference to chopper fed dc motors, mathematical derivations of output voltage are formulated and their performance parameters are computed.
CO3	PO3	1	Design a resistance for breaking operation of chopper fed dc motors by selecting parameters, and finding duty cycle and speed of dc motor.
CO3	PO5	2	Using MATLAB/SIMULINK software the characteristics of chopper fed dc series and separately excited motors are analyzed.
CO3	PO12	1	Recognize the need of modes of operation of chopper fed dc motors, performance evaluation in electric drives are analyzed.
CO3	PSO2	2	With the knowledge of chopper fed dc motors, able to design and analyze the dc drives in industries.
CO4	PO1	2	With the knowledge of fundamental electrical engineering and engineering mathematics, control of induction motor by using AC voltage controller, cycloconverter, VSI and CSI operations are explained.
CO4	PO2	3	With knowledge of control of Induction motor by using braking techniques, their application criteria in specific applications are formulated and performance parameters are analyzed.
CO4	PO3	1	Design an Induction motor fed from different AC to AC converters with the knowledge of PWM techniques.
CO4	PO5	2	Using MATLAB/SIMULINK software, performance characteristics of induction motor drive are analyzed.
CO4	PO12	1	Recognize the need of control of induction motor through different control techniques, AC drives are used in industrial applications.
CO4	PSO2	2	With the knowledge of various AC converter operation and characteristics by using PWM control and regenerative breaking, their role in applications like electric drives for industrial and research sectors are analyzed.
CO5	PO1	2	With the knowledge of fundamental electrical engineering and engineering mathematics, synchronous motor operation by VSI, CSI and Cyclo converters are described.
CO5	PO2	3	Based on the knowledge of Separate control & self control of synchronous motors, performance specifications are mathematically derived.

CO5	PO12	1	Recognize the need of self and separately control synchronous motors by CSI and VSI, AC-AC converters are highly useful in electric drive applications.
CO5	PSO2	2	With the knowledge of load commutated CSI fed synchronous motor, their role in applications like electric drives for industrial and research sectors are analyzed.

SYLLABUS

UNIT I: **[14 Periods]**

Control of DC motors by Single phase and three phase Converters: Introduction to Thyristor controlled Drives, Single Phase semi and Fully controlled converters connected to d.c separately excited and d.c series motors – continuous current operation – output voltage and current waveforms – Speed and Torque expressions – Speed – Torque Characteristics- Problems on Converter fed d.c motors.Three phase semi and fully controlled converters connected to d.c separately excited and d.c series motors – output voltage and current waveforms – Speed and Torque expressions – Speed – Torque characteristics – Problems.

UNIT II: **[08 Periods]**

Four Quadrant operation of DC Drives: Introduction to Four quadrant operation – Motoring operations, Electric Braking – Plugging, Dynamic and Regenerative Braking operations. Four quadrant operation of D.C motors by dual converters.

UNIT III: **[10 Periods]**

Control of DC motors by Choppers: Single quadrant, Two –quadrant and four quadrant chopper fed dc separately excited and series excited motors – Continuous current operation – Output voltage and current wave forms – Speed torque expressions – speed torque characteristics – Problems on Chopper fed d.c Motors .

UNIT IV: **[16 Periods]**

Control of Induction Motor through Stator voltage: Variable voltage characteristics-Control of Induction Motor by Ac Voltage Controllers – Waveforms – speed torque characteristics. Variable frequency characteristics-Variable frequency control of induction motor by Voltage source and current source inverter and cyclo converters- PWM control – Comparison of VSI and CSI operations – Speed torque characteristics ,Static rotor resistance control – Slip power recovery – Static Scherbius drive – Static Kramer Drive – their performance and speed torque characteristics – advantages applications .

UNIT V: **[12 Periods]**

Control of Synchronous Motors: Separate control & self control of synchronous motors – Operation of self controlled synchronous motors by VSI, CSI and cyclo converters. Load commutated CSI fed Synchronous Motor – Operation – Waveforms – speed torque characteristics – Applications – Advantages and Numerical Problems.

TEXT BOOKS:

1. Fundamentals of Electric Drives – by G K Dubey Narosa Publications
2. Power Electronic Circuits, Devices and applications by M.H.Rashid, PHI.

REFERENCE BOOKS:

1. Power Electronics – MD Singh and K B Khanchandani, Tata – McGraw-Hill Publishing company,1998.
2. Modern Power Electronics and AC Drives by B.K.Bose, PHI.

3. Thyristor Control of Electric drives – Vedam Subramanyam Tata McGraw Hill Publilcations.
4. A First course on Electrical Drives – S K Pillai New Age International(P) Ltd. 2nd Editon.

