DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING

LIST OF COURSES OFFERED FOR HONOR PROGRAM (R23)

S.No	Course Title	Contact hours/week			Credits
		L	T	P	
23PEH1	Advanced Electric Machines	3	0	0	3
23PEH2	Advanced Power Converters	3	0	0	3
23PEH3	Energy Storage Devices	3	0	0	3
23PEH4	Smart Grid	3	0	0	3
23PEH5	Machine Modeling and Analysis	3	0	0	3
23PEH6	Advanced Electrical Drives	3	0	0	3
23PEH7	Advanced Electric Machines Lab	0	0	3	1.5
23PEH8	Design and Simulation of Power converters Lab	0	0	3	1.5

B.Tech. (Honors)

23PEH1-Advanced Electric Machines

L	T	P	Cr.
3	0	0	3

Prerequisite: DC Machines & Transformers, Induction and Synchronous Machines

Course Objective: The basic objective of this course is to introduce the theory, construction, design, control electronics, and in-depth analysis of several non-traditional machines such as single-phase special motors, servo motors, stepper motors, reluctance motors and linear motors.

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

CO1: Understand the construction and operation of servomotors and stepper motors. (**Understand-L2)**

CO2: Analyse the construction and operation of single-phase electrical motors. **(Apply-L3)**

CO3: Understand the construction and operation of reluctance motors and linear motors (**Understand-L2)**

UNIT I: SERVOMOTORS

AC Servomotors- Construction-principle of operation – performance characteristics – damped AC servomotors – Drag cup servomotor – applications. DC servomotors – field and armature controlled.

DC servomotors – permanent magnet armature controlled – series split field DC servomotor

UNIT II: STEPPER MOTORS

Stepper motors – Basic principle – different types – variable reluctance- permanent magnet – hybrid type – comparison – theory of operation – monofilar and bifilar windings – modes of excitation – drive circuits – static and dynamic characteristics – applications

UNIT III: SINGLE PHASE SPECIAL ELECTRICAL MACHINES

Single phase special electrical machines – AC series motor construction – principle of working – phasor diagram – universal motor Hysteresis motor- constructional details- principle of operation – torque-slip characteristics – applications.

UNIT IV: RELUCTANCE MOTORS

Reluctance motors – principle of operation – torque equation – torque slip characteristics- applications. Switched reluctance motors – principle of operation – power converter circuits – torque equation – different types – comparison – applications.

UNIT V: LINEAR MOTORS

Linear motors – different types – linear reluctance motor – linear synchronous motors – construction – comparison. Linear induction motors – Expression for linear force – equivalent circuit – applications.

TEXT BOOKS:

1. Miller, T. J. E., Brushless Permanent Magnet and Reluctance Motor Drives, Oxford Science Publications, 1989.

2. Kenjo, T., and Sugawara, A., Stepping Motors and their Microprocessor Controls, Oxford Science Publications, 1984.

3. Venkataratnam K., Special Electrical Machines, CRC Press, 2009.

REFERENCE:

1. Krishnan, R., “Permanent Magnet and BLDC Motor Drives”, CRC Press, 2009.

2. Chang-liang, X., "Permanent Magnet Brushless DC Motor Drives and Controls", Jun 2012.

B.Tech. (Honors)	23PEH2-Advanced Power Converters	L	T	P	Cr.
		3	0	0	3

Prerequisite: Power Electronics

Course Objective: This course deals with principles and basic topologies of non-isolated and isolated converters. It also deals the switching losses, conduction losses taking place in switched mode converters and soft switching converter topologies.

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

CO1: Identify the various types of non-isolated power converter topologies.(**Understand-L2)**

CO2: Analyze the performance of isolated power converter topologies. **(Apply-L3)**

CO3: Understand soft switching techniques and its control techniques. (**Understand-L2)**

CO4: Understand the Power Factor Correction Circuits. (**Understand-L2)**

UNIT I: NON-ISOLATED SWICHMODE POWER CONVERSION

Analysis & Designing of Buck converters, Boost converters, Buck-Boost converters, Cuk converters-continuous and discontinuous modes, applications, problems

UNIT II: ISOLATED SWICHMODE POWER CONVERSION

Requirement for isolation in the switch-mode converters, transformer connection, Forward and fly back converters, power circuit and steady state analysis-Applications. push-pull topologies-Applications, Half bridge and full bridge converters**-** Power circuit and steady state analysis

UNIT III: SOFT SWITCHING CONVERTERS

Classification of Resonant Converters-Basic resonant circuits- Series resonant circuit-Parallel resonant circuits- Resonant switches, Concept of Zero voltage switching-Principle of operation, analysis of M-type and L-type Buck or boost Converters-Concept of Zero current switching-Principle of operation-Analysis of M-type and L-type Buck or boost Converters.

