

Suman Debnath

CONTACT INFORMATION

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LEADERSHIP EXPERIENCE: SUMMARY

- Currently leading two multi-institutional projects (with 16 and 14 colleagues from 8 institutions) funded by Department of Energy (DOE) Solar Energy Technologies Office (SETO) that are worth \$6+M.
- Leading an ongoing laboratory directed research and development (LDRD) project worth 0.45M with 6 colleagues in the team.
- Led/Co-led two multi-laboratory projects from DOE grid modernization laboratory consortium (GMLC) lab call and Transformer Resilience and Advanced Components (TRAC) program in the past three years. Delivered one-of-its-kind approach to identify techno-economic benefits from advanced control approaches in power electronics in power systems. Best paper award was presented for one of the approaches at IEEE Power & Energy Society General Meeting.
- Started career at ORNL by proposing a new concept to the LDRD program in the confluence of power electronics and power systems that led to the 'Flexible Intelligent Real-Time DC-AC Grid Emulator (FIRE)' project worth \$0.713M. This has now been transformed to the \$6+M ongoing SETO projects.
- Developed partnerships and collaborations with multiple stakeholders (21+) for research on power electronics in power systems that included independent system operators (ISOs), utilities, original equipment manufacturers (OEMs), academia.
- Introduced a new area at ORNL in simulation, real-time simulation, and power electronic hardware-in-the-loop (PE-HIL) capability for transmission-connected power electronics. This is an extremely important area with the challenges documented in North American Electric Reliability Corporation (NERC) reports on power electronics in power systems.
- One of the founding members and the first chair of the IEEE East Tennessee (ET) Section Power Electronics Society (PELS)/Power & Energy Society (PES) Joint Chapter. The chapter was awarded one of the high performance chapters world-over by IEEE PES.
- Organizer of several IEEE conferences and support several IEEE conferences through chairing sessions. Chairing special sessions and providing tutorials in IEEE conferences.
- Reviewer in up to 10 journal transactions, several leading conferences, and DOE proposals.
- Involved in 6 standards development committees.
- Started an innovation series within the group to enable development of new concepts and ideas. The series is used to discuss, deliberate, and identify newer methods of describing observed phenomena or developing technical solutions (that can help generate 'out-of-the-box' ideas).
- Developed vision for simulators, real-time simulators, and HIL setups based on gaps identified in existing solutions.
- Delivered a first-of-its-kind real-time simulation platform and simulation algorithms for simulation of power electronics in power systems (based on multi-core digital signal processors [DSP], heterogeneous compute environment of graphics processing unit [GPU] and central processing unit [CPU]). Up to 15 times improvement observed.
- Developed a first-of-its-kind parallel-in-time algorithm for simulation of power electronics, which is an extremely hard problem due to the fast switching nature of the system. It has been shown to provide N times speed-up with N parallel threads available.
- Created a first-of-its-kind PE-HIL capability. This capability can be utilized to evaluate high-voltage modules used in transmission-connected power electronics.
- Delivered one-of-its-kind approach to identify techno-economic benefits from advanced control approaches in power electronics in power systems. Approach is based on facilitating interactions between high-fidelity simulation models of power electronics with their advanced control methods to traditional power grid dynamic models to economic quantification methods. This approach is an enabler for greater integration of power electronics and improved reliability/resilience (that is a challenge otherwise).
- Developed a suite of high-voltage direct current (HVdc) converter models based on advanced

CAPABILITIES/ KNOWLEDGE DEVELOPMENT EXPERIENCE

simulation algorithms to speed-up the simulation by up to 25 times. The models are currently being used by external organizations that led to publications and enhancement in understanding of HVdc systems. These systems are now being considered by utilities and ISOs for integration of wind.

PROFESSIONAL
EXPERIENCE

Oak Ridge National Laboratory, Knoxville, TN, USA

R&D Staff

January, 2020 - Present

- Research & Develop (R&D) of using high-performance computing and applied mathematics algorithms (multi-order, multi-stiff, multi-step, multi-reduction) in simulations and real-time simulations of power electronics in a large extreme fast charger network. Observed up to $36x$ speed-up.
- R&D of integrated development of multi-port autonomous reconfigurable solar power plants (MARS) with HVdc, ac, photovoltaic (PV) systems, and energy storage systems connected. This research explores real-time simulation algorithms, advanced grid-forming and virtual inertia methods, development of PE-HIL methods to evaluate MARS.
- R&D on modeling of large-scale PV plant models and grids with a high-penetration of PV that enable study of reliability under grid events.
- Leading project teams of 16 and 14 colleagues in multi-institutional SETO-funded projects in 2020. Leading a project team of 6 colleagues in LDRD-funded project.
- Mentoring 4 Ph.D. students towards dissertation.
- Mentoring 2 postdoctoral research associates.
- Managing projects worth $\approx \$2.2M$ /year in 2020 as principle investigator (PI).