POWER SYTEM PROTECTION	
EEE 416	**Credits: 3**
Instruction: 3 Periods & 1 Tut/Week	**Sessionals Marks:40**
End Exam: 3 Hours	**End Exam Marks:60**

Course Outcomes: At the end of the course the student will be able to:

CO	BL	CO Statement
CO1	BL-3	**Compare** the construction, operation and applications of electromagnetic relays and Over Current protection. **Determine** the settings of PSM and TMS of Over Current relay. **Explain** the construction, operation and applications of Distance and Differential Protection. **Determine** the minimum value of earthing resistance and percentage of winding unprotected for Alternators. **Determine** relay setting and CT ratio of transformer protected by percentage differential protection.
CO2	BL-2	**Explain** operation of Static Over current, Distance, Differential protection and Microprocessor based relay. **Identify** the difference between electromagnetic and static relays.
CO3	BL-3	**Explain** the construction, operation and applications of various types of Lightning arresters. **Determine** reflected, refracted voltages and currents of Travelling waves.
CO4	BL-3	**Explain** the construction, operation and application of various types of Fuses and Circuit Breakers. **Determine** the TRV/RRRV. **Construct** substation layout and bus bar arrangement using single diagram.

Program Matrix

	Program Outcomes (POs)												**PSOs**	
COs	**Domain Specific POs**					**Domain Independent POs**								
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	3	2	-	-	-	-				-	1	3	
CO2	2	2	-	-	-	-	-				-	1	3	
CO3	2	1	-	-	-	-	-				-	1	3	
CO4	2	3	2	-	2	-	-				-	1	3	

JUSTIFICATION STATEMENT FOR CO-PO MAPPING			
COs	**POs**	**Level**	**Description**
CO1	PO1	2	Basic knowledge of electrical engineering is required to **Explain** the construction and operation of electromagnetic relays.
CO1	PO2	3	**Determine** the settings of PSM and TMS of Over Current relay based on the knowledge of construction and operation of electromagnetic relays.
CO1	PO3	2	Calculate the ratings/design parameters of the various electromagnetic relays with the knowledge of PSM and TMS.
CO1	PO12	1	Recognize the need of relay settings to **Solve** the advanced power system protection problems in the area of power system specialization.
CO1	PSO1	2	**Design** the modern power system components and also solve the advances power system problems in the area of power system specialization using PSM and TMS calculations.
CO2	PO1	2	Basic knowledge of electrical engineering is required to **Explain** operation of

			Static Over current, Distance, Differential protection and Microprocessor based relay.
CO2	PO2	2	**Identify** the difference between electromagnetic and static relays.
CO2	PO12	2	Recognize the need of static and digital relays to **Explain** the advanced power system protection relays in the area of power system specialization.
CO2	PSO1	3	**Design** the modern power system components and also solve the advances power system problems in the area of power system specialization.
CO3	PO1	2	Basic knowledge of electrical engineering is required to **Explain** the construction, operation and applications of various types of Lightning arresters.
CO3	PO2	3	**Determine** the values of reflected, refracted voltages and currents of Travelling waves.
CO3	PO12	1	Recognize the need of lightning arrestors for design of protective equipment and security aspects of power system.
CO3	PSO1	3	Operation and construction of the lightning arresters are needed to **Explain** the advanced power system protection equipment in the area of power system specialization.
CO4	PO1	2	Basic knowledge of electrical engineering is required to **Explain** operation and construction of various types of Fuses and Circuit Breakers and substation layout and bus bar arrangement.
CO4	PO2	3	**Determine** the different parameter of circuit breaker like TRV/RRRV, breaking current, making current etc, and also ratings of the fuses. **Construct** substation layout and bus bar arrangement using single diagram.
CO4	PO3	2	Calculate the ratings/design parameters of circuit breakers with the knowledge of TRV/RRRV, breaking current, making current and also ratings of the fuses.
CO4	PO5	2	Circuit breaker parameters like TRV/RRRV are calculated and analyzed using MATLAB software.
CO4	PO12	1	Recognize the need of TRV/RRRV to design the modern protective equipment under different disturbances.
CO4	PSO1	3	**Design** the modern power system components and also solve the advances power system problems in the area of power system specialization.

SYLLABUS

UNIT-I **[15 Periods]**

PROTECTIVE RELAYING

Faults, causes and effects, Importance of protective relaying, Evolution of protective relays, Protective zones, Primary and backup protection, Desirable qualities of protective relaying, classification of protective relays and schemes, current transformers, potential transformers, basic relay terminology. Operating principle and construction of electromagnetic relays.

Over Current and Earth Fault Protection- Applications of over current protection, relays used in over current protection, time current characteristics, directional relays, protection of parallel feeders, and protection of ring mains. Phase fault and earth fault protection, combined earth fault and phase fault protective scheme, Directional earth fault relay.

UNIT-II **[10 Periods]**

DISTANCE AND DIFFERENTIAL PROTECTION:

Distance Protection - Principle of operation of distance protection, R-X diagram, universal torque equation, impedance, reactance and mho relay. Zones of protection, auto reclosing. Pilot wire protection and carrier current protection.

Differential Protection -Types, protection of generators, protection of transformers, and bus-zone protection.

UNIT-III **[10 Periods]**

STATIC AND NUMERICAL RELAYS

Block diagram representation, Merits and demerits of static relays, amplitude and phase comparators, basic block diagrams of static over current, distance and differential protection. Block diagram of microprocessor based relay, advantages.

