



R. C. PATEL
INSTITUTE OF TECHNOLOGY, SHIRPUR

An Autonomous Institute

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GRADE **A**

ELECTRA

Technical Magazine

**DEPARTMENT OF
ELECTRICAL ENGINEERING**

JUNE 2023 – MAY 2024

DEPARTMENT VISION, MISSION, PEOs & PSOs

VISION

To produce competent Electrical Engineers committed to innovation, sustainability, and service to society.

MISSION

M1: Deliver innovative, interactive learning fostering excellence in Electrical Engineering and emerging technologies.

M2: Cultivate scientific inquiry, ethical responsibility, and interdisciplinary collaboration to address energy, automation, and societal challenges.

M3: Empower diverse students with skills for employment, entrepreneurship, and research, nurturing professionalism and lifelong learning.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

PEO1: Graduates will apply electrical engineering knowledge and innovation to solve complex industrial and societal problems.

PEO2: Graduates will demonstrate ethical leadership and collaborate across disciplines to promote sustainable and inclusive development.

PEO3: Graduates will pursue careers in employment, entrepreneurship, or research, embracing professionalism and lifelong learning.

PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO1 : Power Systems: Analyze and design efficient power systems for generation, transmission, distribution, and smart grid integration.

PSO2 : Machines and Drives: Apply control techniques to electrical machines and drives for industrial, automotive, and renewable energy applications.

PSO3 : Automation and Emerging Tech: Develop intelligent automation using sensors, and IoT.

ABOUT THE DEPARTMENT

The Department of Electrical Engineering at R. C. Patel Institute of Technology (RCPIT), Shirpur was established in June 2012 under the umbrella of The Shirpur Education Society. In a relatively short span, the department has built a strong reputation for its academic excellence, placement success, and student-centric approach.

With a dedicated and experienced faculty team, the department offers specialized knowledge in areas such as Power Quality, Electrical Machines, Power Electronics, Electrical Drives, and Power Systems. The department follows a project-based learning approach, encouraging students to apply theoretical concepts in practical scenarios, thus ensuring they are well-prepared for industry and research.

Electrical Engineering, being a core branch, plays a vital role in the technological and economic growth of the country. The department's curriculum provides a deep foundation in control systems, power generation, high voltage engineering, electrical machines, and circuit analysis, with a strong emphasis on adaptability to emerging technologies.

DIRECTOR'S MESSAGE

I am honored to celebrate the publication of our Electrical Engineering Department's Technical Magazine. This remarkable initiative embodies the spirit of academic rigor, innovation, and collaboration that distinguishes our department. The thoughtfully curated sections—Student Corner, Faculty Corner, and Best Project Abstracts, Converges Glimpse and Hackathon Glipmes - offer a compelling window into the intellectual vitality and creative achievements that characterize our community. Every piece within these pages speaks to the dedication and inventiveness of our students and educators alike.

In an era of unprecedented technological advancement, platforms such as this hold exceptional importance. They cultivate analytical thinking, ignite creative problem-solving, and establish valuable channels for exchanging knowledge and ideas. This magazine transcends mere documentation of accomplishments; it serves as a catalyst for inspiration, encouraging readers to push boundaries and explore new frontiers.

My heartfelt gratitude goes to the editorial team, all contributors, and the faculty mentors whose commitment and insight have transformed this vision into reality. I am confident this publication will endure as an enduring symbol of academic distinction and a source of motivation for generations to come.



Dr. Jayantrao Patil

HOD'S MESSAGE

I am delighted to introduce the newest edition of our Electrical Engineering Department's Technical Magazine.

This publication represents far more than a compilation of scholarly work—it is a living reflection of our shared passion, ingenuity, and steadfast pursuit of excellence in both academic and technological domains.

The magazine's diverse sections—Student Corner, Faculty Corner, Best Project Abstracts, Converges Glimpse, and Hackathon Glimpse—paint a dynamic portrait of our department's character. Each segment highlights the curiosity, innovation, and teamwork that set us apart as a thriving community of thinkers and doers.

In today's landscape of accelerating technological change, the exchange of

knowledge and commitment to lifelong learning have never been more essential. This magazine serves as an invaluable forum where students and faculty alike can share perspectives, showcase their skills, and honor their achievements. Every contribution, from thought-provoking technical pieces to distinguished project summaries, exemplifies the rigor and forward-thinking ethos at the heart of our academic identity.

My sincere appreciation extends to everyone who made this publication possible—our talented students, dedicated faculty, and tireless editorial team. Your collective effort not only elevates our department but also motivates others to pursue their highest potential.

As we look ahead, let us maintain our momentum of innovation, collaboration, and mutual encouragement. I trust this magazine will ignite fresh thinking and nurture a spirit of intellectual exploration that extends well beyond our immediate community.



Dr. Shailaja Patil

MESSAGE BY EDITORIAL BOARD MEMBERS

We are thrilled to share this edition of the Electrical Engineering Department's Technical Magazine—a publication dedicated to showcasing the ingenuity, scholarly achievement, and creative spirit flourishing within our department. This magazine brings together a rich tapestry of insights through the Student Corner, Faculty Corner, and Best Project Abstracts. Each contribution captures the energetic and progressive atmosphere that characterizes the Electrical Engineering Department at RCPIT, Shirpur.

Serving on the editorial board and assembling the work, discoveries, and achievements of our talented students and faculty has been an immensely fulfilling journey. We see this publication not merely as a repository of information, but as a springboard for imagination—one that motivates readers to explore new horizons and challenge conventional thinking.

Our sincere appreciation goes to all who have contributed their time, expertise, and encouragement to make this initiative possible. We hope this magazine becomes a resonant platform for ideas and a tribute to the spirit of excellence that binds our community together.

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INDEX

S.No.	Title	Page No.
1.	Faculty Articles	1-10
2.	Student Articles	11-22
3.	Best Project Abstract	23-27
4.	Converges Glimpse	28-29
5.	Hackathon Glimpse	30





FACULTY ARTICLES

High Voltage Direct Current (HVDC) Transmission Systems - The Backbone of Future Power Networks



Sachin Yashawant Sayais

Assistant Professor - EE

The evolution of electrical power transmission has reached a critical milestone with the widespread adoption of High Voltage Direct Current (HVDC) technology. Between late 2023 and early 2024, several major HVDC projects came online globally, demonstrating the superiority of this technology for long-distance power transmission and interconnection of asynchronous grids.

HVDC systems convert alternating current (AC) to direct current (DC) for transmission, then back to AC for distribution. This process, while requiring sophisticated converter stations, offers significant advantages over traditional AC transmission. The primary benefit is reduced power loss over long distances. While AC transmission suffers from reactive power losses and skin effect, DC transmission maintains constant voltage and current, resulting in losses as low as 3% per 1000 kilometers compared to 6-7% for AC systems.

Recent developments in voltage source converter (VSC) technology have revolutionized HVDC applications. Unlike conventional line-commutated converters (LCC), VSC-HVDC systems use insulated gate bipolar transistors (IGBTs) that provide independent control of active and reactive power. This capability enables black start capability, meaning the system can energize a dead network without external power sources.

The India-UAE subsea HVDC link project, announced in 2023, exemplifies the technology's potential. Spanning approximately 2000 kilometers, this ambitious project will transmit solar power from Indian deserts to Middle Eastern consumers. The system will employ 800 kV DC transmission, reducing the number of conductor pairs needed and minimizing environmental impact.

Another significant advancement is the development of hybrid HVDC breakers. Traditional DC circuit breakers face the challenge that DC current has no natural zero crossing point, making interruption difficult. Modern hybrid breakers combine mechanical switches with power electronic components to create artificial zero crossings, enabling fault current interruption within 2 milliseconds. This breakthrough has made multi-terminal HVDC grids practically feasible.

