EEHN01	ELECTRICAL MACHINE DESIGN	3L:1T:0P	4 Credits
Sessional Marks :**40**		End Semester Examination Marks: **60**	

Course Outcomes: At the end of this course, students will demonstrate the ability to

1. Understand the construction and basic design of transformers
2. Understand the design of rotating machines
3. Understand the design of 3-phase Induction motor
4. Understand the design of synchronous machines.
5. Analyze the Heating and Cooling of Electrical Machines.

UNIT-I

The design Problem: Basic considerations, design specifications, IS specifications, design constraints, design specifications for transformers and rotating machines Design of transformers: Types of core constructions, output equation, principles of design of core, windings, yoke, estimation of main dimensions (H & W) for single phase shell type, core type and 3-phase core type transformers Estimation of no load current from design data

UNIT-II

General Concepts for design of rotating machines: Output equation of dc and ac machines, separation of D and L, Choice of specific loadings Design of dc machines: Choice of number of poles, selection of number of armature slots, choice of armature winding, design of armature, design of commutator Design of field system: tentative design of field system, estimation of filed current

UNIT-III

Design of 3-phase Induction motor: separation of D and L, ranges of specific loadings Stator Design, selection of number of slots, estimation of turns per phase, design of conductor cross section Rotor design: Selection of number of rotor slots, principles of design of squirrel cage and slip ring rotor

UNIT-IV

Design of synchronous machines: Choice of armature windings, types of armature windings, separation of D and L Design of armature, choice of number of slots, estimation of turns per phase conductor cross section, field system design for salient pole and cylindrical pole rotor machines

UNIT-V

Heating and Cooling of Electrical Machines: Estimation of temperature rise, heating time constant, cooling time constant, heating and cooling time curves, volume of coolant required **Design of transformer tank with tubes**: estimation of temperature rise, design of transformer tank

TEXT BOOKS:

1. A.K.Sawhney, “Electrical Machine Design” (Dhanpatrai & Sons)
2. Balbir Singh, “Electrical Machine Design”(Khanna Publishers)

EEHN02	ADVANCED POWER SYSTEM PROTECTION	3L:1T:0P	4 Credits
Sessional Marks :**40**		End Semester Examination Marks: **60**	

Course Outcomes: At the end of this course, students will demonstrate the ability to

1. Learn the importance of static relays.
2. Apply appropriate comparator
3. Learn about digital protection

UNIT: 1

Static Relays: Fundamentals of static relays, Basic Block diagram and principle, Advantages of Static Relays, Types of static relays, Static Over-current relays, Differential relays, Percentage Differential relays, distance relays, characteristics of static relays.

UNIT: 2

Comparators: Need of comparators, General Equations of Comparators, Phase and amplitude Comparators, Analysis of Amplitude and Phase Comparators, Operating principles, Pilot relaying and Carrier current protection schemes, Multi Input Comparator circuits

UNIT: 3

Protection of Transmission lines & Transformers: Classification of protection schemes, zones of protection, 3–zone protection schemes, carrier aided distance schemes, switched distance schemes, Transformer protection, mal operation of relays, Harmonic Restraint relay, Wavelet applications in transformer protection, realization of Elliptical and Quadrilateral characteristics

UNIT: 4

Basic elements of Digital Protection: Historical Developments in digital protection, performance and operational characteristics of digital protection, basic structure of digital relays, components of digital relay, signal conditioning subsystem, conversion subsystem, digital relay subsystem

UNIT: 5

Digital Protection Of Power System Components: New developments in relaying principles, Generator protection, Transmission lines protection, transformer protection, protection of bus bars, fundamentals of travelling wave protection and applications

Text Books:

1. A.G. Phadke and J. S. Thorp, “Computer Relaying for Power Systems”, Wiley/Research studies Press, 2009

2. A.T. Johns and S. K. Salman, “Digital Protection of Power Systems”, IEEE Press,1999

3. Gerhard Zeigler, "Numerical Distance Protection", Siemens Publicis Corporate Publishing, 2006

4. S.R.Bhide "Digital Power System Protection" PHI Learning Pvt.Ltd.2014 5. Electrical Power Systems – C.L. Wadwa

EEHN03	DIGITAL CONTROL SYSTEMS	3L:1T:0P	4 Credits
Sessional Marks :**40**		End Semester Examination Marks: **60**	

Course Outcomes: At the end of this course, students will demonstrate the ability to

1. Identify the basic difference between continuous and digital time control.
2. Evaluate the stability of a system under different placements.
3. Design the digital controllers for industrial applications.
4. Analyze the discrete time systems with state space analysis techniques.

UNIT – I

Introduction – Comparison between analog and digital control – Importance of digital control – Structure of digital control – examples of digital control system – Difference equations – Z – transform – MATLAB examples. Frequency response of discrete-time systems – Properties of frequency response of discrete-time systems – Sampling theorem.

