A Global Initiative of Academic Networks (GIAN)

A one week short term course on

High Voltage Gain Soft-Switching Advanced Current-fed Technologies for Microgrid and Electric Transportation

Sponsored by Ministry of Human Resource Development (MHRD), Govt. of India Under the Scheme 'GIAN'

(18th December 2017 to 23rd December 2017) @ Dept. of EE University College of Engineering, Osmania University, Hyderabad, Telangana- 500 007

Overview

Microgrids and Electric Transportation are seen as effective alternative options to encourage clean environment, reduce emission, more choices to users against utility monopoly, continuous electricity supply, local generation, own back-up, and use of renewable energy sources against conventional fuel depletion threat. Power electronic systems are enabling technologies to promote such technologies to match the source and load profiles. High-frequency power electronics conversion units are preferred to realize low cost, compact, and light weight systems. However, to improve efficiency and reduce cooling/thermal requirements, soft-switching of semiconductor devices needs to be implemented. Current-fed power electronic systems have been demonstrated and justified for low voltage high current applications. Current-fed converters offer short circuit protection and voltage amplification due to input inductor. In addition, inductor is reliable and offers higher lifetime (relatively reduced degradation) compared to electrolytic capacitor used in voltage-fed converters. Alternative energy sources output (solar PV, fuel cells) is low voltage and the same is true for energy storage. Current-fed transformer-less converters are able to boost the source voltage up to 10x. In addition, the variability of renewables varies voltage and current (so the power) output. Therefore, the power electronics interface should accommodate such variations with high performance over entire operating range. The major challenge is to maintain high efficiency with intermittent variability, load profile, and usage. Current-fed converters are superior in performance for such variations and specifications. The major challenge in current-fed is high voltage spike/overshoot across the semiconductor devices at turn-off owing to hard commutation. It needs additional snubber circuits reducing density, efficiency, as well as boost capacity. Advanced current-fed converters with novel modulation and impulse resonance achieve soft-commutation and natural voltage clamping of the devices without external snubber circuit making it snubber-less. Soft-switching of all semiconductor devices is achieved and maintained over wide variation in source voltage and power. Similarly, the attributes of natural device voltage clamping and soft-commutation are also maintained. Conventional current-fed as well as voltage-fed PWM and resonant converters have soft-switching limitations and lose at light load and increased source voltage. Therefore, it is quite obvious that these converters cannot maintain for entire operating range of solar panel, fuel cells, batteries, etc. However, the proposed current-fed converters maintain their originality owing to proposed modulation. Soft-switching, natural voltage clamping, and soft-switching are inherent and maintained with wide variation in source voltage and output power. As additional measures, proposed topologies report negligible circulating current that results in higher efficiency at partial load and increased source voltage, reduced peak current stress across the components and requires low kVA rating devices and magnetics. Major applications include interfacing low voltage dc and high voltage dc grids in a microgrid, renewable energy integration, energy storage, and electric transportation.

Objectives

The primary objectives of the course are as follows:

1) Introducing participants to Microgrid, its components, operation, and enabling technologies.
2) Introducing participants to Electric Transportation and enabling technologies.
3) Understanding and learning High Voltage Gain High-Frequency Power Conversion and Soft-Switching Techniques.
4) Introducing participants to state-of-the art voltage-fed and current-fed technologies: merits, demerits, and applications.
5) Exposing participants to issues associated with traditional voltage-fed technologies and current-fed technologies, their comparison, and performance evaluation for Microgrid and Electric Transportation applications.
6) Learning the concept and design of snubber-less naturally commutated and impulse commutated current-fed topologies.
7) Modelling the current-fed power converters; steady-state and dynamic modelling.
8) Circuit and control design and implementation of current-fed power electronics system.
9) Introducing participants to the state-of-the-art future current-fed technologies and their potential applications.

Course Details	**Day 1: 18th December 2017** **Lectures 1** - Duration 1 hr: AKR Introduction to Microgrid (DC and Hybrid) and its components. **Lecture 2** – Duration 1hr: AKR Introduction to Power Conversion in Electric Transportation (Ground, Aerospace, and Marine including V2G). **Day 2: 19th December 2017** **Lecture 3** – Duration 1 hr: AKR Classical Current-fed Topologies-Study and Evaluation for High Gain, Microgrid, and Electric Transportation, and comparison with traditional voltage-fed topologies.