UNIT-IV **[10 Periods]**

PROTECTION AGAINST OVER VOLTAGES

Causes of over voltages, over voltages due to lightning. Protection against lightning and travelling waves – earth wire, effects of series inductances, shunt capacitance, spark gap, surge arresters, lightning arresters, insulation co-ordination.

UNIT-V **[15 Periods]**

CIRCUIT BREAKERS AND SUBSTATION LAYOUT

Fuses-Types of fuses, high voltage HRC fuses, applications, selection and discrimination.

Circuit Breakers-Principle of operation, formation of arc, methods of arc extinction, transient recovery voltage, resistance switching, switching of capacitor banks and un-loaded lines, current chopping, ratings and characteristics of circuit breakers. Classification, constructional features of air circuit breakers, oil circuit breakers, air blast circuit breakers, SF-6 circuit breakers and vacuum circuit breakers, testing of circuit breakers.

SUB-STATION LAYOUT & BUS BARS: Classification of substations, substation equipment and their function, bus-bar design and schemes of layout.

TEXT BOOKS:

1. Sunil S. Rao, “Switchgear Protection and Power Systems” Khanna Publishers, 13th, edition, 2013,
2. B. Ram and D.N. Viswakarma, “Power System protection and Switchgear” TMH Publications, 2nd, edition, 2013.

REFERENCE BOOKS:

1. C.L. Wadhwa, “Electrical power Systems”, New Age International Publishers, 6th edition, 2010.
2. L. P. Singh, “Protective relaying from Electromechanical to Microprocessors”, New Age International Publishers, 2nd edition, 2004.

POWER ELECTRONICS LABORATORY	
EEE 417	**Credits:2**
Instruction: 3 Periods	**Sessionals Marks:50**
End Exam: 3 Hours	**End Exam Marks:50**

Course Outcomes:
At the end of the course the student will be able to:

COs	BLs	CO Statement
CO1	BL-4	**Analyze** the VI characteristics of SCR and **Illustrate** different turnoff and turn on methods.
CO2	BL-4	**Analyze** the operation of 1-phase & 3-phase rectifier circuits & **Examine** the output waveforms for different firing angles.
CO3	BL-4	**Analyze** the operation of on 1-phase inverter circuits & **Examine** the output waveforms for different frequencies.
CO4	BL-4	**Analyze** the operation of on 1-phase cycloconverter with different frequencies for different loads and **Compare** the output waveforms of 1-phase AC voltage controller circuits for different firing angles for different loads.
CO5	BL-4	**Distinguish** TRC & Frequency control methods on chopper circuits & **Examine** the output waveforms.

Program Matrix

	Program Outcomes (POs)												PSOs	
	Domain Specific POs					Domain Independent POs								
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	3	1	3	3	1			1	1		1	0	2
CO2	2	3	1	3	3	1			1	1		1	0	2
CO3	2	3	1	3	3	1			1	1		1	0	2
CO4	2	3	1	3	2	1			1	1		1	0	2
CO5	2	3	1	3	2	1			1	1		1	0	2

S.No	Name of the Experiment	CO's
1	V-I characteristics of SCR.	CO1
2	SCR firing circuits (R, RC and UJT).	CO1
3	Forced commutation techniques.	CO1
4	Single-phase semi and full converters.	CO2
5	Three-phase semi-converter.	CO2
6	Single-phase AC voltage controller	CO4
7	Single-phase cyclo converter.	CO4
8	Jones Choppers.	CO5
9	Series converter.	CO3
10	Parallel converter.	CO3

ELECTRICAL MACHINES LABORATORY - II	
EEE 418	**Credits:2**
Instruction: 3 Periods	**Sessionals Marks:50**
End Exam: 3 Hours	**End Exam Marks:50**

Course Outcomes:
At the end of the course the student will be able to:

COs	BLs	CO Statement
CO1	BL-4	**Analyze** the performance of transformer for 3 phase to 2 phase or 2 phase to 3 phase conversion and **Separate** the core losses.
CO2	BL-4	**Obtain** the speed control characteristics and efficiency characteristics of 3 phase induction machine and **Analyze** their performance.
CO3	BL-4	**Synchronize** 3phase alternator with supply, **Obtain** voltage regulation characteristics and **Analyze** their performance.

Program Matrix

	Program Outcomes (POs)												PSOs	
	Domain Specific POs					Domain Independent POs								
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	3	2	2	1	1			3	-			2	0
CO2	2	3	3	3	2	2			3	1			0	2
CO3	2	3	3	3	2	2			3	1			2	0

S.No	Name of the Experiment	CO's
1	Verification of Scott connection.	CO1
2	Load test on a 3-phase Induction motor.	CO2
3	No load and Block rotor tests on 3-phaseInduction motor.	CO2
4	Speed control of 3-phase Slip-ring Induction motor.	CO2
5	Regulation of an alternator by EMF and MMF methods.	CO3
6	Regulation of an alternator by ZPF method.	CO3
7	V and Inverted V Curves of Synchronous motor.	CO3
8	Slip test on Salient pole Synchronous machine.	CO3
9	3-phase Induction motor runs as a 1-phaseInduction motor.	CO3
10	R-L-C Load Test on a 1-phaseTransformer.	CO1
11	Equivalent circuit of a 1-phase Induction motor.	CO2
12	Line-excited Induction generator.	CO2
13	Separation of losses in single phase transformer.	CO1

