Department of Electrical Engineering
Indian Institute of Technology (Indian School of Mines) Dhanbad

VIBHAV

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Message from HoD's Desk

By PROF. SUKANTA DAS

Dear All,

At the outset, I convey my heartfelt New Year's Greetings to the readers. I wish you all a year filled with good health, continued academic excellence, and fulfillment. It gives me immense pleasure to present the "December 2025" edition of the Department of Electrical Engineering's monthly newsletter, "VIBHAV".

The month of December 2025 highlights a some notable individual achievements that reflect the dedication, excellence, and collective efforts of our faculty, students, and staff.

I also warmly invite our students to contribute actively toward enhancing the quality, diversity, and outreach of our monthly newsletter. Your constructive feedback and valuable suggestions are most welcome and may be shared at ee@iitism.ac.in to help us continually improve future editions of "VIBHAV".

Thank you for your continued support and engagement.

Best wishes.

About the Department

The Electrical Engineering department was established in the year 2005. The four-year B.Tech. program in Electrical Engineering was started in the academic session 2006-07. Although the Department of Electrical Engineering is one of the latest of the existing departments of the Institute, the Electrical Engineering Section existed as a part of earlier Mining Machinery Engineering department from 1975. Apart from different B.Tech. programs, the department at present also offers M.Tech programs in Power System Engineering and Power Electronics & Electrical Drives. Through funded projects, consultancies, Doctoral, and postdoctoral programs, most of the research activities are being carried out in the department.

The paper entitled, "Virtual Synchronous Generator-Controlled Grid-Forming Wind Turbine Integrated with VSC-HVDC System: Modeling and Performance Evaluation," authored by Arvind Kumar, Prakirty Kumari, and **Dushyant Sharma** has been adjudged as the **Best Paper Award** in the *2025 IEEE 4th International Conference on Smart Technologies for Power, Energy and Control (STPEC 2025)*, organised by the National Institute of Technology Goa, held from 10th–13th December.

Hearty Congratulations to them!

Publications

Journals

- Dhanagare, T. N., He, Q., **Srinivas, V. L.**, Alzhrani, A., Vardhan, A. S., Singh, M., Saket, R. K., & Zhao, X., "Model free control of hybrid fuel-cell and supercapacitor powered electric vehicle," *International Journal of Renewable Energy Development*, 15(1), 204-215, doi: 10.61435/ijred.2026.61095.
- **Bhawana Singh**, Karim Ahmadi Dastgerdi, Nikolaos Athanasopoulos, Wasif Naeem and Benoit Lecallard, "Safe COLREGs-aware Finite-Time Guidance and Control of Marine Vehicles," *Ocean Engineering*, December 2025 [Accepted].
- **B. Bhattacharyya**, S. K. Rajbhar, and S. Basak, "Optimal co-ordination of multitype FACTS controllers for reactive power optimization," *Electric Power Systems Research*, vol. 253, p. 112520, doi: 10.1016/j.epsr.2025.112520.

Conferences

- A. Kumar, P. Kumari, **D. Sharma**, "Virtual Synchronous Generator-Controlled Grid-Forming Wind Turbine Integrated with VSC-HVDC System: Modeling and Performance Evaluation," *2025 IEEE 4th International Conference on Smart Technologies for Power, Energy and Control (STPEC 2025)*, Goa, India, 2025.
- A. Kumar, **D. Sharma**, M. Pal, "Advancing Grid-Forming Converter Control Using Transformer-Based Artificial Intelligence Model: A Performance

Evaluation," *2025 IEEE 4th International Conference on Smart Technologies for Power, Energy and Control (STPEC 2025)*, Goa, India, 2025.

- Anagha Rajendran K. P., **Soumyabrata Barik**, and S. Swain, "Enhancing RDN Performance with Optimized EVCS, DG, and SC Placement Using Zero-Bus logic OR based Forward–Backward Load Flow," *2025 IEEE 4th International Conference on Smart Technologies for Power, Energy and Control (STPEC 2025)*, NIT Goa, India, 2025.
- Anagha Rajendran K. P., **Soumyabrata Barik**, S. Swain, "Novel Zero Bus Logic OR-Based Load Flow for Techno-Economic Optimization of RDNs via Coordinated DG and EVCS Placement," *IEEE International Conference on Power Electronics, Smart Grid and Renewable Energy*, IIT Dharwad, India, 2025.

Outreach Activities

- **Prof. Nitai Pal** conducted Ph.D. Viva-voce Examination for Research Scholar of NIT, Kurukshetra as an External Examiner, held in December 2025.
- **Prof. Nitai Pal** attended the Board of Studies (BoS) meeting online at KIET Group of Institutions (Deemed to be University), Delhi-NCR, Ghaziabad held in December 2025.
- **Prof. Sethupathy S** chaired a technical session in 4th IEEE International Conference on Power Electronics Smart Grid and Renewable Energy (PESGRE), IIT Dharwad, Karnataka, India.
- **Prof. Soumyabrata Barik** chaired a technical session and poster session in 2025 IEEE 4th International Conference on Smart Technologies for Power, Energy and Control (STPEC 2025), organized by NIT Goa.

