

HONOURS

S.No	Course Code	Course Title	Scheme of Instructions Hours per Week				Scheme of Examination Maximum Marks		
			L	T	P	C	I	E	Total
1	23HREEE1	E - Mobility	3	-	-	3	30	70	100
2	23HREEE2	Battery Management Systems	3	-	-	3	30	70	100
3	23HREEE3	Special Machines for Electric Vehicles	3	-	-	3	30	70	100
4	23HREEE4	Grid Interface of Electric Vehicles	3	-	-	3	30	70	100
5	23HREEE5	EV Charging Technologies	3	-	-	3	30	70	100
6	23HREEE6	Project on Electric Vehicles	-	-	-	6	30	70	100

23HREEE1	E - MOBILITY	L	T	P	C
		3	0	0	3

Course Objectives:

- Understand the fundamental concepts and principles of Electric vehicles
- Apply the concepts to implement battery technology
- Apply the concepts to implement charging technology
- Understand the future trends in EVs

Course Outcomes:

The students will be able to:

CO1: Understanding the Fundamentals of Electric Vehicles and Vehicle Dynamics. Choose suitable motors and analyse different power electronics in EVs. -L2

CO2: Analyzing Battery Technologies for Electric Vehicles. -L4

CO3: Understanding and Evaluating Charging Technologies for Electric Vehicles. -L2

CO4: Exploring Future Trends and Innovations in Electric Vehicles.-L5

CO5: Understanding E-Mobility, Policy, and Integration with Smart Grids. -L2

UNIT I**Introduction:**

Introduction to electric vehicles: EV verses gasoline vehicles, vehicle dynamics fundamentals, e-drivetrain, Electric motor, Power electronic in electric vehicles, Regenerative braking.

UNIT II**Battery Technology:**

Battery Technology for EVs: Storage technologies for EV, Battery working principles, Battery losses, Li-ion batteries, Battery pack and battery management system.

UNIT III**Charging Technology:**

Charging Technology of EVs: AC charging - Type 1,2,3, DC charging, Fast charging and its limitations, Smart charging and applications, Vehicle to X(V2X), X2V technology.

UNIT IV**FUTURE TRENDS IN EVs:**

Future trends in e-Vehicles: Wireless charging of EV, On-road charging of EV, Battery swap technology, Solar powered EVs, Charging EVs from renewables.

UNIT V

E-Mobility:

E-mobility: electrification challenges, business, connected mobility and autonomous mobility case study in Indian Roadmap Perspective, Policy- EVs in infrastructure system, integration of EVs in smart grid, social dimensions of EVs.

Textbooks:

1. Iqbal Hussain, —Electric & Hybrid Vehicles – Design Fundamentals, Second Edition, CRC Press, 2011.
2. James Larminie, —Electric Vehicle Technology Explained, John Wiley & Sons, 2003.

Reference Books:

1. Mehrdad Ehsani, Yimin Gao, Ali Emadi, —Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, CRC Press, 2010.
2. Sheldon S. Williamson, Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles, Springer, 2013.
3. Sandeep Dhameja, —Electric Vehicle Battery Systems, Newnes, 2000
4. Tariq Muneer and Irene Illescas García, —The automobile, In Electric Vehicles: Prospects and Challenges, Elsevier, 2017.

Online Learning Resources:

1. <https://nptel.ac.in/courses/108106170>

B.Tech (EEE)

23HREEE2	BATTERY MANAGEMENT SYSTEMS	L	T	P	C
		3	0	0	3

Course Objectives:

- Understand the basics of batteries and its parameters
- Apply the concepts to create Battery Management System
- Create Physical and Simulation models for Battery Management System
- Design different Battery Management Systems

Course Outcomes:

After completion of this course, student will be able to

CO1: Understand the role of battery management system -L2

CO2: Identify the requirements of Battery Management System. L2

CO3: Interpret the concept associated with battery charging / discharging process.-L3