Environmental considerations strongly favor HVDC deployment. A bipolar HVDC line requires only two conductors compared to three for AC transmission at equivalent power levels. This translates to narrower right-of-way requirements, reduced visual impact, and lower construction costs. For submarine or underground cables, HVDC eliminates capacitive charging currents that limit AC cable length to approximately 50 kilometers.

The integration of offshore wind farms represents another compelling HVDC application. Wind farms located hundreds of kilometers from shore generate AC power that must be transmitted to mainland grids. Converting to HVDC at the offshore platform enables efficient transmission without intermediate substations. Several European projects implemented this approach in 2023, with individual farms transmitting over 1000 MW through single HVDC cables.

Challenges remain in HVDC technology deployment. Converter stations represent significant capital investments, typically justified only for transmission distances exceeding 600 kilometers for overhead lines or 50 kilometers for cables. Harmonics generated by converter operation require sophisticated filtering systems. Protection and control systems must respond to DC faults faster than AC equivalents, demanding advanced monitoring and computational capabilities.

The future of HVDC technology appears promising. Research focuses on increasing voltage levels to 1100 kV and beyond, further improving efficiency. Solid-state transformer integration may eliminate the need for separate converter stations. As renewable energy sources proliferate in remote locations, HVDC will become increasingly essential for connecting generation to load centers, making it a cornerstone technology for sustainable electrical infrastructure.

Perovskite Solar Cells – Breaking Efficiency Barriers



Krunalkumar Gandhi

Assistant Professor – EE

The photovoltaic industry witnessed remarkable progress in 2023 with perovskite solar cells achieving unprecedented efficiency levels. These third-generation solar cells have emerged as serious contenders to traditional silicon technology, offering the potential to revolutionize solar energy conversion through their unique material properties and manufacturing advantages.

Perovskite materials are crystalline structures with the general formula ABX_3 , where A and B are cations and X is an anion. In photovoltaic applications, typical compositions include methylammonium lead iodide or formamidinium lead iodide. The term perovskite refers to the crystal structure, named after Russian mineralogist Lev Perovski, rather than a specific chemical composition. This structural flexibility allows researchers to tune optical and electronic properties by substituting different elements.

The physics behind perovskite solar cells explains their exceptional performance. These materials exhibit direct bandgaps between 1.5 and 2.3 electron volts, ideal for absorbing visible light spectrum. Unlike silicon, which has an indirect bandgap requiring thicker layers for adequate absorption, perovskites achieve similar absorption in layers just 300–500 nanometers thick. This dramatic thickness reduction translates to lower material costs and faster manufacturing processes.

In November 2023, researchers at King Abdullah University announced a certified efficiency of 33.7% for a perovskite-silicon tandem cell. This achievement surpassed the theoretical Shockley-Queisser limit of 33.7% for single-junction cells. Tandem architecture stacks a perovskite top cell that absorbs high-energy photons above a silicon bottom cell that captures lower-energy photons, extracting more energy from the solar spectrum than either material alone.

The manufacturing process for perovskite cells offers significant advantages over silicon. Solution processing techniques, including spin coating, slot-die coating, and inkjet printing, enable room-temperature fabrication on flexible substrates. This contrasts sharply with silicon cell production, which requires energy-intensive processes at temperatures exceeding 1000 degrees Celsius. Roll-to-roll manufacturing demonstrated in 2024 showed potential for producing perovskite modules at one-tenth the cost of silicon equivalents.

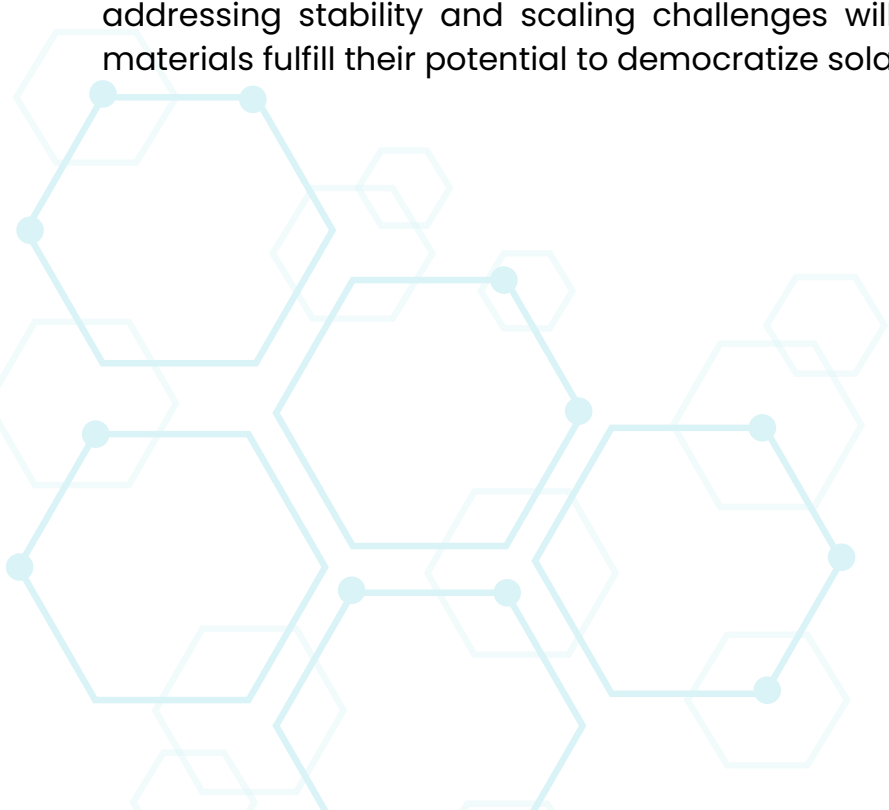
However, stability challenges have historically hindered commercial deployment. Perovskite materials degrade when exposed to moisture, oxygen, ultraviolet radiation, and elevated temperatures. Degradation mechanisms include ion migration within the crystal structure, phase transitions, and chemical reactions with atmospheric components. Unencapsulated perovskite cells might lose 50% efficiency within hours of air exposure.

Recent breakthroughs addressed these stability concerns. Researchers developed passivation strategies using organic molecules that bind to crystal surface defects, preventing moisture ingress and reducing non-radiative recombination. Encapsulation techniques borrowed from organic LED manufacturing created hermetic barriers protecting cells from environmental factors. Some formulations achieved operational lifetimes exceeding 5000 hours under accelerated aging conditions, equivalent to 20-25 years of outdoor operation.

Lead toxicity presents another challenge for commercialization. Although perovskite cells contain small amounts of lead (approximately 1 gram per square meter), comparable to traditional CRT televisions, environmental regulations in some jurisdictions restrict lead-containing products. Research into lead-free alternatives using tin, germanium, or bismuth showed promise, though efficiency and stability remained below lead-based counterparts as of early 2024.

The commercial landscape for perovskite technology evolved rapidly in 2023. Multiple startups announced pilot production lines for building-integrated photovoltaics, targeting applications where flexibility and lightweight properties provide advantages over rigid silicon panels. Tandem cell manufacturers partnered with established silicon producers to retrofit existing facilities, potentially accelerating market entry.

Looking forward, perovskite solar cells may dominate portable electronics, building-integrated applications, and eventually utility-scale generation. Continued research addressing stability and scaling challenges will determine whether these promising materials fulfill their potential to democratize solar energy access worldwide.



Superconducting Magnetic Energy Storage (SMES) – Power Quality Enhancement



Yogesh Kalidas Kirange

Assistant Professor – EE

Electrical power systems increasingly demand rapid-response energy storage solutions capable of maintaining grid stability amid growing renewable energy penetration. Superconducting Magnetic Energy Storage (SMES) systems have emerged as a promising technology offering instantaneous power delivery and exceptional cycling capability, addressing critical needs in modern power networks.

SMES systems store electrical energy in the magnetic field created by direct current flowing through a superconducting coil. When certain materials are cooled below their critical temperature (typically around 4-10 Kelvin for conventional superconductors), electrical resistance vanishes completely. Current established in a superconducting loop continues flowing indefinitely without energy loss, maintaining the magnetic field and stored energy.