	Lecture 4 – Duration 1 hr: AKR High-frequency power conversion and soft-switching techniques (PWM, Resonant, and Transition types; zero current turn-off and zero voltage turn-on). **Day 3: 20th December 2017** **Lectures 5** - Duration 1 hr: AKR Advanced Current-fed Topologies-Analysis and Design –I **(Impulse Commutated)**. **Lecture 6** – Duration 1 hr: AKR Advanced Current-fed Topologies-Analysis and Design –II **(Snubber-less, Naturally Commutated)**. **Tutorial 1**- Duration1 hr: AKR Mathematical exercise on design of the various topologies: Component's values and ratings and their simulation. Calculating performance (various losses, total losses, and efficiency, soft-switching). **Day 4: 21st December 2017** **Lecture 7** – Duration 1 hr: AKR Steady-state Modelling and design of High Gain Current-fed Technologies (non-isolated transformer-less). **Lecture 8**: - Duration1 hr: AKR Dynamic (small signal) Modelling and Control Design and Implementation for Current-fed Technologies (isolated and non-isolated). **Tutorial 2**- Duration1 hr: AKR Mathematical exercise on deriving transfer function and development of close loop controller for given topology. **Day 5: : 22nd December 2017** **Lecture 9** – Duration 1 hr: AKR Three-phase and Bidirectional Current-fed Technology: Study, Analysis, and Design. **Lecture 10**– Duration 1hr: AKR Applications, Challenges, and further Scope of Current-fed technologies. **Tutorial 3** – Duration 1 hr: AKR Mathematical exercise on design of the bidirectional and three-phase converters topologies: Component's values and ratings and their simulation. Calculating performance (various losses, total losses, and efficiency, soft-switching). **Day 6: 23rd December 2017** **Examination**
Who Should Attend	Executives, Engineers and researchers from manufacturing, service and government organizations including R&D laboratories. Student at all levels (BTech/MSc/M.Tech/PhD) or Faculty from academic institutions and technical institutions.

Fees	The participation fees for taking the course is as follows: **Participants from Abroad : US $500** **Industry/ Research Organizations: Rs. 6,000 /-** **Faculty from Academic Institutions: Rs. 3,000 /-** **Student Participants: Rs. 1,000/-** The above fee includes all instructional materials, tutorials, assignments and internet facility. On request, accommodation will be provided for few participants (on first come first basis) in the campus on payment.
How To Register	**Stage1:** Web (Portal) Registration: Visit GIAN Website at the link: http://www.gian.iitkgp.ac.in/GREGN/index and create login user ID and Password. Fill up blank registration form and do web registration by paying **Rs. 500**/- on line through Net Banking/ Debit/ Credit Card. This provides the user with life time registration to enroll in any no. of GIAN courses offered. **Stage2:** Course Registration (Through GIAN Portal): Log in to the GIAN portal with the user ID and Password created. Click on "Course Registration" option given at the top of the registration form. Select the Course title "Advanced Electromagnetic Engineering" from the list and click on "Save" option. Confirm your registration by Clicking on "Confirm Course". Only Selected Candidates will be intimated through E-mail by the Course Coordinator. They have to remit the necessary course fee in the form of DD drawn in favor of "**PRINCIPAL UCE OU COORDINATOR GIAN"** payable at SBI, University College of Engineering, Osmania University, Hyderabad-500 007. OR through NEFT/RTGS: Name of the Beneficiary: The Principal UCE , OU Account Name: **PRINCIPAL UCE OU COORDINATOR GIAN** Name of The Bank: State Bank of India, Osmania University, Hyderabad Beneficiary A/C No: 37072716197 Bank MICR Code: 500002342 IFSC Code: SBIN0020071

Prof. Akshay Kumar Rathore: Course Faculty (AKR)

Akshay K. Rathore (Senior Member, IEEE) is an Associate Professor at Department of Electrical and Computer Engineering, Concordia University, Montreal, Canada since 2016. He was an Assistant Professor at National University of Singapore (NUS), Singapore from 2011-2015. He received his Masters degree in Electrical Machines and Drives from Indian Institute of Technology, BHU, Varanasi, India in 2003 and was awarded Gold Medal for securing highest standing among all electrical engineering specializations.