PROJECT WORK	
EEE 4110	**Credits: 4**
Instruction: 6 Periods / Week	**Sessionals Marks:60**
End Exam: ---	**End Exam Marks:60**

Course Outcomes: At the end of the course the student will be able to:

COs	BLs	CO Statement	POs
CO1	BL-3	**Identify** the mathematical, engineering and other relevant knowledge that applies to a problem.	PO1
CO2	BL-3	**Demonstrate** the ability to **Identify** and **Characterize** an engineering problem through review research literature describing the causes of the problem and its effects using first principles of mathematics, natural sciences, and engineering sciences.	PO2 PO12 PSO1 PSO2
CO3	BL-3	**Create Select** and **Apply** appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling (design) of complex engineering activities with an understanding of the limitations.	PO3 PO5
CO4	BL-3	**Analysis** of cost-effective, environmental friendly designs of engineering systems with effective team work, presentation skills.	PO7 PO9 PO10 PO11

ENGINEERING ECONOMICS AND MANAGEMENT	
EEE 421	**Credits: 3**
Instruction: 3 Periods & 1 Tut/Week	**Sessionals Marks:40**
End Exam: 3 Hours	**End Exam Marks:60**

Course Objectives:

- To familiarize the students with the concepts of Economics.
- To gain basic understanding of management and manage organizations effectively and to relate the concepts of management with industrial organizations
- To help the students to understand the factors affecting productivity and to acquaint them with the major aspects of production management
- To make them to know the basics of Accounting, entrepreneurship and marketing management.

Course Outcomes: At the end of the course the student will be able to:

CO1	Understand the concepts of Economics
CO2	Gain basic understanding of management and to relate the concepts of management with industrial organizations and manage organizations efficiently
CO3	Have the basic knowledge of production management and make decisions proficiently
CO4	Understand the basic concepts of accounting, finance and marketing management

Program Matrix

COs	Program Outcomes (POs)												PSOs	
	Domain Specific POs					Domain Independent POs								
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	-	-	-	-	-	-	-	1	2	-	3	1		
CO2	-	-	-	-	-	-	-	1	2	-	3	1		
CO3	-	-	-	-	-	-	-	1	2	-	3	1		
CO4	-	-	-	-	-	-	-	1	2	-	3	1		

SYLLABUS

UNIT I: Fundamentals of Economics: [10 Periods]

Wealth, Welfare and Scarce Definitions of Economics; Micro and Macro Economics; Demand- Law of Demand, Elasticity of Demand, Types of Elasticity and Factors determining price elasticity of Demand: Utility- Law of Diminishing Marginal Utility, its limitations and exceptions. [**CO 1]**

UNIT II: Forms of Business Organizations: [10 Periods]

Features, merits and demerits of Sole Proprietorship, Partnership and Joint Stock Company- Public Enterprises and their types. **(CO 2)**

UNIT III: Introduction to Management: [20 Periods]

Functions of Management- Taylor's Scientific Management; Henry Fayol's Principles of Management; **Human Resource Management** –Basic functions of Human Resource Management (in brief). **(CO 2) Production Management:** Production Planning and Control, Plant Location, Break-Even Analysis- Assumptions, limitations and applications. **(CO 3)**

UNIT IV: Financial Management: [10 Periods]

Types of Capital: Fixed and Working Capital and Methods of Raining Finance; Final Accounts-Trading Account, Statement of Profit and Loss and Balance Sheet (simple problems) **(CO 4)**

UNIT V: Marketing Management and Entrepreneurship: [10 Periods]

Marketing Management: Functions of marketing and Distribution Channels. **Entrepreneurship**: Definition, Characteristics and Functions of an Entrepreneur. **(CO 4)**

Text Books:

1. S.C. Sharma and Banga T. R., Industrial Organization & Engineering Economics, khanna Publications, Delhi-6. (2006) **(Units covered – 3,4 and 6)**
2. A.R. AryaSri, Managerial Economics and Financial Analysis, TMH Publications, new Delhi, (2014) **(Units covered – 1,2,4 and 5)**
3. S.N.Maheswari, SK Maheswari, Financial Accounting Fifth Edition, Vikas Publishing HousePvt. Ltd., New Delhi, (2012) **(Units covered – 5)**

NON-LINEAR SYSTEMS PROFESSIONAL ELECTIVE-IV	
EEE 422 (1)	**Credits: 3**
Instruction: 3 Periods & 1 Tut/Week	**Sessionals Marks:40**
End Exam: 3 Hours	**End Exam Marks:60**

SYLLABUS

UNIT-I:
Introduction to Non-Linear System: Classification of non-linearity, types of non-linearity in physical system, jump phenomena and critical jump resonance curve, methods of analysis of non-linear systems and comparison, isoclines, singular point, limit cycle.

UNIT-II:
Phase Plane Analysis: Concept of phase plane, phase trajectory, phase portraits, methods of plotting phase plane trajectories Vander Pol's equation, stability from phase portrait, time response from trajectories, isoclines method, Pell's method of phase trajectory, and Delta method of phase trajectory construction.