UNIT – II

ADC model – DAC model – Transfer function of zero order hold – DAC – Analog Subsystem, and ADC Combination Transfer Function – Closed loop transfer function – Steady state error and its constants (MATLAB commands).

UNIT – III

Definitions of stability (Asymptotic stability, exponential stability etc) – stable z-domain pole placement locations – stability conditions – Stability determination (Routh array) – Nyquist criterion.

UNIT – IV

Root locus – root locus design (P-control, PI -control, PD) – Z - domain root locus – z-domain root locus design digital implementation of analog controller design (differencing methods forward and backward) – bi linear transformation – direct z-domain controller design – frequency response design – Finite time response settling time.

UNIT – V

Concept of state space method – state space representations of discrete time systems – solving discrete time state space equations – Pulse transfer function matrix – Discretization of continuous state space equations – Liapunov stability analysis (discrete time) Controllability – observability – design via pole placement – state observers.

Text Books:

1. Kannan M. Moudgalya, 'Digital Control', Wiley Publishers, 1st Illustrated Edition, 2007.
2. M.Gopal, 'Digital Control Engineering', New Age International (ltd) Publishers, 1st Edition Reprint (2003), 1998.
3. Katsuhiko Ogata, 'Discrete Time Control Systems', Pearson Education Publications, 2nd Edition, 2005.

EEHN04	ADVANCED POWER ELECTRONICS	3L:1T:0P	4 Credits
Sessional Marks :**40**		End Semester Examination Marks: **60**	

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

1. Learn the characteristics of GTOs, IGBTs and use them in practical systems
2. Knowledge of working of multi-level VSIs, DC-DC switched mode converters, cyclo-converters and PWM techniques and the ability to use them properly
3. Acquire knowledge of power conditioners and their applications
4. Ability to design power circuit and protection circuit of PSDs and converters

UNIT-I

High-Power Switching Devices: Gate Turn-Off (GTO) Thyristor, Gate-Commutated Thyristor (GCT), Insulated Gate Bipolar Transistor (IGBT), Other Switching Devices, Operation of Series-Connected Devices Main Causes of Voltage Unbalance, Voltage Equalization for GCTs, Voltage Equalization for IGBTs

UNIT-II

Two-Level Voltage Source Inverters: Introduction, Sinusoidal PWM, Modulation Schemes, Harmonic Content Over-modulation, Third Harmonic Injection PWM, Space Vector Modulation Switching States, Space Vectors, Dwell Time Calculation, Modulation Index Switching Sequence, Spectrum Analysis, Even-Order Harmonic Elimination, Discontinuous Space Vector Modulation

UNIT-III

Cascaded H-Bridge Multilevel Inverters: Introduction, H-Bridge Inverter Bipolar Pulse-Width Modulation, Unipolar Pulse-Width Modulation, Multilevel Inverter Topologies, CHB Inverter with Equal dc Voltage, H-Bridges with Unequal dc Voltages, Carrier Based PWM Schemes, PWM Schemes, Staircase Modulation

UNIT-IV

Diode-Clamped Multilevel Inverters : Three-Level Inverter, Converter Configuration, Switching State, Phase-Shifted Multicarrier Modulation, Level-Shifted Multicarrier Modulation, Comparison Between Phase- and Level-Shifted Commutation, Space Vector Modulation, Stationary Space Vectors, Dwell Time Calculation, Relationship Between *Vref*, Location and Dwell Times Switching Sequence Design, Inverter Output Waveforms and Harmonic Content, Even-Order Harmonic Elimination, Neutral-Point Voltage Control, Causes of Neutral-Point Voltage Deviation, Effect of Motoring and Regenerative Operation, Feedback Control of Neutral-Point Voltage

UNIT-V

Other Space Vector Modulation Algorithms: Discontinuous Space Vector Modulation , SVM Based on Two-Level Algorithm , High-Level Diode-Clamped Inverters, Four- and Five-Level

Diode-Clamped Inverters, Carrier-Based PWM, NPC/H-Bridge Inverter: Inverter Topology, Modulation Scheme, Waveforms and Harmonic Content

Text Books:

1. Bin Wu ," High Power Converters and AC Drives (IEEE Press 2008)
2. By Dorian O Neacsu, " Power Switching Converters: Medium and High Power"

EEHN05	HYBRID ELECTRICAL VEHICLES	3L:1T:0P	4 Credits
Sessional Marks :**40**		End Semester Examination Marks: **60**	

Course Outcomes: At the end of this course, students will demonstrate the ability to

1. Understand the basics and configurations of electric vehicles and hybrid electric vehicles.
2. Analyze the power converters used in hybrid electric vehicles
3. Know different batteries and other energy storage systems.

