CURRICULUM & SYLLABI

M.Tech. in Electric Vehicles

Effective from AY: 2026-27



NATIONAL INSTITUTE OF TECHNOLOGY WARANGAL
HANUMAKONDA, TELANGANA STATE

Table of Contents

VISION AND MISSION OF THE INSTITUTE 2
VISION AND MISSION OF THE DEPARTMENT 3
PROGRAM EDUCATIONAL OBJECTIVES 4
PROGRAM OUTCOMES 4
CURRICULUM 5
THE OVERALL CREDIT STRUCTURE 9
SYLLABI 10

Vision and Mission of the Institute

National Institute of Technology Warangal

VISION

Towards a Global Knowledge Hub, striving continuously in pursuit of excellence in Education, Research, Entrepreneurship and Technological services to the society

MISSION

- Imparting total quality education to develop innovative, entrepreneurial and ethical future professionals fit for a globally competitive environment.
- Allowing stakeholders to share our reservoir of experience in education and knowledge for mutual enrichment in the field of technical education.
- Fostering product-oriented research for establishing a self-sustaining and wealth-creating centre to serve the societal needs.

Vision and Mission of the Department

Department of Electrical Engineering

VISION

To excel in education, research and technological services in electrical engineering in tune with societal aspirations.

MISSION

- Impart quality education to produce globally competent electrical engineers capable of extending technological services.
- Engage in research & development in cutting edge and sustainable technologies.
- Nurture scientific temperament, professional ethics and industrial collaboration.

M.Tech. in Electric Vehicles

Program Educational Objectives

PEO-1	Design and develop innovative products and services towards the ecosystem of Electric Vehicle Technology
PEO-2	Utilize the latest technologies and tools to in the design and implement products and systems for Electric Vehicles
PEO-3	Communicate effectively to propagate ideas and promote teamwork
PEO-4	Attain intellectual leadership skills to cater to the changing needs of the Electric Vehicle industry, academia, society and environment

Program Articulation Matrix

PEO / Mission Statements	PEO-1	PEO-2	PEO-3	PEO-4
Impart quality education to produce globally competent electrical engineers capable of extending technological services	3	3	3	2
Engage in research & development in cutting-edge and sustainable technologies	3	3	2	3
Nurture scientific temperament, professional ethics and industrial collaboration	3	3	2	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Program Outcomes

PO-1	**Develop** scientific temperament and analytical thinking abilities to pursue research and tackle complex problems related to Electric Vehicle Technology.
PO-2	**Communicate** effectively with teams of multidisciplinary expertise & technical communities on engineering issues pertinent to Electric Vehicle technologies.
PO-3	**Deploy** latest technologies to improve the designs of Electric Vehicles.
PO-4	**Develop** eco-friendly and sustainable technologies using the knowledge of power conversion, drive propulsion and charging infrastructure.
PO-5	**Cultivate** an attitude of self-learning to cope with ever changing tools and technologies and be productive throughout his / her career.
PO-6	**Foster** a temperament to manage projects, organizations and entrepreneurial ventures maintaining financial integrity and professional ethics.

CURRICULUM

M.Tech. in Electric Vehicles

1st Semester

S.No.	Code	Course Title	L-T-P	Credits
1	EE56001	Architecture of Electric Vehicles	3-0-0	3
2	EE56003	Power Converters for Electric Vehicles	3-0-0	3
3	EE56005	Digital Controllers for Electric Vehicles	3-0-0	3
4	EEXXXX	Program Elective – I	3-0-0	3
5	EEXXXX	Program Elective – II	3-0-0	3
6	EE56007	Digital Controllers for Electric Vehicles Lab	0-1-2	2
7	EE56009	Power Converters Simulation for Electric Vehicles Lab	0-1-2	2
			Total Credits	**19**

2nd Semester

S.No.	Code	Course Title	L-T-P	Credits
1	EE56002	Propulsion and Control of Electric Vehicles	3-0-0	3
2	EE56004	Energy Storage Devices and Systems	3-0-0	3
3	EEXXXX	Program Elective – III	3-0-0	3
4	EEXXXX	Program Elective – IV	3-0-0	3
5	EEXXXX	Program Elective –V	3-0-0	3
6	EE56006	Propulsion and Control of Electric Vehicles Lab	0-1-2	2
7	EE56008	Charging and Battery Engineering Lab	0-1-2	2
8	EE56096	Minor Project	0-0-0	2
			Total Credits	**21**

3rd Semester

S.No.	Code	Course Title	L-T-P	Credits
1	EE56089	Seminar and Technical Writing	0-0-0	2
2	EE56091	Summer Internship/Research Experience	0-0-0	2
3	EE56093	Comprehensive Viva-Voce	0-0-0	2
4	EE56097	Dissertation: Part – A	0-0-0	8
			Total Credits	**14**

4th Semester

S.No.	Code	Course Title	L-T-P	Credits
1	EE56098	Dissertation: Part – B	0-0-0	12
			Total Credits	**12**

Program Elective Courses

Program Elective – I		
S.No.	**Code**	**Course Title**
1	ME56031	Automotive Chassis
2	EE16021	Wide Band Gap Devices in Power Electronics Applications
3	EE56021	Electromagnetic Interference and Compatibility for Electric Vehicles

Program Elective – II		
S.No.	**Code**	**Course Title**
1	ME56033	Automotive Safety
2	EE56023	Wireless Power Conversion Systems
3	EE56025	Sensors and Instrumentation for Electric Vehicles

Program Elective – III		
S.No.	**Code**	**Course Title**
1	EE56022	AI Applications in Electric Vehicles
2	EE16026	Control and Integration of Renewable Energy Sources
3	ME56032	Aerodynamics of Automobiles

Program Elective – IV		
S.No.	**Code**	**Course Title**
1	EC36044	Vehicular Communication Systems
2	EE56024	Electric Vehicle Charging Infrastructure and Smart Grid Integration
3	EE56026	IoT Applications in Electric Vehicles
4	EE56028	Thermal Management in EVs

Program Elective – V		
S.No.	**Code**	**Course Title**
1	EE56030	Automotive Functional Safety and Testing
2	EE56032	Aerial Electric Vehicular Technology
3	EE56034	Sliding Mode Control and Observation
4	EE56036	Machine Design for E-Mobility

The Overall Credit Structure

Credits in Each Semester					
	I Sem	**II Sem**	**III Sem**	**IV Sem**	**Total**
Program Core	13	10	0	0	23
Program Elective	6	9	0	0	15
Seminar and Technical Writing	0	0	2	0	2
Minor Project	0	2	0	0	2
Summer Internship/Research Experience	0	0	2	0	2
Comprehensive Viva-Voce	0	0	2	0	2
Dissertation: Part-A	0	0	8	0	8
Dissertation: Part-B	0	0	0	12	12
Total credits (Sem. wise)	**19**	**21**	**14**	**12**	**66**

1st Semester

EE56001 **3-0-0 (3)**

Architecture of Electric Vehicles

Pre-Requisites: None

Course Outcomes:

CO-1	Understand the concepts of architecture of electric vehicles and subsystems of EVs, HEVs and PHEVs.
CO-2	Analyze the drive-train topologies and advanced propulsion techniques, and select and size major EV components.
CO-3	Analyze energy flow, efficiency, and performance metrics of different EV topologies.
CO-4	Identify the suitable power converter topologies for motor control and hybrid energy storage

Course Articulation Matrix:

CO/PO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	3	3	2	1	2	1
CO-2	3	3	2	2	2	2
CO-3	3	3	2	2	2	3
CO-4	3	3	3	3	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Introduction to Electric Vehicles: Evolution of transportation: Conventional vehicle, basics of vehicle performance, History and development of EVs, classification, architecture of two-wheelers, three-wheelers, four-wheelers, heavy vehicles and their propulsion systems, components, specifications, and challenges in EV.

Configuration of Hybrid Electric Vehicles: Parallel-Hybrid, Series-Hybrid, Series-Parallel hybrid, Complex hybrid architectures. Power flow analysis, Hybrid electric vehicle configurations for various operating modes. Electric Hybrid Vehicles: Battery-Battery, Battery-Fuel Cell, Battery-Solar PV Configurations. Plug-in Hybrid Vehicles, operating principle, architectures, and challenges related to grid connection. Range Extended Electric Vehicles.

Electric Propulsion Systems: Electric Drive Trains: Basic concept of electric traction, introduction to various electric drive- train topologies, power flow control in electric drive-train topologies, energy efficiency analysis. Configuration and control schemes of Induction Motor drives, BLDC motor drives, Synchronous Motor (PMSM) drives, Switch Reluctance Motor drives, Comparative analysis and selection criteria. Thermal management of electric motors.

Energy Storage Systems: Introduction to Battery Charging Systems: Overview of battery technologies used in EVs, Battery characteristics and charging requirements, charging curves and profiles (CC, CV, CC-CV methods), Types of chargers (on-board and off-board), AC and DC charging fundamentals, Charging efficiency and losses, Introduction to EV charging standards and protocols.

Battery Management System (BMS) Fundamentals: Functions of BMS, BMS architecture (centralized, distributed, modular), Battery parameters monitoring (voltage, current, temperature), State estimation techniques (State of Charge (SOC), State of Health (SOH), State of Power (SOP)), Data acquisition and communication in BMS, Active and passive Cell balancing techniques, Thermal management and protection systems.

Learning Resources:

Text Books:

1. Ali Emadi, Advanced Electric Drive Vehicles, CRC Press, 2015.
2. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2021, 3rd Edition.
3. Mehrdad Ehsani et al., Modern Electric, Hybrid Electric, and Fuel Cell Vehicles, CRC Press, 2004.

Reference Books:

1. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2023, 3rd Edition.
2. James D. Halderman, Curt Ward, Pear Son, Electric and Hybrid Electric Vehicles, 2023, 1st Edition.
3. Aunpam Singh, Electric Vehicles and the end of ICE Age, 2022, 2nd Edition.
4. James Larminie, Electric Vehicle Technology Explained, Wiley

EE56003 **3-0-0 (3)**

Power Converters for Electric Vehicles

Pre-Requisites: None

Course Outcomes:

CO-1	Comprehend the power conversion concepts & role in Electric vehicles
CO-2	Design and Analyze the performance of converters for electric transportation.
CO-3	Design & Analyze the control schemes for EV power Conditioning Systems.
CO-4	Classify the apt power converter topologies for E-mobility.

Course Articulation Matrix:

CO/PO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	3	3	3	3	1	1
CO-2	3	3	3	3	1	1
CO-3	3	3	3	3	1	1
CO-4	3	3	3	3	3	1

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Introduction: Basics and Essence converters in Electric Mobility (E-Mobility), Basics and Switching characteristics of Power Devices- Power MOSFET, IGBTs and Wide band gap devices (GaN & SiC), Gate driver circuits.

DC-DC Converters: Introduction, **non-isolated-** buck, boost, buck-boost, CUK converters. **Isolated-** forward, fly-back, push-pull, half-bridge and full-bridge converters - Design Relations- duty ratios, inductor, and filter capacitors. Multi-output DC-DC converters for EV auxiliary loads. LED driver circuits with dimming control for EV lights. voltage mode control (VMC), current mode control (CMC).

Bidirectional DC-DC Converters (BDCs): Introduction, Concept of Bidirectional Power flow converter**, non-isolated-** buck/boost and buck-boost based BDCs. **Isolated-**Dual Active Bridge (DAB) converter.