Associate R&D Staff

October, 2016 - December, 2019

- R&D of real-time and offline simulation algorithms, platforms, and models of various HVdc converter substations. Observed up to $15x$ improvement in speed/computational resources used in real-time simulations.
- R&D of control algorithms in multi-terminal dc (MTdc) systems (up to 7-terminals) to provide inertial and primary frequency response and local voltage support in asynchronous interconnections. Up to 50% improvement in frequency response observed using advanced control algorithms for HVdc systems connecting asynchronous grids.
- R&D of using high-performance computing and applied mathematics algorithms in hybrid simulation based on electromagnetic transient (EMT) and transient stability (TS) simulations.
- R&D of integrated development in MARS. This research involved advanced EMT modeling of MARS and connected ac grids, development of advanced virtual inertia and coordinated control algorithms, and development of wide bandgap device-based power electronics that support such systems.
- Led a prototype development team to build a real-time power electronics emulator of modular multilevel converter (MMC).
- Involved in research of transmission-distribution ac-dc grid architectures that support smart mobility.
- Led project team of 16 colleagues in a multi-institutional SETO-funded project in 2019, 17 colleagues in TRAC-funded multi-lab project in 2017 and 2018, 8 colleagues in LDRD-funded project in 2017 and 2018.
- Mentored 5 Ph.D. students towards dissertation.
- Mentored 4 interns and 1 postdoctoral research associate.
- Managed projects worth $\approx \$1.65M$ /year in 2019, $\$1M$ /year in 2018, and $\$360K$ /year in 2017 as PI.

Postdoctoral Research Associate

July, 2015 - September, 2016

- R&D of real-time simulation algorithms, platforms, models, and control algorithms of HVdc systems. Up to $25x$ faster simulation algorithm developed.
- Was involved in research and development of high-power wireless system.
- Guided a Ph.D. student towards development of 3D printed packaging and layout of bare wide-bandgap semiconductor dies for a solar inverter project.
- Was actively involved in writing grant proposals for DOE funding opportunities on microgrids and

HVdc/MVdc systems. A grant was awarded to ORNL in collaboration with Pacific Northwest National Laboratory, as participant, on value modeling of HVdc/MVdc systems in 2016-17.

- Submitted an LDRD proposal, as co-PI, on emulating HVdc systems.

P C Krause and Associates, Inc., West Lafayette, Indiana USA

Project Engineer

January, 2014 - April, 2014

Researched on real-time simulation of detailed power electronic circuits and drive systems of high bandwidth on Opal-RT systems. This capability provided an ability to study configurations of different shipboard drives.

RESEARCH
EXPERIENCE

Purdue University, West Lafayette, Indiana USA

Research Assistant

December, 2011 - February, 2015

Researched and developed control algorithms for next generation modular multilevel converter based high-voltage high-power wind energy conversion systems. Developed a multi-state control optimization method that improves performance by more than 10 times. This approach has been, since, applied to other applications like optimal control of HVdc systems.

Collaboration Project

May, 2014 - February, 2015

Generation of non-parametric models of MMCs based on pseudo-random binary sequence technique and development of controllers based on constrained optimization-based loop-shaping technique. Collaborated with other postdoctoral research associates and students in this project.

Industry Project (Cummins Inc.)

May, 2014 - December, 2014

Mentored a graduate student on an industry project on detailed analysis, construction and testing of a 6-kW soft-switching bi-directional isolated dc-dc converter for hybrid electric vehicles.

Mentored Graduate Students

May, 2014 - December, 2014

Mentored two graduate students working on modeling of conducted electro-magnetic interference of MMCs, and medium voltage modular isolated/non-isolated dc-dc converters.

Research Assistant

June, 2011 - December, 2011

Researched on application of single input dual output converters to power electronic control and dimming of LED lighting. The goal was reduced cost of LED lighting.

Indian Institute of Technology, Madras, Tamil Nadu India

Research Assistant

January, 2009 - April, 2010

Explored non-linear dynamic modeling of solar panel interconnections and optimized power generated by them. New algorithms developed for optimization of the power under different partial shading conditions that generate multiple maximas.

