ECE 590 I
POWER & ENERGY SYSTEMS SEMINAR

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Exploring Power Conversion Based on Piezoelectrics: Converters, Components, and Capabilities

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ABSTRACT

Miniaturized power electronic systems have the potential to revolutionize technologies in transportation, energy systems, manufacturing, healthcare, information technology and many other far-reaching applications. Today, such miniaturization is fundamentally bottlenecked by passive components, particularly magnetics, which have long been integral to power electronics but pose inherent size and performance challenges at small scales. Such challenges motivate the investigation of alternative passive component technologies for future power conversion such as piezoelectric substances, which store energy in their mechanical compliance and inertia. Piezoelectrics offer several potential performance, form factor and manufacturability advantages over power electronics, and unlike magnetics, piezoelectrics exhibit favorable scaling characteristics for miniaturization.

In this talk, we explore how we can leverage piezoelectrics to substantially miniaturize power conversion, which requires fundamental reassessment of the power conversion architectures and the piezoelectric components themselves. We first identify practical dc-dc converter circuit topologies and control strategies that efficiently utilize piezoelectrics as sole passive components, without magnetics. Then, we establish piezoelectric component design strategies to maximize power density and efficiency of the design. We also discuss the scalability of the power density and efficiency to small sizes and how piezoelectric-based converters may pave the way for major advances in power converter miniaturization.

BIO

Jessica Boles received her B.S. and M.S. degrees in electrical engineering from the University of Tennessee, Knoxville (UTK) in 2015 and 2017, respectively. She is now a PhD candidate in the Power Electronics Research Group at the Massachusetts Institute of Technology (MIT), where she leads a research team with multiple projects focused on piezoelectric-based power conversion. Her research interests span power conversion circuit topologies, passive components, and control techniques, with an emphasis on miniaturization.

Boles is a recipient of the NSF Graduate Research Fellowship, the MIT Collamore-Rogers Fellowship, and the UTK Bodenheimer Fellowship. Her work has received a Best Paper Award at the 2019 IEEE Workshop on Control and Modeling for Power Electronics and presentation awards at the NSF Engineering Research Centers Perfect Pitch Competition, the IEEE Applied Power Electronics Conference and Exposition, and MIT's Microsystems Annual Research Conference. For service, she has received the MIT EECS Department Head Special Recognition Award, the UTK EECS Student Leadership Award, and the General Motors EcoCAR 3 Outstanding Women in Engineering Award.