Inverters / Rectifiers for E-Mobility: Inverters - Single-phase & Three-phase, PWM techniques - single-pulse, multiple-pulse and sinusoidal PWM techniques, selective harmonic elimination, Carrier and Vector based PWM methods. Three-level diode clamped, active neutral clamped, T-type and cascaded H-Bridge multi-level converters.

Rectifiers- Classical rectifier with power factor correction (PFC), PWM rectifiers/Bidirectional AC-DC converters (1-phase & 3-Phase) with V2G & G2V modes of operation, and interleaved and Totem-pole converters. Converters for wireless power transfer (WPT), concept of solid-state transformer for Bidirectional AC/DC power flow.

Learning Resources:

Text books:

1. M.H. Rashid **:** Power Electronics Handbook, Butterworth-Heinemann, 2017, 4th edition.
2. Umanand, L.: Power Electronics: Essentials and Applications, John Wiley India, 2009, 1st Edition.
3. N Mohan, T.M. Undeland, WP.Robbins**:** Power Electronics: Converters, Applications**,** John Wiley & Sons, 2003,3rd Edition.
4. Bin Wu, Mehdi Narimani: High Power Converters and AC Drives, Wiley-IEEE Press, 2017,2nd Edition.

References:

1. R.W. Erickson and Dragan Maksimonic, Fundamentals of Power Electronics, Springer, 2020, 3rd Edition.
2. Abraham I. Pressman, Keith Billings & Taylor Morey: Switching Power Supply Design, McGraw Hill International, 3rd Edition, 2009.
3. Jayant Baliga B: Fundamentals of Power Semiconductor Devices, Springer, 1st Edition 2008.
4. Derek A Paice: Power Electronic Converter Harmonics: Multipulse Method for Clean Power, Wiley-IEEE Press, 1st Edition, 15th Sept 1999.
5. IEEE Transactions on Power Electronics & IEEE Transactions on Transportation Electrification.

Other Suggested Readings:

1. https://nptel.ac.in/courses/108105066
2. https://nptel.ac.in/courses/108102145
3. http://digimat.in/nptel/courses/video/108101038/L36.html
4. http://digimat.in/nptel/courses/video/108101126/L92.html

EE56005 **3-0-0 (3)**

Digital Controllers for Electric Vehicles

Pre-Requisites: None

Course Outcomes:

CO-1	Develop Assembly Language Programs for the Digital Signal Processors
CO-2	Configure and use Digital Input / Output lines and ADCs
CO-3	Configure and use Interrupts and Event Managers for PWM generation
CO-4	Employ DSPs for the real time control of Power Electronic Converters

Course Articulation Matrix:

CO/PO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	3	3	2	1	2	1
CO-2	3	3	2	1	2	1
CO-3	3	3	2	2	2	3
CO-4	3	3	3	3	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

TMS320LF2407 DSP Controller: Brief Introduction to Peripherals – Fixed point Processors, Floating Point Processor, Types of Physical Memory - Software Tools.

C2XX DSP CPU and instruction set: Introduction to the C2xx DSP Core and Code Generation - The Components of the C2xx DSP Core - Mapping External Devices to the C2xx Core and the Peripheral Interface -System Configuration Registers –Memory -Memory Addressing Modes -Assembly Programming Using the C2xx DSP Instruction Set.

Parallel and Serial Data Transfer: Pin Multiplexing (MUX) and General Purpose I/O Overview - Multiplexing and General Purpose I/O Control Registers - Using the General Purpose I/O Ports.

Interrupt system of TMS320LF2407: Introduction to Interrupts - Interrupt Hierarchy - Interrupt Control Registers - Initializing and Servicing Interrupts in Software, real time control with interrupts.

The analog-to-digital converter (ADC): ADC Overview - Operation of the ADC and programming modes.

Event Managers (EVA, EVB): Overview of the Event Manager (EV) - Event Manager Interrupts - General Purpose (GP) Timers- Compare Units - Capture Units and Quadrature Encoded Pulse (QEP) Circuitry - General Event Manager Information - PWM Signal Generation with Event Managers and interrupts, Measurement of speed with Capture Units, Implementation of Space Vector Modulation with DSP TMSLF2407A.

Introduction to TMS320F28XXX DSP Controller.

Learning Resources:

Text Books:

1. Hamid A. Tolyat, DSP based Electromechanical Motion Control, CRC press, 2003, 1st Edition.

2. TMS320x2806x Piccolo Technical Reference Manual, Texas Instruments, 2017.

Reference Books

1. TMS320F/C24x DSP Controllers Reference Guide: CPU and Instruction Set - Literature Number: SPRU160C 2.
2. TMS320F/C24x DSP Controllers Reference Guide: System and Peripherals - Literature Number: SPRU357C

Other Suggested Readings:

1. https://www.ti.com/lit/ug/spru160c/spru160c.pdf
2. https://www.ti.com/lit/ug/spru357c/spru357c.pdf

EE16007 **0-0-2 (2)**

Digital Controllers for Electric Vehicle Lab

Pre-Requisites: None

Course Outcomes:

CO-1	Configure the on-chip peripherals, such as ADC, Digital I/O, and QEP to suit the control requirements of Power Converters
CO-2	Configure Interrupts and Event Manager to implement Pulse Width Modulation.
CO-3	Develop Assembly and C programming languages for DSPs to achieve real-time control of Power Electronic Converters.
CO-4	Implement control schemes for different electrical drives.

Course Articulation Matrix:

CO/PO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	3	-	3	1	3	2
CO-2	3	-	3	1	3	2
CO-3	3	-	3	1	3	2
CO-4	3	-	3	1	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

List of Experiments:

1. General Programs to get the familiarit/ny of addressing modes, instruction set, arithmetic and logical operations of TMS320LF2407 processor such as:
   A. Arithmetic and logical operations
   B. Direct & Indirect Data Transfer
   C. Sorting of Data in Ascending order and Descending order
   D. Square root of positive integer
   E. Maximum and minimum of given set of numbers
2. Study of the on-chip ADC of TMS320LF2407 processor.
3. Study of the GPIO functionality of TMS320LF2407 processor.
4. Waveform generation with on board DAC of EVM TMS320LF2407
5. PWM signal generation using event manager with dead time
6. Study of the interrupts of TMS320LF2407 processor
7. Study of the phenomenon of aliasing withTMS320LF2407 processor
8. Study of Quadrature Encoder Pulse (QEP) Unit using C programming
9. Implementation of SVPWM with TMS320LF2407

10. Implementation of Sine PWM with Launch XL-F28377S using C programming
11. Control of BLDC motor with DRV8301 using Assembly / C programming
12. Hardware in loop (HIL) with 28XXX processor using CCS/ MATLAB

Learning Resources:

Text Books:

1. Hamid A. Tolyat, DSP based Electromechanical Motion Control, CRC Press, 2003, 1st Edition.
2. TMS320x2806x Piccolo Technical Reference Manual, Texas Instruments, 2017.
3. Gregory L. Plett, *Battery Management Systems, Vol. 1 & 2*, Artech House, 2015.

Reference Books:

1. TMS320F/C24x DSP Controllers Reference Guide: CPU and Instruction Set - Literature Number: SPRU160C
2. TMS320F/C24x DSP Controllers Reference Guide: System and Peripherals - Literature Number: SPRU357C

EE56009 **0-0-2 (2)**

Power Converters Simulation for Electric Vehicles Lab

Pre-Requisites: None

Course Outcomes:

CO-1	Apply simulators as a learning aid to gain insight regarding power electronic converters and drive systems
CO-2	Validate the performance of power converters with different PWM schemes
CO-3	Analyze the dynamic behaviour of DC-DC converters
CO-4	Develop simulation models of advanced EV power conversion systems, including bidirectional DC–DC converters, Dual Active Bridge (DAB) converters, and battery systems

Course Articulation Matrix:

CO/PO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	3	-	3	1	3	2
CO-2	3	-	3	1	2	2
CO-3	3	-	3	1	3	2
CO-4	2	-	3	1	2	2

1 - Slightly; 2 - Moderately; 3 - Substantially

List of Experiments:

1. Simulation of buck, boost, and buck-boost DC-DC converters in CC & DC modes of operation using SIMULINK
2. Simulation of DC-DC converters with State-space modelling using SIMULINK
3. Study of the dynamic behaviour of the DC-DC converters through numerical integration methods using MATLAB
4. Study on the design of PI controllers and stability analysis for a DC-DC buck Converter using MATLAB
5. Sine-PWM techniques for single-phase half-bridge, full-bridge and three-phase inverters using MATLAB
6. Study of the spectral performance of half-bridge, full-bridge and three-phase inverters using Fast Fourier Transforms
7. Space vector modulation (SVM) for three-phase two-level inverters
8. Closed-loop implementation of single-phase high-power factor rectifiers (Boost rectifier and PWM rectifier)
9. Multicarrier PWM techniques for three-phase diode-clamped and cascaded H-bridge
10. Simulation of Bidirectional DC-DC Converter (Buck-Boost type) for EV battery charging and regenerative braking
11. Simulation of Dual Active Bridge (DAB) Converter for isolated EV power conversion

12. Battery Modeling and SOC Estimation using MATLAB/Simulink

Learning Resources:

Text Books:

1. N. Mohan, T.M. Undeland, W.P. Robbins, Power Electronics: Converters, Applications and Design, John Wiley & Sons, 2003, 3rd Edition.
2. Rama Krishnan, Electric motor drives: modeling, analysis, and control, Pearson Education India, 2015, 1st Edition.
3. M.B. Patil, V. Ramanarayanan, V.T. Ranganathan, Simulation of Power Electronic Circuits, Narosa, 2013, 1st Edition.
4. Ali Emadi, Advanced Electric Drive Vehicles, CRC Press, 2017
5. Mehrdad Ehsani, Yimin Gao, Sebastien E. Gay, Ali Emadi, Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 3rd Edition, 2018

Reference Books:

1. Bimal K. Bose, Modern Power Electronics and AC Drives, Pearson, 1st Edition, 2015
2. Bin Wu, High-Power Converters and AC Drives, Wiley-IEEE Press, 2nd Edition, 2017

Other Suggested Readings:

1. https://www.mathworks.com/solutions/electrification.html
2. https://nptel.ac.in/courses/108108035
3. https://nptel.ac.in/courses/108104140
4. https://nptel.ac.in/courses/108107128

2nd Semester

EE56002 **3-0-0 (3)**

Propulsion and Control of Electric Vehicles

Pre-Requisites: None

Course Outcomes:

CO-1	Model Induction motors and PMSMs using the reference frame theory
CO-2	Design generic control systems for the drives employed in electric vehicles
CO-3	Develop high performance induction motor drives with Scalar and Vector control (Field-oriented control (FOC)).
CO-4	Strategize & Implement vector control schemes for PMSMs and BLDC motors to suit the EV requirements

Course Articulation Matrix:

CO/PO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	3	3	3	3	1	1
CO-2	3	3	3	3	1	1
CO-3	3	3	3	3	1	1
CO-4	3	3	3	3	3	1

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Introduction: Estimation of Speed Torque characteristics of EVs, Selection of motors for EVs, Force and Thrust calculation of EVs

Separately Excited DC-motor Drives: Introduction, Review of DC-motor drives, Speed control of a Separately excited DC motor drive with controlled rectifiers and choppers, Design of control loops.

