



R. C. PATEL

INSTITUTE OF TECHNOLOGY, SHIRPUR

An Autonomous Institute

**NAAC**  
GRADE **A**

# ELECTRA

Technical Magazine

**DEPARTMENT OF  
ELECTRICAL ENGINEERING**

**JUNE 2024 – MAY 2025**

# DEPARTMENT VISION, MISSION, PEOs & PSOs

## VISION

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

## MISSION

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**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)

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**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)

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**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 deeply proud to witness the release of the Electrical Engineering Department's Technical Magazine. This publication stands as a vibrant testament to our department's academic excellence, technical innovation, and collaborative spirit.

Through its diverse sections—Student Corner, Faculty Corner, and Best Project Abstracts, Converges glimpse and Hackathon glimpse -the magazine beautifully captures the intellectual energy and creative endeavors that define our community. Each contribution reflects the passion and ingenuity of our students and faculty.

In today's rapidly evolving technological landscape, initiatives like this are more vital than ever. They foster critical thinking, spark innovation, and create meaningful opportunities for knowledge sharing. Beyond showcasing talent, this magazine serves as a wellspring of inspiration for all who engage with it.

I extend my sincere appreciation to the editorial team, contributors, and faculty mentors whose dedication and vision have brought this publication to life. May this magazine continue to flourish as a beacon of learning and excellence for years to come.



**Dr. Jayantrao Patil**

## HOD'S MESSAGE

It is with great pride that I present the latest edition of the Electrical Engineering Department's Technical Magazine.

This publication transcends a mere collection of articles and achievements—it embodies our collective spirit, creativity, and unwavering commitment to academic and technological excellence.

Through segments including the Student Corner, Faculty Corner, and Best Project Abstracts, Converges glimpse and Hackathon glimpse, the magazine captures the vibrant essence of our department. These sections illuminate the intellectual curiosity, innovative thinking, and collaborative efforts that distinguish us as a community of scholars and practitioners.

In an era of rapid technological evolution, continuous learning and knowledge sharing are paramount. This magazine provides a vital platform for our students and faculty to express ideas, demonstrate expertise, and celebrate accomplishments. From insightful technical articles to award-winning project abstracts, each contribution reflects the high standards and progressive vision that define our academic culture.

I extend my deepest gratitude to all contributors—students, faculty members, and the editorial team—whose dedication has brought this publication to fruition. Your efforts enrich our department and inspire others to reach for excellence.

As we move forward, let us continue to innovate, collaborate, and inspire one another. May this magazine spark new ideas and cultivate a culture of learning that resonates far beyond these pages.