UNIT IV: CONTROL METHODS FOR SWITCHING POWER CONVERTERS

Control methods for buck, boost and forward dc-dc converters using State-space Modelling, Converter Transfer Functions, Pulse Width Modulator Transfer Functions

UNIT V: POWER FACTOR CORRECTION CIRCUITS

Introduction, Definition of PF and THD, Power Factor Correction, Energy Balance in PFC Circuits, Passive Power Factor Corrector, Basic Circuit Topologies of Active Power Factor Correctors, System Configurations of PFC Power Supply.

TEXT BOOKS:

1. Ned Mohan, Undeland and Robbin, ‘Power Electronics: converters, Application and design’, John Wiley and sons.Inc, Newyork, 2006.

2. Robert Erickson and Dragon Maksivimovic “Fundamentals of Power Electronics”, Springer Publications.

REFERENCE:

1. Philip T.Krein “Elements of Power Electronics”, Oxford University Press

2. L. Umanand “Power Electronics Essentials & Applications”, Wiley India Private Limited.

3. Issa Batarseh “Power Electronics Circuits”, John Wiely, 2004.

B.Tech. (Honors) **23PEH3-Energy Storage Devices**

L	T	P	Cr.
3	0	0	3

Pre-requisites: Applied Chemistry, Electric and Magnetic Fields

Course Educational Objective: This course enables the student to understand the concept of and analyze the various types of energy storage and applications of energy storage systems.

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

CO1: understand the necessity and usage of different energy storage schemes for different applications. **(Understand-L2)**

CO2: Analyze preliminary thermal and electrochemical storage systems. **(Understand-L2)**

CO3: Familiarize the operations of fuel cell and hybrid storage systems. **(Understand-L2)**

CO4: Specify appropriate energy storage technology for a particular context involving renewable energy resources. **(Apply-L3)**

UNIT I: NECESSITY OF ENERGY STORAGE

Need for energy storage, Types of energy storage-Thermal, electrical, magnetic, chemical and super conducting magnetic storage systems, comparison of energy storage technologies – Applications.

UNIT II: THERMAL STORAGE

Types - Modelling of thermal storage units - Simple water and rock bed storage pressurized water storage system–Modelling of phase change storage system–Simple units, packed bed storage units-Modelling using porous medium approach.

UNIT III: FUNDAMENTAL CONCEPTS OF BATTERIES

Measuring of battery performance - Charging and discharging of a battery - Storage density - Energy density - Safety issues - Types of batteries - Lead Acid, Nickel, Cadmium, Zinc Manganese dioxide and modern batteries - Zinc-Air, Nickel Hydride, Lithium ion Battery.

UNIT IV: HYBRID STORAGE DEVICES

Flywheel - Super capacitors - Principles & Methods – Applications - Compressed air Energy storage - Concept of Hybrid Storage - Applications. Super Conducting Magnetic Storage systems-system capabilities, Developments in Super Conducting Magnetic Storage systems.

UNIT V: FUEL CELL

Fuel Cell–History of Fuel cell, Principles of Electrochemical storage–Types–Hydrogen oxygen cells, Hydrogen air cell, Hydrocarbon air cell, alkaline fuel cell, detailed analysis– advantage and drawback of each type.

TEXT BOOKS:

1. Ibrahim Dincer and Mark A. Rosen, “Thermal Energy Storage Systems and Applications”, John Wiley & Sons 2011.

2. Ru-shiliu, Leizhang, Xueliang sun,”Electrochemical technologies for energy storage and conversion”, Wiley publications, 2012 .

REFERENCE:

1. Viswanathan B and M Aulice Scibioh, “Fuel Cells – Principles and Applications”,Universities Press 2007.

2. Rebecca L. and Busby, Penn Well Corporation, “Hydrogen and Fuel Cells”

3. Bent Sorensen, “Hydrogen and Fuel Cells: Emerging Technologies and Applications”, Elsevier, UK 2011.

L	T	P	Cr.
3	0	0	3

B.Tech. (Honors) **23PEH4-Smart Grid**

Pre-requisite: Basic Electrical Engineering, Power Systems, Signals & Systems

Course Objectives: This course enables the student to learn the architecture, functions, and components of smart grids. It also covers the control technologies, integration of renewable energy and distributed generation.