Reference Frame Theory: Concept of space vector, components of space vector, direct and quadrature axis variables, various types of transformation, condition for power invariance, Expression for power with various types of transformation, Transformations between reference frames, Clarke and Park's Transformations, Variables observed from various frames.

Theory of symmetrical Induction Machines: Voltage and torque in machine variables, Derivation of *dq0* model for a symmetrical induction machine, Voltage and torque equation in arbitrary reference frame variables, Analysis of steady- state operation.

Induction Motor drives: Implementation of V/f control with slip speed compensation scheme, Principle of vector control of IM, Indirect vector control with feedback and with feed-forward, Indirect vector control in various frames of reference, Decoupling of vector control with feed-forward compensation.

Permanent Magnet Drives: Types, Construction, operating principle, Expression for torque, Model of PMSM, Implementation of vector control for PMSM, MTPA control and field weakening with IPMSMs, BLDC drives.

Learning Resources:

Text Books:

1. Electric motor drives: modeling, analysis, and control, Rama Krishnan, Pearson Education India, 2015, 1st Edition.
2. Modern Power Electronics & AC Drives, B.K. Bose, Pearson Education India, 2015, 1st Edition.

Reference Books:

1. Advanced Electrical Drives: Analysis, Modeling, Control, Rik De Doncker, Duco W. J. Pulle, André Veltman, Springer, 2011.
2. Analysis of Electric Machinery & Drive systems, Paul C. Krause, Oleg W, Scott D. Sudhoff, IEEE Press, 2013, 3rd Edition.
3. Vector Control of Electric Drives: Peter Vas, Oxford Publishers, 1990.
4. High-power Converters and AC Drives: Bin-Wu, IEEE Press, John Wiley & Sons, 2016.
5. Modeling, Simulation and Control of Electrical Drives, Mohammed Fazlur Rahman, Sanjeet K. Dwivedi, Institution of Engineering and Technology, 2019.

EE56004 **3-0-0 (3)**

Energy Storage Devices and Systems

Pre-Requisites: None

Course Outcomes:

CO-1	Understand the concepts of storage elements, hybrid storage systems for electric vehicles and their corresponding power electronic converters
CO-2	Analyze the mathematical models of various storage elements and charging methods.
CO-3	Analyze hybrid energy storage methodologies and the energy management systems
CO-4	Identify the suitable power converter topologies for hybrid energy storage systems.

Course Articulation Matrix:

CO/PO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	3	3	3	3	1	1
CO-2	3	3	3	3	1	1
CO-3	3	3	3	3	1	1
CO-4	3	3	3	3	3	1

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Introduction: Basics of portable sources of electrical energy, Power Density Vs Energy Density concept, Range of EV based on stored energy, Energy Storage: Storage requirements for Electric Vehicles, Types of Energy Storage Systems: Electrolytic Capacitors, Battery Energy Storage System, Fuel Cell Energy Storage, Supercapacitors Energy Storage Systems, Flywheel Energy Storage Systems, Compressed air energy storage systems and Super conducting Magnetic Energy Storage Systems (SMES). Hybridization of different energy storage devices, Power pack management systems, standardized Drive cycle calculations.

Modelling of Storage Elements: Battery Characteristics**,** Definition of state of charge, Depth of Discharge, Battery parameters, SOC estimation and Battery characterization, C-rate calculations**,** Battery Modeling: Mathematical Model, Electro Chemical Model, Electrical circuit model, supercapacitor model.

Power Converters for Hybrid Energy Storage Systems (HESS): Basics of Bi-directional DC-DC converters, Problems, Z-source converters, Classification of passive, semi-active and full-active converter configuration for HESS, Multi- input Bi-directional DC-DC converters and its advantages, Multiple parallel-connected converter, Dual active-bridge converter, multiple modes single converter, interleaved converter, switched capacitor converter, coupled inductor-based configurations.

Control of Different HESS Configurations: PI controller, Model Predictive Control, Sliding Mode Control, Hysteresis control for HESS. Battery Management Systems: over voltage protection, under voltage protection, short circuit protection, cell voltage monitoring, State-of-Charge estimation, thermal management, fault diagnosis, state-of-health estimation and communication interface.

Charging methods of Storage systems: Constant current and constant voltage methods, constant power charging methods, Active and passive Cell balancing techniques, Charger classifications and standards, Indian standards, European standards, Chinese standards, Japanese chargers, and US charges, selection of AC charging systems, DC charging systems, wireless chargers. Applications and Challenges.

Learning Resources:

Text Books:

1. Ali Emadi, Advanced Electric Drive Vehicles, CRC Press, 2015.
2. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2021, 3rd Edition.

Reference Books:

1. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2023, 3rd Edition.
2. James D. Halderman, Curt Ward, Pear Son, Electric and Hybrid Electric Vehicles, 2023, 1st Edition.
3. Aunpam Singh, Electric Vehicles and the end of ICE Age, 2022, 2nd Edition.
4. Transactions and journal papers.

Other Suggested Readings:

1. https://nptel.ac.in/courses/108/106/108106170/
2. https://nptel.ac.in/courses/108/102/108102121/

EE56006 **0-1-2 (2)**

Propulsion & Control of Electric Vehicles Lab

Pre-Requisites: None

Course Outcomes:

CO-1	Study of a Chopper-Controlled Separately Excited DC Motor Drive
CO-2	Implementation of Scalar and Vector Control for IM drives
CO-3	Speed and torque control of induction motor and PMSM drives for EV applications
CO-4	Study of regenerative (four-quadrant operation) for IM and PMSM Drives.

Course Articulation Matrix:

CO/PO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	3	-	3	1	2	2
CO-2	3	-	3	1	3	2
CO-3	3	-	3	1	3	2
CO-4	3	-	3	1	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

List of Experiments

1. Study of a Separately Excited DC motor drive with a DC-DC Buck converter.
2. Open-loop speed control of three-phase induction motor using V/f control technique.
3. Implementation of space vector modulation with DSP TMS320LF2407A for V/f control of induction motor drive.
4. Closed-loop speed control of three-phase induction motor using the slip- compensation technique.
5. Speed response of a three-phase induction motor using Field Oriented control.
6. Speed control of three-phase permanent magnet synchronous motor (PMSM) using field oriented control (FOC).
7. Speed control of a BLDC motor drive.
8. Torque-Speed characteristics of a three-phase induction motor using IM-IM drive.
9. Speed control of three-phase induction motor drive using three-level Neutral Point Clamped inverter.
10. Torque-Speed characteristics of a three-phase Permanent Magnet Synchronous Motor drive.

Learning Resources:

Text Books:

1. Paul C. Krause, Oleg W, Scott D. Sudhoff, Analysis of Electric Machinery & Drive Systems, IEEE Press, 2013, 3rd Edition.
2. B.K. Bose, Modern Power Electronics & AC Drives, Pearson Education India, 2015, 1st Edition.
3. R. Krishnan, Electric Motor Drives: Modeling, Analysis and Control, Pearson Education India, 2015, 1st Edition.

EE56008 **0-1-2 (2)**

Charging and Battery Engineering Lab

Pre-Requisites: None

Course Outcomes:

CO-1	Study of Bi-directional DC-DC converters and calculation of drive cycle energy efficiency.
CO-2	Evaluate performance indices for portable sources of energy.
CO-3	Design control and drive circuitry for Hybrid Energy Storage Systems.
CO-4	Implement control strategies for different charging methods.

Course Articulation Matrix:

CO/PO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	3	3	2	1	2	1
CO-2	3	3	2	1	2	1
CO-3	3	3	2	2	2	3
CO-4	3	3	3	3	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

List of Experiments:

1. Performance analysis of converters for slow battery charging (THD, power factor, current ripple, thermal analysis).
2. Performance analysis of converters for fast battery charging (THD, Power Factor, Current ripple, thermal analysis).
3. Controller design for CC and CV charging for Battery and Supercapacitors.
4. Bi-Directional DC-DC chargers for Hybrid Energy Storage Systems.
5. Voltage Cell-Balancing Techniques for different Batteries
6. Drive cycle energy efficiency for smooth road and jig-jag roads
7. Regenerative braking in EV
8. Fuel cell based EV
9. Thermal characteristics of Battery pack at different C-ratings.

Learning Resources:

Text Books:

1. Muhammad H. Rashid, Power Electronics - Circuits, Devices and Applications, Pearson, 2018, 4th Edition.
2. Mohan Undeland Robin, Power Electronics - Converters, Applications and Design, John Wiley & Sons, 2002, 3rd Edition.
3. Technical Notes of HIOKI.
4. Vedam Subramanyam: Electric Drives Concepts & Applications –Tata McGraw Hill Edn. Pvt.Ltd, 2011, 2nd Edition.

EE56096 **0-0-0 (2)**

Minor Project

Pre-Requisites: None

Course Outcomes:

CO-1	Apply engineering principles to real-world projects
CO-2	Plan and monitor project tasks individually or as a team
CO-3	Demonstrate practical experience in project execution
CO-4	Communicate project findings clearly through reports and presentations

Course Articulation Matrix:

CO/PO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	2	1	2	1	3	1
CO-2	2	1	2	1	3	1
CO-3	2	3	2	1	3	1
CO-4	2	3	2	1	3	1

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Students are expected to choose real world or relevant problems and apply the engineering principles learned, to solve the problem through building prototypes or simulations or writing codes or establishing processes/synthesis/correlations etc. The department constituted panel can decide the suitability and worthiness of the project.

Learning Resources:

1. Journal and conference papers from reputed publishers such as IEEE, Elsevier, and Wiley.
2. Research Articles / Reports available on Internet.

3rd Semester

E56089 **0-0-0 (2)**

Seminar and Technical Writing

Pre-Requisites: None

Course Outcomes:

CO-1	Consolidate ideas based on expert talks attended
CO-2	Prepare a well-organized report employing elements of critical thinking and technical writing
CO-3	Demonstrate the ability to describe, interpret and analyze the subject matter and develop competence in presenting

Course Articulation Matrix:

CO/PO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	2	1	1	1	2	2
CO-2	2	1	1	1	2	2
CO-3	2	1	3	1	2	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Description:

In Seminar and Technical Writing, every student is expected to prepare a well-organized report based on one / all of the following:

- by attending at least 5 expert lectures/ invited talks/ Seminar/ Popular lectures etc. organized by the institute/any of the departments, ideally in a specific domain or with the same theme.
- prepare a business or marketing plan based on patent search

The student is expected to consolidate the ideas from these lectures/patent searches and may even include material from other sources to strengthen the content of the report. The student should prepare a well-organized report based on the above and present it to the panel constituted by the department, for evaluation.

Learning Resources:

1. Journal and conference papers from reputed publishers such as IEEE, Elsevier, and Wiley.
2. Research Articles / Reports available on Internet.

EE56091 **0-0-0 (2)**

Summer Internship/Research Experience

Pre-Requisites: None

Course Outcomes:

CO-1	Apply engineering principles to real-world problems, gaining practical experience
CO-2	Plan, manage and execute the work with ethical consideration
CO-3	Review the social and environmental impact of the work
CO-4	Communicate the learnings through report and presentation

Course Articulation Matrix:

CO/PO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	1	1	2	2	3	2
CO-2	1	1	2	2	3	3
CO-3	1	2	2	2	3	2
CO-4	1	3	2	2	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Description:

Every student has to undergo either a Summer Internship / Research project. The summer internship may be undergone in an Industry/Research organization or any premier academic Institution, including NIT Warangal for 6-8 weeks. The research project shall be registered under the guidance of any faculty member in the institute. The student is required to submit a report and present the work before an evaluation committee, nominated by the Head of the Department.