UNIT-III:
Frequency Domain Analysis: Absolute stability, Describing function, DF of typical nonlinearities stability analysis using DF method, stability studies using DF method.

UNIT-IV:
Liapunov Stability: Autonomous Systems: Stability of equilibrium point. Concepts of positive definite/semi definite, negative definite/ semi definite, indefinite functions, Lyapunov function, Liapunov Stability: asymptotic stability, global asymptotic stability, instability.

UNIT-V:
Linearization: Linear systems, linearization of nonlinear systems, input state linearization about equilibrium point, **f**eedback linearization and input/output linearization.

TEXT BOOK:

1. M.Vidyasagar, 'Nonlinear systems Analysis', 2nd Edition, 1991, prentice-Hall Inc.
2. Nonlinear Systems: Hassan K. Khalil, Prentice Hall of India, second edition.
3. Nonlinear Control Systems: Hassan K. Khalil, Prentice Hall of India.

REFERENCE BOOK:

1. Control System Engineering: Nagrath and Gopal, Wiley Eastern.
2. Applied Nonlinear Control: Jean Jacques E Slotine, Weiping Li
3. Automatic Control System: George J. Thaler Brown, Jaico Publications

POWER SYSTEM RELIABILITY PROFESSIONAL ELECTIVE-IV	
EEE 422 (2)	**Credits: 3**
Instruction: 3 Periods & 1 Tut/Week	**Sessionals Marks:40**
End Exam: 3 Hours	**End Exam Marks:60**

Course Outcomes: At the end of the course the student will be able to:

CO1	Understand the importance of maintaining reliability of power system components.
CO2	Apply the probabilistic methods for evaluating the reliability of generation and transmission systems.
CO3	Assess the different models of system components in reliability studies.
CO4	Assess the reliability of single area and multi area systems.

Program Matrix

COs	Program Outcomes (POs)												PSOs	
	Domain Specific POs					Domain Independent POs								
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	2	2	2	1	2	1	1	0	2	1		
CO2	2	2	2	2	2	1	2	2	2	0	2	1		
CO3	2	2	2	2	2	1	2	2	2	0	2	1		
CO4	2	2	2	2	2	1	2	2	2	0	2	1		

SYLLABUS

UNIT-I **[12 Periods]**

BASIC REIABILITY CONCEPTS

The general reliability function, the exponential distribution – mean time to failures – series and parallel systems, markov process – continuous Markov process – Recursive techniques –Simple series and parallel system models.

UNIT-II **[12 Periods]**

GENERATING CAPACITY – BASIC PROBABILITY METHODS

The generation system model – Loss of load indices – Capacity expansion analysis – scheduled outages. Load forecast uncertainty Loss of energy indices, the frequency and duration method.

TRANSMISSION SYSTEMS RELIABILITY EVALUATION

Radial configuration, conditional probability approach, network configurations, state selection.

UNIT-III **[12 Periods]**

GENERATION PLANNING

Comparative economic assessment of individual generation projects, investigation and simulation models, heuristic and linear programming models, probabilistic generator and load models.

UNIT-IV **[12 Periods]**

TRANSMISSION PLANNING

Deterministic contingency analysis, probabilistic transmission system–reliability analysis, reliability calculations for single area and multi–area power systems.

UNIT-V **[12 Periods]**

DISTRIBUTION PLANNING

Network configuration design-consisting of schemes, security criteria configuration synthesis.

Text Books:

1. Roy Billinton and Ronald N Allan, "Reliability Evaluation of Power Systems", PPC, 2nd Edition, 1996.
2. V. Sankar, "System Reliability Concepts",Himalaya Publishing House, 2015.
3. R.L. Sullivan, "Power System Planning", McGraw Hill International, 1977.
4. Wheel Wright and Makridakis, "Forecasting methods and Applications", John Wiley, 1992.
5. J. Endremyl, "Reliability Modelling in Electric Power Systems", John Wiley, 2005.

DESIGN OF ELECTRICAL MACHINES PROFESSIONAL ELECTIVE-IV	
EEE 422 (3)	**Credits: 3**
Instruction: 3 Periods & 1 Tut/Week	**Sessionals Marks:40**
End Exam: 3 Hours	**End Exam Marks:60**

Course Objectives:

At the end of the course students should understand

- D.C machines designing part
- Design of transformers
- Design of Induction motors
- Design of Synchronous machines

Contribution to Outcomes:

This course used lectures assignments and class tests to enable the students to

CO1	Design of Armature winding ,field winding & Armature slots.
CO2	Design the core dimensions and windings of Three phase and single phase Transformers.
CO3	Design the main dimensions, rotor & stator slots and air gap length of Induction and synchronous machines.

SYLLABUS

UNIT I: [10 Periods]

Rating and Heating of Motors:

Heating effects, loading conditions and classes of duty, determination of power ratings of motors for different applications, effect of load inertia, load equalization and fly wheel, calculations, environmental factors.

