GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3172414
Semester – VII
Subject Name: Vehicular Power Electronics

Type of course: Professional Elective Course

Prerequisite: Control Theory – Electrical Machines and Applications – Basic Power Electronics Devices: Circuits and Applications – Power Electronics Circuit-I – Power Electronics Circuits-II.

Rationale: The use of Power electronics will play important role in making highly efficient electric vehicles having low pollution and better fuel economy. The course is aimed to enable students to comprehend future trends in Electrical vehicle. This subject will be helpful to enhance the knowledge of Power Electronics used in up-coming electrical vehicle technology.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	2	4	70	30	30	20	150

Content:

Sr. No.	Content	Total Hours
1	Introduction: • Electric and Hybrid Electric Vehicles – Configuration of Electric Vehicles – Performance of Electric Vehicles – Traction Motor Characteristics – Tractive Effort and Transmission – Requirement – Vehicle Performance – Tractive Effort in Normal Driving • Energy Consumption Concept of Hybrid Electric Drive Trains – Architecture of Hybrid Electric Drive Trains – Series Hybrid Electric Drive Trains – Parallel Hybrid Electric Drive Trains.	8
2	Electric Propulsion / Automotive Motor Drive: • EV Consideration – DC Motor Drives and Speed Control – Four Quadrant Operation – Induction Motor Drives – Different Control Schemes • Permanent Magnet Motor Drives – Switch Reluctance Motor Drive for Electric Vehicles – Configuration and Control of Drives – Regenerative Braking of AC & DC Motors.	8
3	Design of Electric and Hybrid Electric Vehicles: • Series Hybrid Electric Drive Train Design: Operating Patterns – Control Strategies – Sizing of Major Components - Power Rating of Traction Motor – Power Rating of Engine/Generator	6

	• Design of PPS Parallel Hybrid Electric Drive Train Design: Control Strategies of Parallel Hybrid Drive Train – Design of Engine Power Capacity – Design of Electric Motor Drive Capacity – Transmission Design – Energy Storage Design	
4	Energy Storage & Energy Sources for EV and HEV • Energy Storage Requirements – Battery Parameters – Types of Batteries – Modelling of Battery • Fuel Cell Basic Principle and Operation – Types of Fuel Cells – PEMFC and Its Operation – Modelling of PEMFC • Ultra-Capacitors – Types of PV Technology – Electrical Characteristics and Performance of PV Cells	8
5	Power Electronic Converter for Battery Charging: • Charging Methods for Battery - Termination Methods – Charging from Grid- Cell balancing, its importance. • The Z-Converter – Isolated Bidirectional DC-DC Converter – Design of Z-Converter for Battery Charging – High-Frequency Transformer Based Isolated Charger topology – Transformer Less topology.	7
6	Energy Management Systems for Electric Vehicles: • Energy Management Strategies: Introduction to Energy Management Strategies Used in Hybrid and Electric Vehicles – Classification of Different Energy Management Strategies – Comparison of Different Energy Management Strategies – Implementation Issues of Energy Management Strategies	7

Suggested Specification Table with Marks (Theory): (for BE only)

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
20	**30**	**15**	**15**	**10**	**10**

Legends: R: Remembrance; U: Understanding; A: Application - N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

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Reference Books/Material:

1. Modern Electric - Hybrid Electric - and Fuel Cell Vehicles: Fundamentals - Theory - and Design by M. Ehsani, Y. Gao, S. Gay and Ali Emadi, CRC Press
2. Electric and Hybrid Vehicles: Design Fundamentals by Iqbal Husain, CRC Press
3. Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles by Sheldon S. Williamson, Springer
4. Modern Electric Vehicle Technology by C C Chan and K T Chau, Oxford University Press
5. Advanced Electric Drives Vehicles by Ali Emadi, CRC Press

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

Sr. No.	CO statement	Topics Mapped	Marks % weightage
CO-1	Discuss the configuration and performance of Electric & Hybrid vehicles.	1, 2, 3, 4	35%
CO-2	Select appropriate Electric propulsion system and Motor control systems for Electric and Hybrid vehicle.	2, 3	20%
CO-3	Choose proper energy storage systems with its charging topology for Electric and Hybrid vehicle applications.	4, 5	25%
CO-4	Discuss energy storage devices and its management system for Electric and Hybrid vehicle.	6	20%

Laboratory/Practical Work:

Objectives: The laboratory work is aimed at putting the theory learnt in class in practice and to show that the results are matched with theory closely. In this context, following are the core objectives for laboratory work of this subject.

- Study various motor drives and their control for EVs and HEVs.
- Study the regenerative braking of AC & DC motors in EVs and HEVs.
- Study various energy storage requirements and Battery parameters for EVs and HEVs.
- Study energy management strategies for EVs and HEVs.
- Study the design of battery chargers for EVs.

Directions for Laboratory work:

- ✓ The list of experiments is given as a sample.
- ✓ Minimum 10 experiments should be carried out.
- ✓ Similar laboratory work fulfilling the objectives can also be considered.
- ✓ Each experiment may be simulated before verifying practically.
- ✓ As far as possible, **printed manual should be preferred** so that students can concentrate in laboratory experiments and related study. The sample list of experiments is given below.

Suggested List of Experiments and Design Based (DP)/Open Ended Problems:

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Total 10 experiments are suggested for the course. Depending upon suitability, other experiments may be conducted. Over and above 10 performance experiments, self-study work may be given to students. This includes study of EVs, HEVs, battery chargers, battery testing, etc.

Suggested List of Experiments:

1. To study basics of Electric and Hybrid Electric Vehicles and their performance.
2. To study Series and Parallel hybrid electric drive trains.
3. To study role of Permanent Magnet Motor Drives in Electric Vehicle.
4. To study and simulate SRM Drive for Electric Vehicles.
5. To study regenerative braking of AC & DC motors in electric drive.
6. To study Series Hybrid Electric Drive Train Design.
7. To study control strategies of parallel hybrid drive train.
8. To study energy storage requirements and Battery parameters in EV.
9. To simulate isolated bidirectional DC-DC converter.
10. To study energy management strategies used in hybrid and electric vehicles

Software/Major Equipment:

Open-source software - CRO/DSO - Multi-meters - volt/current meters - Breadboard - necessary components, etc.