The fundamental energy storage equation for SMES is $E = 0.5 \times L \times I^2$, where E represents stored energy, L is coil inductance, and I is current magnitude. Practical systems achieve energy densities of 2-7 kilojoules per kilogram, lower than batteries but with power densities exceeding 10,000 watts per kilogram. This characteristic makes SMES ideal for applications requiring brief, intense power pulses rather than long-duration energy supply.

A typical SMES system comprises four main components: the superconducting coil, cryogenic refrigeration system, power conditioning unit, and control system. The coil, usually wound from niobium-titanium or niobium-tin wire, operates immersed in liquid helium at 4.2 Kelvin. Modern systems increasingly employ closed-cycle cryocoolers instead of liquid cryogen, reducing operational complexity and eliminating helium replenishment requirements.

Power conditioning units convert DC stored in the coil to AC grid frequency through voltage source converters. These converters employ IGBT-based topology enabling four-quadrant operation, meaning the system can rapidly switch between charging, discharging, and reactive power modes. Response times under 10 milliseconds enable SMES to address voltage sags, frequency deviations, and other transient disturbances before conventional generators can respond.

Several utility-scale SMES installations demonstrated practical benefits in 2023. A 10 MW system deployed in South Korea provided frequency regulation services, responding to grid frequency deviations within 4 milliseconds compared to 10–15 seconds for conventional generators. The system cycled over 10,000 times during its first year without performance degradation, demonstrating the technology's exceptional durability.

Manufacturing techniques significantly impact SMES performance and cost. Solenoid coils represent the simplest geometry but generate large external magnetic fields requiring heavy shielding. Toroidal configurations confine magnetic flux within the coil structure, eliminating external fields and reducing shielding requirements. Recent designs employ force-balanced coils where internal mechanical forces largely cancel, minimizing structural support requirements.

High-temperature superconductors (HTS) operating above 77 Kelvin using liquid nitrogen cooling offer compelling advantages over conventional superconductors. Yttrium barium copper oxide (YBCO) and bismuth strontium calcium copper oxide (BSCCO) materials enable operation at temperatures achievable with mechanical refrigeration, eliminating liquid helium dependency. Several manufacturers demonstrated HTS-SMES prototypes in 2023, though material costs remained significantly higher than conventional alternatives.

Economic analysis reveals SMES occupies a specific niche in energy storage applications. Capital costs typically range from 300–500 per kilowatt-hour, substantially higher than batteries at \$150–300 per kilowatt-hour. However, when evaluated on power capacity ($\$/kW$) rather than energy capacity ($\$/kWh$), SMES becomes competitive for applications requiring rapid response and high cycling rates. Operational costs prove minimal, with efficiency exceeding 95% and virtually no degradation over millions of cycles.

Applications extend beyond grid stabilization. SMES systems protect sensitive loads like semiconductor fabrication facilities from momentary power quality disturbances. Electromagnetic launchers and pulsed power systems utilize SMES to accumulate energy slowly then release it rapidly. Research facilities employ SMES to power particle accelerators and fusion experiments requiring precise, repeatable power pulses.

Future developments focus on increasing energy capacity while reducing costs. Hybrid systems combining SMES with batteries or flywheels aim to leverage the complementary characteristics of different storage technologies. Advanced materials research pursues room-temperature superconductors that would eliminate refrigeration requirements entirely, though practical implementation remains years away.

Silicon Carbide (SiC) Power Devices – Transforming Power Electronics



Dr. Shailaja Arjun Patil

Professor - EE

The power electronics industry experienced a fundamental shift during 2023 as silicon carbide (SiC) semiconductor devices transitioned from niche applications to mainstream adoption. This wide-bandgap material offers superior electrical and thermal properties compared to traditional silicon, enabling more efficient, compact, and capable power conversion systems across numerous applications.

Silicon carbide is a compound semiconductor formed from silicon and carbon atoms arranged in a crystalline structure. Unlike silicon with a bandgap of 1.1 electron volts, SiC exhibits a bandgap of 3.2 electron volts. This wider bandgap translates to several critical advantages: breakdown electric field ten times higher (3 MV/cm vs 0.3 MV/cm), thermal conductivity three times greater, and stable operation at temperatures exceeding 200 degrees Celsius where silicon devices would fail catastrophically.

The physics underlying SiC advantages explains the performance improvements observed in practical devices. Higher breakdown field strength allows thinner drift regions in power devices, reducing on-state resistance proportionally. For a 1200-volt rated device, a SiC MOSFET requires a drift layer just 10 micrometers thick compared to 100 micrometers for silicon, reducing conduction losses by an order of magnitude. Combined with faster switching speeds enabled by superior electron mobility, SiC devices achieve efficiency improvements of 2-3% in typical converter applications.

Manufacturing SiC devices presents unique challenges compared to silicon processing. Growing large, defect-free SiC crystals requires temperatures exceeding 2000 degrees Celsius under controlled atmospheric conditions. Physical vapor transport (PVT) method, the dominant growth technique, slowly sublimates SiC powder onto a seed crystal over several days. Despite five decades of development, commercially available SiC wafers remain limited to 200 millimeter diameter compared to 300 millimeter silicon wafers, contributing to higher device costs.

Industry adoption accelerated dramatically in 2023. Major automotive manufacturers announced complete transition to SiC inverters for electric vehicle powertrains.

Tesla expanded SiC usage across its entire model range, achieving 8-10% efficiency improvements that translated to 30-40 kilometers of additional driving range. Traditional automakers including General Motors, Volkswagen, and Hyundai committed to SiC technology for vehicles launching in 2024-2025, creating unprecedented demand for manufacturing capacity.

Power supply applications similarly embraced SiC technology. Server power supplies incorporating SiC rectifiers and switches demonstrated 96-98% efficiency compared to 92-94% for silicon equivalents. This 3-4% improvement sounds modest but carries enormous significance for data centers consuming terawatt-hours annually. Reduced losses translated to lower cooling requirements, enabling higher power density designs that save valuable rack space and reduce infrastructure costs.

Thermal management advantages proved equally important as electrical performance. Silicon power devices typically require operation below 125-150 degrees Celsius junction temperature, necessitating substantial heatsinks that dominate converter size and weight. SiC devices reliably operate at 175-200 degrees Celsius junction temperatures, reducing cooling requirements by 30-40%. Some automotive inverters eliminated liquid cooling entirely, using only compact air-cooled heatsinks to manage thermal loads.

Reliability concerns initially limited SiC adoption but extensive testing through 2023 validated long-term durability. Early devices exhibited gate oxide instability under high temperature bias conditions, potentially shifting threshold voltage over time. Manufacturers implemented improved oxidation processes and screening procedures that essentially eliminated these issues. Automotive qualification testing including 3000-hour operation at maximum rated conditions demonstrated reliability equivalent to or exceeding silicon devices.

Economic factors increasingly favor SiC deployment despite higher upfront costs. While SiC MOSFETs cost 3-5 times more than comparable silicon IGBTs in 2023, system-level analysis revealed compelling value propositions. Reduced passive components (smaller inductors, capacitors, and heatsinks) offset device costs. Improved efficiency reduced operational expenses. Higher power density enabled smaller, lighter products. For many applications, total cost of ownership favored SiC solutions even before considering performance advantages.

The supply chain evolved rapidly to meet demand. Major semiconductor foundries expanded SiC fabrication capacity by 300-400% between 2022 and 2024. New crystal growth facilities came online, though wafer supply remained constrained relative to demand. Automotive manufacturers negotiated long-term supply agreements, in some cases investing directly in manufacturers to secure production allocation.

Looking ahead, SiC technology will likely dominate power electronics in voltage ranges from 650 volts to 3300 volts. Research focuses on reducing defect density, increasing wafer size to 200 millimeters and beyond, and developing novel device structures. As manufacturing scales and costs decline, SiC will enable more efficient electrical infrastructure from renewable generation through transmission to end-use applications.



