MHRD Scheme on Global Initiative on Academic Network (GIAN)

COURSE TITLE: Recent Advancement on Electric Vehicle

1.0 Overview

Due to the ever-growing need for higher fuel economy and minimal environmental impacts, advanced battery technologies are being researched for electric vehicles (EVs) at a brisk rate. The improvement of energy and power density of such systems, while improving the overall safety is the most important energy storage system requirements for plug-in hybrid electric and all-electric vehicles (PHEV and EV). Keeping this fact in mind, this presentation will primarily discuss critical comparative issues of the most popularly proposed battery storage systems for EVs/PHEVs. This course also addresses the current practical issues in such systems. Characteristics of the main types of energy storage systems will be discussed, including electro-chemical batteries, regenerative fuel cells, and electrostatic devices such as ultra-capacitors. The design approach for future combined photovoltaic (PV) and grid infrastructures for EV/PHEV charging will also be presented.

Furthermore, in recent years, lithium-ion (Li-ion) batteries, although popularly proposed, have been highly uneconomic for EV energy storage, overshooting cost requirements by a large margin. They provide a good solution for EV and PHEV applications, but main issues include: cycle life, calendar life, energy density, power density, and lately, safety. These issues can be addressed successfully by using a simple practical approach: a power electronics cell voltage equalizer. The purpose of the second part of this seminar is to demonstrate the role of power electronics intensive battery management solutions to reach the cost breakpoint of a PHEV/EV. The Li-ion rechargeable cell has been studied thoughtfully, but there exists no cost analyses of the benefits of using advanced power electronics to protect the cells on board the vehicle. Thus, the seminar will emphasize the importance of power electronics based solutions and energy management techniques for EVs/PHEVs.

This course will be useful for engineers and managers with entry-level and/or medium-level knowledge of power electronics and motor drives. The talk would also be suitable for engineers with entry-level knowledge of power electronics and motor drives applications towards energy storage.

2.0 Objectives

The primary objectives of the course are as follows:

i) Exposing participants to the fundamental architecture of hybrid electric vehicles & Pure Electric Vehicles.
ii) Understanding of various electric motors based on their performance, and selection of suitable one depending on the specific requirement of electric vehicle.
iii) Providing exposure to various control algorithms available for AC motor drive.
iv) Minimization of problems related to ruggedness & reliability of the electric vehicle by incorporating sensorless electric drive train design.
v) Types of machines suitable for electrical/hybrid vehicle applications and their challenges
vi) Understanding role of power electronics, existing circuitry and their limitations
vii) Designing of the controls required for this applications and their demands from the industry

viii) Understanding battery technology
ix) Modeling of Electric and Hybrid Electric Vehicles

3.0 Teaching Faculty with allotment of Lectures and Tutorials

1. **Prof. Sheldon S. Williamson (SSW) : 12 hrs lectures and 6 hrs tutorials**
2. **Prof Avik Bhattacharya (AB) : 8 hrs lectures and 14 hrs tutorials**

4.0 Course details

4.1 Tentative Duration: August 22-26, 2022 (5 days): 20 hrs lectures and 20 hrs Tutorials

4.2 Tentative Lecture Schedule

Lec 1: 1hr: AB
History of hybrid vehicles, architectures of HEVs, series and parallel HEVs, complex HEVs

Lec 2: 1hr: AB
Inverter topology for electric vehicles.

Lec 3: 1hr: AB
Realization of electric drive for electric vehicles using Variable Frequency Drive(VFD) & introduction of Field Oriented Control (FOC) of AC motor.

Lec 4: 1hr: AB
Implementation of Field Oriented Control for AC motor drive using synchronously rotating reference frame as well as rotor reference frame. Direct torque control algorithm for AC motor drive.

Lec 5: 1hr: AB
Analysis on various control strategies of some special machines like Linear Induction Motor and Brushless DC Motor in the context of electric vehicle design.

