

POWER ENGINEERING SYSTEMS FACULTY CANDIDATE SEMINAR

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WANG 1004

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Enhancing Performance and Utilization of Battery Energy Storage Systems for Electric
Mobility and Storage Applications Using Active Control

Abstract

The presentation highlights how power converters enhance the performance and utilization of lithium-ion (Li-ion) batteries during their first and second life. Operating battery cells according to their capabilities and reusing them when appropriate helps minimize adverse environmental impacts and maximize economic benefits.

Marium Rasheed's research advances state-of-the-art hybrid energy storage systems (HESSs) for electric vehicles (EVs) by presenting a novel composite hybrid energy storage system (CHESS) architecture that parallels an energy-dense and power-dense battery pack through a supercapacitor. The proposed novel architecture integrates Lithium-ion (Li-ion) battery packs with different chemistries into a single unit, extracting maximum performance and life from each battery pack. It overcomes the limitations of existing HESSs and offers considerable weight reduction compared to traditional battery solutions, making it attractive to the industry. However, several operational and manufacturing causes lead to uneven aging in cells, resulting in battery packs that reach premature end-of-life (EOL). To minimize cell aging and improve cell utilization, CHESS comprises an integrated energy transfer unit (ETU) that serves three purposes: energy management, battery management, and supplying power to auxiliary loads on a vehicle. The ETU comprises modular isolated dual active bridge (DAB) dc-dc converters rated at relatively low power. As part of her research, Marium developed a multi-loop control approach for the dc-dc converters in the ETU for cell-level, module-level, and pack-level state-of-charge (SOC) balancing, and supporting low-voltage auxiliary loads, while providing propulsion power through the high-voltage dc bus. The ETU adds only minimal cost and weight to CHESS, thus ensuring that the technology is cost-effective and scalable.

The processing of retired batteries from EVs is an emerging challenge yet to be well studied. Marium's research proposes a new active reconditioning approach with the potential to make short-term reconditioning of batteries before their second life feasible. The novel method uses grid-tied inverters with active battery management systems (BMSs) designed to connect to and provide differential control of individual cells. The process takes retired battery packs with high-capacity mismatches among their cells and reconditions them into packs with homogeneous capacity

through active charge and discharge control. The approach can help overcome the drawbacks of traditional repurposing approaches by increasing the economic revenue generated from retired batteries.

While existing modular active balancing systems benefit relatively small battery packs, they are not cost-effective for large packs used in grid-scale energy storage systems. Large battery packs require more power converters for balancing. The proposed five-port differential power processing triple active bridge (DTAB) converter topology offers significant value compared to existing modular active BMSs by reducing component count per active-balancing output to make active or hybrid cell balancing circuits cost-effective.

Biography

Marium Rasheed is an electrical engineering Ph.D. candidate at Utah State University (USU). She is a graduate research assistant at the NSF Engineering Research Center for Advancing Sustainability through Powered Infrastructure for Roadway Electrification (ASPIRE). Marium received a B.S. degree in electrical engineering in 2017 from the School of Science and Engineering at Lahore University of Management and Sciences (LUMS), Lahore, Pakistan. Marium works at the intersection of power electronics and battery energy storage systems, intending to make low-carbon modes of transportation more affordable for the public. Her research focuses on modeling, designing, and controlling high-efficiency and high-power density DC-DC power converters for electrified vehicles, roadway infrastructure, and energy storage systems. She has been developing power converter topologies and control techniques for battery cell balancing, charging, and management. Marium worked as a power electronics intern at Apple and Electric Power Systems in 2021 and at Texas Instruments in 2019.

She has received several national and international awards, including the Best Oral Presentation Award at the leading power electronics conference, IEEE APEC in 2021, the 2021 Outstanding Doctoral Student Researcher of the Year in the Department of Electrical and Computer Engineering at USU, and the 2022 Outstanding Engineering Ph.D. Scholar of the Year at USU, among others. In 2022, Marium won third prize at the NSF Perfect Pitch Competition for her Ph.D. research. In 2021, Marium became the first woman from Pakistan and Utah to have been awarded the Atlantic Council Global Energy Center's Women Leaders in Energy and Climate Change Fellowship. She is a 2022 Clean Energy Leadership Institute Fellow. She is an active member of several power electronics and women in engineering affinity groups, including IEEE and SWE.

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