UNIT II: [15 Periods]

D.C.MACHINES:

E.M.F generated from full pitch - fractional pitch with and without distributed windings - distribution factor. Design of main dimensions from output equation - Design of Armature windings - Design of field system - Design of inter pole and commutator.

UNIT III: [10 Periods]

TRANSFORMERS:

Derivation of output equation - volt per turn importance and calculation of main dimensions for three phase and single phase transformers - window dimensions – Yoke design and coil design - Design of tank with tubes.

UNIT IV: [13 Periods]

INDUCTION MOTOR:

Derivation of output equation - calculation of main dimensions – Stator design - number of slots - shape and area of slots - Rotor design for squirrel cage and slip ring types.

UNIT V: [12 Periods]

SYNCHRONOUS MACHINES:

Derivation of output equation - Calculations of Main Dimensions for salient pole and cylindrical rotor alternators - Stator design - number of stator slots and slot dimensions – Pole design for salient pole generators - pole winding calculations. Design of rotor for cylindrical rotor alternator - Design of rotor windings.

TEXT BOOKS:

1. A.K. Sawhney, A Course in Electrical machine Design, Dhanpatrai & Sons,
2. M.G. Say,Performance and Design of AC Machines 3rd Edition.
3. A.E. clayton, Performance and Design of AC Machines 2004.

PROCESS CONTROL AND AUTOMATION PROFESSIONAL ELECTIVE-IV	
EEE 422 (4)	**Credits: 3**
Instruction: 3 Periods & 1 Tut/Week	**Sessionals Marks:40**
End Exam: 3 Hours	**End Exam Marks:60**

SYLLABUS

UNIT I: **[12 Periods]**
Fundamentals of Process Control: Definition of industrial processes and control, Hierarchies in process control systems, block diagram representation of process control system, Current trends in computer control of process plants.

UNIT II: **[12 Periods]**
Strategies for Computer-Aided Process Control: Definition of process, Open loop control, closed loop control, basic principles of Single Controller loop, effects of P, PI and PID controllers, control system response, controllability of process, PID controller tuning techniques, closed loop cycling technique, multi-variable control, feed forward control.

UNIT III: **[12 Periods]**
Programmable Logic Controllers (PLCs): Introduction, principles of operation, architecture of programmable logic controllers, programming the programmable controllers, programming languages, ladder diagram instruments, software, configurations, applications.

UNIT IV: **[12 Periods]**
Distributed Control Systems: Introduction, functional requirements of distributed control system, system architecture, distributed control systems, Leeds and Northup Max-1 distributed control systems, Control bailey Micro – Z distributed control systems.

UNIT V: **[12 Periods]**
Industrial control Applications: Automation strategy of Thermal power plant, distributed system structure of Thermal power plant, man-machine interface, Automation strategy of water treatment plant, distributed digital control, Automation and production planning of steel plant.

Textbooks:

1. Computer based Industrial Control, Krishna Kant, Prentice-Hall India, 2003.
2. Computer Aided Process Control, S.K.Singh, Prentice-Hall India, 2005.

Reference books:

1. Process Dynamics and Control, Seborg, D.E., T.F. Edgar, and D.A. Mellichamp, John Wiley, 2004.
2. Johnson D Curtis, Instrumentation Technology, Prentice-Hall India, (7th Edition), 2002.
3. S.K. Singh, Process control concepts, Prentice-Hall India, 2009.

ENERGY MANAGEMENT & CONTROL	
EEE 423	**Credits: 3**
Instruction: 3 Periods & 1 Tut/Week	**Sessionals Marks:40**
End Exam: 3 Hours	**End Exam Marks:60**

Course Outcomes: At the end of the course the student will be able to:

CO	BL	CO Statement
CO1	BL-3	**Apply** Lagrange multiplier method to **Determine** optimal solution through unit commitment and Economic load dispatch including transmission losses.
CO2	BL-4	**Model** the single area and two area load frequency control and **analyze** the steady state and dynamic response of power system.
CO3	BL-4	**Analyze** Automatic Voltage Regulator mechanism and **Classify** various excitation systems
CO4	BL-2	**Identify** different levels of the EMS and State their functions. **Describe** Operating States of Power System.
CO5	BL-3	**Discuss** about energy management system and **Apply** Energy diagnosis procedure for Power Distribution systems, Lighting systems, Compressed Air system, Air Condition and Ventilation system.

Program Matrix

COs	Program Outcomes (POs)												PSOs	
	Domain Specific POs					Non-Domain Independent POs								
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	3	1	-	2	-	-	-	-	-	-	1	2	-
CO2	2	3	2	-	2	-	-	-	-	-	-	1	2	-
CO3	2	3	1	-	-	-	-	-	-	-	-	1	2	-
CO4	2	3	-	-	-	-	-	-	-	-	-	1	2	-
CO5	2	3	-	-	-	-	-	-	-		-	1	2	-