Nadeem Akhtar

Assistant Professor - EE

The intersection of neuroscience and electrical engineering has spawned a revolutionary computing paradigm called neuromorphic engineering. This approach mimics biological neural networks using analog and mixed-signal circuits, offering potentially dramatic improvements in energy efficiency for specific computational tasks. Throughout 2023 and early 2024, neuromorphic systems transitioned from research curiosities to practical implementations addressing real-world problems.

Biological neurons communicate through electrochemical signals, integrating inputs from thousands of synaptic connections and generating output spikes when accumulated charge exceeds a threshold. This analog, event-driven operation contrasts sharply with digital computers executing synchronous, deterministic instructions. A human brain containing approximately 86 billion neurons consumes merely 20 watts while performing complex cognitive tasks that challenge the most powerful supercomputers consuming megawatts.

Neuromorphic circuits implement similar principles using transistors in subthreshold operation, where drain current depends exponentially on gate voltage. This operating regime enables individual transistors to model ion channel dynamics while consuming nanoamperes of current. A single silicon neuron circuit might contain 10-20 transistors operating in subthreshold mode, generating action potentials in response to integrated synaptic inputs while consuming nanowatts of power.

Silicon synapses store connection weights as analog voltages on capacitors or floating gates. These weights modulate the amplitude of signals transmitted between neurons. Learning occurs through synaptic weight modification guided by spike-timing-dependent plasticity (STDP) rules observed in biological systems. When a presynaptic spike precedes a postsynaptic spike by a few milliseconds, the synaptic weight increases; reversed timing decreases the weight. This local learning rule enables networks to self-organize without centralized control.

Intel's Loihi 2 processor, released in late 2022 and widely deployed in 2023, exemplifies commercial neuromorphic technology. This chip contains 1 million silicon neurons and 120 million programmable synapses fabricated in a 4-nanometer process. Operating at 2 watts, Loihi 2 achieves computational efficiency of 1 trillion synaptic operations per watt, roughly 1000 times more efficient than GPUs for sparse, event-driven workloads.

Applications leveraging neuromorphic advantages emerged across diverse domains. Gesture recognition systems processed camera inputs directly with neuromorphic vision sensors that output pixel-level brightness changes rather than complete frames. This event-driven approach reduced data volume by 90–99% while responding to movements within single-millisecond latency. Manufacturing inspection systems detected product defects in real-time using neuromorphic processors consuming watts rather than kilowatts.

Neuromorphic auditory processing demonstrated particular promise. Cochlear-inspired analog circuits extracted acoustic features with microsecond temporal resolution and sub-milliwatt power consumption. Keyword spotting systems deployed in battery-powered devices achieved always-on operation lasting months on coin cell batteries, impossible with conventional digital signal processors. These systems operated entirely locally, addressing privacy concerns by avoiding cloud-based processing.

The design methodology for neuromorphic systems differs fundamentally from traditional circuit design. Rather than specifying exact transfer functions, designers establish constraints allowing circuits to self-configure through learning. Network topology, connectivity patterns, and plasticity rules define system behavior more than precise parameter values. This approach tolerates device variations and embraces analog circuit characteristics traditionally considered problematic.

Challenges remain in neuromorphic engineering adoption. Lack of standardized programming models hinders application development. Each neuromorphic platform uses proprietary frameworks requiring specialized expertise. Theoretical understanding of why certain network architectures and learning rules work remains incomplete, making systematic design difficult. Analog circuits suffer from device mismatch and temperature sensitivity, requiring careful layout and calibration.

Hybrid approaches combining neuromorphic and conventional processing showed particular promise in 2024. Systems used neuromorphic front-ends for efficient sensor processing while employing digital processors for tasks requiring precise arithmetic. This partitioning leveraged strengths of each paradigm. Automotive perception systems employed neuromorphic vision sensors reducing data bandwidth by 10–100x before conventional processors performed semantic segmentation and decision making.

Research directions for neuromorphic engineering include developing memristor-based synapses offering non-volatile weight storage, investigating three-dimensional integration to increase connectivity, and exploring optical implementations for high-bandwidth inter-neuron communication. Theoretical work aims to establish formal design methodologies translating application requirements into network architectures. As edge computing demands escalate and battery life becomes increasingly critical, neuromorphic approaches offer compelling advantages for specific applications. While unlikely to replace conventional processors for general computation, neuromorphic circuits will find growing adoption where real-time processing, energy efficiency, and adaptive behavior provide value.



STUDENT'S ARTICLES

Energy Harvesting from Ambient Sources – Powering IoT Devices



Shweta Salunkhe

B. Tech EE IV-Year

The expansion of Internet of Things (IoT) devices has created a pressing need for sustainable power solutions. Energy harvesting technology, which captures and converts ambient energy into electrical power, emerged as a practical solution during 2023. This approach eliminates battery replacement in remote sensors and wearable devices, enabling truly autonomous operation.

Energy harvesting extracts usable electricity from environmental sources including light, heat, vibration, and radio frequency radiation. While individual sources provide modest power levels typically measured in microwatts to milliwatts, modern ultra-low-power electronics can operate on these levels for many applications. A sensor node consuming 50 microwatts continuous power needs merely 1.2 milliwatt-hours daily, achievable through small solar cells or vibration harvesters.

Photovoltaic energy harvesting represents the most mature and widely deployed approach. Small solar cells generating 10-100 milliwatts from indoor lighting can power sensors, displays, and wireless transmitters. Unlike outdoor solar requiring direct sunlight, indoor photovoltaics operate under artificial lighting conditions providing 100-500 lux illumination. Modern indoor solar cells achieve 20-30% efficiency converting fluorescent or LED lighting to electricity, sufficient for many applications.

Thermoelectric generators (TEGs) harvest energy from temperature differences using the Seebeck effect. When two dissimilar conductors experience a temperature gradient, voltage develops proportional to the difference. Wearable devices leverage body heat against ambient air temperature, typically a 5-10 degree gradient generating 10-100 microwatts per square centimeter. Industrial applications harvest waste heat from machinery or pipes, capturing energy otherwise dissipated uselessly.

Piezoelectric harvesting converts mechanical vibration or strain into electricity. Piezoelectric materials like lead zirconate titanate (PZT) generate charge when

mechanically stressed. Floor tiles in high-traffic areas convert footsteps to electricity, potentially generating 2-10 watts per footstep. Bridge monitoring sensors harvest vibration energy from vehicle traffic. Wearable devices extract energy from body motion during walking or exercise.

Electromagnetic harvesting uses moving magnets near coils to induce current through Faraday's law. This approach suits applications with regular motion like rotating machinery or oscillating structures. Small generators attached to rotating parts harvest several milliwatts from machinery vibration. Kinetic watch movements use similar principles, generating microwatts from wrist motion throughout the day.

Radio frequency (RF) harvesting captures ambient radio waves from cellular towers, WiFi routers, and broadcast transmitters. Specialized antennas tuned to specific frequencies rectify received signals to DC voltage. While power levels are tiny (measured in microwatts), they provide continuous availability regardless of environmental conditions. Some researchers demonstrated data transmission powered entirely by received RF energy from interrogating devices.

Power management electronics prove critical for practical energy harvesting systems. Ambient sources produce intermittent, variable power requiring storage and regulation for stable operation. Maximum power point tracking circuits optimize energy extraction from sources with varying output characteristics. Ultra-low quiescent current regulators enable efficient operation even when harvested power drops to microwatts. Energy storage elements like supercapacitors or thin-film batteries accumulate energy during abundance for use during scarcity.

Real-world deployments in 2023 demonstrated energy harvesting viability. Building automation sensors powered by indoor solar eliminated 10,000+ battery replacements annually in large commercial buildings. Industrial condition monitoring sensors operating in hazardous areas used thermoelectric generation from process heat, eliminating explosion-proof battery compartments and maintenance access requirements. Wildlife tracking collars harvested solar energy, extending operational lifetime from months to years while reducing animal capture frequency for battery replacement.