Lec 6: 1hr: AB
Discussion on various control strategies of Switched Reluctance Motor and Permanent Magnet Synchronous Motor (both radial & axial flux PMSM) to find their feasibility in terms of electric vehicle application.

Lec 7: 1hr: AB
Continuation of Discussion on various control strategies of Switched Reluctance Motor and Permanent Magnet Synchronous Motor (both radial & axial flux PMSM) to find their feasibility in terms of electric vehicle application.

Lec 8: 1hr: AB

Implementation of sensorless control to improve the ruggedness and reliability of electric drive train.

Lec 9: 1hr: SSW

History of electric, hybrid electric, and plug-in hybrid electric vehicles.

Lec 10: 1hr: SSW

Vehicle design fundamentals.

Lec11: 1hr: SSW

Traction motors and drives for electric vehicle propulsion.

Lec 12: 1hr: SSW

Electric energy storage systems and power devices.

Lec 13: 1hr: SSW

Traction power electronic converters and control.

Lec 14: 1hr: SSW

Electric vehicle drivetrain design.

Lec 15: 1hr: SSW

Practical electric vehicle design considerations (with examples).

Lec 16: 1hr: SSW

Electric vehicle charging infrastructure design.

Lec 17: 1hr: SSW

Design of wireless charging infrastructure.

Lec 18:

Electrification of heavy-duty mass transit systems.

Lec 19: 1hr: SSW

Role of renewable energy in transportation electrification.

Lec 20: 1hr: SSW

Integration of electric vehicles with the smart grid.

Date of Examination:

31st August 2022 (tentative)

5.0 Who can attend

- Executives, engineers and researchers from manufacturing, service and government organi-zations including R&D laboratories.
- Student students at all levels (BTech/MSc/MTech/PhD) or Faculty from reputed academic institutions and technical institutions.

6.0 Detailed CV of Experts

6.1 CV of Prof. Sheldon S. Williamson

Sheldon S. Williamson received his Bachelors of Engineering (B.E.) degree in Electrical Engineering with high distinction from University of Mumbai, Mumbai, India, in 1999. He received the Masters of Science (M.S.) degree in 2002, and the Doctor of Philosophy (Ph.D.) degree (with Honors) in 2006, both in Electrical Engineering, from the Illinois Institute of Technology, Chicago, IL, specializing in automotive power electronics and motor drives, at the Grainger Power Electronics and Motor Drives Laboratory. From June 2006 to May 2011, Dr. Williamson held a Tenure-track Assistant Professor position in the Department of Electrical and Computer Engineering, at Concordia University, in Montreal, Canada. Also, from June 2011 to June 2014, Dr. Williamson held a tenured Associate Professor position at Concordia University. Currently, Dr. Williamson is a Professor and NSERC Canada Research Chair in Electric Energy Storage Systems for Transportation Electrification at the University of Ontario-Institute of Technology (UOIT), in Oshawa, Ontario, Canada. He is the Founder and Director of the Smart Transportation Electrification and Energy Research (STEER) group, within the Department of Electrical, Computer, and Software Engineering, at UOIT. His main research interests include power electronics, electric energy storage systems, and motor drives for transportation electrification and electrified autonomous e-mobility.

Dr. Williamson has offered numerous conference tutorials, lectures, and short courses in the areas of electric transportation, electric energy storage systems, as well as automotive power electronics, and motor drives. He is the principal author/co-author of over 300 journal and conference papers. He is also the author/co-author of several books and book chapters on electric transportation and energy storage systems. He was the General Chair for the IEEE International Conference on Industrial Technology, held in Toronto, Ontario, in May 2017. He will be the General Chair for the Annual Conference of the IEEE Industrial Electronics Society (IECON), to be held in Toronto, in Oct. 2021. In addition, he has also served on the technical program committees of several IEEE conferences in the past.