JUSTIFICATION STATEMENT FOR CO-PO MAPPING			
Cos	**POs**	**Level**	**Description**
CO1	PO1	2	Student will be able to find an optimal solution using basic mathematical optimization techniques.
CO1	PO2	3	Students will be able to identify and formulate problems in the area of economic operation of power system.
CO1	PO3	1	Design economic system components that meet economic, environmental, social, political, ethical, health and safety, and sustainability requirements
CO1	PO5	2	Student will be able to design economic network in power system simulation tools.
CO1	PO12	1	Student will be able to formulate the problems in the area of power system control and recognize the need for life –long learning in context of technological change in integrated power system operation and control.
CO1	PSO1	2	Identify and formulate problems in the area of economic operation of power system.
CO2	PO1	2	Student will be able to predict the constraints involved in load dispatch of different types of power plant and find an optimal solution using basic

			mathematical optimization techniques.
CO2	PO2	3	Students will be able to identify and formulate problems in the area of economics of power system.
CO2	PO3	2	Design single area control system components that meet economic, environmental, social, political, ethical, health and safety, and sustainability requirements
CO2	PO5	2	Student will be able to design single area control network in power system simulation tools.
CO2	PO12	1	Student will be able to formulate the problems in the area of power system control and recognize the need for life –long learning in context of technological change in integrated power system operation and control.
CO2	PSO1	2	Identify and formulate problems in the area of economic operation of power system.
CO3	PO1	2	Student will be able to formulate problems in Automatic Generation control and voltage control by using basic mathematical techniques.
CO3	PO2	3	Students will be able to identify and formulate problems inAutomatic Generation control.
CO3	PO3	1	Design economic system components that meet economic, environmental, social, political, ethical, health and safety, and sustainability requirements
CO3	PO12	1	Student will be able to formulate the problems in the area of power system control and recognize the need for life –long learning in context of technological change in integrated power system operation and control.
CO3	PSO1	2	Identify and formulate problems in the area of economic operation of power system.
CO4	P01	2	Student will be able to predict the different operating states of power system and find an optimal solution using basic mathematical optimization techniques.
CO4	PO2	2	Students will be able to identify and formulate problems in the area of economics of power system.
CO4	PO12	1	Student will be able to formulate the problems in the area of power system control and recognize the need for life –long learning in context of technological change in integrated power system operation and control.
CO4	PSO1	2	Identify and formulate problems in the area of economic operation of power system.
CO5	P01	2	Student will be able to identify the equipment and domain of energy conservation and audit in power systemand find an optimal solution using basic mathematical optimization techniques.
CO5	PO2	2	Student will be able to design, analyze and evaluate an energy audit and the benefits of different energy management techniques
CO5	PO12	1	Student will be able to select appropriate energy conservation method to reduce the wastage of energy and recognize the need for life –long learning in context of technological change in integrated power system operation and control
CO5	PSO1	2	Identify and formulate problems in the area of economic operation of power system using different energy management techniques.

SYLLABUS

UNIT-I **[12 Periods]**

ECONOMIC OPERATION OF POWER SYSTEMS

Various aspects of economic operation, characteristics of steam, cogeneration and hydroelectric units, economic dispatch problem of thermal units with and without considering transmission losses using Lambda–iteration method, derivation of transmission loss formula, coordination equation, penalty factors, unit commitment problem and solution using Lagrange relaxation method, economic dispatch versus unit commitment, hydrothermal coordination problem and solution using Lagrange relaxation method, optimal load flow problem.

UNIT-II **[12 Periods]**

REAL POWER AND FREQUENCY CONTROL

Basic generator control loops, importance of frequency control, load-frequency control model, automatic generation control, automatic generation control in single and two-area systems, automatic generation control with economic dispatch control, speed governor dead-band and its effect on automatic generation control.

UNIT-III **[12 Periods]**

REACTIVE POWER AND VOLTAGE CONTROL

Reactive power flow, methods of voltage control-injection of reactive power by using shunt capacitors, series capacitors, synchronous compensators, tap-changing transformers, booster transformers and phase-shift transformers, types of excitation system, block diagram of automatic voltage regulator, automatic voltage regulator model.

UNIT-IV **[12 Periods]**

EMERGENCY CONTROL

Energy control center – various levels – national, regional and state level – SCADA system – computer configuration – function – monitoring, data acquisition and controls – EMS system, Power system operating states and control actions, power system security, power system state estimation-static and dynamic.

UNIT-V **[12 Periods]**

ENERGY AUDITING

Energy management system model, definition of energy audit, contents of energy audit, energy audit laws and regulations, key reasons for energy audit, energy diagnosis methods, energy diagnosis of power distribution systems, lighting systems, compressed air system, air condition and ventilation system, case study.

Text Books:

1. Hadi Sadat, “Power System Analysis”, TMC Publications, 3rd edition, 2010.
2. B. M. Weedy & B. Cory, “Electric Power Systems”, Wiley Publications, 4th edition, 2012.
3. O.I.Elgerd “Electric Energy Systems Theory-An Introduction”, TMH edition, 2nd edition, 2012.
4. I.G. Nagrath & D.P. Kothari, “Modern Power System Analysis“, TMH Publications, 4th edition, 2011.

