GUJARAT TECHNOLOGICAL UNIVERSITY

Master of Engineering Syllabus

Subject Code : 3726402

Subject Name : Battery Management Systems for Electric Vehicles

WEF Academic Year :	2023 - 24
Semester :	2
Category of the Course :	Core

Prerequisite :	A bachelor's degree in electrical engineering, mechanical engineering, or a related field. Basic knowledge of electric vehicles and energy storage systems.
Rationale :	This course focuses on the principles, design, and implementation of Battery Management Systems (BMS) for Electric Vehicles (EVs). Students will learn about the critical role of BMS in optimizing battery performance, safety, and longevity in electric vehicles. The course covers both theoretical and practical aspects of BMS, including state-of-charge estimation, thermal management, cell balancing, fault detection, and control strategies.

Course Scheme :

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

Course Content :

Sr. No.	Course Content	No. of Hours	% of Weightage
1	**Introduction to Electric Vehicles and Batteries** • EV Types and Classification • Types of Batteries Used in EVs • Battery Pack Architecture in EVs • BMS functions and objectives • Electrochemistry of Lithium-ion Batteries • Battery Components and Materials • Battery capacity, voltage, and energy • Battery degradation and aging mechanisms	08	18%

2	**Battery Modeling and State estimation** • Battery Modelling Approaches • State-of-Charge (SoC) and State-of-Health (SoH) Estimation • State-of-health Estimation • Equivalent Circuit Models	05	12%
3	**Battery Thermal Management** • Importance of Thermal Management • Heat Generation in Batteries • Cooling and Heating Strategies	05	12
4	**Battery Safety** • Battery Safety Fundamentals • Safety Standards and Regulations • BMS for Safety and Fault Tolerance	05	12%
5	**Cell Balancing and SOC Control** • Cell Balancing Techniques • State-of-Charge Control Algorithms • Energy Management Strategies • Voltage and current regulation • Overcurrent and overvoltage protection	05	12%
6	**BMS Design and Integration** • BMS Hardware Components • Data Acquisition and Communication • Integration with EV Control Systems • BMS integration with EV power electronics • CAN bus communication standards • CAN bus communication for EV application • Testing and validation of BMS • Case studies of BMS in commercial EVs • Emerging trends and future directions • Battery Degradation and Life Estimation • BMS for Solid-State Batteries • Future Directions in BMS Technology	08	18%
7	**Final Project and Assessment** • Capstone project involving the design, simulation, or analysis of a BMS for a hypothetical electric vehicle application. • Final written report and presentation.	06	16%
	Total	**42**	**100**

Reference Book :

1. "Battery Management Systems for Large Lithium-Ion Battery Packs" by D. U. Sauer and M. P. M. Furukawa
2. "Battery Systems Engineering" by C. Daniel and S. Haran
3. "Battery Management Systems for Large Lithium-Ion Battery Packs" by H. H. G. S. Pei and P. M. G. P. S. Wood
4. "Robust Battery Management Systems: Theory, Algorithms, and Software" by Balakumar Balasingam (Artech House Power Engineering Library)
5. Research papers and articles on recent advancements in BMS technology

Course Outcome :

After Completion of the Course, Student will able to :

No.	Course Outcomes	RBT Level*	% weightage
01	To learn BMS objectives and functions for EVs along with battery pack degradation and ageing effects	Remember L1, Understand, Analyze L4	20%
02	To Analyze the different aspects of BMS like state estimation, safety and thermal management for EVs.	Remember L1, Understand L2, Evaluate L5	25%
03	To understand the cell balancing and SOC control for BMS design and Integration for EVs applications.	Remember L1, Understand L2, Apply L3, Evaluate L5, Create L6	30%
04	To Evaluate and simulate proper sizing and design of battery pack with BMS of EV under consideration.	Apply L3, Analyze L4, Evaluate L5, Create L6	25%

*RM: Remember, UN: Understand, AP: Apply, AN: Analyze, EL: Evaluate, CR: Create

CO's	Program Outcomes (PO's)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1			2	1	1	1	1		1	1
CO2	3	1		1	2	1	1		1	1		1
CO3	3	2	2	1	1	1	1		2	1	1	1
CO4	3	3	3	2	2	1	1		3	1	1	1

Suggested Course Practical List :

1. Study about battery management system and analysis of battery pack development of different kind of EVs.
2. Simulation and analysis of voltage and SOC characteristics of EV batteries at different C levels.
3. Simulation and analysis of degradation of EV batteries at different drive cycles with given life cycle.
4. Simulation and analysis different battery models for SOC estimation.
5. Simulation and analysis of thermal management system of battery pack.
6. Study and analysis of different case studies pf BMS in commercial EVs.
7. Simulation of battery pack with EV's electric drive and charging station.
8. Design and development of BMS for hypothetical 2W and 4W electric vehicle.

List of Laboratory/Learning Resources Required :

1. MATLAB (with ADVISOR tool)
2. Visit city bus charging station.
3. Visit any battery manufacturing facilities

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