Dr. Williamson is the beneficiary of numerous awards and recognitions. He was the recipient of the prestigious “paper of the year” award, for the year 2006, in the field of Automotive Power Electronics, from the IEEE Vehicular Technology Society (IEEE VTS). In addition, he has also received several “best paper” awards for papers he has co-authored with his graduate research students in major IEEE conferences. He was awarded the prestigious Sigma Xi/IIT Award for Excellence in University Research, for the academic year 2005-2006. In 2006, he also received the “Best Research Student” award, Ph.D. category, within the ECE Department, at the Illinois Institute of Technology, in Chicago, IL.

Dr. Williamson is a Senior Member of the IEEE and is a Member of the IEEE Power Electronics Society (IEEE PELS) and the IEEE Industrial Electronics Society (IEEE IES). He also currently serves as a Distinguished Lecturer of the IEEE Vehicular Technology Society (VTS). He is an

Associate Editor for the IEEE Transactions on Industrial Electronics, IEEE Transactions on Power Electronics, IEEE Transactions on Transportation Electrification, and the IEEE Journal of Emerging and Selected Topics in Power Electronics. He is also a Member of the prestigious IEEE Transportation Technologies Awards Committee (IEEE Medal Award). Dr. Williamson is currently the Area Chair for IEEE Region 7 (IEEE Canada) Industrial Electronics Society. He is also the Past Chair of the IEEE IES Technical Committee on Transportation Electrification. Dr. Williamson also serves as the Chair of the IEEE Toronto Section IEEE Industrial Electronics Society Chapter.

6.2 CV of Prof. Avik Bhattacharya

Course Coordinator Brief CV:
Dr. Avik Bhattacharya
Assistant Professor
Department of Electrical Engineering
I.I.T. Roorkee
Email:avik.iitkgp@gmail.com, bavikfee@iitr.ac.in
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- **Professional Experience**

S. N.	Post Held	Institute/Organization	Period	Nature of Duties
1.	Sr. Design Engineer	Solar Semiconductor	2010 – 2011	R&D
2.	Technical Engineer	HCL Technology	2011 – 2013	R&D
3.	Manager and Head	Samtel Avionics	2013 – 2014	R&D
4.	Assistant Professor	IIT Roorkee	2014 – till date	R&D

- **Specialization and Expertise**

  DC Micro Grid, Power Quality
  Electric Vehicle, Power
  Electronics

- **Awards and Distinctions**

  Dr. Fatema Rashid Best Paper Awards in ICAEE 2015-DHAKA

- **Selected list of Publications**

1. H. Ahmed and **A. Bhattacharya**, "PMSG-based VS-WECS for constant active power delivery to standalone load using direct matrix converter-based SST with BESS," in *IET Generation, Transmission & Distribution*, vol. 13, no. 10, pp. 1757-1767, 21 5 2019.
2. Muneer V and **Avik Bhattacharya, "**Peak power demand management by using SMC-controlled three-level CHB-based three-wire and four-wire SAPF", IEEE Transactions on Industrial Informatics 17 (8), 5270-5281, 2020.
3. Muneer V and **Avik Bhattacharya**, "Eight-switch CHB-based three-level three-phase shunt active power filter", IET Power Electronics 13 (16), 3511-3521, 2020.