**Dr. Shailaja Patil**

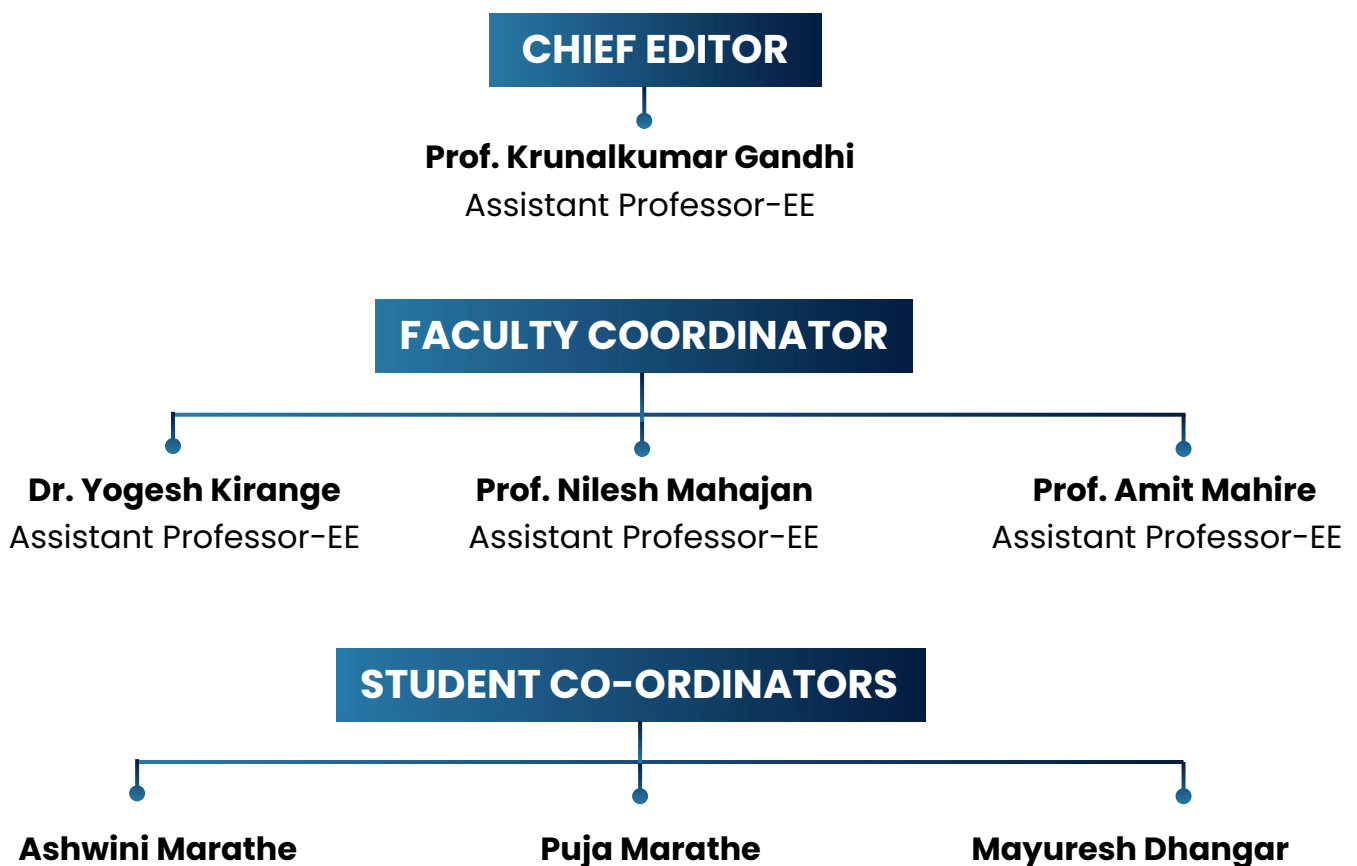
# MESSAGE BY EDITORIAL BOARD MEMBERS

We are delighted to present this edition of the Electrical Engineering Department's Technical Magazine—a platform that celebrates the creativity, innovation, and academic excellence thriving within our community.

This magazine weaves together diverse perspectives through the Student Corner, Faculty Corner, and Best Project Abstracts. Each section reflects the vibrant and dynamic culture that defines the Electrical Engineering Department at RCPIT, Shirpur.

As members of the editorial board, curating the thoughts, ideas, and accomplishments of our students and faculty has been a deeply rewarding experience. We envision this publication as more than an informative resource—it is a catalyst for inspiration, encouraging all readers to push the boundaries of knowledge and innovation.

We extend our heartfelt thanks to everyone who contributed to and supported this endeavor. May this magazine serve as a powerful voice for ideas and a celebration of the excellence that unites us.



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# FACULTY ARTICLES

## Power Electronics Advances for Electric Vehicles



### **DR. Nadeem Akhtar**

Associate Professor - EE

Power electronics forms the backbone of electric vehicle technology by enabling efficient conversion and control of electrical energy throughout the vehicle. Recent advancements in semiconductor devices and converter topologies have significantly improved the efficiency, power density, and reliability of EV powertrains, making electric mobility more practical and sustainable.

### **Wide Bandgap Semiconductors**

Conventional power electronic systems rely on silicon semiconductors, which are now approaching their theoretical performance limits. Wide bandgap semiconductors such as silicon carbide and gallium nitride provide superior electrical characteristics, including higher breakdown voltage, faster switching capability, and improved thermal performance. Silicon carbide devices, with a bandgap of 3.26 eV, are increasingly replacing silicon IGBTs in traction inverters, leading to substantial reductions in switching losses and enabling operation at higher temperatures and voltages. Gallium nitride devices, while less common in high-power traction systems, are widely adopted in onboard chargers due to their extremely fast switching speeds, which allow compact and lightweight power conversion systems.

### **Traction Inverter Developments**

The traction inverter is a critical component that converts DC battery power into three-phase AC power for driving the electric motor. Recent developments focus on improving efficiency and reducing electromagnetic interference. Multilevel inverter topologies generate output voltages in smaller steps, which reduces harmonic distortion and improves power quality. Integration of the inverter and motor into a single housing further reduces size and weight while enhancing thermal management. Additionally, the use of SiC devices enables higher switching frequencies, allowing smaller passive components and increasing overall power density.