He received his PhD degree in Power Electronics from University of Victoria, Victoria, BC, Canada in 2008. He was a recipient of NSERC Research Assistantship, University PhD full Fellowship, and Thouvenelle Graduate Scholarship. From Sept 2008-Oct. 2010, he had two subsequent postdoctoral appointments with University of Wuppertal, Germany, and University of Illinois at Chicago, USA. He was a Visiting Professor at University of Technology at Belfort-Montbelliard (UTBM), France in 2015. He is among founding members of IEEE International Transportation Electrification Conference, India (ITEC-India) held in Chennai on Aug 2015 and is a biennial event.

Dr. Rathore has been working on analysis, design, and development of high-density soft-switching power electronics systems, in particular, current-fed topologies and novel pulse width modulation (PWM) techniques for low voltage high current applications including renewables, distributed generation, microgrid, and electric transportation applications. He has successfully designed and developed several current-fed topologies in his lab and has demonstrated high performance. Presently, he invented a novel and innovative modulation technique to achieve snubber less zero current commutation and natural device voltage clamping of current-fed converters (single-phase and three-phase topologies) solving their traditional problem of turn-off voltage spike and opening its market for industries. Recently, he designed and developed other class Impulse Commutated Current-fed Converters (single-phase and three-phase) with soft switching or semiconductor devices and solving classical turn-off device voltage overshoot problem. In addition, he contributed to development of synchronous optimal PWM (SOP) techniques for low switching frequency of medium voltage multilevel inverter topologies for high power industrial ac drives and common mode elimination. He has 1 patent, commercialized by WEG Brazil. He is currently working with several industries including Hydro-Quebec, OPAT-RT, Infolytica and CIMA+.

At NUS Singapore, he was the coordinator of NUS-IIT Bombay joint PhD program. At NUS Singapore, he was responsible for teaching and course revamp on Smart Grids, Modeling and Control of Advanced Power Converters, and Modeling and Control of Electric Drives. He developed a lab manual for undergraduate course Solar Photovoltaic Energy Systems. He is currently the leader on current-fed research area.

Dr. Rathore secured above 3M$ research funding at Singapore through various industries and government agencies. He has supervised over 15 PhDs, 3 postdoctoral research fellows, 6 research engineers, and 6 master students. His two undergraduate students received Power Engineering Gold Medal for their projects.

Dr. Rathore is elected Distinguished Lecturer (DL) of IEEE Industry Applications Society (IAS) for 2017-18. He is elected to Member-at-Large in

Executive Board of IEEE IAS for 2017-18. He served as a panelist in invited onsite review panel of National Science Foundation (NSF), USA for evaluation of research proposals for funding in the area of Energy, Power, Control, and Network (EPCN).

Dr. Rathore is a recipient of 2013 IEEE IAS Andrew W. Smith Outstanding Young Member Award (first working in Asia to receive this award) and 2014 Isao Takahashi Power Electronics Award. He has been listed in Marquis Who's Who in Science and Engineering in 2006, Who's Who in the World, and Who's Who in America in 2008. He was a consultant to WEG, Brazil, Crenergy Systems Pte Ltd, and Singapore and Robert Bosch (SEA) Pte Ltd, Singapore. He has published over 170 research papers in reputed journals including 55 IEEE Transactions and IEEE international conferences, has 1 patent, and contributed to two book chapters in Springer and Taylor and Francis. He delivered tutorials in IEEE International Conferences in Japan, India, China, and Nepal. He delivered technical guest lectures at various industries including ABB Baden, Switzerland, ABB Chennai, India, GE Bangalore, India, Schneider Electric Vancouver, Canada, and Delta-Q Burnaby, Canada. He has made several industry visits including Nextek Power Systems, USA, Princeton Power Systems, USA, Enphase Energy, USA, and KacoSolar, Germany. He has been a Technical Program Committee member for IAS Annual Meeting, ECCE, APEC, ECCE-Asia, ITEC-India, and PEDES. He is a Member of IAS Industrial Power Converters Committee, Industrial Drives Committee, Industrial Automation and Control Committee, Transportation Systems Committee, and Renewable and Sustainable Energy Conversion Systems Committee.