Learning Resources:

1. Journal and conference papers from reputed publishers such as IEEE, Elsevier, and Wiley.
2. Research Articles / Reports available on Internet.

EE56093 **0-0-0 (2)**

Comprehensive Viva-Voce

Pre-Requisites: None

Course Outcomes:

CO-1	Comprehend the knowledge gained in the course work
CO-2	Demonstrate the ability in problem solving
CO-3	Communicate effectively using engineering terminology

Course Articulation Matrix:

CO/PO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	1	2	1	1	2	-
CO-2	1	2	1	1	2	-
CO-3	1	3	1	1	2	-

1 - Slightly; 2 - Moderately; 3 - Substantially

Description:

In Comprehensive viva-voce each student will be evaluated for their overall comprehension of the course work and laboratory training that they have undergone. The students will be expected to answer questions orally, write down simple equations, draw plots, schematics, write simple code etc. as questioned by the panel. Assessment will be done by the panel based on the student response.

Learning Resources:

1. Reading Material of all the courses.
2. Case Studies/Industrial training reports
3. Mini projects taken up.

EE56097 **0-0-0 (8)**

Dissertation: Part – A

Pre-Requisites: None

Course Outcomes:

CO-1	Identify a topic in advanced areas of Electrical Engineering.
CO-2	Review literature to identify gaps and define objectives and scope of the work.
CO-3	Employ the ideas from literature and develop research methodology.
CO-4	Develop a model, experimental set-up and / or computational techniques necessary to meet the objectives.

Course Articulation Matrix:

CO/PO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	3	2	3	1	-	3
CO-2	3	2	3	1	-	3
CO-3	3	3	3	3	3	3
CO-4	3	3	3	3	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Description:

Students are expected to choose real-world contemporary problem and apply the engineering principles learned, to solve the problem through building prototypes or simulations or writing codes or establishing processes/synthesis/correlations etc. The department constituted panel will decide the suitability and worthiness of the project

Dissertation Evaluation:

i. The dissertation shall be submitted as per the schedule given in the academic calendar.
ii. The dissertation supervisor will periodically review the progress of the student and finally give his/her assessment of the work done by the student.
iii. The Dissertation Part – A will be evaluated for 100 marks, with the following weightages:

Sub-component	**Weightage**
a) Periodic evaluation by Guide	40 marks
b) Mid-term review	20 marks
c) End Semester viva-voce examination	40 marks

Evaluation Criteria

The student will be evaluated by the panel based on the below criteria. Weightage for each criterion will be determined by the panel and will be informed to the students.

Criteria	Description	Weightages
I	Selection of Topic	10
II	Literature Survey	25
III	Defining the Objectives and Solution Methodology	35
IV	Performance of the Task	30

Evaluation Criteria - CO Mapping:

CO / Criteria	CO1	CO2	CO3	CO4
I	X			
II		X		
III			X	
IV				X

Refer to the M.Tech. – Regulations for any further information regarding mid-term review and end semester evaluation, etc.

4th Semester

EE56098 **0-0-0 (12)**

Dissertation: Part – B

Pre-Requisites: None

Course Outcomes:

CO-1	Identify the materials and methods for carrying out experiments/develop a code.
CO-2	Execute the research methodology with a concern for society, environment and ethics
CO-3	Analyse, discuss and justify the results/trends and draw valid conclusions.
CO-4	Prepare the report as per recommended format and present the work orally adhering to stipulated time.
CO-5	Explore the possibility to publish/present a paper in peer reviewed journals/conference proceedings without plagiarism.

Course Articulation Matrix:

CO/PO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	2	-	3	3	2	3
CO-2	2	-	3	3	2	3
CO-3	3	-	3	3	2	3
CO-4	3	3	3	3	3	3
CO-5	3	3	3	-	-	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Description:

Students are expected to choose real-world contemporary problem and apply the engineering principles learned, to solve the problem through building prototypes or simulations or writing codes or establishing processes/synthesis/correlations etc. The department constituted panel will decide the suitability and worthiness of the project.

Dissertation Evaluation:

i. The dissertation shall be submitted as per the schedule given in the academic calendar.
ii. The dissertation supervisor will periodically review the progress of the student and finally give his/her assessment of the work done by the student.
iii. The Dissertation Part – B will be evaluated for 100 marks, with the following weightages:

Sub-component	**Weightage**
a) Periodic evaluation by Guide	40 marks
b) Mid-term review	20 marks
c) End Semester viva-voce examination	40 marks

Evaluation Criteria:
The student will be evaluated by the panel based on the below criteria as a continuation of Dissertation Part A. Weightage for each criterion will be determined by the panel and will be informed to the students.

Task	Description	Weightages
IV	Performance of the Task	30
V	Dissertation Preparation	20
VI	Review (Presentation & Understanding)	30
VII	Viva-Voce	10
VIII	Publications /Possibility of publication	10

Evaluation Criteria-CO Mapping:

CO / Criteria	CO1	CO2	CO3	CO4	CO5
IV	X	X			
V				X	
VI			X		
VII				X	
VIII					X

Refer to the M.Tech. – Regulations for any further information regarding mid-term review, end semester evaluation, template for report preparation and plagiarism guidelines etc.

Program Electives

ME56031 **3-0-0 (3)**

Automotive Chassis

Pre-Requisites: None

Course Outcomes:

CO-1	Understand the requirements of a chassis frame, types of frames and types of bodies
CO-2	Understand power steering principle and types of power steering systems
CO-3	Understand various types of Suspensions used in Vehicles
CO-4	Adapt recent innovations in automobile sector like wheels, tyres, air conditioning and lighting

Course Articulation Matrix:

CO/PO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	3	2	2	-	1	1
CO-2	3	2	2	-	1	1
CO-3	3	2	2	-	1	1
CO-4	3	2	2	-	1	1

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Introduction: Classification of vehicles, chassis, layout of chassis and sub systems Cooling and Lubrication Systems.

Frame and Body: Types of chassis – light, medium and heavy-duty vehicle chassis. Role and requirements of a chassis frame, types of frames and types of bodies.

Steering System: Steering linkage, steering geometry, types of steering gearbox, Power steering principle and types of power steering systems.

Suspension System: Types of suspension – rigid axle suspensions and independent suspensions, types of suspension spring – leaf spring, coil spring, torsion bar spring, air spring, rubber spring and hydro elastic spring. Role and types of shock absorber, construction and working. Pneumatic suspension system.

Brake System: Stopping distance, time, braking efficiency, classification of brakes, drum, disc brakes, construction, working of mechanical, hydraulic, pneumatic, power assisted brakes, servo brakes, purpose, layout of anti-lock braking system, drum brake and disc brake diagnostics.

Tyres and Wheels: Types, construction of wheel, tyre requirements, bias ply, radial ply tyres and tubeless tyres.

Learning Resources:

Text Books:

1. Automotive Mechanics, Srinivasan S, McGraw-Hill, 2003, 2nd Edition.
2. Automotive Mechanics, William Crouse and Donald Anglin, 10th Edition, McGraw-Hill, 2010.
3. Automobile Engineering, Vol.1 and Vol.2, K.M.Gupta, Umesh Publications, 2002.

Reference Books:

1. Automotive Mechanics, Giri N. K., Khanna Publications, 2008.
2. The Motor Vehicle, Garrett T. K., Newton K. and Steeds W., 13th Edition, Butterworth Heinemann, 2001.
3. Automotive Mechanics, Joseph Heitner 2nd edition, East-West Press, 1999.

EE16021 **3-0-0 (3)**

Wide Band Gap Devices in Power Electronics Applications

Pre-Requisites: None

Course Outcomes:

CO-1	Introduce the basic operation of wide band gap devices and their characteristics
CO-2	Ability to do electrical and thermal modeling of wideband devices, as well as EMI filter design for high-frequency power converters
CO-3	Familiar with compact single-layer and multilayer PCB designs according to industrial needs
CO-4	Utilize wide band gap devices for real-time applications through simulation and experimental studies

Course Articulation Matrix:

CO/PO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	2	1	2	3	1	1
CO-2	2	1	2	3	1	1
CO-3	2	1	2	3	1	2
CO-4	2	1	2	3	1	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Wide Band Gap Devices: Introduction to basic power devices, characteristics, and applications - Silicon Power MOSFETs 1976-2010, SiC Planer Power MOSFETs, SiC Trench-Gate Power MOSFETs, Need of GaN device, Basic GaN Transistor structure, GaN Vertical Power HEFTs and Horizontal Power HEFTs, Different types of wide band gap devices, advantages and challenges in designing converters with wide band gap devices.

GaN Transistor Characteristics & Driver Circuits: Turn ON and Turn OFF switching characteristics of GaN devices, Hard switching loss analysis, Gate driver design, Impact of gate resistance, dv/dt and di/dt immunity, etc., Protection design for double pulse test set-up.

Modeling and Measurement of GaN Transistors: Electrical and thermal modeling of GaN transistors, Thermal management, and Reliability.

High-frequency design complexity: The impact of parasitic inductance and capacitance, EMI filter design for high-frequency power converters, and Heat sink design.

PCB Design: Power circuit design, Driver circuit design, Single layer and Multilayer PCBs, separation of the power circuit and driver circuit, High-frequency power loop optimization.

Applications: GaN in AC/DC & DC/AC Power Converters, GaN in Switched Mode Power Amplifiers, Electric Vehicle Applications, and Renewable Applications.

Learning Resources:

Text Books:

1. A. Lidow, J. Strydom, M. D. Rooij, D. Reusch, GaN Transistors for Efficient Power Conversion, Wiley, 2014.
2. G. Meneghesso, M. Meneghini, E. Zanoni, “Gallium Nitride-enabled High Frequency and High-Efficiency Power Conversion,” Springer International Publishing, 2018.
3. Maurizio Di Polo Emilio, GaN and SiC Power Devices, Springer, 2024.

Reference Books:

1. B.J.Baliga, “Gallium Nitride and Silicon Carbide Power Devices,” World Scientific Publishing Company, 2017.
2. F. Wang, Z. Zhang and E. A. Jones, Characterization of Wide Bandgap Power Semiconductor Devices, IET, 2018.
3. Application notes: Gate driver design by wolfspeed, Infineon, Onsemi.

Other Suggested Readings:

1. https://nptel.ac.in/courses/108108377

EE56021 **3-0-0 (3)**

Electromagnetic Interference and Compatibility for Electric Vehicles

Pre-Requisites: None

Course Outcomes:

CO-1	Understand basic mechanisms and sources of EMI, modelling of EMI generation using simulation and scripting tools such as spice, finite element solvers (2D FEMM or Fast solvers or using python)
CO-2	Designing of proper grounding and shielding scheme for ensuring signal integrity of a typical power converter, ability to design surge protection circuit for a given power converter.
CO-3	Understanding of conducted emission path and sources, its measurement tools and relevant standards for EMI compliance.
CO-4	Develop understanding on radiated emissions its related standards and different techniques to mitigate these emissions in power electronic converter using shielding, bonding and EMI filter design techniques.

