

Dr. Deepakkumar M. Fulwani

CONTACT INFORMATION

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My research lies at the intersection of power engineering and control theory, with contributions spanning DC microgrids, power converters, electric vehicles, electric drives, and advanced control strategies. I also bring expertise in embedded systems for real-time implementation of control algorithms.

I currently serve as Associate Editor for *IEEE Transactions on Industrial Electronics* and as Editor for *Scientific Reports* (Nature Publishing Group). Previously, I was Associate Editor for *IEEE Transactions on Industry Applications* and have been a technical program committee member for several national and international conferences.

I have supervised 8 Ph.D. dissertations and currently guide 8 doctoral candidates, in addition to mentoring 21 Master's students. I am equally committed to advancing engineering pedagogy and improving teaching methodologies.

At the Indian Institute of Technology Jodhpur, I have held multiple academic-administrative positions, including Coordinator (PG Programs), Coordinator (Faculty), Associate Dean (Planning and Resource Generation), and Associate Dean (Faculty). I presently serve as Head of the Rishabh Center for Research and Innovation in Clean Energy.

RESEARCH INTERESTS

Grid-forming inverters; microgrids; drives and control of power converters.

EDUCATION

Ph.D. July 2006 to November 2009

Indian Institute of Technology Bombay (IIT Bombay), Mumbai, India

Thesis Title: *Sliding Mode Control Strategies using Nonlinear Sliding Surfaces*

Awarded for "Excellence in Ph.D. Thesis work" in 48th Convocation of IIT Bombay.

Master of Engineering (M.E.) (Automation and Control) July 1999 to January 2001

Department of Electrical Engineering,

L. D. College of Engineering, Ahmedabad, India

- Grade: First-class distinction

Bachelor of Engineering (B.E.) (Electrical Engineering) July 1995 to July 1999

Government Engineering College, Bhuj, India

- Grade: First-class distinction

AWARDS AND RECOGNITION

- Editorial Board member (Associate Editor) of *IEEE Transactions on Industrial Electronics* since June 2024.
- Editorial Board member (Editor) for *Scientific Reports* (Nature Publishing Group) since 2023.
- Teaching Excellence Award (class size 30 to 60), Indian Institute of Technology Jodhpur, 2020.
- Awarded for "Excellence in Ph.D. Thesis work" in 48th Convocation of Indian Institute of Technology Bombay, 2010.
- Guest Associate Editor for Special Issue on Structured DC Microgrids, *IEEE Journal on Emerging and Selected Topics in Power Electronics*, July 2017.
- Young Faculty Research Fellowship (Visvesvaraya Programme, MeitY, Govt. of India), 2018.
- Associate Editor, *IEEE Transactions on Industry Applications*, 2019 to 2022.
- Reviewer for: *IEEE Transactions on Automatic Control*; *IEEE Transactions on Industrial Electronics*; *Automatica*; *Asian Journal of Control*; *International Journal of Control*; *International Journal of Robust and Nonlinear Control*; *IEEE Journal on Emerging and Selected Topics in Power Electronics*; *IEEE Transactions on Power Electronics*; *IEEE/ASME Transactions on Mechatronics*; *IEEE Transactions on Circuits and Systems*; *IEEE Transactions on Smart Grid*; *IEEE Access*, etc.; TPC member of many international conferences; Technical Chair for IEEE-PEDES 2022 (500+ submissions).

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IIT Jodhpur, India

Talk 1: DC Microgrids: Impedance Shaping and Ripple Distribution Consensus

Beginning in the first decade of the 21st century and still continuing, the distributed generation has significantly advanced the integration of renewable energy sources to the main grids globally. Microgrids have seen worldwide deployments due to their modularity, ability to reduce grid dependencies and economic benefits. There has been significant interest in DC Microgrids (DCMG) and Hybrid AC/DC Microgrids in the last decade driven by better efficiency by avoiding multiple conversions, compatibility of many AC loads with DC, and some emerging applications like hydrogen electrolyzers and electric ships generally use DC systems. Furthermore, many applications like Vehicular power system, telecom power system and green data centres intrinsically use DC systems. In particular, growing power demand of green data centres across the globe and need of AC/DC hybrid Microgrids necessitate research and development for DC Microgrids.

A DC Microgrid consists of multiple sources of different kinds and distributed loads. In many applications, single phase AC loads are also fed through DCMG. The integration of single-phase AC loads through inverters induces second-order oscillations in both the source currents and the DC bus voltage, thus compromising the overall efficiency and reliability of DC microgrid systems. To address these challenges, this talk discusses an Adaptive Sliding Mode Control-based Output Impedance Shaping (ASMC-OIS) scheme aimed at precise voltage regulation, proportional load current sharing, and effective second-order ripple attenuation in DCMG. The proposed control framework enhances the output impedance of the source-interfacing converters at twice the AC line frequency, through robust control technique, thereby suppressing the propagation of second-order ripple currents through the converter stages. These oscillations are instead redirected towards the DC-link capacitor or distributed to network nodes equipped with active or passive ripple mitigation filters, thus increasing the energy utilization and density of the associated ripple filtering converters. To ensure accurate proportional current sharing among distributed energy resources (DERs), a dynamic consensus-based secondary control layer is incorporated. The stability of the proposed control methodology is established with multiple source nodes using Lyapunov-based techniques.

Talk 2: Cyber Attack Resilient Control for DC Microgrids.

In distributed control frameworks for DC microgrids (DCMGs), communication infrastructure plays a crucial role in enabling coordination among nodes. However, this reliance also introduces vulnerabilities to cyber-attacks, which may disrupt control performance or even threaten system stability. This talk introduces a resilient control strategy designed to detect and counteract attacks on both actuators and sensors within the DCMG. A dynamic detection method is first presented, utilizing a finite-state machine (FSM) that compares real-time and estimated signals to identify anomalies indicative of cyber intrusions. Upon detection, a mitigation scheme employing a sliding-mode functional observer (SMFO) which estimates the control input. This estimated control input is used to replace compromised signals. This SMFO framework is effective in the face of noise and parameter uncertainties. The talk will also present covert attack detection based on structural properties of the system. Converter-level detection metric will be discussed that relies on both measured and internal states of each node. In contrast to existing methods, the proposed metric is explicitly designed to remain invariant to line and load variations, ensuring high sensitivity to attack vectors alone. The proposed methods have been tested both in simulations and through experimental validation on a 4-node microgrid prototype, demonstrating its practical effectiveness in enhancing system resilience.

Talk 3: Event Triggered Control of Power Converters

Traditional fixed-frequency control in power converters often leads to significant efficiency degradation under light-load conditions due to constant switching losses. To address this, dynamically adjusting the switching frequency based on system demand has emerged as a more effective approach. In this presentation, a variable-frequency modulation technique grounded in Event-Triggered Sliding Mode Control (ETSMC) is introduced. By aligning switching events with the actual dynamic requirements of the converter, this method minimizes unnecessary switching activity, thereby enhancing overall efficiency without sacrificing control quality. Notably, the widely used hysteresis-based sliding mode control is shown to be a particular instance of the proposed ETSMC framework, underlining its broad applicability.