AMPED – 2025

The Electrical Engineering Society successfully organized AMPED on December 3rd, 2025, from 10:00 am to 4:00 pm, as an intensive one-day technical competition designed to challenge, engage, and inspire undergraduate and graduate students in core areas of electrical engineering. The event aimed to bridge the gap between theory and practical application by encouraging participants to think critically and creatively while solving real engineering problems. Students participated in teams of two, fostering collaboration, effective communication, and teamwork (skills essential for profes-

sional engineering practice). AMPED attracted enthusiastic participation and created a competitive yet collaborative environment where students could showcase their technical competence and innovative thinking.

The first half of the competition was dedicated to hands-on analog circuit design, where teams worked on breadboards to implement functional and innovative circuits. Participants were tasked with designing circuits capable of solving differential equations as well as creating adjustable inverter and non-inverter configurations using operational amplifiers. This round emphasized practical understanding, component-level optimization, and creativity. Teams were evaluated based on the correct functioning of their circuits, the efficient use of components, specifically resistors, capacitors, and op-amps (and the overall elegance of the design). Special recognition was given to teams that presented highly novel, minimalistic, and efficient circuit solutions, and such teams were declared winners of this round, highlighting innovation alongside technical accuracy.

The second half of AMPED transitioned into a MATLAB simulation and programming challenge, testing participants' analytical and computational skills. Once again working in teams of two, students were required to write MATLAB functions to perform tasks such as rotating matrices, computing Fourier series coefficients, simulating power systems, and designing a buck-boost converter. Each problem consisted of multiple sub-questions with varying levels of difficulty, ensuring that both fundamental understanding and advanced problem-solving abilities were assessed. Teams were judged on the correctness, clarity, and simplicity of their code, with emphasis on structured logic and efficient implementation. The event concluded with the announcement of winners and distribution of prizes, bringing the competition to a successful close and leaving participants with a rewarding learning experience and valuable practical exposure.

International Collaborative Research with Institute of Protein Research (Osaka University, Japan)

Dr. Haswanth Vundavilli undertook an international research visit to the Institute of Protein Research, Osaka University, Japan, from December 13th to 21st, 2025, as part of an ongoing international collaborative research initiative. This visit was fully funded by Osaka University, which awarded support for both travel and research execution in recognition of the scientific merit and collaborative potential of the proposed work. During his stay, Dr. Vundavilli was hosted in Dr. Kenji Mizuguchi's laboratory, where he actively engaged in advanced research activities focused on applying single-cell genomics approaches to investigate the molecular mechanisms underlying the progression of hepatocellular carcinoma (HCC). The collaborative work emphasized leveraging high-resolution cellular data to better understand tumor heterogeneity and disease evolution, laying the foundation for more precise diagnostic and therapeutic strategies.

During his visit, Dr. Vundavilli delivered an invited talk titled "Integrating Multi-Modal Data Using Machine Learning for Advancing Personalized Medicine." In this presentation, he explained in a clear and accessible manner how combining different types of biological and clinical data can significantly improve disease understanding and support better clinical decision-making. He emphasized that relying on a single data type often provides an incomplete picture of complex diseases such as cancer, whereas integrating multiple data sources allows researchers and clinicians to capture disease heterogeneity more accurately and identify clinically meaningful patterns. In his talk, Dr. Vundavilli outlined two main research objectives. The first objective focused on developing a hybrid multi-omics machine learning framework that integrates RNA expression data, protein profiles, latent molecular factors, and clinical metadata to accurately classify different subtypes of hepatocellular carcinoma and identify reliable biomarkers that can guide personalized treatment strategies. The second objective aimed at creating a multi-omics workflow combining tissue RNA, plasma RNA, and plasma proteomics data to discover and validate blood-based biomarkers for the early detection and monitoring of disease progression in MASLD-related hepatocellular carcinoma. By presenting these objectives, he highlighted the translational potential of his work in moving from complex data analysis toward practical, non-invasive tools for precision medicine.

In addition to his research and seminar activities, Dr. Vundavilli engaged in extensive interactions with faculty members and graduate students across the institute, fostering scientific discussions and exploring potential future collaborations. These interactions facilitated the exchange of ideas, methodologies, and perspectives across disciplines, further strengthening the international partnership between the institutions. Overall, the visit proved to be highly productive and impactful, contributing significantly to ongoing collaborative research efforts while opening new avenues for future joint projects in cancer genomics and personalized medicine.