Course Articulation Matrix:

CO/PO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	3	3	3	3	1	1
CO-2	3	3	3	3	1	1
CO-3	3	3	3	3	1	1
CO-4	3	3	3	3	3	1

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Introduction: Need for EMI and EMC compliance, Sources of EMI, Conducted and Radiated EMI emission and susceptibility, EMI Testing and Measurement setups and Compliance categories

EM field basics and tools for analysis: Modelling using Spice: Basic converter modelling to predict EM emissions and its frequency spectrum, Parasitic estimation using field theory: basics of harmonic analysis, quasi static analysis, fundamentals of finite element analysis, extracting parasitic using 2D FEMM, basic 3D modelling, parasitic extractions using either using fast solvers (Fast henry, fast cap) or by python.

Design for signal integrity: Safety & signal grounds, low & high frequency grounding methods, grounding of amplifiers and cable shields, isolation, neutralizing transformers, Low frequency magnetic shielding, shield grounding at high frequencies, digital grounding.

Conducted emissions and design for surge immunity: Spice modelling of a generic converter to model conducted EMI, Common mode and differential mode emissions, safety regulations (ground return currents), Power line filters, Line impedance stabilization network (LISN), suppressing EMI at sources, Basic line filter design types of power line surges, design for surge compliance.

Radiated Emissions and immunity: Typical Radiated compliance test setups, near and far fields/ impedances and sources, Types of cables, Mechanism of EMI emission / Coupling in cables, Shielding Effectiveness, loss due to absorption and reflection effects, standing wave effects, composite absorption and reflection losses for electric fields / magnetic fields, Effect of Apertures, Electrical Bonding, Shape and Material for Bond straps, General Characteristics of good bonds.

EMI standards and filter design: Power Line Filter Design-Common-Mode Filter, Differential-Mode filter, Combined CM and DM filter, IEC and MIL standards on EMI, Modelling of conducted emissions in a generic converter, EM filter design,.

Learning Resources:

Text Books:

1. Engineering Electromagnetic Compatibility by Dr. V.P. Kodali, IEEE Publication, Printed in India by S. Chand & Co. Ltd., New Delhi, 2000.
2. Henry W. Ott, Electromagnetic Compatibility Engineering, John Wiley & Sons, Inc., New York, 2009
3. Andrzej M. Trzynadlowski, EMI Effects of Power Converters, in Power Electronics Handbook, 2024, 5th Edition.

Reference Books:

1. Paolo Stefano Crovetti, Electromagnetic Interference and Compatibility, MDPI, 2021.
2. Keith H Billings, Taylor Morey, Handbook on Switch-Mode power supplies, McGraw-Hill Publisher,2011, 3rd Edition.
3. Abraham I. Pressman, Keith Billings, Taylor Morey, Switching Power Supply Design, McGraw Hill International, 2009, 3rd Edition.

Other Suggested Readings:

1. https://nptel.ac.in/courses/108105375
2. https://nptel.ac.in/courses/108106138

ME56033 **3-0-0 (3)**

Automotive Safety

Pre-Requisites: None

Course Outcomes:

CO-1	Understand the role of the vehicle body for safety
CO-2	Distinguish between the concepts of Active and Passive safety
CO-3	Identify different safety systems and their role in automobiles
CO-4	Classify active, passive safety systems and collision warning systems

Course Articulation Matrix:

CO/PO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	2	2	1	-	1	1
CO-2	2	2	1	-	1	1
CO-3	2	2	1	-	1	1
CO-4	2	2	1	-	1	1

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Unit I
INTRODUCTION
Design of the vehicle body for safety, engine location, deceleration of vehicle inside passenger compartment, deceleration on impact with stationary and movable obstacle, concept of crumble zone, safety sandwich construction.

Unit II
SAFETY CONCEPTS
Safety Concepts- Active safety, driving safety, conditional safety, perceptibility safety, operating safety, passive safety: exterior safety, interior safety, deformation behaviour of vehicle body, speed and acceleration characteristics of passenger compartment on impact. **Active Safety:** Cruise control system, Lane departure warning, Safety equipment: Seat belt, regulations, automatic seat belt tightened system, Anti-locking braking system (ABS).

PASSIVE SAFETY Seat belt, regulations, automatic seat belt tightener system, collapsible steering column, tiltable steering wheel, air bags, electronic system for activating air bags, bumper design for safety.

Unit III
COLLISION WARNING AND AVOIDANCE Collision warning system, causes of rear end collision, frontal object detection, rear vehicle object detection system, object detection system with braking system interactions.

Unit IV
COMFORT AND CONVENIENCE SYSTEM Steering and mirror adjustment, central locking system, Garage door opening system, tyre pressure control system, rain sensor system, environment information system.

Learning Resources:

Text Books:

1. Robert Bosch GmbH, Automotive Handbook, SAE publication, 2011, 8th Edition.
2. Srinivasan S, Automotive Mechanics, Tata McGraw- Hill, Publisher, 2015, 2nd Edition.
3. Jullian Happian-Smith, An Introduction to Modern Vehicle Design, SAE, 2002.

Reference Books:

1. Johnson W, and Mamalis A G, Crashworthiness of Vehicles, MEP – London, 1995.
2. Vehicle Service Manuals of reputed manufacturers.

EE50623 **3-0-0 (3)**

Wireless Power Conversion Systems

Pre-Requisites: None

Course Outcomes:

CO-1	Understand the principles and operating modes of wireless power transfer (WPT) systems
CO-2	Analyse and design power converters for WPT systems
CO-3	Design resonant inductive and capacitive power transfer systems
CO-4	Analyse control, communication strategies and standards for WPT systems

Course Articulation Matrix:

CO/PO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	3	-	3	1	3	2
CO-2	3	1	3	1	3	2
CO-3	3	1	3	2	3	2
CO-4	3	-	3	1	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Power Converters for WPT systems

DC-DC Converter topologies, Resonant converter topologies, Soft-switching, Bi-directional converters, Control schemes.

Inductive Power Transfer (IPT) Systems

Magnetic coupling and equivalent circuit models, Resonant compensation topologies: Series, Parallel, LCC, LLC, High-frequency inverter design for IPT, Coil design and optimization for alignment tolerance.

Capacitive Power Transfer (CPT) Systems

Principles of capacitive coupling and electric field distribution, Coupler geometry and dielectric effects, Compensation circuits and driver design, Comparison of IPT and CPT performance.

Control, Communication, and Safety

Power control strategies and frequency tracking, Foreign object detection and misalignment handling, Communication interfaces: Power Line Communication (PLC), Bluetooth Low Energy (BLE), and Near Field Communication (NFC), Safety, EMI/EMC standards.

Emerging Applications

Dynamic EV charging and roadway-embedded systems, Wireless charging for mobile devices and UAVs, Biomedical and implantable energy transfer, Hybrid WPT systems and simultaneous power/data transfer.

Fundamentals of Chargers: Charger classifications and standards, selection of AC charging systems, DC charging systems, Converter topologies for charging, wireless chargers.

Learning Resources:

Text Books:

1. Z. Zhang and H. Pang, Wireless Power Transfer: Principles and Applications. New York, NY, USA: Wiley-IEEE Press, 2022.
2. Z. Mohamed, Wireless Power Transfer: Fundamentals and Technologies. London, UK: InTech, 2016.

Reference Books:

1. Naoki Shinohara (Editor), Wireless Power Transfer: Theory, technology, and applications, IET, 2018.
2. Taimoor Khan, Nasimuddin, Y. M. M. Antar, Elements of Radio Frequency Energy Harvesting and Wireless Power Transfer Systems, CRC Press, 2020.
3. Research Publications.

EE56025 **3-0-0 (3)**

Sensors and Instrumentation for Electric Vehicles

Pre-Requisites: None

Course Outcomes:

CO-1	Understand characteristics of various sensors and transducers used for electric vehicles.
CO-2	Analysis of signal conditional circuits for various applications in EV systems.
CO-3	Apply Nano and micro sensors for EV system.
CO-4	Identify suitable sensors for applications in EV system

Course Articulation Matrix:

CO/PO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	3	3	3	3	1	1
CO-2	3	3	3	3	1	1
CO-3	3	3	3	3	1	1
CO-4	3	3	3	3	3	1

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Introduction: Static characteristics: Accuracy, precision, resolution, sensitivity, Linearity- static calibration - Dynamic characteristics - Design of Zero order and first order systems using mathematical modelling- Time response of first order system using simulation tool. Transducers: Active and Passive, Based on Output Signal: Analog and digital, based on Application (Physical Quantity), direct and inverse, primary and secondary transducers, Sensor calibration.

Position and Torque sensors: Strain Gauges, LVDT, piezoelectric sensors, Hall effect or AMR sensors, TMR (Tunneling Magnetoresistance) sensor, Speed measurement - Encoders, Resolvers, R/D Converters, Hall current sensors and current sampling - Optical tachometer, stroboscopic tachometer. Applications: Motor control position and angle sensor and Motor control speed, Pedal and Throttle Position Sensors.

Current Sensors: 4-20 mA current loops, Hall effect or shunt resistors based current sensor, Nonisolated and Isolated shunt Current Sensor, Applications: Battery system, Electric drivetrain, System protection and Energy management

Voltage Sensors: Isolated voltage-sensing amplifiers and modulators: single ended output and differential output. Nonisolated: Single-ended voltage sensing and difference amplifiers. Applications: Battery status monitoring, Fault detection for protection against overvoltage, undervoltage and transient spikes, Energy management

Temperature sensors: RTDs, thermocouples, NTC (Negative Temperature Coefficient) thermistor, PTC,

silicon-based PTC. Applications: temperature of the motor windings, battery system and In-cabin temperature sensors

Pressure Sensors: Piezoelectric Pressure Sensors, Stainless steel pressure transducers, Applications: Battery system, Thermal management system, Pneumatic and braking systems

Acceleration and vibration measurement: capacitive accelerometer, piezoelectric accelerometers, angular accelerometer, velocity sensor, Vibration measurement: displacement pickup, velocity pickup and acceleration pickup.

Sensors for automation vehicles: Ultrasonic Sensors, Radar Sensors, LIDAR (Light Detection and Ranging), Cameras

MEMS (Micro-Electro-Mechanical Systems): Inertial Sensors (IMU – Inertial Measurement Unit), Pressure Sensors, Gas & Air Quality Sensors, Accelerometer, MEMS Microphones for Noise Control, Surface Acoustic Wave (SAW) sensors.

Signal Conditioning: Instrumentation amplifiers, Analog and Digital filter design and Adaptive filter design- design of amplifiers, antialiasing filters, Opto couplers - Buffer amplifiers, Noise Reduction Techniques in Signal Conditioning

Learning Resources:

Text Books:

1. Patranabis.D: Sensors and Transducers, Prentice Hall of India, 2021, 2nd Edition.
2. Ernest O. Doebelin, Dhanesh N. Manik: Doebelin's Measurement Systems, McGraw Hill, 2019, 7th Edition.
3. Shantanu Bhattacharya, Avinash Kumar Agarwal, Om Prakash, Shailendra Singh, “Sensors for Automotive and Aerospace Applications”, Springer Publishers, 2019.
4. Ribbens W. Understanding automotive electronics: an engineering perspective. Butterworth-Heinemann publications; 2017.