Dr. Rathore is paper Review Chair of IEEE Transactions on Industry Applications for Industrial Automation and Control Committee (IACC) for 2016-18. He is Vice-Chair of IAS Renewable and Sustainable Energy Conversion Systems Committee for 2016-17. He was IACC Awards Sub-Committee Chair for 2014-17. He is an Associate Editor of IEEE Transactions on Industry Applications, IEEE Transactions on Industrial Electronics, IEEE Transactions on Transportation Electrification, IEEE Transactions on Sustainable Energy, IEEE Journal of Emerging Selected Topics in Power Electronics, and IET Power Electronics. He has edited 5 special issues on Transportation Electrification on various IEEE Journals. He received several best paper presentation award in key IEEE conferences in USA, Japan, India, and Austria.

Dr. Rathore is Chair of IEEE IAS Chapter, Montreal, Canada. He established and is mentoring IEEE IAS SB at Indian Institute of Technology (IIT), BHU, Varanasi, Uttar Pradesh Section, India (established Jan 2016), Malviya National Institute of Technology (MNIT), Jaipur, India and Concordia University, Montreal, Canada.

Dr. Rathore served in award committee member for IEEE IAS Andrew W Smith Outstanding Young member Achievement Award, 2015- 16. He was IAS nominated Academia Interface Committee Chair and IAS YPP Event Organizer and Moderator at ITEC- India 2015, Chennai, India. He was a panelist at YPP event at APEC 2015, Charlotte, USA. He also served in the capacity of Secretary (2013-14) and Committee member (2011-12) for IEEE IAS Singapore Chapter.

Prof. B. Mangu: Course Coordinator

Dr. B. Mangu is a Professor in the Department of Electrical Engineering, University College of Engineering, Osmania University, Hyderabad. He received his B.E. and M.E. degrees from Osmania University, University College of Engineering, Hyderabad.

He was awarded Ph.D degree in the Department of Electrical Engineering at IIT Bombay. He has 16 years of experience in the area of Electrical Engineering. His areas of interest include Renewable Energy Systems and Power Electronics. He has published 25 papers in international conferences and IEEE transactions.

Prof. B. Mangu is the Principal Investigator for two research projects funded by DST-PURSE (Department of Science & Technology - Promotion of University Research and Scientific Excellence) and Technical Education Quality Improvement Programme (TEQIP). A Course titled "High Voltage Gain Soft-Switching Advanced Current-fed Technologies for Microgrid and Electric Transportation is approved by the Apex Body, Global Initiative of Academic Networks(GIAN), MHRD, Govt. of India, which will be conducted during 18th-23rd December 2017. He has been honored with IEEE IAS-PELS travel grant of $500 honorarium to attend the 2014 IEEE Energy Conversion Congress and Exposition (ECCE) during 14th -18th September 2014 in Pittsburgh, Pennsylvania, USA. This paper is selected as a best paper.

He is an active member of IEEE Power Electronics Society, IEEE Power & Energy Society, IEEE Industrial Electronics Society and IEEE Industry Applications Society. He has served in the Osmania University, College of Engineering under various capacities like Head of the Department, Chairman Board of Studies, Faculty Adviser, Hostel Warden and at present serving as Chairperson, Board of Studies in Electrical Engineering(Global). He is a member of Board of Studies in Electrical Engineering, JNTU Hyderabad.

He was a member in a team 15 members participated in the Mahindra Solar Rise challenge, leading the Power Electronics group. Delivered lectures on simulation tools (SABER, PVSyst); organized by National Centre for Photovoltaic Research and Education (NCPRE), Ministry of New and Renewable Energy, Government of India. Delivered lectures on various power electronics related topics to the participants from academia and industry; organized by NCPRE and SEMI India. Conducted drives and power electronics lab sessions for officials from Indian Railways under Continuing Education Program; organized by IIT Bombay.

He has delivered several expert lectures at different platforms in the area of Electrical Engineering. With more than 16 years of teaching experience and research experience, he is guiding 9 Ph.D Scholars in the area of Design of Power Electronic Converters for integration of renewable sources. He has visited countries like United States of America(USA) and Canada etc. and presented research papers in International Conferences.

For further details Contact

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