EDUCATION

Purdue University, West Lafayette, Indiana USA

Ph.D., Electrical and Computer Engineering, May 2015

- Dissertation Topic: "Control of Modular Multilevel Converters for Grid-integration of Full-scale Wind Energy Conversion Systems"

Indian Institute of Technology, Madras, Tamil Nadu India

Bachelors & Masters in Electrical Engineering with specialization in Power Systems/Power Electronics, May 2010

- Dissertation Topic: "Maximizing the Power Obtained from Solar Panel Interconnections"

HONORS AND
AWARDS

IEEE PES best paper award for paper in IEEE PES-GM conference in 2020.

Elevated to IEEE Senior Member, an honor bestowed only to those who have made significant

contributions to the profession ($\approx 10\%$).

Awarded several Department of Energy (DOE) grants worth multi-million in 2018-2020.

IEEE IES student best paper award for paper in IEEE Trans. on Industrial Electronics in 2016.

Certificate of appreciation for being an exceptional reviewer for IEEE Transactions on Power Delivery in 2015.

Best poster award in the Building Research Collaborations: Electrical Systems Workshop, 2013.

Honor mention recipient of the Link Foundation Energy Fellowship Program for the years 2013-2015.

Proposal Reviewer

- Power America
- Small Business Innovation Research (SBIR) - Small Business Technology Transfer (STTR)

Professional Affiliations

- IEEE *2013 - Present*
- IEEE Industrial Electronics Society *2014 - Present*
- IEEE Power Electronics Society *2015, 2017 - Present*
- IEEE Power & Energy Society *2017 - Present*
- IEEE Industrial Applications Society *2014*

Conference Organization

- Program subcommittee member in IEEE ECCE *2017 - 2018*
- Tutorial Chair in IEEE WiPDA *2018 - Present*
- Technical Program Chair in IEEE PEDG *Present - 2021*
- Session Chair in several IEEE conferences like ITEC, APEC, ECCE *2017 - Present*

Standards Development

- IEEE high voltage power electronics stations subcommittee (guest) *2016-Present*
- UL STP 3001 member *2016-Present*
- IEEE Standard for Interconnection and Interoperability of Inverter-Based Resources Interconnecting with Associated Transmission Electric Power Systems (P2800) (guest) *2018-Present*
- IEEE-CIGRE B4-82 Use of Real Code in EMT Models *2019-Present*
- CIGRE C4-56 Electromagnetic transient simulation models for large-scale system impact studies in power systems having a high penetration of inverter connected generation (shadow member) *2019-Present*
- CIGRE B4-85 Interoperability in HVDC systems based on partially open-source software *2020-Present*

Chair, IEEE PES/PELS ET Section Joint Chapter

June, 2017 - Present

- Lead in establishing IEEE PES/PELS ET section joint chapter to organize power systems and electronics events (networking, distinguished lectures).
- Successful completion of first two year with 20 events and ongoing third year with 10+ events.
- Increased participation in Executive Committee to 10+ members. Society membership increased to 100+.
- Supported women-in-engineering through engagement in the Executive Committee and talks on women-in-engineering.
- Supported students' engagement through talks supported at Universities/Colleges, active engagement with the student chapters through faculty and introduction of liaison between the chapters.
- Awarded one of the high performance chapters world-over by IEEE PES for activities in 2019.

Journal Reviewer

- IEEE Transactions on Energy Conversion *June, 2017 - Present*
- IEEE Transactions on Transportation Electrification *July, 2016 - Present*
- IEEE Transactions on Industry Applications *September, 2015 - Present*

PROFESSIONAL
SERVICE/ SOCIETY
AFFILIATIONS

- IEEE Transactions on Industrial Electronics *July, 2015 - Present*
- IEEE Transactions on Smart Grid *August, 2014 - Present*
- IEEE Transactions on Power Electronics *October, 2013 - Present*
- IEEE Transactions on Energy Conversion *February, 2013 - Present*
- IEEE Transactions on Power Delivery *November, 2012 - Present*

Conference Reviewer

- Annual Conference of IEEE Industrial Electronics Society (IECON), 2014.
- IEEE Applied Power Electronics Conference and Exposition (APEC), 2011-2014, 2017-2018.
- IEEE Energy Conversion Congress and Exposition (ECCE), 2016-2018.
- IEEE Workshop on Wide Bandgap Power Devices & Applications (WiPDA), 2016, 2018-2019.
- IEEE Transportation Electrification Conference and Expo (ITEC), 2017-2018.
- IEEE Power & Energy Society - General Meeting (PES-GM), 2016, 2020.
- IEEE Electronic Power Grid (eGRID), 2018.