Challenges limiting broader adoption include power-hungry communications protocols, energy storage limitations, and variable ambient conditions. Wireless transmission consumes orders of magnitude more power than sensing or processing, requiring careful protocol optimization or duty cycling. Energy storage components add size, weight, and cost while introducing potential failure modes. Ambient source availability varies unpredictably, requiring systems to tolerate extended periods without harvested energy.

Future research directions include developing more efficient transducers, improving energy storage, and designing adaptive systems that match operation to available energy. Hybrid approaches combining multiple harvesting methods may provide more consistent power than single sources.



Aryan Jadhav

B. Tech EE IV-Year

Electric arc furnaces (EAF) represent one of the most power-intensive industrial processes, consuming up to 500 megawatts during operation while presenting significant electrical engineering challenges. These furnaces use high-current electric arcs to melt scrap metal for steel production. Understanding EAF operation and associated power system impacts became increasingly important in 2023 as steel manufacturing shifted toward electric processes for environmental reasons.

An EAF consists of a cylindrical steel shell lined with refractory material, a removable or tilting roof, and three large graphite electrodes extending through the roof. The electrodes, typically 500–700 millimeters in diameter and several meters long, connect to a high-power transformer supplying 50,000–100,000 amperes at 400–1000 volts. During operation, operators lower the electrodes near scrap metal charged in the furnace. When energized, electric arcs form between electrodes and metal, reaching temperatures of 3000–3500 degrees Celsius.

The electrical circuit forms a three-phase star configuration with arcs acting as variable resistances. Arc resistance is not constant but depends on arc length, current magnitude, and plasma composition. This nonlinear, time-varying behavior creates significant power quality challenges. Arc initiation requires high voltage to ionize the gap, but once conducting, arc voltage drops dramatically. The resulting negative dynamic resistance characteristic can trigger resonance with power system impedance.

Power consumption during EAF operation varies dramatically through the melting cycle. Initial boring-in consumes 80–120 MVA as long arcs penetrate and melt scrap. Mid-cycle flat bath operation uses 50–70 MVA with shorter, more stable arcs. Final refining may require only 20–30 MVA. Total cycle time ranges from 30–90 minutes depending on charge size and furnace capacity. This intermittent, high-magnitude load creates substantial challenges for supplying utilities.

Harmonics represent a major power quality concern with EAF operation. The nonlinear arc characteristics generate odd and even harmonic currents, with second through seventh harmonics typically dominating. Harmonic content varies throughout the melt cycle, ranging from 5–15% total harmonic distortion. These harmonics can overload

power factor correction capacitors, overheat transformers, and interfere with protective relays. Harmonic filters using tuned LC circuits or active power electronics mitigate these issues.

Voltage flicker presents another significant challenge. Rapid arc length variations cause corresponding voltage fluctuations at the point of common coupling. Large EAFs can create voltage variations of 1-3%, sufficient to cause noticeable light flicker for other utility customers. Severity depends on the ratio of system short circuit capacity to furnace power. Utilities require flicker assessment studies before approving new EAF installations or expansions.

Modern EAF installations employ sophisticated control systems managing multiple objectives simultaneously. Electrode regulators maintain optimal arc length by continuously adjusting electrode position, typically moving 10-50 times per second. These systems use multiple feedback signals including arc voltage, current, and sometimes acoustic or optical emissions. Advanced controllers employ artificial intelligence to learn optimal control strategies, reducing power consumption by 3-5% while improving productivity.

Power electronics play increasing roles in EAF applications. Series reactors once used to limit short circuit current are being replaced by thyristor-controlled reactors offering variable impedance. Some installations employ static VAR compensators (SVC) or static synchronous compensators (STATCOM) for reactive power control and flicker mitigation. These devices respond within single-cycle time frames, far faster than mechanical switchgear, providing superior power quality control.

Transformer design for EAF service differs significantly from standard distribution transformers. EAF transformers must withstand frequent overloads, harmonic heating, and mechanical stresses from short circuits. Designs emphasize robust mechanical construction, oversized cooling systems, and specialized insulation. Some installations use saturable reactors in the secondary circuit providing variable impedance without moving parts, though modern designs increasingly favor electronic solutions.

Energy efficiency improvements implemented in 2023 reduced EAF electrical consumption. Oxy-fuel burners supplement electrical heating during early melt stages, reducing arc-on time by 15-20%. Scrap preheating using off-gas heat recovery captures otherwise wasted energy. Optimal charging practices minimize voids in scrap piles, reducing parasitic arc losses. These measures combined decreased electrical consumption from 380-450 kWh per ton to 320-380 kWh per ton of steel produced.

Environmental drivers accelerated EAF adoption over traditional blast furnace steelmaking. EAF processes emit 75% less CO₂ than blast furnaces while consuming recycled scrap rather than virgin iron ore. Global EAF steel production capacity increased 12% in 2023, with several regions planning complete phase-out of blast furnaces by 2030-2035. This transition demands substantial electrical infrastructure investment to supply increased industrial loads while maintaining power quality for other consumers.

Future developments in EAF technology focus on increasing productivity, improving power quality, and reducing electrode consumption. Direct current (DC) arc furnaces using single electrodes eliminate some power quality issues inherent to three-phase AC designs. Integration with renewable energy sources and energy storage systems may enable demand response participation, shifting operation to off-peak periods or times of abundant renewable generation.

Phase-Locked Loops (PLL) in Modern Grid-Connected Inverters



Sunil Khatal

B. Tech EE IV-Year

Phase-locked loops (PLL) serve critical functions in grid-connected power electronic systems, enabling synchronization between inverters and utility grids. As renewable energy sources and distributed generation proliferated during 2023, understanding PLL operation and design became essential for electrical engineers. These control systems ensure stable, synchronized operation while handling grid disturbances and maintaining power quality.

A PLL is a feedback control system that generates an output signal whose phase is related to the phase of an input signal. In grid applications, PLLs detect grid voltage frequency and phase angle, providing reference signals for inverter control. This synchronization enables coordinated energy injection and proper reactive power control. Without accurate phase tracking, inverters would inject currents with arbitrary phase relationships, potentially damaging equipment or destabilizing the grid.

The basic PLL structure contains three essential blocks: phase detector, loop filter, and voltage-controlled oscillator (VCO). The phase detector compares input grid voltage with the VCO output, generating an error signal proportional to phase difference. The loop filter, typically a proportional-integral (PI) controller, processes this error signal to produce a control voltage. The VCO adjusts its output frequency based on control voltage, closing the feedback loop and driving phase error toward zero.

Synchronous reference frame PLLs (SRF-PLL) dominate grid applications due to superior performance compared to simpler approaches. SRF-PLL transforms three-phase grid voltages into a rotating reference frame aligned with voltage vectors. In this frame, balanced three-phase voltages appear as DC quantities, simplifying phase detection and filtering. The transformation uses Park's transformation, requiring the angle being estimated as input, creating an inherent feedback structure.

Mathematical analysis reveals PLL behavior. The closed-loop transfer function resembles a second-order system characterized by natural frequency and damping ratio. These parameters determine transient response speed and stability. Typical designs target damping ratios of 0.7-1.0, providing fast response without excessive overshoot. Natural frequency selection balances competing objectives: higher frequency improves disturbance rejection but increases sensitivity to grid harmonics and noise.

Grid disturbances significantly challenge PLL performance. Voltage sags, phase jumps, frequency deviations, and harmonics all affect phase detection accuracy. Unbalanced voltages create double-frequency oscillations in the synchronous reference frame, potentially causing phase angle errors. Modern PLL implementations incorporate additional filtering and compensation to handle these non-ideal conditions. Adaptive filters adjust bandwidth based on detected disturbances, reducing errors without sacrificing response speed during normal operation.

