INSTITUTE	**FACULTY OF TECHNOLOGY**
PROGRAM	**MASTER OF TECHNOLOGY in ELECTRICAL ENGINEERING**
SEMESTER	**2**
COURSE TITLE	**BATTERY CHARGERS IN EV**
COURSE CODE	**01PE1203**
COURSE CREDITS	**4**

Objective:

1 Main objective of subject is to introduce and analyse the converter topology used in battery charging system of electric vehicle and also analyse its impact on the grid.

Course Outcomes: After completion of this course, student will be able to:

1 Elaborate various grind connected converter for EV battery charging.
2 Analyse the impact of battery charging converter on power system.
3 Analyse the operation of various resonant converters for EV charging system.
4 Develop battery charger for an EV

Pre-requisite of course: Basics of Electrical Engineering (or equivalent subject)

Teaching and Examination Scheme

Theory Hours	Tutorial Hours	Practical Hours	ESE	IA	CSE	Viva	Term Work
3	0	2	50	30	20	25	25

Contents : Unit	Topics	Contact Hours
1	**LLC Resonant Converters** Overview of series, parallel and series-parallel resonance converter,, Half bridge LLC resonant converter: topology, operation and control,, Full bridge LLC resonant converter: topology, operation and control, design of LLC resonant converter.	10
2	**Dual Active Bridge (DAB) Converter** Basic Principle of DAB Converters, Control of Voltage-Fed DAB Converters,, Control of Current-Fed DAB Converters, Key Issues,, Unified Boundary Trapezoidal Modulation Control,, A Current-Fed Dual Active Bridge DC–DC Converter Using Dual PWM Plus Double Phase Shifted Control.	10
3	**Wireless Power Transfer (WPT) for Electric Vehicles (EVs)** Basics of WPT Technology, Modelling the WPT System,, WPT for EV Charging,, Design Challenges and Optimization Candidates,, Optimization of Resonator Design, Future Directions and Trends	10

DR. TAPANKUMAR ANIRUDHDH TRIVEDI
Digitally signed by (Name of HOD)

DR. RAJENDRASINH BAHADURSINH JADEJA
Digitally signed by (Name of Dean/ Principal)

Contents : Unit	Topics	Contact Hours
4	**Battery Charger Impact on Grid** 1-phase fully controlled converter, 3-phase fully controlled converter,, 1-phase PWM AC-DC converter, strategy used for power factor correction,, Harmonics Impact, Harmonics Compensation,, Current Demand Impact and current demand minimization.	8
5	**Charging Infrastructures** Introduction, Understanding charging economics,, Commercial charging and pricing models,, Load managements for large scale EV integration.	4
Total Hours		**42**

Suggested List of Experiments:

Contents : Unit	Topics	Contact Hours
1	**Experiment No. 01** To verify the performance of Isolated Flyback converter.	2
2	**Experiment No. 02** To verify the performance of Isolated Forward converter	2
3	**Experiment No. 03** To verify the performance of Isolated Push-Pull converter.	2
4	**Experiment No. 04** To verify the performance of half bridge and full bridge converter	2
5	**Experiment No. 05** To Simulate the performance of ZVS Resonant converter.	2
6	**Experiment No. 06** To Simulate of half bridge LLC resonant converter for battery charging application	2
7	**Experiment No. 07** To simulate and analyze a full bridge LLC resonant converter for battery charging application	2
8	**Experiment No. 08** To Simulate of DAB Converter and verify the bidirectional flow of power	2
9	**Experiment No. 09** To simulate and compare the performance of different phase shift for DAB converter.	2
10	**Experiment No. 10** To calculate the design parameter for Wireless charging technology of EV batteries.	2
Total Hours		**20**

DR. TAPANKUMAR ANIRUDHDH TRIVEDI
Digitally signed by (Name of HOD)

DR. RAJENDRASINH BAHADURSINH JADEJA
Digitally signed by (Name of Dean/ Principal)

Textbook :

1 Electric Vehicle Technology Explained, James Larminie Oxford Brookes University,, Oxford,, NA

2 Modern Electric Vehicle Technology,, 2. C.C Chan, K.T Chau:, Oxford University Press Inc., New York, 2001

3 Electric and Hybrid Vehicles: Design Fundamentals,, Iqbal Hussein,, CRC Press,, 2003

4 Hybrid Electric Vehicles Principles And Applications With Practical Perspectives, Chris Mi, M. Abul Masrur, David Wenzhong Gao, Wiley Publication, 2011

5 Plug in Electric Vehicle in Smart Grids, Sumedha Rajakaruna, Farhad Shahnia, Arindam Ghosh, Springer Singapore Heidelberg New York Dordrecht London, -

6 HFrequency Isolated Bidirectional Dual Active Bridge DC–DC Converters with Wide Voltage Gain, Deshang Sha, Guo Xu, Gain, Springer Nature Singapore Pte Ltd, 2019

References:

1 Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, CRC Press, 2004

Suggested Theory Distribution:

The suggested theory distribution as per Bloom's taxonomy is as follows. This distribution serves as guidelines for teachers and students to achieve effective teaching-learning process

Distribution of Theory for course delivery and evaluation					
Remember / Knowledge	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Higher order Thinking / Creative**
5.00	10.00	15.00	30.00	20.00	20.00

Instructional Method:

1 The course delivery method will depend upon the requirement of content and need of students. The teacher in addition to conventional teaching method by black board, may also use any of tools such as demonstration, role play, Quiz, brainstorming, MOOCs etc

2 The internal evaluation will be done on the basis of continuous evaluation of students in the laboratory and classroom

3 Practical examination will be conducted at the end of semester for evaluation of performance of students in laboratory.

4 Students will use supplementary resources such as online videos, NPTEL videos, e-courses, Virtual Laboratory

Supplementary Resources:

1 https://www.coursera.org/learn/plug-into-the-future-ev-charging-essentials

2 https://innovationspace.ansys.com/courses/courses/guide-to-ev-charging-infrastructure/lessons/ev-battery-chargers-lesson-1/

3 https://innovationspace.ansys.com/product/guide-to-ev-charging-infrastructure/

DR. TAPANKUMAR ANIRUDHDH TRIVEDI
Digitally signed by (Name of HOD)

DR. RAJENDRASINH BAHADURSINH JADEJA
Digitally signed by (Name of Dean/ Principal)