4. Ginbar Ensermu, **Avik Bhattacharya** and Nigamananda Panigrahy, "Real-Time Simulation of Smart DC Microgrid with Decentralized Control System under Source Disturbances", Arabian Journal of Science and Engineering, Springer, 2019.
5. Toshi Sharma and **Avik Bhattacharya**, "Sensorless Direct Torque Control of PMSM Drive for EV Application", 2018 2nd International Conference on Power, Energy and Environment: Towards Smart Technology (ICEPE), 2018.
6. Toshi Sharma and **Avik Bhattacharya, "** Performance Analysis of Encoderless DTC of IPMSM for Wide Operating Range", Arabian Journal of Science and Engineering, Springer 2019.
7. Suraj Kumar Chaurasiya, **Avik Bhattacharya** and Sharmili Das, "Reduced switch multilevel converter topology to improve magnetization and demagnetization characteristics of an SRM", 2022 IEEE International Conference on Power Electronics, Smart Grid and Renewable Energy, 2-5 Jan 2022.
8. **A. Bhattacharya**, C. Chakraborty and S. Bhattacharya, "*Current compensation in shunt type active power filters*," IEEE Industrial Electronics Magazine, vol.3, no.3, pp.38-49, 2009.
9. **A. Bhattacharya** and C. Chakraborty, "*A Shunt Active Power Filter with Enhanced Performance Using ANN based Predictive and Adaptive Controllers*,", IEEE Transactions on Industrial Electronics, vol.58,no.2,pp.421-428,Feb.2011
10. **A.Bhattacharya**, C.Chakraborty, S.Bhattacharya, . *"Parallel-Connected Shunt Hybrid Active Power Filters Operating at Different Switching Frequencies for Improved Performance*", Industrial Electronics, IEEE Transactions on, On page(s): 4007 - 4019 Volume: 59, Issue: 11, Nov. 2012
11. Anirban Sinha Ray and **Avik Bhattachraya**,"*Improved Tracking of Shunt Active Power Filter by Sliding Mode Control*," Electrical Power and Energy system, Elsevier.Vol-78,Pg. No. 916- 925,June 2016.
12. Muneer V and **Avik Bhattacharya** " A novel reduced switched three phase unified power quality conditioner " IEEE conference, INDICON 2017
13. Muneer V and **Avik Bhattacharya** "Cascaded H-Bridge based Three-Phase Four-Wire UPQC " IEEE conference, ICIIS 2018
14. Muneer V and **Avik Bhattacharya** "Cascaded H Bridge Multi Level Inverter Based Unified Power Quality Conditioner" IEEE conference, PIICON 2018
15. Muneer V and **Avik Bhattacharya** "Eight Switch CHB based Three Phase Shunt Active Filter" IEEE conference, PEDES 2018.

- **Patents**

Patent filed under 35 U.S.C. $119 to U.S. Provisional Patent Application number 61/313,896, in March 15, 2010, "Systems and Methods for operating a Solar Direct Pump"

Name of the company: Solar Semiconductor

- **Major Sponsored R&D Projects completed/handled**

1	**Title:**	**Permanent Magnet Synchronous Generator Based Novel Bi-directional Converter for Wind Applications**
	Funding Agency	IIT ROORKEE
	Role	Principal Investigator
	Cost	10 Lakhs
	Tenure	3 years
	Status	Completed

2	**Title:**	**An Investigation on Solid State Transformer**
	Funding Agency	**SCIENCE & ENGINEERING RESEARCH BOARD (SERB)**
	Role	Principal Investigator
	Cost	25 Lakhs
	Tenure	3 years
	Status	Closure report submitted

3	**Title:**	**Investigation on MRAS based Direct Torque Controlled PMSM drive for EV Application**
	Funding Agency	**COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH (CSIR)**
	Role	Principal Investigator
	Cost	25 Lakhs
	Tenure	3 years
	Status	Closure Report Submitted

4	**Title:**	**Mobile Substation and Grid Storage System (MOBISUB)**
	Funding Agency	Department of Science & Technology (DST)
	Role	Co-Principal Investigator
	Cost	Rs. 1.47 Crores
	Tenure	2 Years 9 Months
	Status	Ongoing

Extra Information

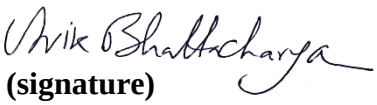
Scholarly and Professional Activities	
IEEE	Sr Member and Reviewer: Transactions on Industrial Electronics, Power Electronics
IET	Sr. Member and review on Power Electronics , GTD

NPTEL On line Certificate Courses:

Title	Duration	Tenure	Status
Facts Devices	20Hrs	July – Sept. 2018	Completed

Advance Power Electronics and Control	20Hrs	Jan. – April 2019	Completed
DC micro grid and Control	20Hrs	July – Sept. 2019	Completed
Power Quality	20Hrs	Jan --April 2020	Completed

Course Coordinators



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