Reference books:

1. L.P. Singh, "Advanced Power System Analysis and Dynamics", New Academic Science Ltd., 6th edition, 2011.
2. Mahalanabis A. K., Kothari D.P. and Ahson S.I., "Computer Aided Power System Analysis and Control, TMH Publications, 1999.
3. BSR Energy Management Hand Book (e-book).
4. Amit Kumar Tyagi, "Energy Audit and Management", Tata Energy Rersearch Institute (TERI), 2001.
5. Paul W. Callghan, "Energy Management and a comprehensive Guide".

POWER SYSTEM SIMULATION LABORATORY	
EEE 424	**Credits: 2**
Instruction: 3 Periods	**Sessionals Marks:50**
End Exam: 3 Hours	**End Exam Marks:50**

Course Outcomes: At the end of the course the student will be able to:

COs	BLs	CO Statement
CO1	BL-3	**Obtain** Y-bus and **Determine** String efficiency using MATLAB program.
CO2	BL-4	**Analyze** the performance of transmission lines, transient stability and economic dispatch using MATLAB program.
CO3	BL-4	**Analyze** and **Simulate** symmetrical, unsymmetrical faults and load flow methods for a given power system network using ETAP software.
CO4	BL-4	**Analyze** and **Simulate** single area and two-area load frequency mechanism using MATLAB software.

Program Matrix

	Program Outcomes (POs)												PSOs	
	Domain Specific POs					Domain Independent POs								
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	3	2	3	3				1	1		1	2	0
CO2	2	3	2	3	3				1	1		1	2	0
CO3	2	3	2	3	3				1	1		1	2	0
CO4	2	3	2	3	3				1	1		1	2	0

S.No	Name of the Experiment	CO's
1	Formation of Y-bus using MATLAB Software	CO1
2	Performance Analysis of Transmission Lines using MATLAB Software	CO2
3	String Efficiency of the Insulator using MATLAB Software	CO1
4	Solution of Swing Equation using MATLAB Software	CO2
5	Optimal Operation of Thermal Units without considering Transmission Losses using MATLAB Software	CO2
6	Optimal Operation of Thermal Units considering Transmission Losses using MATLAB Software	CO2
7	Three Phase Short circuit Analysis using ETAP Software	CO3
8	Load Flow Analysis using ETAP Software	CO3
9	Single Area Load Frequency Control Using MATLAB Software	CO4
10	Two Area Load Frequency Control Using MATLAB Software	CO4

CONTROL SYSTEMS LABORATORY	
EEE 425	**Credits: 2**
Instruction: 3 Periods	**Sessionals Marks:50**
End Exam: 3 Hours	**End Exam Marks:50**

Course Outcomes: At the end of the course the student will be able to:

COs	BLs	CO Statement
CO 1	BL- 4	**Obtain** the speed-torque characteristics of DC and A.C Servo motors and **Analyze** their performance.
CO 2	BL- 4	**Obtain** the characteristics of Synchro, BLDC motor, DC position control system and Magnetic amplifier and **Analyze** their performance.
CO 3	BL- 4	**Analyze** the response of 1st, 2nd and 3rd order systems with and without feedback and **Compare** their waveforms graphically for different input signals.
CO 4	BL- 4	**Design** the compensators and **Determine** their stability using Bode plot techniques.
CO 5	BL- 4	**Estimate** the effect of Temperature control system and **Compare** with and without controllers

Program Matrix

	Program Outcomes (POs)												**PSOs**	
	Domain Specific POs					**Domain Independent POs**								
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	3	1	3		1	-	-	1	1	-	1	0	1
CO2	2	3	1	3		1	-	-	1	1	-	1	0	1
CO3	2	3	1	3		1	-	-	1	1	-	1	0	1
CO4	2	3	1	3		1	-	-	1	1	-	1	0	1
CO5	2	3	1	3		1	-	-	1	1	-	1	0	1

S.No	Name of the Experiment	CO's
1	Study of Lead, Lag and Lead-Lag compensating networks.	CO4
2	Speed - Torque characteristics of a DC Servomotor.	CO1
3	To study the 'Magnetic Amplifier'.	CO2
4	Linear system simulator	CO3
5	Speed torque characteristics of A.C. Servo motor	CO1
6	Synchro transmitter and receiver pair	CO2
7	DC Motor Speed control characteristics	CO1
8	To study the D.C Position control system	CO2
9	To study the temperature controller using P, PI, PD and PID modes of operation	CO5
10	To study the performance of BLDC motor	CO2

PROJECT WORK	
EEE 426	**Credits: 8**
Instruction: 6 Periods / Week	**Sessional Marks:60**
End Exam: 3 Hours	**End Exam Marks:80**

Course Outcomes: At the end of the course the student will be able to:

COs	BLs	CO Statement	POs
CO1	BL-4	**Conduct** scientific, engineering experiments using hardware and software tools of their own, **Analyse** and **Interpret** data.	PO2 PO3 PO4 PO5 PO6 PSO1 PSO2
CO2	BL-4	**Demonstrate** collaborative skills and independent learning through working in a team to complete a task within a stipulated time using project management tools.	PO9 PO11
CO3	BL-4	**Demonstrate** skills with ethical responsibility in writing project reports and oral presentation of the work to a panel of experts.	PO8 PO10