Reference Books:

1. Patranabis: Principles of Industrial Instrumentation, Tata McGraw Hill, New Delhi, 2017, 4th Edition.
2. Randy Frank, Understanding Smart Sensors, Artec House Boston. London, 2000.
3. Hillier's Fundamentals of Automotive Electronics, 6th ed., Oxford Univ Publisher, 2014.
4. Alan S. Morris and Reza Langari, 2nd ed., Measurement and Instrumentation, Theory and Application, Academic Press, 2015.
5. Muhammad H. Rashid, Handbook of Power Electronics in Autonomous and Electric Vehicles, Academic Press, 2024, 1st Edition.

Other Suggested Readings:

1. http://www.digimat.in/nptel/courses/video/108108147/L19.html
2. https://nptel.ac.in/courses/112106913

EE56022 **3-0-0 (3)**

AI Techniques for Electric Vehicles

Pre-Requisites: None

Course Outcomes:

CO-1	Develop mathematical-based AI models for EV subsystems
CO-2	Design advanced AI-based BMS algorithms with uncertainty handling
CO-3	Formulate and solve optimal control and energy management problems using AI/ML
CO-4	Design and analyze AI-based solutions for electric vehicle infrastructure and predictive maintenance

Course Articulation Matrix:

CO/PO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	3	3	3	2	2	1
CO-2	3	3	3	2	2	2
CO-3	3	2	3	2	3	2
CO-4	3	2	3	2	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

AI Foundations for EV Applications: Optimization concepts in machine learning: gradient descent, loss functions, and regularization. Model evaluation metrics and bias–variance trade-off. Introduction to probabilistic learning and Bayesian inference. Overview of AI workflow, including data acquisition, preprocessing, feature engineering, model training, validation, and deployment, with applications in electric vehicle systems.

Battery Management Systems: Battery modelling using equivalent circuit models (Rint, Thevenin) and data-driven approaches. AI-based State of Charge (SOC) and State of Health (SOH) estimation using regression models and neural networks. Neural network-based parameter identification and thermal behaviour prediction. Introduction to battery degradation mechanisms and data-driven degradation modelling techniques.

Electric Powertrain: Electric vehicle powertrain energy management strategies. Application of machine learning techniques for efficiency optimization and drive cycle analysis. Reinforcement learning for control of torque and speed in electric drives. AI-based approaches for performance optimization and fault-aware operation of motors and power electronic converters.

EV Charging Infrastructure: EV charging standards and architectures (AC/DC charging). Smart charging and load management using machine learning techniques. Demand forecasting for charging stations using time-series models. Reinforcement learning-based charging scheduling and introduction to vehicle-to-grid (V2G) optimization for grid support.

Predictive Maintenance: Fault detection and diagnostics in EV subsystems using classification and anomaly detection techniques. Machine learning approaches for battery, motor, and inverter fault identification. Remaining Useful Life (RUL) estimation using regression and time-series models. Condition monitoring using data-driven approaches.

Future Trends: Implementation of AI models using Python libraries such as NumPy, Pandas, Scikit-learn, and PyTorch. Handling and preprocessing of EV-related datasets. Case studies on SOC/SOH estimation, energy management, and charging optimization.

Learning Resources:

Text Books:

1. Ian Goodfellow, Yoshua Bengio, Aaron Courville: Deep Learning, 2016.
2. Kevin P Murphy: Probabilistic Machine Learning: An Introduction, MIT Press, 2022.
3. James Larminie, John Lowry: Electric Vehicle Technology Explained, 2nd Edition, Wiley, 2012.
4. Sheldon Williamson: Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles, Springer, 2013.

Reference Books:

1. S. Onori, L. Serrao, G. Rizzoni: Hybrid Electric Vehicles: Energy Management Strategies. Springer, 2016.
2. Y. Zhang & C. Mi: Advanced Battery Management Technologies for Electric Vehicles, Wiley, 2018.
3. Aurélien Géron: Hands-On Machine Learning with Scikit-Learn, Keras & TensorFlow, 2nd Edition, O'Reilly, 2019.
4. Gregory L. Plett – Battery Management Systems Vol I and II, Artech House Publishers, 2015.

Other Suggested Readings:

1. Relevant Journal Papers.

EE16026 **3-0-0 (3)**

Control & Integration of Renewable Energy Sources

Pre-Requisites: None

Course Outcomes:

CO-1	Understand different renewable energy sources and storage devices
CO-2	Model and simulate renewable energy sources
CO-3	Analyze and simulate control strategies for grid-connected and off-grid systems
CO-4	Develop converters to comply with grid standards to obtain grid integration

Course Articulation Matrix:

CO/PO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	2	3	2	3	3	2
CO-2	3	3	3	3	3	2
CO-3	3	3	3	3	3	2
CO-4	3	3	3	3	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Introduction: Electric grid, Utility ideal features, Supply guarantee, power quality, Stability and cost; Importance & Effects of Renewable Energy penetration into the grid, Boundaries of the actual grid configuration, Consumption models and patterns.

Dynamic Energy Conversion Technologies: Introduction, types of conventional and nonconventional dynamic generation technologies, principle of operation and analysis of reciprocating engines, gas and micro turbines, hydro and wind-based generation technologies.

Static Energy Conversion Technologies: Introduction, types of conventional and nonconventional static generation technologies; Principle of operation and analysis of fuel cell, photovoltaic systems and wind generation technologies; MPPT techniques and its classifications, principle of operation and partial shading effects; Storage Technologies -batteries, fly wheels, super capacitors and ultra-capacitors.

Control Issues and Challenges: Linear and nonlinear controllers, predictive controllers and adaptive controllers, Load frequency and Voltage Control, PLL, Modulation Techniques, Control of Diesel, PV, wind and fuel cell-based generators, Dimensioning of filters, Fault-ride through Capabilities.

Integration of Energy Conversion Technologies: Introduction & importance, sizing, Optimized integrated systems, Interfacing requirements, Distributed versus Centralized Control, Grid connected Photovoltaic systems – classifications, operation, merits & demerits; Islanding Operations, stability and protection issues, load sharing, operation & control of hybrid energy systems, Solar Photovoltaic applications. IEEE & IEC codes and standards for renewable energy grid integrations.

Learning Resources:

Text Books:

1. G. Masters, Renewable and Efficient Electric Power Systems, IEEE-John Wiley and Sons Ltd. Publishers, 2013, 2nd Edition.
2. A. Mahaboob Subahani, G. R. Kanagachidambaresan, M. Kathiresh, Integration of Renewable Energy Sources with Smart Grid, Willey 2021.
3. Felix A. Farret, M. Godoy Simoes, Integration of Renewable Sources of Energy, Wiley, 2017, 2nd Edition.

Reference Books:

1. Chetan Singh Solanki, Fundamentals, Technologies & Applications, Solar Photovoltaic, PHI Publishers, 2019, 3rd Edition.
2. Quing-Chang Zhong, Control of Power Inverters in Renewable Energy and Smart Grid Integration, IEEE-John Wiley and Sons Ltd. Publishers, 2013, 1st Edition.
3. Bin Wu, Yongqiang Lang, Navid Zargari, Power Conversion and Control of Wind Energy Systems, IEEE-John Wiley and Sons Ltd. Publishers, 2011, 1st Edition.
4. S. Chowdhury, S. P. Chowdhury, P. Crossley, Microgrids and Active Distribution Networks, IET Power Electronics Series, 2012.

Other Suggested Readings:

1. https://nptel.ac.in/courses/108/102/108102145/
2. https://nptel.ac.in/courses/103/103/103103206/

ME56032 **3-0-0 (3)**

Aerodynamics of Automobiles

Pre-Requisites: None

Course Outcomes:

CO-1	Recognize the role of fluid mechanics in the aerodynamic design of Electric Vehicles
CO-2	Comprehend aerodynamic forces, moments, and resistances to vehicle motion
CO-3	Understand the concepts drag and lift to shape the body of Electric Vehicles
CO-4	Appreciate the relation between tractive resistance, drag reduction and fuel consumption

Course Articulation Matrix:

CO/PO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	2	1	2	-	1	1
CO-2	2	1	2	-	1	1
CO-3	2	1	2	-	1	1
CO-4	2	1	2	-	1	1

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

UNIT-I:
Fluid properties: Density, specific weight, specific gravity, Viscosity, Vapor Pressure, Surface tension Kinematics of Fluids: Lagrangian and Eulerian description, Velocity potential, Stream function and Vorticity.

Boundary Layer Theory-Formation, growth and separation of boundary layer-Integral momentum principles to compute drag and lift forces.

Properties of incompressible fluids, external flow phenomena related to vehicles, aerodynamic forces and moments, resistances to vehicle motion.

UNIT-II:

Aerodynamics on Passenger Cars: Car as a bluff body, drag and lift, drag fractions and their local origins - front end, windshield and a-pillar, roof, rear end, plan view and side panels, underbody, wheels and wheel housings, front spoiler, rear spoiler.

UNIT-III:

Aerodynamics on Commercial Vehicles: Relation between tractive resistance, drag reduction and fuel consumption, aerodynamic drag coefficients of various commercial vehicles, drag minimization on trucks, buses, add-on devices for drag reduction.

UNIT-IV:

Wind Tunnels for Automotive Aerodynamics: Introduction, principle of wind tunnel technology, limitation of simulation, stress with scale models, full scale wind tunnels, measurement techniques, equipment and transducers.

Learning Resources:

Text Books:

1. Franck .M White: Fluid Mechanics, Tata Mc GrawHill Publication 2011.
2. Hucho W. H., Butterworth: Aerodynamics of Road Vehicles, 1997.
3. R. H. Barnard: Road Vehicle Aerodynamic Design, An Introduction, Mechaero Publications, 2010, 3rd Edition.

Reference Books:

1. Vehicle Aerodynamic, SP-1145, SAE, 1996.
2. Automotive Aerodynamic, Update SP-706, SAE, 1987.
3. Low Speed Wind Tunnel Testing, Alan Pope, Jewel B. Barlow, William H. Rae, John Wiley & Sons, 1998, 3rd Edition.

EC36044 **3-0-0 (3)**

Vehicular Communication Systems

Pre-Requisites: None

Course Outcomes:

CO-1	Explain the fundamentals of vehicular communication systems, including V2X use cases, channel characteristics, and basic wireless communication concepts.
CO-2	Analyze the impact of vehicular channel impairments (Doppler, fading) on signal transmission using fundamental probability and modulation knowledge.
CO-3	Compare IEEE 802.11p/DSRC and C-V2X standards in terms of architecture, protocols, and suitability for safety applications.
CO-4	Identify security threats in vehicular networks and describe basic countermeasures including PKI and pseudonymity.
CO-5	Apply edge computing and resource management concepts to improve latency and reliability in dense V2X scenarios.
CO-6	Simulate a basic V2X communication scenario using standard tools (e.g., MATLAB/Simulink or ns-3) to evaluate performance metrics (BER, throughput).

Course Articulation Matrix:

CO/PO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	3	2	1	1	1	3
CO-2	3	3	2	2	2	1
CO-3	2	3	2	1	2	2
CO-4	2	2	2	2	1	3
CO-5	2	3	3	2	3	2
CO-6	2	3	2	3	3	1

1 - Slightly; 2 – Moderately; 3 - Substantially

Syllabus:

Introduction to Vehicular Communication Systems: Need for V2X, types (V2V, V2I, V2P, V2N), use cases (safety, traffic efficiency, infotainment), Overview of C-ITS, comparison with traditional wireless networks.