Weak grid conditions present particular challenges. In strong grids, short circuit capacity far exceeds inverter capacity, maintaining nearly constant voltage regardless of inverter operation. Weak grids with high impedance exhibit voltage variations due to inverter current injection. This creates coupling between PLL dynamics and inverter current control, potentially causing instability. Researchers developed specialized PLL designs with reduced bandwidth specifically for weak grid applications.

Implementation of PLLs in digital control systems requires careful consideration of sampling and computational delays. Discrete-time implementation introduces phase lag proportional to sampling frequency. For systems sampling at 10 kHz (typical for grid inverters), 100-microsecond delays significantly affect stability margins. Designers employ lead compensation or predictive algorithms to counteract these effects, maintaining stability while achieving fast response.

Advanced PLL variants address specific application challenges. Dual second-order generalized integrator (DSOGI-PLL) provides enhanced immunity to grid imbalances and harmonics. Multiple complex coefficient filters (MCCF-PLL) offer adjustable filtering characteristics. Adaptive notch filter PLLs specifically target dominant harmonic frequencies in polluted grid conditions. Selection among these variants depends on expected grid conditions and performance requirements.

Testing and validation of PLL implementations became increasingly important as grid codes evolved. Standards like IEEE 1547-2018 specify strict requirements for phase angle accuracy, frequency tracking range, and transient response. Inverters must remain synchronized during voltage sags down to 50% rated voltage and frequency excursions of plus or minus 3 Hz. Hardware-in-the-loop testing platforms simulate various grid conditions, validating PLL performance before field deployment.

Real-world installations in 2023 demonstrated the critical importance of robust PLL design. Several incidents of inverter instability traced back to inadequate PLL tuning

under weak grid conditions. Conversely, well-designed systems successfully handled severe grid disturbances including phase-to-ground faults and temporary overvoltages without disconnection. These experiences emphasized that PLL design requires careful analysis considering both normal operation and worst-case scenarios. Future PLL research focuses on improving performance in extremely weak grids where renewable generation capacity approaches or exceeds local load. Traditional PLLs may fail completely when grid strength falls below critical thresholds. New approaches incorporating grid strength estimation and adaptive bandwidth adjustment show promise for maintaining synchronization even in challenging conditions. Machine learning techniques are being explored to optimize PLL parameters based on real-time grid condition assessment.

Understanding PLL technology is essential for engineers working with grid-connected power electronics. As electrical grids incorporate increasing amounts of converter-interfaced generation, the collective behavior of millions of PLLs affects overall system stability. Proper design, implementation, and testing of these critical control functions will enable reliable integration of renewable energy while maintaining grid reliability and power quality.

Light Detection and Ranging (LiDAR) Systems – Electrical Engineering Perspective



Patil Pranjal

B. Tech EE III-Year

Light Detection and Ranging (LiDAR) technology has revolutionized autonomous vehicles, robotics, and mapping applications. From an electrical engineering viewpoint, LiDAR systems integrate optical components, high-speed electronics, and sophisticated signal processing. Advances in semiconductor lasers, photodetectors, and processing capabilities during 2023 enabled more capable and affordable systems, accelerating adoption across multiple industries.

LiDAR operates by emitting laser pulses and measuring the time-of-flight (TOF) for reflected light to return. Since light travels at a known constant speed (approximately 300,000 kilometers per second), measuring time delays with nanosecond precision enables distance calculation. A 1-nanosecond timing resolution corresponds to 15-centimeter range resolution, adequate for most applications. Achieving this precision requires careful electrical design of laser drivers, timing circuits, and detection systems.

The laser source represents a critical component determining system performance. Most automotive LiDAR systems employ near-infrared lasers at 850, 905, or 1550 nanometer wavelengths. These wavelengths offer good atmospheric transmission while remaining invisible to human eyes. Laser diodes at 905 nanometers dominate automotive applications due to mature silicon detector technology and lower cost. However, 1550-nanometer fiber lasers enable higher power levels since eye-safety limits are more relaxed at this wavelength.

Pulse generation electronics must create extremely short, high-power optical pulses. Typical pulses last 3-10 nanoseconds with peak powers of 30-100 watts. This requires fast laser driver circuits capable of delivering 5-20 ampere pulses with rise and fall times under 2 nanoseconds. High-speed GaAs or SiGe transistors switching at hundreds of megahertz drive laser diodes through impedance-matched transmission lines. Careful PCB layout minimizes parasitic inductance and capacitance that would slow pulse edges.

Photodetectors convert returned optical signals to electrical currents for processing. Avalanche photodiodes (APD) provide internal gain through avalanche multiplication, amplifying weak optical signals without external amplifiers. Silicon APDs offer gains of 10-100 with low noise, detecting single photons under ideal conditions. However, APD gain varies with temperature and bias voltage, requiring compensation circuits. Single-photon avalanche diodes (SPADs) operating in Geiger mode provide ultimate sensitivity but require complex quenching and timing circuits.

Timing measurement methods determine range accuracy. Early systems used analog approaches measuring pulse time-of-flight directly with high-speed comparators and time-to-digital converters. Modern designs increasingly employ digital signal processing, sampling detector output at multi-gigahertz rates and using correlation techniques to determine echo timing. This approach improves noise immunity and enables simultaneous detection of multiple echoes from semi-transparent objects.

Scanning mechanisms create two-dimensional or three-dimensional point clouds by directing laser beams across the field of view. Mechanical systems use rotating mirrors or entire sensor assemblies, achieving 360-degree coverage at 5-20 rotations per second. MEMS mirrors provide solid-state scanning over limited fields of view, typically 30-120 degrees horizontal by 10-30 degrees vertical. Optical phased arrays, analogous to radar phased arrays, enable electronic beam steering without moving parts, though practical implementations remained limited in 2023.

Signal processing extracts useful information from raw detector outputs. Real-time processing identifies valid echoes while rejecting noise from sunlight, other LiDAR systems, or electronic interference. Algorithms cluster detected points into objects, classify object types, and track motion over time. High-end automotive systems process over 1 million points per second, requiring specialized processors or FPGAs. Some manufacturers developed custom ASICs integrating timing, processing, and control functions in single chips.

Interference between multiple LiDAR systems operating simultaneously emerged as a practical concern in 2023. As vehicle density increased, the probability of receiving pulses from nearby vehicles' LiDAR systems increased proportionally. Mitigation strategies include randomizing pulse timing, using orthogonal codes similar to CDMA cellular systems, and detecting interference through pattern recognition. Standards organizations began developing protocols for cooperative interference avoidance.

Power consumption and thermal management constrain automotive LiDAR design. Continuous operation at 20–30 watts in confined spaces without active cooling requires careful thermal design. Pulsed laser operation reduces average power compared to peak power, but still generates significant heat. Efficient laser drivers minimizing switching losses and optimized processing that disables unused circuits help reduce power consumption.

Cost reduction remained a primary focus for automotive manufacturers. Early LiDAR systems cost \$10,000–75,000, prohibitive for mass-market vehicles. Technology improvements reduced costs to \$500–1000 for automotive-grade systems by late 2023. Further reductions require integration of discrete optical and electronic components into monolithic or hybrid assemblies manufacturable with semiconductor processes. Several companies demonstrated prototype systems-on-chip integrating lasers, detectors, and processing in single packages.

Reliability and environmental robustness present ongoing challenges. Automotive systems must operate from minus 40 to plus 85 degrees Celsius, survive mechanical shocks and vibrations, and maintain performance despite contamination on optical surfaces. Hermetic packaging protects sensitive components while optical coatings resist scratching and degradation. Continuous self-monitoring detects component degradation before performance falls outside specifications.

Applications beyond automotive expanded in 2023. Industrial robots used LiDAR for navigation and obstacle avoidance in warehouses and factories. Surveying systems captured detailed 3D building models for construction and renovation. Agriculture deployments mapped crop height and density for precision farming. Security systems detected intrusions across perimeters. As costs decline and capabilities improve, LiDAR technology will enable new applications across diverse fields.

