Advanced Current-fed Power Conversion Technologies for Residential Nanogrid and Transportation Electrification

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Overview

Residential Nanogrids 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 transformerless 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 snubberless. 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 nanogrid, renewable energy integration, energy storage, and electric transportation.

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Modules	
	Day 1 **<u>13 November 2023, Monday</u>** **10 AM to 11 AM: Inauguration** **11:15 AM to 12:15 PM: Akshay Rathore** "Introduction to Residential Nanogrid and its components: Definition, sizing, capacity and role of power conversion systems" **2:00 PM to 3:00 PM – Akshay Rathore** "Introduction to role of Power Conversion in Electric Transportation: propulsion and charging systems". **Day 2** **<u>14 November 2023, Tuesday</u>** **10 AM to 12:00 PM: Akshay Rathore** "Introduction to Voltage-fed and Current-fed Technologies: State-of-the-art and advanced topologies, modulation, and control" and "High-frequency power conversion and soft-switching techniques; State-of-the-art and advanced Pulse width modulated (PWM) and resonant power converters" **2:00 PM to 4:00 PM – Akshay Rathore** Exercises: Design and simulation of voltage-fed dc/dc converters to determine and observe "Duty Cycle Loss", "Rectifier diode voltage overshoot", and the "effect of transformer leakage inductance". **Day 3** **<u>15 November 2023, Wednesday</u>** **10 AM to 12 PM: Akshay Rathore** "Comparison of Voltage-fed and current-fed technologies-merits/demerits" and "Performance evaluation of Voltage-fed and current-fed technologies for Microgrid and Electric Transportation applications" **2:00 PM to 4:00 PM – Pabitra Kumar Biswas** " Overview and classification of dc/dc converters" „DC-DC converter for Electric vehicles" **Day 4** **<u>16 November 2023, Thursday</u>** **10 AM to 12 PM: Akshay Rathore** "Classical Current-fed Topologies-Analysis, Design, and Results" and "Advanced Current-fed Topologies-Analysis and Design –I (Snubberless and Naturally Commutated)" **2:00 PM to 4:00 PM – Anagha Bhattacharya** " Control of inverters in microgrid part 1 and part 2" **Day 5** **<u>17 November 2023, Friday</u>** **10 AM to 12 PM: Akshay Rathore** "Advanced Current-fed Topologies-Analysis and Design –II (Impulse Commutated)" and "Applications, Challenges, and further Scope of Current-fed technologies" **2:00 PM to 3:00 PM – Akshay Rathore** Exercise: Design and simulation on the performance evaluation of snubberless, naturally clamped, current-fed soft-switching dc-dc converters and impulse current-fed soft-switching dc-dc Converters **3:00 PM to 4:00 PM – Akshay Rathore**

	"Opportunities in IEEE Industry Applications Society and How to write an IEEE Transactions paper" **4:00 to 5:00 PM – Closing ceremony, Test and feedback**
You Should Attend If…	• Executives, engineers and researchers from industries, government, public sectors, and organizations including R&D laboratories. • Students at all levels (BTech/MTech/PhD) and Faculty from academic and technical institutions
Fees	The participation fees for taking the course is as follows: **Participants from abroad : US $300** **Industry/ Research Organizations: Rs. 5000** **Academic Institutions: Rs. 2000** **Researchers: Rs.1000** **M.Tech students: Rs.500** The above fee include all instructional materials, computer use for tutorials and assignments, laboratory equipment usage charges, 24 hr free internet facility. The participants will be provided with accommodation on payment basis.

The Faculty

Dr. Akshay K. Rathore is an IEEE Fellow and expert in power electronics and control of electrical motor drives. He is one among those receiving multiple international prestigious awards in his early young career and appointed to high level committees. He contributed to above 110 journal papers including 98 IEEE Transactions. He holds 1 granted patent that is licensed to WEG Brazil and commercialized in high power sectors. He is currently a full Professor and Program leader of Electrical Power Engineering at Singapore Institute of Technology, Singapore. He received the Gold Medal for securing the highest academic standing in his Master's degree among all electrical engineering specializations at Indian Institute of Technology (BHU) Varanasi, India. He received his PhD degree in Power Electronics from University of Victoria, British Columbia, Canada in 2008. He had two subsequent postdoctoral research appointments with the University of Wuppertal, Germany, and the University of Illinois at Chicago, USA. He has served as an Assistant Professor at the National University of Singapore and as an Associate Professor at Concordia University, Montreal, Canada where he was listed in the Provost Circle of Distinction in 2021 and served as Graduate Program Director and Chair of Graduate Awards during 2020-21. Dr. Rathore is a recipient of the 2013 IEEE IAS Andrew W. Smith Outstanding Young Member Achievement Award, 2014 Isao Takahashi Power Electronics Award, 2017 IEEE IES David Irwin Early Career Award, 2019 IES Publications Service Recognition Award, 2020 IEEE IAS Outstanding Area Chair Award, 2020 IEEE Bimal Bose Award for Industrial Electronics Applications in Energy Systems and 2021 Nagamori Award.

Dr. Pabitra Kumar Biswas completed his B.Tech from Asansol Engg. College, WBUT, India. He received his ME. Degree (EE Power Electronics and Drives) on 2007 from Bengal Engineering and Science University, West Bengal, India and PhD. Degree in Electrical Engineering on 2013 from National Institute of Technology, Durgapur, India He is presently working as an Associate Professor in Electrical and Electronics Engineering in National Institute of Technology, Mizoram, India. He was HoD of EEE Department from Februry, 2015 to August 2019. He has published a numbers of research papers in National/International Conference and Records/Journals. He has a book and more than 6 book chapters and filed three patents. He has completed one DST-SERB project. He has about 15 years of academic as well as research experience. He has guided 7 PhD students and more than 10 M.Tech students and Ten more are pursuing their research at present. He has reviewed papers in reputed International Conference and Journals. He has successfully organized a GIAN course, two short term course (NaMPET) and three FDP (ATAL). He is Senoir member of IEEE and Fellow of Institute of Engineers and International Association of Engineers. He is also a Fellow Membership (FSASS) of SAS society. He has received Best paper award and Best Researcher Award (International Scientist Awards on Engineering, Science and Medicine). His research interests include Electromagnetic Levitation System, Active Magnetic Bearing, Power electronics Converters, PMSM and BLDC Motor Drives, Electric Vehicles and Renewable energy.

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Dr. Anagha Bhattacharya received his PhD. Degree in Electrical Engineering on 2022 from Jadavpur University and M.Tech from NIT Silchar. He is currently working as an Assistant professor in

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Electrical and Electronics Engineering in National Institute of Technology, Mizoram, India. He was Head of the Department in Electrical and Electronics Engineering in NIT MIZORAM. He has published a numbers of research papers in National/International Conference and Records/Journals. He has over 14 years of academic experience. He has about 14 years of academic as well as research experience. He has guided more than 5 M.Tech students and more than 10 UG students. He has reviewed papers in reputed International Conference and Journals. He has successfully organized a GIAN course and FDP (ATAL).His research interests include Microgrid, Power Systems Optimization and Deregulation. He is a regular speaker on human values.