Wireless Communication Fundamentals for V2X: Review of analog modulation (AM, FM), Digital modulation (BPSK, QPSK, QAM), Multipath fading, Doppler effect, shadowing, Probability basics: SNR, BER, outage probability

Vehicular Channel Characteristics: Large-scale and small-scale fading models specific to vehicles, Doppler shift and coherence time, Channel estimation basics.

Standards and Protocols: IEEE 802.11p / WAVE architecture, DSRC vs C-V2X (LTE-V2X, NR-V2X basics), Message sets: BSM, CAM, DENM, 3GPP specifications

Physical Layer Design for V2X: OFDM basics, Interference management, Beamforming concepts

Security and Privacy: Threats: jamming, spoofing, Sybil, false info, PKI for V2X, pseudonymity, Basic cryptography concepts (XOR, hashing)

Resource Management & Edge Computing: Radio resource management basics, Congestion control in dense V2X, Edge computing for low latency, Introduction to federated learning

Emerging Trends: 6G V2X requirements, Role of AI/ML in V2X, Real-world testbeds and simulation tools (OMNeT++, SUMO)

Learning Resources:

Text books

1. C. Campolo, A. Molinaro, and R. Scopigno, Vehicular ad hoc Networks: Standards, Solutions, and Research, 1st ed. Cham, Switzerland: Springer, 2015.
2. A. Emadi, Advanced Electric Drive Vehicles, 1st ed. Boca Raton, FL, USA: CRC Press, 2015.
3. Hussein, Electric and Hybrid Vehicles: Design Fundamentals, 3rd ed. Boca Raton, FL, USA: CRC Press, 2021.

Reference Books

1. H. T. Mouftah and M. E. Eltoweissy, Vehicular Ad Hoc Networks: From Simulation to Real-World Deployment, Boca Raton, FL, USA: CRC Press, 2016.
2. M. Ehsani, Y. Gao, S. E. Gay, and A. Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, 3rd ed. Boca Raton, FL, USA: CRC Press, 2023.

Standards and Technical Specifications

1. IEEE, "IEEE Standard for Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications," in *IEEE Std 802.11-2020 (Revision of IEEE Std 802.11-2016)*, pp. 1–4379, Feb. 2021. doi: 10.1109/IEEESTD.2021.9363693.
2. 3GPP, "Enhancement of 3GPP support for V2X scenarios," 3rd Generation Partnership Project (3GPP), TS 22.186, Rev. 16.2.0, Sept. 2019. [Online]. Available: https://www.3gpp.org/ftp/Specs/archive/22_series/22.186/

Other Suggested Readings:

1. https://nptel.ac.in/courses/108/106/108106170/
2. https://nptel.ac.in/courses/108/102/108102121

EE 56024 **3-0-0 (3)**

Electric Vehicle Charging Infrastructure and Smart Grid Integration

Pre-Requisites: None

Course Outcomes (COs):

CO1	Understand EV charging technologies, standards, and infrastructure components
CO2	Plan and design EV charging stations considering grid connectivity and safety
CO3	Analyze the impact of large-scale EV charging on power systems and distribution networks.
CO4	Apply smart charging, demand response, and Vehicle-to-Grid (V2G) strategies.

Course Articulation Matrix:

CO/PO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO1	2	2	2	2	1	2
CO2	3	2	3	3	1	2
CO3	3	2	3	3	1	2
CO4	3	2	3	3	1	2

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction to EV Charging Infrastructure: Overview of electric vehicle ecosystem; EV charging levels (Level 1, Level 2, and DC fast charging); charging standards and connectors (CCS, CHAdeMO, GB/T, Type-2); architecture of EV charging stations; AC and DC charging technologies; wireless and inductive charging concepts; safety standards and regulatory frameworks.

Planning and Deployment of EV Charging Stations: Types of charging stations (home, public, workplace, and fleet charging); site selection and infrastructure planning; grid connection requirements; economic and environmental considerations; charging station business models; urban planning considerations and charging network optimization.

Impact of EV Charging on Electric Power Systems: EV load modelling and forecasting; impact of EV charging on distribution networks; peak load and transformer loading; voltage profile and power quality issues; harmonic distortion due to power electronic converters; impact on generation scheduling and load curves.

Smart Charging and Grid Integration: Smart charging strategies; demand response for EV charging; Vehicle-to-Grid (V2G) and Grid-to-Vehicle (G2V) concepts; bidirectional power flow; communication protocols such as OCPP and ISO 15118; cybersecurity in EV charging networks; role of EVs in ancillary grid services.

Renewable Energy Integrated EV Charging (Qualitative): Solar and wind powered EV charging stations; integration of battery energy storage systems; microgrid-based EV charging infrastructure; smart city integration; lifecycle assessment of EV charging infrastructure; global case studies and policy frameworks for EV charging deployment.

Learning Resources:

Text Books:

1. Iqbal Husain, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2021,3rd Edition.
2. Sheldon S. Williamson, Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles, Springer International Publishing, 2013.
3. Jianhui Wang, Chongqing Kang, and Qixin Chen, Electric Vehicle Integration into Modern Power Networks, Springer, 2013.

Reference Books:

1. James Momoh, Smart Grid: Fundamentals of Design and Analysis, IEEE Press / Wiley, 2012.
2. Tariq Muneer and Mohamed Kolhe, Electric Vehicles: Prospects and Challenges, Elsevier (Academic Press), 2017.
3. Rajeev Thakur and Sheldon Williamson, Plug-in Electric Vehicles in Smart Grids: Charging Strategies, Springer, 2015.

EE56026 **3-0-0 (3)**

IoT Applications in Electric Vehicles

Pre-Requisites: None

Course Outcomes:

CO-1	Explain the fundamental concepts of IoT and its relevance to EV.
CO-2	Develop IoT enabled systems for real-time battery monitoring.
CO-3	Apply IoT for real-time monitoring and optimization of powertrain systems.
CO-4	Identify security challenges and implement control algorithms using IoT for ADAS.

Course Articulation Matrix:

CO/PO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	3	3	3	3	1	1
CO-2	3	3	3	3	1	1
CO-3	3	3	3	3	1	1
CO-4	3	3	3	3	3	1

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Introduction to IoT in EVs: Definition, history, and evolution of IoT; Key concepts, terminologies, and the role of IoT in electric vehicles; Layers of IoT architecture: sensing, communication, processing, and application; Components: sensors, actuators, gateways, and cloud; Communication protocols: Wi-Fi, Bluetooth, Zigbee, LoRa, NB-IoT; Vehicular protocols: V2V, V2I, V2X.

IoT for Battery Management and Monitoring: Architecture of IoT-enabled BMS; Data acquisition from battery cells and modules; Real-time monitoring of voltage, current, and temperature; Predictive Analytics and Remote Diagnostics.

IoT for Powertrain and Energy Management: Role of IoT in powertrain control and optimization; Monitoring motor speed, torque, and efficiency; IoT-based Energy Management Systems (EMS); Smart Charging and Predictive Maintenance.

IoT Security and Data Management in EVs: Common security threats and vulnerabilities in IoT-enabled EVs; Encryption techniques and intrusion detection/prevention systems; Cloud and edge computing for data management; Privacy and Compliance.

IoT for Autonomous Driving and ADAS: Role of IoT in enabling autonomous driving and perception systems (LiDAR, radar, cameras); Data fusion and environment understanding; V2X communication standards and protocols; IoT-based control systems and decision making; Simulation, testing, and AI-based security solutions.

Learning Resources:

Text Books:

1. Rajkumar Buyya and Amir Vahid Dastjerdi: Internet of Things: Principles and Paradigms, 2016.
2. Maciej Kranz: Building the Internet of Things, Wiley, 2016.

Reference Books:

1. Perry Lea: IoT and Edge Computing for Architects, 2020,2nd Edition.
2. Radovan Miucic: Connected Vehicles: Intelligent Transportation Systems, Springer Nature Link, 2019.
3. "The Fourth Industrial Revolution" by Klaus Schwab, 2017.

Other Suggested Readings:

1. https://nptel.ac.in/courses/108/106/108106170/
2. https://nptel.ac.in/courses/108/102/108102121/

EE56028 **3-0-0 (3)**

Thermal Management in EVs

Pre-Requisites: None

Course Outcomes:

CO-1	Understand heat transfer fundamentals and estimate thermal loads for EV batteries, motors, and power electronics.
CO-2	Analyze the impact of thermal management on EV performance, safety, efficiency, and driving range.
CO-3	Understand battery thermal management systems, including cooling methods and thermal runaway mitigation.
CO-4	Evaluate thermal management strategies for EV motors, power electronics, HVAC systems, and related safety and sustainability standards.

Course Articulation Matrix:

CO/PO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	3	3	2	1	2	1
CO-2	3	3	2	1	2	1
CO-3	3	3	2	2	2	3
CO-4	3	3	3	3	2	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Fundamentals for heat transfer for EVs: Conduction, convection, and radiation basics in EV systems, Heat exchangers, fins, and heat-sink concepts for EV components, Estimation of cooling/heating loads for battery, motor, and electronics.

Thermal management in EV: Role of temperature in EVs: battery, motor, power electronics, cabin comfort, and range, Major heat sources: battery pack, power electronics (inverter, DC–DC), motor, cabin HVAC, Impact of temperature on performance, safety, lifetime, and efficiency

Battery Thermal management: Heat generation mechanisms in Li-ion cells and packs, Passive (air, phase-change materials) and active (liquid cooling, refrigerant-based) BTMS, Temperature uniformity, thermal runaway, and emergency cooling strategies

Thermal management for Motor and Power electronics: Losses and heat sources in electric motors and power electronics, Air-cooled and liquid-cooled motor/heat-sink designs (minichannel, immersed cooling), Active methods: jet impingement, heat pipes, thermoelectric (Peltier) cooling, and synthetic jets.

Heating Ventilation and Air conditioning system: Heat pump vs resistive HVAC; energy penalty on range, integrated thermal management: battery cool, motor cooling, and cabin HVAC sharing one coolant loop, Energy efficiency and COP-based analysis for EV thermal systems

Safety standard and sustainability: Safety aspects: thermal runaway propagation, fire-retardant materials, emergency cooling, Relevant standards and regulatory guidelines for EV thermal systems, Sustainability and lifecycle impact of cooling fluids, materials, and design choices

Learning Resources:

Text Books:

1. Hafiz Muhammad Ali, “Thermal Management for Batteries: From Basic Design to Advanced Simulation and Management Methods,” Academic Press Inc, 2024, 1st Edition.
2. Ashwani Kumar, Mukesh Kumar Awasthi, “Thermal Battery Management System for Hybrid and Electric Vehicles,” Wiley, 2025.
3. I. Dincer, H. S. Hamut, and N. Javani, Thermal Management of Electric Vehicle Battery Systems, Wiley, 2017

Reference Books:

1. Fethi Aloui, Edwin Geo Varuvel, Ankit Sonthalia, “Handbook of Thermal Management Systems e-Mobility and Other Energy Applications,” 2023, 1st Edition.
2. D Rahn and Chao-Yang Wang, “Battery Systems Engineering,” Wiley, 2013
3. Y. Shabany, “Heat Transfer: Thermal Management of Electronics” CRC press, 2009.