Battery Management Systems (BMS) – Ensuring Safe Energy Storage



Pratiksha Patil

B. Tech EE IV-Year

Battery Management Systems (BMS) serve as the critical electronic intelligence protecting lithium-ion battery packs while optimizing performance and longevity. These systems monitor cell voltages, temperatures, and currents, implementing control algorithms that prevent damage while maximizing usable capacity. As electric vehicles and grid storage deployments accelerated through 2023, BMS technology evolved to handle larger packs with improved accuracy and functionality.

Lithium-ion batteries offer high energy density but require careful management to prevent safety hazards. Overcharging individual cells can trigger thermal runaway, a self-accelerating reaction potentially leading to fire or explosion. Deep discharge damages electrode materials, permanently reducing capacity. Operating outside specified temperature ranges accelerates aging. The BMS continuously monitors all parameters, intervening when conditions approach dangerous thresholds.

A typical BMS architecture contains three hierarchical levels: cell monitoring units, pack controllers, and system supervisors. Cell monitoring units measure voltage for each cell or parallel group, typically 8-16 cells per unit. These specialized integrated circuits include high-resolution analog-to-digital converters achieving millivolt accuracy despite common-mode voltages of hundreds of volts. Daisy-chained communication links report measurements to pack controllers while consuming minimal quiescent current.

Temperature monitoring provides essential data for thermal management and safety. NTC thermistors placed strategically throughout the pack detect local hot spots before they spread. BMS processors compare temperatures against limits, reducing charge/discharge current or activating cooling systems when necessary. Advanced thermal models predict temperature evolution based on current profiles, enabling proactive cooling system control that maintains optimal operating temperature ranges.

Current measurement enables state-of-charge estimation and power capability prediction. Hall-effect sensors or shunt resistors measure pack current with accuracy

typically better than 0.5%. High-side shunt configurations avoid common-mode voltage complications but require isolated measurement circuits. Low-side shunts simplify electronics but compromise safety since shunt failures could create unprotected current paths.

State-of-charge (SOC) estimation combines coulomb counting with open-circuit voltage measurements and impedance models. Coulomb counting integrates current over time, tracking charge flow into and out of the battery. Errors accumulate from measurement inaccuracy and unmodeled losses, requiring periodic calibration. Extended Kalman filters or equivalent observers fuse multiple information sources, achieving SOC estimation accuracy within 2-5% despite uncertainties.

Cell balancing addresses capacity mismatches between cells in series strings. Manufacturing variations, temperature gradients, and aging cause cells to reach voltage limits at different SOC levels. Without balancing, the weakest cell limits string capacity. Passive balancing dissipates excess charge through resistors, simple but wasteful. Active balancing transfers charge between cells using DC-DC converters, improving efficiency but adding cost and complexity. Most automotive applications employ passive balancing with 50-200 milliampere balancing currents.

Safety functions represent the most critical BMS responsibility. Contactors controlled by the BMS disconnect battery from load during faults or emergency conditions. Multilayer safety architecture implements independent monitoring with diverse hardware and software. Watchdog timers detect processor failures. Voltage and current limits employ both software checks and hardware comparators that trigger disconnection without processor involvement. This redundancy ensures safe shutdown even when primary control fails.

Communication interfaces connect BMS to vehicle controllers or grid control systems. CAN bus protocols dominate automotive applications, transmitting SOC, available power, and status information at 10-100 millisecond intervals. Wireless interfaces using Bluetooth or WiFi enable diagnostic access and over-the-air updates. Functional safety standards like ISO 26262 define requirements for communication integrity and fault detection.

Diagnostic capabilities have expanded significantly. Modern BMS store detailed histories of operating conditions, enabling analysis of degradation mechanisms. Impedance spectroscopy measurements characterize cell health without full charge-discharge cycles. Machine learning algorithms trained on extensive aging data predict remaining useful life with improving accuracy. Some systems adapt charging profiles based on predicted degradation, extending lifetime at the expense of slightly reduced near-term capacity.

Aging management strategies implemented by BMS significantly impact total cost of ownership. Limiting maximum SOC to 80-90% rather than 100% reduces degradation rates by 30-50%. Minimizing time at high temperature through active cooling extends

life. Optimizing charging rates based on temperature and current SOC reduces stress. While these measures slightly reduce immediate performance, they substantially extend battery life, often by 2-5 years in automotive applications.

Grid-scale BMS implementations in 2023 demonstrated new capabilities. String-level monitoring enabled megawatt-hour installations containing thousands of cells. Predictive maintenance algorithms scheduled cell replacement before failures occurred. Integration with grid operators enabled battery participation in frequency regulation and demand response programs while respecting battery limitations. Some systems implemented virtual power plant functionality, coordinating multiple distributed batteries as single controllable resources.

Cost pressures drive BMS integration trends. Custom ASICs combine monitoring, balancing, and control functions previously requiring multiple discrete components. Some battery manufacturers integrate BMS electronics directly into cell modules or packs, reducing wiring and improving reliability. Wireless monitoring architectures eliminate daisy-chain communication wiring, though concerns about wireless interference and cybersecurity remain.

Future BMS developments focus on artificial intelligence, cloud connectivity, and second-life applications. AI algorithms optimize charging based on user patterns and grid conditions. Cloud connectivity enables fleet-level insights into battery performance and aging. As automotive batteries reach end-of-life for vehicle applications at 70-80% capacity, BMS systems enable repurposing for stationary storage. This second-life usage improves economic viability and sustainability of battery technology.

Understanding BMS technology is essential for engineers working with energy storage systems. These systems exemplify multidisciplinary engineering, combining analog circuit design, digital control, embedded software, and thermal management. As energy storage becomes increasingly central to electrical infrastructure, BMS technology will continue evolving to enable safer, more capable, and longer-lasting battery systems.



BEST PROJECT ABSTRACT

Energy analysis of EVs on different driving cycle

Sandip Pawar, Anand Jadhav, Sarang Patil, Darshan Mali

The exponential growth in vehicle population and dominance of old vintage vehicles on Indian roads make the issue of inspection and maintenance a prime concern in India. In the last decade several aggressive initiatives to control vehicle pollution have been taken in India but most of the steps are directed towards new vehicle emission norms and fuel quality improvements. In major cities there exist a mandatory system for inspection and maintenance but it is now increasingly felt to upgrade the present system to a more effective one in the near future. Every commercial vehicle in India has to go for a mandatory fitness test.

Motor vehicles are the prime source of transportation where vehicles with the Petrol or Diesel play a major part. This project designs an embedded system for a vehicle, which senses the gases like carbon monoxide. If the level of the Carbon monoxide (CO) increases than the normal level (10 ppm to 100 ppm) then an alarm is generated automatically. A warning message is sent to the RTO office via GSM Module as well as it display on LCD display. The advantage of this system is proper detection and faster response time leading to faster diffusion of the situation, compared with the manual methods.

This system is reliable and easy as compare to the ordinary system of Pollution Under Control(PUC) check by PUC meter on highway. In the implementation, the device has been used to measure the Carbon monoxide(CO) level in vehicles and only sense the Carbon monoxide(CO).

Protection of Power Transformer Based on MATLAB/SIMULINK

Koli Saurav, Chaudhari Yash

A distribution system's transformer is one of the key pieces of equipment that can malfunction in a number of ways. The most serious type of all are internal winding problems. Differential protection schemes are typically used to protect transformers.