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

CO 1: Understand the structure and benefits of smart grids. **(Understand-L2)**

CO 2: Analyze communication technologies and protocols in smart grids. **(Apply-L3)**

CO 3: Evaluate smart grid components like smart meters, energy storage, and distributed generation. **(Apply-L3)**

CO 4: Apply concepts in demand response and load management. **(Apply-L3)**

CO 5: Identify and address cyber security challenges in smart grids **(Understand-L2)**

UNIT – 1: Introduction to Smart Grids

Evolution of Power Grids: Traditional Grids vs. Smart Grids-Key Characteristics of Smart Grids: Efficiency, Reliability, Flexibility-Smart Grid Architecture: Components and Functions-Generation, Transmission, Distribution, and Consumption Sectors-Smart Grid Vision, Goals, and Benefits-Economic, Environmental, and Operational Benefits-Role of ICT in Smart Grids: Data Management and Communication Infrastructure.

UNIT – 2: Smart Grid Communication and Networking:

Communication Technologies for Smart Grids:Wired (Ethernet, Fiber Optics) and Wireless (Zigbee, Wi-Fi, Cellular)-Power Line Communication (PLC) for Smart Metering and Control-Smart Metering Systems: Functionality and Communication Protocols: Advanced Metering Infrastructure (AMI)-Protocols in Smart Grids: IEC 61850, Modbus, DNP3, and others-Data Acquisition and Control Systems in Smart Grids-Integration of Internet of Things (IoT) in Smart Grid Communication.

UNIT – 3: Smart Grid Components and Technologies

Smart Meters: Role, Functionality, and Types-Energy Storage Systems: Batteries, Supercapacitors, Flywheels, and Their Role in Grid Stability-Distributed Generation and Renewable Energy Integration: Solar, Wind, and Microgrids-Energy Management Systems (EMS): Load Flow Analysis and Optimization Techniques-Smart Grid Automation: SCADA Systems, Automated Metering, and Fault Detection-Real-Time Monitoring and Control: Techniques and Technologies.

UNIT – 4: Integration of Renewable Energy and Demand-Side Management

Challenges in Integrating Renewable Energy into the Grid: Variability, Intermittency, and Storage Solutions-Role of Smart Grids in Renewable Energy Integration: Grid Stability and Power Quality, Wind and Solar Power Forecasting Techniques-Demand-Side Management (DSM) and Smart Appliances: Load Shifting, Load Shedding, and Peak Demand Reduction, Role of Consumers in Grid Optimization (Smart Home Technologies)-Electric Vehicle (EV) Integration and Smart Charging Infrastructure

UNIT – 5: Security, Privacy, and Policy Issues in Smart Grids

Cyber security in Smart Grids: Threats, Vulnerabilities, and Risks :Cyber Attacks on Critical Infrastructure-Privacy Concerns and Data Protection in Smart Grid Systems: Consumer Data, Smart Meters, and Privacy Regulations-Authentication, Authorization, and Secure Communication Protocols: IEC 62351 Security Standards-Smart Grid Regulations and Policies: Global Standards and Frameworks.

NIST, IEC, IEEE Standards, Policy Challenges in Grid Modernization and Renewable Energy Adoption-Future Trends and Challenges in Smart Grid Development.

Textbooks:

1. "Smart Grids: Infrastructure, Technology, and Solutions" by Stuart Borlase
2. "Smart Grid: Fundamentals of Design and Analysis" by James A. Momoh
3. "Renewable Energy: Power for a Sustainable Future" by Godfrey Boyle
4. Smart Grid Security: An End-to-End View of Security in the New Electric Grid" by Tony Flick and Justin Morehouse

Reference Books:

1. "Smart Grid: Technology and Applications" by Janaka Ekanayake, Kithsiri Liyanage, Jiangzhou Wang, Nick Jenkins, and Xiangyu Zhang
2. "The Smart Grid: Enabling Energy Efficiency and Demand Response" by Galina P. L. P. Shapiro.
3. "The Smart Grid: Enabling Energy Efficiency and Demand Response" by Clark W. Gellings.