CO4: Analyze various parameters of battery and battery pack. L4

CO5: Design the model of battery pack. L5

UNIT I**Introduction:**

Introduction to Battery Management System, Cells & Batteries, Nominal voltage and capacity, C rate, Energy and power, Cells connected in series, Cells connected in parallel, Electrochemical and lithium-ion cells, Rechargeable cell, Charging and Discharging Process, Overcharge and Undercharge, Modes of Charging

UNIT II**Battery Management System:**

Introduction and BMS functionality, Battery pack topology, BMS Functionality, Voltage Sensing, Temperature Sensing, Current Sensing, BMS Functionality, High-voltage contactor control, Isolation sensing, Thermal control, Protection, Communication Interface, Range estimation, State-of charge estimation, Cell total energy and cell total power

UNIT III**Battery State Of Charge And State Of Health Estimation:**

Battery state of charge estimation (SOC), voltage-based methods to estimate SOC, Model-based state estimation, Battery Health Estimation, Lithium-ion aging: Negative electrode, Lithium ion aging: Positive electrode, Cell Balancing, Causes of imbalance, Circuits for balancing

UNIT IV**Modelling and Simulation:**

Equivalent-circuit models (ECMs), Physics-based models (PBMs), Empirical modelling approach, Physics-based modelling approach, Simulating an electric vehicle, Vehicle range calculations, Simulating constant power and voltage, Simulating battery packs

UNIT V

Design Of Battery Management Systems:

Design principles of battery BMS, Effect of distance, load, and force on battery life and BMS, energy balancing with multi-battery system

Textbooks:

1. Plett, Gregory L. Battery management systems, Volume I: Battery modelling. Artech House, 2015.
2. Plett, Gregory L. Battery management systems, Volume II: Equivalent-circuit methods. Artech House, 2015.

Reference Books:

1. Bergveld, H.J., Kruijt, W.S., Notten, P.H.L —Battery Management Systems -Design by Modelling|| Philips Research Book Series 2002.
2. Davide Andrea,|| Battery Management Systems for Large Lithium-ion Battery Packs|| Artech House, 2010
3. Pop, Valer, et al. Battery management systems: Accurate state-of-charge indication for battery-powered applications. Vol. 9. Springer Science & Business Media, 2008.

Online Learning Resources:

23HREEE3	SPECIAL MACHINES FOR ELECTRIC VEHICLES	L	T	P	C
		3	0	0	3

Course Objectives:

- Understand various Motor Drives useful for EV applications
- Apply the concepts to implement various designs
- Analyze performance of various Motor Drives
- Evaluate the usage of specific drive for EV application

Course Outcomes:

After completion of this course, student will be able to

CO1: Understanding the Fundamentals of Permanent Magnet (PM) Brushless Motor Drives. -L2

CO2: Analyzing Switched Reluctance Motor (SRM) Drives. -L4

CO3: Evaluating Stator-Permanent Magnet (PM) Motor Drives. -L4

CO4: Understanding and Designing Magnetic-Gear Motor Drives. -L2

CO5: Exploring Advanced Magnetless and Multiphase Motor Drives. L5

UNIT I**Permanent Magnet (PM) Brushless Motor Drives:**

Structure of PM Brushless Machines, Principle of PM Brushless Machines Modeling of PM Brushless Machines, Inverters for PM Brushless Motors Motor Control, Design Criteria of PM Brushless Motor Drives for EVs, Design Examples of PM Brushless Motor Drives for EVs, Application, Advantages and Limitations for EVs.

UNIT II**Switched Reluctance Motor Drive:**

Structure of SR Machines, Principle of SR Machines, SR Converters Topologies, SR Motor Control, Design Criteria of SR Motor Drives for EVs, Examples of SR Motor Drives for EVs, Application, Advantages and Limitations for EVs.