STUDENTS' CORNER

Quantum Memory Breakthrough

Subrat Panda– (24JE0177)

Introduction

For decades, the "Holy Grail" of quantum engineering has been the development of a quantum memory that is both highly efficient and noise-free. In classical electrical engineering, we often deal with the trade-off between gain and noise figure, amplifying a signal too much, and you inevitably amplify the noise floor. In the quantum realm, this problem is existential. To build a "Quantum Internet," we need to store fragile quantum states (photons) and retrieve them later. However, previous attempts faced a brutal bottleneck: increasing storage efficiency typically triggered nonlinear noise processes, specifically Four-Wave Mixing (FWM), which destroyed the fidelity of the quantum information.

That bottleneck has effectively been shattered. In a breakthrough paper published in *Physical Review Letters* in late 2025, a research team led by Professors Weiping

Zhang and Liqing Chen has demonstrated a new "intelligent spin-wave compaction" strategy. Their system achieves a memory efficiency of 94.6% while maintaining a fidelity of 98.91%, effectively realizing "near-perfect" quantum memory for broadband signals.

Breaking the Efficiency-Noise Trade-Off

The core of this development lies in a Rubidium-87 (^{87}Rb) vapor cell acting as the storage medium. In a typical Raman memory setup, an optical signal (the data) is mapped onto an atomic spin wave (the storage) using a strong control laser.
Historically, when engineers tried to capture broadband signals (high speed) with high efficiency, they had to increase the optical depth or control power. This, unfortunately, triggered FWM, generating "anti-Stokes" noise photons that mixed with the signal, degrading the Signal-to-Noise Ratio (SNR). Previous high-bandwidth memories often saw efficiencies drop to less than 1% to avoid this noise.
The researchers solved this by identifying a specific mathematical mapping between the light and the atoms: the Hankel Transform. They discovered that the "temporal" waveform of the input light maps directly to the "spatial" distribution of the spin wave inside the cell. If the spin wave is too long, it leaks out of the cell or generates noise. The solution, therefore, was to "compact" this spin wave into a perfect, localized shape inside the atomic vapor.

The Solution: AI-Driven Control

This is where the Electrical Engineering aspect becomes fascinating. You cannot simply "wish" the spin wave to be compact; you must shape the electromagnetic fields driving the interaction. The team employed an Intelligent Differential Evolution (DE) Algorithm—a feedback control loop driven by machine learning.

- **Input:** The system sends a Gaussian-shaped signal pulse (17 ns duration).
- **Processing:** The algorithm dynamically adjusts the temporal waveform of the "write" laser ($\Omega_w(t)$) via an Acousto-Optic Modulator (AOM).
- **Feedback:** It monitors the efficiency (η) and the noise ratio (ϵ) in real-time.

By iterating through different waveform shapes, the AI found an optimal control pulse that "compacted" the spin wave distribution. This ensured that almost all the optical energy was stored (high efficiency) and very little interaction length was left over for noise to generate (high fidelity).

Key Performance Metrics

The results, verified in late 2025, establish a new industry benchmark and demonstrate a significant advancement over existing approaches. Some key outcomes are:
Fidelity achieved an unconditional value of 98.91%, substantially exceeding the 66.7% "no-cloning limit" required to confirm genuine quantum operation.
and, noise suppression was reduced to just 0.026 photons per pulse, indicating exceptional control over unwanted signal interference.
Broadband capability was demonstrated with support for a 60 MHz bandwidth, confirming the system's ability to store high-speed signals rather than only slow, narrowband pulses.

The Quantum Internet

Why does this matter to us as future engineers? Because high-efficiency memory is the missing component for Quantum Repeaters. Just as classical optical fiber networks need repeaters to boost signals over long distances, a Quantum Internet needs repeaters to distribute entanglement. Without high-efficiency memory, the signal degrades exponentially. This new architecture opens the door for quantum networks spanning over 500 km, capable of securing Quantum Key Distribution (QKD) and distributed quantum computing. The researchers noted that while their current setup is limited to 60 MHz by the AOM bandwidth, the physical principle—the Hankel Transform mapping—is fundamentally bandwidth-unlimited. This suggests that terahertz-speed quantum memories could be engineered using this exact same control theory approach.

Conclusion

This research marks the transition of quantum memory from a "noisy experimental curiosity" to a high-fidelity component ready for system integration. By combining advanced physics (Hankel transforms) with modern control engineering (AI optimization), the team at Shanghai Jiao Tong University has provided the blueprint for the memory modules that will likely power the quantum networks of the 2030s.

Upcoming Major Events

IEEE International Conference on "Condition Assessment Techniques in Electrical Systems", "CATCON-2026" under IEEE Dielectrics and Electrical Insulation Society (DEIS) to be held during 18th – 20th December 2026.

Editorial Team