Online Learning Resources:

1. https://archive.nptel.ac.in/courses/108/107/108107113

		L	T	P	Cr.
B.Tech. (Honors)	**23PEH5-Machine Modeling and Analysis**	3	0	0	3

Pre-requisites: Electrical Circuits and Electrical Machines
Course Objectives: This course enables the student to analyze the performance of electrical machines under both steady-state and transient conditions. It also covers the transformation, mathematical model of three phase Induction/synchronous motors and dynamic modeling of special machines.
Course Outcomes:
At the end of the course, student will be able to:

CO1: Develop mathematical modeling of DC machines for steady state & transient analysis. **(Apply-L3)**
CO2: Develop the mathematical modeling of three phase induction motor. **(Apply-L3)**
CO3: Understand reference frame theory for the modeling of induction Motors in different reference frames. **(Understand-L2)**
CO4: Develop the mathematical modeling of synchronous motor in rotor's reference frame. **(Apply-L3)**
CO5: Develop the mathematical models of special electrical machines. **(Understand-L2)**

UNIT– 1:DC Motor Modeling
Importance of mathematical modeling of electrical machines, Mathematical model of separately excited D.C. motor and D.C. Series motor in state variable form – Mathematical model of D.C. shunt motor and D.C. Compound motor in state variable form, Steady state analysis – Transient state analysis, Transfer function of the D.C. motor, Sudden application of inertia load.

UNIT– 2:Reference Frame Theory & 3-phase Induction Motor dq model
Linear transformation – Phase transformation (abc to αβ0) – Power equivalence, Active transformation (αβ0 to dq0), transformations in complex plane, Commonly used reference frames and transformation between reference frames, Circuit model of a 3 phase Induction motor – Flux linkage equation – dq transformation of flux linkages in the complex plane – voltage equations

UNIT– 3: Modeling of 3-phase Induction motor in various reference frames
Voltage equation transformation to a synchronous reference frame, dq model of induction motor in the stator reference frame, rotor reference frame and arbitrary reference frame, power equation, electromagnetic torque equation, state space model in induction motor with flux linkages as variables and current-flux variables

UNIT– 4: Modeling of 3-phase Synchronous Motor
Synchronous machine inductances – Circuits model of a 3-phase synchronous motor – derivation of voltage equations in the rotor's dq0 reference frame electromagnetic torque – State space model with flux linkages as variables.

UNIT– 5: Special Machines
Modeling of Permanent Magnet Synchronous motors – Modeling of Brushless DC Motor, Analysis of Switch Reluctance Motors.

Text Books

1. Generalized theory of Electrical Machines - Fifth edition, Khanna Publishers P. S. Bimbhra, 1985.
2. AC Motor control and electric vehicle applications – Kwang Hee Nam – CRC press, Taylor & Francis Group, 2010

Reference Books:

1. Electric Motor Drives - Modeling, Analysis& control - R. Krishnan- Pearson Publications- 1st edition -2002.
2. Switched Reluctance Motor Drives: Modeling, Simulation, Analysis, Design, and Applications - R.Krishnan , CRC Press, Year: 2001
3. Analysis of Electric Machinery and Drive Systems, 3rd Edition-Wiley-IEEE Press- Paul Krause, Oleg Wasynczuk, Scott D. Sudhoff, Steven Pekarek, Junr 2013..

Online Learning Resources:

1. https://archive.nptel.ac.in/courses/108/106/108106023/

B.Tech. (Honors)

23PEH6-Advanced Electrical Drives

3	0	0	3

Pre-requisite: Knowledge of Power Electronics, Electrical Machines and Control Systems

Course Objectives: This course enables the student to learn the advanced control schemes for induction motor drives. It also covers the control strategies for PMSM, BLDC, and SRM drives.

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

CO1: Understand the concepts of scalar and vector control methods for drive systems**. (Understand-L2)**
CO2: Identify suitable control techniques for induction motor and Synchronous motor for specific applications. **(Understand-L2)**
CO3: Analyze different control techniques for SRM drives. **(Understand-L2)**
CO4: Analyze various controllers for BLDC drives. **(Understand-L2)**

Unit I: Vector Control of Induction Motor Drives
Principles of scalar and vector control, principle of direct vector control, indirect vector control, implementation-block diagram; estimation of flux, flux weakening operation.

UNIT-II Direct Torque Control of Induction Motor Drives
Principle of Direct torque control (DTC), concept of space vectors, DTC control strategy of induction motor, comparison between vector control and DTC, applications, space vector modulation-based DTC of induction motors.

Unit III Control of Synchronous Motor Drives
Synchronous motor and its characteristics- Control Strategies-Constant torque angle control- power factor control, constant flux control, flux weakening operation, load commutated inverter fed synchronous motor drive, motoring and regeneration, phasor diagrams.

