

NEWSLETTER



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UNIVERSITY OF WISCONSIN-MADISON

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Congratulations, Professor Gupta!



Professor Mahima Gupta, an Associate Director of WEMPEC, won a \$2.9M ARPA-E grant to develop a disruptive multi-terminal high-voltage DC converter substation design to strengthen the nation's transmission technologies. Here is a look into her upcoming research.

What is high voltage DC and what are its advantages over AC?

Nobody is probably old enough now to have lived through the war of currents! It's roughly one and a half century ago now. There's historically been a fight between DC and AC, and I feel like we have returned to it. We have an AC infrastructure, but many of our devices are DC, like the batteries in phones and laptops.

If transmission distance is short, AC is preferred because of cost and infrastructure. But with very long-distance transmission lines, DC clearly wins in terms of reduced losses in the transmission system and overall cost.

How can long distance transmission be beneficial?

Honestly, I've been thinking about this since I was a child. Imagine that you have an energy source of any form: chemical, mechanical, kinetic, nuclear... anything. The energy might be converted into electrons in a corner of the country where not a whole lot of people can use those electrons.

Just imagine us having the capability to move that electron thousands of miles, without significant loss, from one corner of the country to another corner to, say, power your phone so that you can post on social media, or to power essential equipment to hospitals, or to power the construction equipment sitting here to get our new engineering building up and running!

If we want to move energy over very long distances with very high voltage - in this particular funding opportunity, one megavolt - DC transmission provides much lower losses. This project will be looking at implementing a high-voltage DC substation, compactly, robustly and cost effectively.

Who is involved in the project?

It's a big team of a total of seven organizations: UW-Madison ECE and Mechanical Engineering and Arizona State University are the academic institutions involved. There's also magnetics vendor SNC Manufacturing, HVDC manufacturer Siemens Energy, IEEE-2800 compliance experts from Electric Power Research Institute, inter-regional developers from Grid United, and Ideal Power, a small business four-quadrant device supplier. We are bringing together expertise with power electronics as the core, along with control systems, thermal design, protection systems, power devices, magnetics and systems integration to make this disruptive power electronics technology into reality.

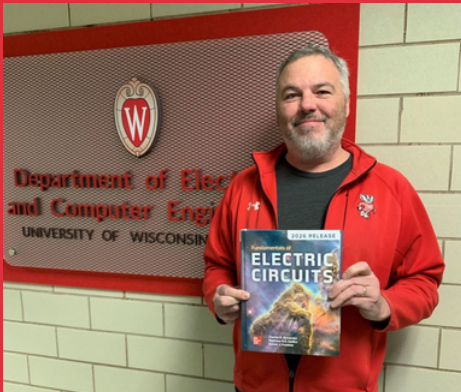
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How will building this HVDC substation prototype expand current power electronics knowledge?

The voltage range is under 320 kV DC in most HVDC systems today across the country. We are looking at pushing the voltage levels to +/- 525 kV DC. Each converter size is two to three times bigger than what exists today. Our project studies much higher voltage levels, more than two times higher power levels, and power electronics that are sized three to five times smaller. The amount of power we are going to push through the same volume is going to be much larger. At the core of this is a new power electronics converter topology that brings the galvanically isolating device, i.e. a 60 Hz transformer inside the converter. New materials in magnetics along with advanced control and thermal design considerations can help us achieve the project's power density, high voltage isolation, and multi-terminal power transmission goals. I'm hoping that we will push it out of our university doors and take it to the next step for commercial deployment by the end of three years.

EMPOWERING THE NEXT GENERATION!



Associate Teaching Professor and WEMPEC affiliate Steve Fredette recently coauthored 'Fundamentals of Electric Circuits', continuing a well-known text that helps make circuit analysis clearer, more engaging, and easier to understand for students. The book balances theory with worked examples, practice problems, and real-world applications. Reflecting Fredette's teaching style, the book is a thoughtful, student-centered contribution to how linear circuits are taught and learned.

Recent publication

Eric Haag, Yuhao Chen, Giri Venkataramanan, Manish K. Singh,
"Assessing Power Flow Controllability via Variable Line Reactance"

- Large data center loads and inverter-based generation increases stress on transmission networks. Power flow controllers (PFCs) adjust effective line reactances to redistribute flows and improve transmission network utilization.
- This paper introduces a framework to quantify network flow controllability – the extent to which line flows can be reshaped through reactance adjustments.
- Researchers conducted empirical studies of the IEEE 39-bus system to examine how controllability varies with the number of PFCs and their reactance adjustment range, finding installing PFCs on all lines enables complete controllability of feasible flow patterns.
- Analyses employ a mixed-integer linear program for PFC sizing and siting optimization. Findings are validated under AC power flow physics using an optimization routine that steers flows toward desired setpoints.