A differential over current relay may not be able to be operated by an internal fault because the rise in current is quite small for early faults or shorted turns that account for less than 10 percent of the total turns. Due to the severity of these internal winding defects, the distribution system must be shut down and the transformer must be completely damaged. It is not viable to conduct a practical experimental study of internal winding defects in distribution transformers since doing so could cause the transformer to break completely. Therefore, Typically, computer simulations are used for these types of analyses. Thus far, EMP simulations have been used for the majority of study related to internal winding failures in transform-ers. Equations are used to represent the transformer in this work, which also takes into account the transformer's equivalent circuit. Primary and secondary side flow equations are internal variables in the suggested model, while primary voltages are provided as inputs and secondary currents as outputs. The MATLAB/SIMULINK programme is utilised to model and simulate the inter turn failures of distribution transformers. Equations are used in the modelling of transformer inter-turn faults, and the outcomes verify the model that is put forth.

Water Pumping System Using Solar and Wind Power

Sejal Chaudhari, Dimpal Chaudhari, Yogendra Sonawane

The global water demand is increasing constantly due to growing populations, which now account for 16.5% of all countries. Fossil fuel-derived electricity, which is used to pump this water, extends the pump's life cycle and increases greenhouse gas emissions. As power electronics and drives have advanced, renewable energy sources like the sun and wind can now be used to generate electricity for water pumping, minimizing greenhouse gas emissions.

This study proposes the use of renewable energy sources, such as solar and wind energy, to generate electricity to pump water underground to meet energy requirements without producing greenhouse gases. Photovoltaic cells receive energy from sunlight, which is then used to pump water. However, because sunlight is a natural resource, there are times when conditions like climate change or seasonal concerns like the rainy season prevent the solar panel from producing enough power to pump the entire amount of water. Similarly, wind turbines generate wind energy based on wind velocity, which can become insufficient at times due to climate challenges.

Thus, the two types of energy sources are combined to provide a sufficient amount of power, and a hybrid system that utilizes both solar and wind energy to pump water is used. If, however, the energy generated by both sources is greater than or equal to what is needed, storage batteries are used to store the excess energy and supply.

Automatic Load Sharing of Transformer using Arduino UNO

Pawara Dakshata Pandit

The distribution transformer's ability to perform well is necessary for a power system to operate dependably. Therefore, in order to assess the distribution transformer's performance, it is imperative that critical parameters such as voltage and current be monitored and controlled. As a result, it aids in preventing or lessening the disruption brought on by the unexpected, sudden failure.

The main goal of the proposed work is to protect the transformer against overload situations. This can be accomplished by connecting an additional transformer in parallel with an Arduino, relay, and micro-controller and Internet of Things (IoT) that shares the first transformer's extra load. Priority-based load shedding of consumers will occur if the load rises above the capacity of the two transformers, ensuring uninterrupted power supply to hospitals, businesses, and other establishments.

When a transformer is overloaded, its efficiency decreases and its winding's become overheated and perhaps burnt. Thus, the transformer is protected by sharing the load. To do this, a second transformer will be connected in parallel with an Arduino micro-controller on the other end. The first transformer's load is compared to the reference value by both controllers. The load remaining after the load surpasses the reference value will be shared by the second transformer. The system will shut down if the load is greater than the capacity of both transformers. The control station is also informed about load sharing via IoT. Both transformers will have adequate maintenance facilities thanks to this arrangement. As a result, the time, temperature, and load shared with another transformer are all recorded. They can bring in around a year's worth of data. Together, they make the system incredibly dependable and efficient.

Power Quality Improvement through VFD-fed Induction Motor Drive in Textile Industry

Rajvardhan Jadhav, Neha Magare, Akanksha Awchare

This study conducts a comprehensive analysis of power quality improvement within the textile industry by focusing on variable frequency drive (VFD)- fed induction motor technology. It investigates the detrimental effects of harmonics stemming from nonlinear loads, primarily FD-driven motors, on productivity and energy consumption across Indian textile firms. The research underscores the significance of power system optimization, as harmonics lead to increased heating and utility costs and pose challenges such as eddy current losses in transformers serving harmonic loads. The study's primary objective is to evaluate the application and impact of VFD-fed induction motor drive systems, emphasizing their potential to enhance power quality, reduce energy usage, and streamline operational processes.

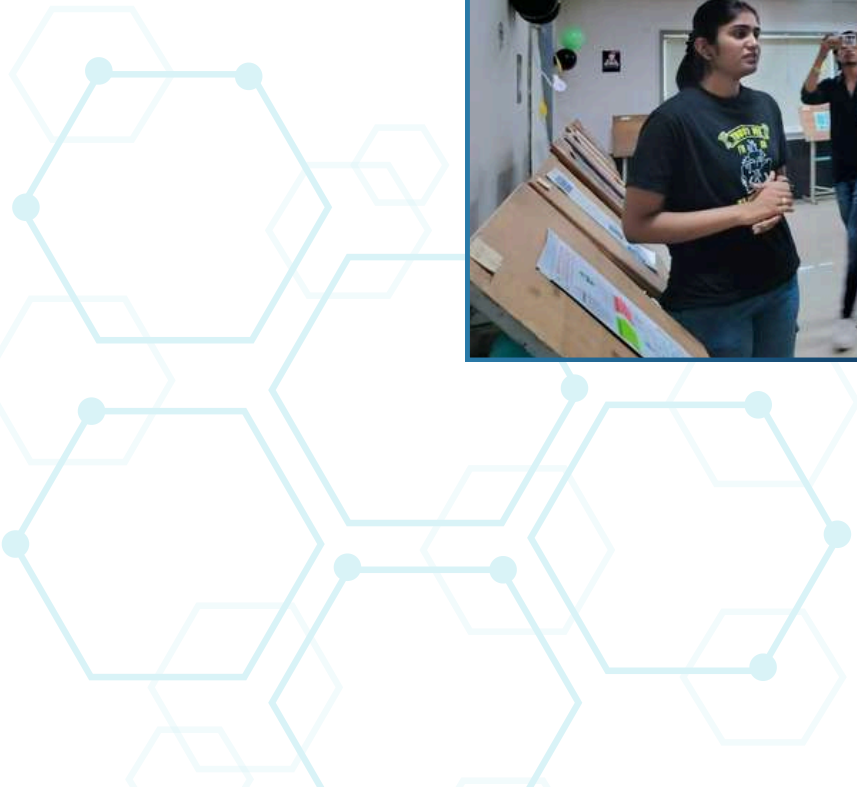
Furthermore, the paper highlights the limitations of eddy current drives, which include a limited speed range, imprecise speed control, reduced energy efficiency at lower speeds, and maintenance, noise, and vibration concerns before implementing VFD drive. In contrast, VFDs offer greater versatility and efficiency, making them preferable for applications demanding precise control over a wide speed range. The study presents a case study of a 110 KW, 4-pole induction motor VFD drive in a textile mill's spinning section, recording various parameters at different load conditions. Additionally, this work demonstrates the effectiveness of output parameters using experimental setup and MATLAB/SIMULINK MODEL. Hence, this work achieves all physical FD and motor parameters, the energy consumption of an industry.



CONVERGES GLIMPSE

The Department of Electrical Engineering recently participated in the "Converges'24" national-level technical event hosted by the R. C. Patel Institute of Technology, Shirpur. As a part of this event, the students of the electrical engineering department organized two fascinating events - "Waste to Watt" and "Electrotoy". These events aimed to showcase innovative solutions for waste management and introduce the participants to the world of electrical toys. The event was a grand success and received an overwhelming response from the students and faculty alike.







HACKATHON GLIMPSE

The Sustainable Energy Hackathon–2023, organized by the Energy Club, Department of Electrical Engineering, was held with great enthusiasm and active participation. The event provided a dynamic platform for students to dream, think, and innovate solutions focused on sustainable energy challenges.

Participants worked collaboratively in teams, engaging in brainstorming, coding, and prototype development under expert mentorship. The atmosphere throughout the hackathon was filled with creativity, technical discussions, and innovative problem-solving. Students showcased their ideas through practical demonstrations and presentations, reflecting their commitment to sustainability and engineering excellence.

The hackathon not only enhanced technical skills but also fostered teamwork, leadership, and innovation, making it a memorable and impactful experience for all participants.





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