Unit-IV Control of Switched Reluctance Motor Drives
SRM Structure-Stator Excitation-techniques of sensor less operation-convertor topologies-SRM Waveforms-SRM drive design factors-Torque controlled SRM-Torque Ripple-Instantaneous Torque control -using current controllers-flux controllers.

Unit-V Control of BLDC Motor Drives
Principle of operation of BLDC Machine, Sensing and logic switching scheme, BLDM as Variable Speed Synchronous motor-methods of reducing Torque pulsations -Three-phase full wave Brushless dc motor -Sinusoidal type of Brushless dc motor - current controlled Brushless dc motor Servo drive.

Text Books:

1. Bose B. K., "Power Electronics and Variable Frequency Drives‟, IEEE Press, Standard Publisher Distributors. 2001.
2. Krishnan R., “Electric Motor Drives – Modelling, Analysis and Control”, Prentice Hall of India Private Limited.

Reference Books:

1. Switched Reluctance Motors and Their Control-T. J. E. Miller, Magna Physics, 1993.
2. Power electronic converters applications and design-Mohan, Undeland, Robbins-Wiley Publications

3. De Doncker, Rik W., Pulle, Duco W.J., Veltman, Andre, "Advanced Electrical Drives", Springer, 2020.
4. Ned Mohan, "Advanced Electric Drives: Analysis, Control, and Modeling Using MATLAB/Simulink®", John Wiley & Sons, Inc, 2014.

Online Learning Resources:

1. https://nptel.ac.in/courses/108104011
2. https://nptel.ac.in/courses/108102046

B.Tech. (Honors)	23PEH7-Advanced Electric Machines Lab	L	T	P	Cr.
		0	0	3	1.5

Prerequisite: DC Machines & Transformers, Induction and Synchronous Machines

Course Educational Objective: This course enables the student to provide practical exposure to various advanced electrical machines through simulation and experimentation.

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

CO1: Analyze the performance of AC Servomotor using trainer kit. **(Apply-L3)**

CO2: Examine the performance of DC Servomotor, Stepper motor, AC series motor and universal motors using simulation tools **(Apply-L3)**

CO3: Analyze the performance of Hysteresis motor, Reluctance motor, linear synchronous motor and Linear induction motor using simulation tools **(Apply-L3)**

LIST OF EXPERIMENTS

1. Performance of AC Servomotor using trainer kit
2. Performance of DC Servomotor using simulation tools
3. Performance of Stepper motor using simulation tools
4. Performance of AC series motor using simulation tools
5. Performance of universal motor using simulation tools
6. Performance of Hysteresis motor using simulation tools
7. Performance of Reluctance motor using simulation tools
8. Performance of linear reluctance motor using simulation tools
9. Performance of linear synchronous motor using simulation tools
10. Performance of Linear induction motor using simulation tools

B.Tech. (Honors) **23PEH8-Design and Simulation of Power Converters Lab**

L	T	P	Cr.
0	0	3	1.5

Prerequisite: Power Electronics

Course Educational Objective: This course enables the student to provide practical exposure to various advanced power converters and hardware modules through experimentation and software tools to simulate various advanced power electronic converters.

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

CO1: Analyze the performance of different power converters using trainer kits. **(Apply-L3)**

CO2: Evaluate the performance of different non isolated dc-dc power converters using simulation tools **(Apply-L3)**
CO32: Examine the performance of different isolated dc-dc power converters using simulation tools **(Apply-L3)**

LIST OF EXPERIMENTS

1. Performance of Buck converter with R and RL loads
2. Performance of Buck-Boost converter with R and RL loads
3. Power factor correction of microcontroller-based boost converter
4. Load voltage & current characteristics of dc-dc forward converter with R & RL loads using simulation tools.
5. Load voltage & current characteristics of dc-dc cuk converter with R & RL loads using simulation tools.
6. Load voltage & current characteristics of dc-dc fly back converter with R & RL loads using simulation tools.
7. Load voltage & current characteristics of dc-dc push-pull converter with R & RL loads using simulation tools.
8. Load voltage & current characteristics of dc-dc Half bridge converter with R & RL loads using simulation tools.
9. Load voltage & current characteristics of dc-dc Full bridge converter with R & RL loads using simulation tools.
10. DC output voltage & AC link voltage characteristics of isolated dc-dc resonant converter