Unit III**Stator-PM Motor Drives:**

Doubly-Salient PM Motor Drives, Flux-Reversal PM Motor Drives, Flux-Switching PM Motor Drives, Hybrid-Excited PM Motor Drives Flux-Mnemonic PM Motor Drives, Design Criteria of Stator-PM Motor Drives for EVs, Application, Advantages and Limitations for EVs.

UNIT IV**Magnetic-Geared Motor Drives:**

Principle of MG Machines, Modeling of MG Machines, Inverters for MG Motors, MG Motor Control, Design Criteria of MG Motor Drives for EVs, Application, Advantages and Limitations for EVs

UNIT V

Advanced Magnetless Motor Drives and Multiphase Motor Drives:

Introduction of Advanced Magnetless technology, Synchronous Reluctance Motor Drives, Doubly-Salient DC Motor Drives, Flux-Switching DC Motor Drives, Design Criteria of Advanced Magnetless Motor Drives for EVs, Application, Advantages and Limitations for EVs. Multiphase Induction Motor drives – principle, operation and control, Multiphase PMSM machine – principle, operation and control, Fault tolerant operation of multiphase drives

Textbooks:

1. Mehrdad Ehsani, Yimin Gao, Sebatien Gay and Ali Emadi, —Modern Electric, Hybrid Electric and Fuel cell vehicles: Fundamentals, Theory and Design, CRC Press, 2004.
2. James Larminie and John Lory, —Electric Vehicle Technology – Explained, John Wiley & Sons Ltd, 2003.

Reference Books:

1. Sandeep Dhameja, —Electric Vehicle Battery Systems, Butterworth – Heinemann, 2002.
2. Ronald K Jurgen, —Electric and Hybrid – Electric Vehicles, SAE, 2002.
3. Ron Hodgkinson and John Fenton, —Light Weight Electric/Hybrid Vehicle Design, Butterworth – Heinemann, 2001.
4. Iqbal Husain, —Electric and Hybrid Vehicles- Design Fundamentals, CRC Press, 2011.

23HREEE4	GRID INTERFACE OF ELECTRIC VEHICLES	L	T	P	C
		3	0	0	3

Course Objectives:

- Understand the Grid interfacing concept of EVs
- Analyze the EV impact on grid
- Design new types of charging facilities for EVs
- Evaluate the role of EV as ancillary service

Course Outcomes:

After completion of this course, student will be able to

CO1: Understanding the Fundamentals of Smart Grid and Electric Vehicle Integration Analyze Impact of EV on smart grid -**L2**

CO2: Analyzing the Impact of EVs and V2G on the Smart Grid and Renewable Energy Systems - **L3**

CO3: Applying Power Conversion Technologies for Smart Grids and Electric Vehicles- **L4**

CO4: Designing Control and Management Strategies for PEV Parking Lots -**L5**

CO5: Evaluating the Role of PEVs as Ancillary Services in Smart Grids -**L4**

UNIT I**Introduction to Smart Grid and PEV:**

Introduction to smart grid and microgrid, Impact of PEVs on Distributed Energy Resources in the Smart Grid, V2G Technology and PEVs Charging Infrastructures

UNIT III**Impact of V2G and G2V on the Smart Grid and Renewable Energy Systems:**

Types of Electric Vehicles, Motor Vehicle Ownership and EV Migration, Impact of Estimated EVs on Electrical Network, Impact on Drivers and the Smart Grid, Standardization and Plug-and-Play

UNIT III**Power Conversion Technology in the Smart Grid and EV:**

Impacts of EV Penetration on Grid Power Profile, Requirements of Its Control and Monitoring, Hybrid EV Powertrain Architectures, Control, Monitoring and Management Strategies of EV, V2G Communication System, System model of EV, Case study of three phase fault and its impact

UNIT IV**Planning, Control and Management Strategies for Parking Lots for PEVs:**

Introduction to PEV Charging Facility, Long-Term Planning for PEV Parking Lots, Control and Management of PEV Parking Lots - stages of implementation