EE56030 **3-0-0 (3)**

Automotive Functional Safety and Testing

Pre-Requisites: None

Course Outcomes:

CO-1	Impart knowledge of functional safety lifecycle per ISO 26262, EV-specific hazards, and testing protocols
CO-2	Design safety-oriented hardware/software architectures and apply decomposition for EV power electronics/BMS.
CO-3	Evaluate EV testing standards (ISO 12405, AIS-038/048, UN R100) and regulatory requirements.
CO-4	Foster skills in fault injection, EMC testing, and regulatory homologation.

Course Articulation Matrix:

CO/PO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	2	2	2	3	3	3
CO-2	2	2	2	3	3	3
CO-3	2	2	2	3	3	3
CO-4	2	2	2	3	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Functional Safety fundamentals

ISO 26262 overview, safety lifecycle, HARA, ASIL A-D determination, exposure/controllability. EV hazards (battery thermal runaway, motor faults)

Safety Management and Concept Development

Functional/technical safety concepts, FMEA/FTA/DFMEA. EV-specific: BMS safety, powertrain faults. Safety requirements allocation

Hardware and Software Safety

Hardware metrics (SPFM, LFM), software unit design/integration. EV applications: Inverters, ADAS ECUs, cybersecurity (ISO/SAE 21434). Fault-tolerant designs,

EV testing and Validation

System integration testing, HIL/MIL, fault injection. Standards: ISO 26262 Part 4-8, battery (IEC 62660), EMC (CISPR 25), crash/functional safety, HIL/MIL for EMI fault injection

EMI Mitigation Techniques:

Filters (ferrite cores, Y-capacitors) for conducted EMI in chargers/BMS, Shielding/grounding cables, enclosures; PCB layout optimization, Software: Spread-spectrum PWM to reduce peak emissions.

Regulation and EV certification

AIS-038/048/102, UN R100, CMVR type approval. V&V processes, production release, decommissioning

Learning Resources:

Text Books:

1. Functional Safety in Modern Mobility: ISO 26262 and Beyond, Notion Press, 2024.
2. Nicolas Navet: Automotive Embedded Systems Handbook, 2008.
3. EV Testing: ISO 12405, IEC 62660 series.
4. David J. Smith & Kenneth G.L. Simpson: Safety Critical Systems Handbook, 2016,4th Edition.

Software / Tools:

1. MATLAB/Simulink
2. PLECS / LTspice
3. Excel for battery sizing
4. CAN communication simulation tools (optional)

EE56032 **3-0-0 (3)**

Aerial Electric Vehicular Technology

Pre-Requisites: None

Course Outcomes:

CO-1	Analyze and size the propulsion, power electronics, and energy storage systems of a UAV, given a specified mission profile, payload, and range requirement.
CO-2	Design and evaluate fault-tolerant power distribution architectures appropriate for safety-critical aerial applications, applying redundancy and reliability principles.
CO-3	Synthesize and tune a multi-loop flight control system for UAVs to achieve optimized controller performance.
CO-4	Understand methods to generate optimal trajectories and path planning techniques for UAVs

Course Articulation Matrix:

CO/PO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	3	3	2	3	1	2
CO-2	3	2	3	2	1	1
CO-3	3	2	3	3	1	2
CO-4	3	3	1	3	1	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Introduction: Taxonomy of UAVs- Quadcopter, fixed wing and eVTOL. Fundamentals of kinematics for UAVs – Propulsion, Lift, Drag and Gravity. Dynamic Modeling of UAVs. Operation protocols for UAV systems.

Drone Sensors and Actuators: Significance and selection of various sensors and actuators for UAVs - BLDC motors, Autopilot, IMU, GPS, Accelerometers. Sensor-actuator topologies for different UAV applications.

Energy Management System: Battery monitoring system architecture. Distributed battery management for sensors and actuators for indoor, outdoor and challenging terrains. Battery optimization for effective propulsion. Hybrid energy systems - battery + supercapacitor, battery + fuel cell (hydrogen). Battery safety in crash scenarios - thermal runaway in enclosed cabins.

Power Electronics: Topologies for Safety Critical Flight Control in UAVs. Power and Thermal management during flight transitions. Battery pack recommendations for different drone structures and maneuvers. Active and passive Cell balancing techniques for optimum battery utilization.

Automatic Control for Drones: Control system foundations for UAVs - Flight controllers/autopilot. Simulation of PID tuning for Autopilot. Controller performance optimization techniques. Trajectory generation methods.

Surveillance Technologies for Drones: Path planning algorithms for UAVs- Dijkstra, A-star, RRT. Implementation in Python, Q-ground control. Simultaneous Localization and Mapping, Introduction to computer vision in UAV applications.

Learning Resources:

Text Books:

1. Valavanis, K. P., & Vachtsevanos, G. J. (Eds.) - Handbook of Unmanned Aerial Vehicles, Springer, 2015.
2. Quan, Q. - Introduction to Multicopter Design and Control, Springer, 2017.
3. Beard, R. W., & McLain, T. W. (2012). Small Unmanned Aircraft: Theory and Practice. Princeton University Press.
4. K. A. De Jong, Evolutionary Computation: A Unified Approach. Cambridge, MA, USA: MIT Press, 2006.

Reference Books:

1. Leishman, J. G. -Principles of Helicopter Aerodynamics (2nd ed.), Cambridge University Press, 2006.
2. Mohan, N., Undeland, T. M., & Robbins, W. P. - Power Electronics: Converters, Applications, and Design (3rd ed.), Wiley, 2002.
3. Gavin, D. B., & Denton, T. -Electric and Hybrid Vehicles (2nd ed.), Routledge, 2020

Other Suggested Readings:

1. Mahony, R., Kumar, V., & Corke, P. "Multirotor Aerial Vehicles: Modeling, Estimation, and Control of Quadrotor," IEEE Robotics & Automation Magazine, 19(3), 2012.
2. Harber, D., et al.-Distributed Electric Propulsion - A Review," Aerospace Science and Technology, 2021.
3. ArduPilot Documentation - ardupilot.org
4. PX4 Autopilot Developer Guide - docs.px4.io
5. NASA Urban Air Mobility (UAM) Grand Challenge - nasa.gov/uam
6. Job Aviation S4 Technical Reports - jobya.com

EE56034 **3-0-0 (3)**

Sliding Mode Control and Observation

Pre-Requisites: None

Course Outcomes (COs):

CO-1	Apply fundamental principles of linear algebra to perform rigorous stability and controllability analysis of complex dynamical systems.
CO-2	Design robust sliding mode controllers by defining sliding surfaces and discontinuous control laws to ensure system performance against parametric uncertainties.
CO-3	Development of the discrete-time sliding mode schemes to overcome hardware-based limitations and minimize chattering, enabling effective digital implementation.
CO-4	Synthesize advanced sliding mode observers to achieve accurate state estimation and Implement higher-order sliding mode control techniques to achieve superior tracking precision

Course Articulation Matrix:

CO/PO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	3	2	3	3	1	2
CO-2	3	2	3	3	1	2
CO-3	3	2	3	3	1	2
CO-4	3	2	3	3	1	2

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Recapitulation on linear algebra: Matrix Multiplication, Column Space, Null Space, Rank, Vector Space, Inner Product, Inverse of a Matrix, Existence of Solution.

Classical Sliding Mode Controller: Variable Structure Systems, Concept of Sliding Surface, Reachability Conditions, Switching Control Action, Fillippov Trajectories.

Discrete Time SMC: Chattering in Continuous Time, Discrete Time Development, Quasi-Sliding Mode, Discrete Reaching Laws and Sliding Surface Design.

Robust Estimation using Sliding Modes: Luenberger Observers, Sliding Mode Observers: Utkin, Walcott and Zak, Canonical Structures (Discontinuous observer), Fault Reconstruction.

Higher Order Sliding Modes: Concept of Relative Degree, Order of Sliding Mode, Twisting Control, Super-twisting Control Scheme.

Learning Resources:

Text Books:

1. C Edwards, SK Spurgeon, Sliding mode control: theory and applications, CRC press, 1998
2. Y. Shtessel, C. Edwards, C., L. Fridman, L. and A. Levant, Sliding mode control and observation, 2014, New York: Birkhäuser.

Other Suggested Readings:

1. https://www.youtube.com/watch?v=79dt59E3l9M&list=PLHEIL5MR2cEHz5Fa56pS0lyz-6S_S1w78
2. https://www.youtube.com/watch?v=Nl6UlqdEeWc&list=PLJmxjP-2T4kvpU21YdGIrIXUYVjss1t0j
3. https://www.youtube.com/watch?v=TD8Esd9c4GE

EE56036 **3-0-0 (3)**

Machine Design for E-Mobility

Pre-Requisites: None

Course Outcomes (COs):

CO1	Understand the fundamentals of electrical and magnetic design concepts.
CO2	Design and analyze induction motors for electric vehicle applications
CO3	Design and assess PMSM/IPMSM drives for high-performance electric vehicles.
CO4	Evaluate and identify suitable rotating machines for electric vehicle (EV) applications.

Course Articulation Matrix:

CO/PO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	3	2	3	3	2	2
CO-2	3	2	3	3	2	2
CO-3	3	2	3	3	2	2
CO-4	3	2	3	3	2	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Introduction to E-Mobility Traction Motors
EV Drive Requirements: Acceleration, torque-speed characteristics, efficiency maps, and high-speed operation, Machine Types for EV: Comparative analysis of PM Motors (PMSM, SPMSM, IPMSM), Induction Motors (IM), Design Constraints: Weight reduction, volume constraints, and thermal management, Motor Standards: Regulatory requirements and standard operating procedures.

Magnetic and Electrical Design Fundamentals
Sizing Equations: Derivation of output equations, Specific Loadings: Selection of specific magnetic and electric loadings for EV applications, Magnetic Circuit Analysis: Air gap calculation, Carter's coefficient, real and apparent flux density, Winding Design: AC machine windings, distributed vs. concentrated, single/multi-layer.

Induction Motor (IM) Design
Rotor Design: End ring and rotor bar design for traction drives, Leakage Reactance: Calculation of slot and end ring leakage.

Permanent Magnet Synchronous Machine (PMSM/IPMSM)
Design Magnet Materials: High-temperature magnet properties and NdFeB characteristics, Rotor Design: Surface vs. Interior permanent magnet (IPMSM) design for high-speed rotors, Magnetic Circuit: Calculation of permanent magnet mmf and permeance coefficient, Cogging Torque & Torque Ripple: Reduction techniques (skewing, step skewing, pole shaping), Field Weakening: Designing for wide speed range (high RPM).

Learning Resources:

Text Books:

1. A.K. Sawhney, “A Course in Electrical Machine Design,” Dhanpat Rai & Co. (P) Limited, 2016, 6th Edition.
2. M.G. Say, “Performance and Design of AC Machines,” , CBS Publishers and Distributors Pvt. Ltd. 2002, 1st Edition.

Reference Books:

1. John G. Hayes, G. Abas Goodarzi, “Electric Powertrain: Energy Systems, Power Electronics and Drives for Hybrid, Electric and Fuel Cell Vehicles,” John Wiley & Sons Inc., 2018, 1st Edition.
2. R. Krishnan, “Electric Motor Drives Modeling, Analysis, and Control,” Pearson Education India, 2015, 1st Edition.

Online resources:

1. https://nptel.ac.in/courses/108102372