UNIT– 1

Introduction: History of hybrid vehicles, architectures of HEVs, series and parallel HEVs, complex HEVs.

UNIT– 2

Hybridization of Automobile: Fundamentals of vehicle, components of conventional vehicle and propulsion load, Drive cycles and drive terrain; Concept of electric vehicle and hybrid electric vehicle, Plug-in hybrid vehicle, constituents of PHEV, comparison of HEV and PHEV, Fuel Cell vehicles and its constituents.

UNIT– 3

Plug-in Hybrid Electric Vehicle: PHEVs and EREVs blended PHEVs, PHEV Architectures, equivalent electric range of blended PHEVs; Fuel economy of PHEVs, power management of PHEVs, end-of-life battery for electric power grid support, vehicle to grid technology, PHEV battery charging.

UNIT– 4

Power Electronics in HEVs: Rectifiers used in HEVs, voltage ripples; Buck converter used in HEVs, non-isolated bidirectional DC-DC converter, regenerative braking, voltage source inverter, current source inverter, isolated bidirectional DCDC converter, PWM rectifier in HEVs, EV and PHEV battery chargers.

UNIT– 5

Battery and Storage Systems: Energy Storage Parameters; Lead–Acid Batteries; Ultra capacitors; Flywheels - Superconducting Magnetic Storage System; Pumped Hydroelectric Energy Storage; Compressed Air Energy Storage - Storage Heat; Energy Storage as an Economic Resource Course.

Text Books:

1. Ali Emadi, Advanced Electric Drive Vehicles, CRC Press, 2014.
2. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.

Reference Books:

1. MehrdadEhsani, YimiGao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.
2. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003.

3. H. Partab: Modern Electric Traction –DhanpatRai& Co, 2007.
4. Pistooa G., "Power Sources, Models, Sustainability, Infrastructure and the market", Elsevier 2008
5. Mi Chris, Masrur A., and Gao D.W., "Hybrid Electric Vehicle: Principles and Applications with Practical Perspectives" 1995.

EEHN06	INDUSTRIAL APPLICATIONS OF ELECTRICAL ENGINEERING	3L:1T:0P	4 Credits
Sessional Marks :**40**		End Semester Examination Marks: **60**	

Course Outcomes: At the end of this course, students will demonstrate the ability to

1. Select appropriate wiring components for electrical safety practices.
2. Design the HT connection with appropriate protection and compensations for Industrial, Residential and commercial applications.
3. Evaluate and select an appropriate motor to a particular application.
4. Design a lightning scheme for interior and exterior illumination application.

UNIT-I

Components in Electrical Systems: LT system wiring components, selection of cables, wires, switches, distribution box, metering system, Tariff structure, protection components- Fuse, MCB, MCCB, ELCB, inverse current characteristics, symbols, single line diagram (SLD) of a wiring system, Contactor, Isolator, Relays, MPCB, Electric shock and Electrical safety practices.

UNIT – II

Industrial Electrical Systems: HT connection, industrial substation, Transformer selection, Industrial loads, motors, starting of motors, SLD, Cable and Switchgear selection, Lightning Protection, Earthing design, Power factor correction - kVAR calculations, type of compensation, Introduction to PCC, MCC panels. Specifications of LT Breakers, MCB and other LT panel components.

UNIT – III

Residential and Commercial Electrical Systems: Types of residential and commercial wiring systems, general rules and guidelines for installation, load calculation and sizing of wire, rating of main switch, distribution board and protection devices, earthing system calculations, requirements of commercial installation, deciding lighting scheme and number of lamps, earthing of commercial installation, selection and sizing of components.

UNIT – IV

Special-Purpose Motors: Textile motors, Crane motors, determining the size of motor, Sugar centrifuge motors, Motors for deep-well pumps, Motors for agricultural application, Motors for mines, collieries and quarries, Motors for thermal power station auxiliaries, Selection of a special-purpose motor.

UNIT – V

Illumination Systems: Production of light, Laws of illumination, lighting calculation, Interior and exterior illumination systems, lighting schemes, design on lighting scheme; Electrical lamps, factory lighting, flood lighting, gaseous discharge lamps, high pressure and low-pressure neon lamps, high frequency, low pressure discharge tubes, induction lamps, LED lamps, Simple problems.

Text Books:

1. S. L. Uppal and G. C. Garg," Electrical Wiring, Estimating & Costing", Khanna publishers, 2008.
2. K. B. Raina," Electrical Design, Estimating & Costing", New age Inter- national, 2007.
3. S. Singh and R. D. Singh," Electrical estimating and costing", Dhanpat Rai and Co., 1997.
5. H. Joshi," Residential Commercial and Industrial Systems", McGraw Hill Education, 2008
6. K.C.Agarwal "Industrial Power Engineering and Applications Handbook", Newnes Power Engineering Series., 2001.