UNIT V**PEV as Ancillary Service in Smart Grid:**

Introduction to Ancillary Services, PEV Charger Optimization, PEV as ancillary source, Control Strategies for PEVs to Follow the Individual Operation Values, Systems and Control Algorithm for Smart PEV Chargers, Avoiding the Harmonic Propagation Within the Grid, Case study

Textbooks:

1. Lu, J. and Hossain, J., Vehicle-to-grid: linking electric vehicles to the smart grid. Institution of Engineering and Technology, 2015.
2. Rajakaruna, S., Shahnian, F. and Ghosh, A. eds., Plug In Electric Vehicles in Smart Grids: Integration Techniques. Springer, 2014.

Reference Books:

1. Rajakaruna, S., Shahnian, F. and Ghosh, A. eds., Plug in electric vehicles in smart grids: charging strategies. Springer, 2014.
2. Salman, S.K., Introduction to the Smart Grid: Concepts, Technologies and Evolution (Vol. 94). IET., 2017.

23HREEE5	EV CHARGING TECHNOLOGIES	L	T	P	C
		3	0	0	3

Course Outcomes:**CO1:** Understanding Battery Basics and Key Parameters-L2**CO2:** Analyzing Battery Modeling Techniques and Capacity Estimation-L3**CO3:** Exploring Charging Infrastructure and Regulatory Frameworks-L4**CO4:** Evaluating Battery Charging Techniques and Performance-L3**CO5:** Understanding Power Electronics in EV Charging Systems-L3**UNIT I****Battery Basics:**

Battery parameters- Cell and Battery Voltages, Charge (or Amp hour) Capacity, Energy Stored, Specific Energy, Energy Density, Specific Power, Amp hour (or Charge) Efficiency, Energy Efficiency, Self-discharge Rates, Battery Geometry, Battery Temperature, Heating and Cooling Needs 35 3.2.12 Battery Life and Number of Deep Cycles Types of batteries- lead-acid, nickel based sodium based, lithium batteries, metal-air batteries. Refilled Batteries.

UNIT II**Battery Modeling:**

The Purpose of Battery Modelling, Electrochemical model, black box model, equivalent circuit model - Battery Equivalent Circuit, Modelling Battery Capacity, Simulating a Battery at a Set Power, Calculating the Peukert Coefficient, Approximate Battery Sizing, Battery state of charge estimation.

UNIT III**Charging Infrastructure:**

EV supply equipment, charging standards, classification of charging infrastructure, connecting EVs to the electricity grid, regulatory framework for EV charging connections, communication protocols for smart charging, Battery Management System.

UNIT IV**Battery Charging Techniques:**

Basic Terms for Evaluating Charging Performances, Charging Algorithms for Li-Ion Batteries, Optimal Charging Current Profiles for Lithium-Ion battery, Lithium Titanate Oxide Battery with Extreme Fast Charging Capability. Super Capacitors for battery charging.

UNIT V**Power Electronics in EV Charging:**

Active front end rectifiers - Forward converters, half and full bridge DC-DC converters, power factor correction converters, decreasing impact on the grid and switches, bidirectional battery

chargers, wireless charging.

TEXT BOOKS:

- 1 James Larminie, John Lowry, —Electric Vehicle Technology Explained, Wiley, 2012.
- 2 RuiXiong, Weixiang Shen, —Advanced Battery management Technologies for Electric Vehicle, Wiley, 2018

REFERENCES:

- 1 Handbook of Electric Vehicle Charging Infrastructure Implementation, NITI Aayog, Government of India.
- 2 Chris Mi, M. AbulMasrur, Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives, Wiley, 2017
- 3 Bruno Scrosati, Jurgen Garche, Werner Tillmetz, Advances in Battery Technologies for Electric Vehicles, Wood head Publishing Series in Energy, 2015
- 4 Sheldon S. Williamson , Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles, Springer, 2013

23HREEE6	PROJECT ON ELECTRIC VEHICLES	L	T	P	C
		0	0	6	3