## **Onboard Charger Innovations**

Onboard chargers play a vital role in converting AC grid power to DC for battery charging. Modern chargers are designed for high efficiency and flexibility. Bidirectional charging capability enables vehicle-to-grid and vehicle-to-home operation, allowing EVs to act as energy storage systems. Advanced power factor correction techniques, such as totem-pole PFC, improve efficiency by minimizing conduction losses. Wide input voltage operation ensures compatibility with global charging standards, while interleaved converter architectures reduce current ripple and improve thermal performance.

## **DC-DC Converter Advancements**

Electric vehicles use high-voltage battery packs along with low-voltage auxiliary systems. High-efficiency bidirectional DC-DC converters connect these systems and ensure stable power delivery. Resonant converter topologies such as LLC converters minimize switching losses and achieve very high efficiencies. Multiphase converter designs distribute power across multiple paths, reducing component stress and enhancing reliability. The shift from traditional 12-volt systems to 48-volt auxiliary architectures further improves efficiency and supports increasing electrical loads in modern vehicles.

## **Thermal Management in Power Electronics**

As power density increases, effective thermal management becomes essential to maintain performance and reliability. Direct liquid cooling is widely adopted due to its superior heat removal capability compared to air cooling. Phase-change materials are being explored to absorb transient thermal spikes during high load conditions. Advanced packaging techniques, including double-sided cooling of semiconductor devices, significantly enhance heat dissipation and extend component lifetime.

## **High-Voltage EV Architectures**

A major trend in EV design is the transition from 400-volt to 800-volt battery systems. Higher voltage operation enables faster charging by reducing current for the same power level, which lowers resistive losses and allows lighter cables and connectors. This also improves overall vehicle efficiency and supports more compact motor designs. The successful implementation of 800-volt architectures relies heavily on silicon carbide semiconductors, which can efficiently operate at such high voltages.

## **Electromagnetic Compatibility Considerations**

High-frequency switching in modern power electronic systems introduces electromagnetic interference that can affect vehicle electronics. Engineers address these challenges through careful filter design, optimized PCB layouts, and effective shielding techniques. Advanced control strategies such as spread-spectrum modulation further reduce peak emissions, ensuring compliance with automotive EMC standards.

## Reliability and Battery Management Systems

Automotive power electronics must operate reliably under extreme environmental conditions, including wide temperature ranges, vibration, humidity, and long service lifetimes. Rigorous testing such as power cycling and thermal cycling ensures durability. Battery management systems play a crucial role in ensuring safe battery operation by monitoring cell voltages, current, and temperature, performing cell balancing, and estimating battery state-of-charge and state-of-health.

### Conclusion

Power electronics advancements are fundamental to the performance and reliability of electric vehicles. The adoption of wide bandgap semiconductors, high-voltage architectures, and advanced converter designs has enabled highly efficient and compact powertrains. Continued research and development in this field will further enhance EV performance and contribute significantly to sustainable transportation.

## Quantum Computing and Its Impact on Electrical Engineering

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### Nilesh Suresh Mahajan

Assistant Professor - EE

The year 2025 has been declared by the United Nations as the International Year of Quantum Science and Technology, commemorating one hundred years since the birth of quantum mechanics. This milestone coincides with rapid progress in quantum computing, which is beginning to influence multiple areas of electrical engineering, from hardware design and signal processing to cryptography and communication systems.

### Fundamentals of Quantum Computing

Classical computers process information using bits that exist strictly as either 0 or 1. In contrast, quantum computers use quantum bits, or qubits, which exploit quantum mechanical properties such as superposition and entanglement. Superposition allows a qubit to exist in multiple states simultaneously, while entanglement creates strong correlations between qubits such that the state of one instantaneously affects others. These properties enable quantum computers to process information in fundamentally different ways, offering potential speedups for certain classes of problems that are infeasible for classical systems.

## Recent Technical Progress

Over the past two years, quantum computing has shown clear signs of maturation. In 2024, Google introduced its Willow processor, demonstrating improved error correction where increasing qubit count actually reduced overall error rates. IBM advanced its roadmap toward fault-tolerant quantum computing by focusing on logical qubits and more efficient error correction codes, aiming for large-scale systems later this decade. China also reported significant progress in both superconducting and photonic quantum platforms. Investment in quantum technology surged in 2025, with billions of dollars committed by private companies and governments, highlighting strong global confidence in the field's long-term potential.

## From Physical to Logical Qubits

A major shift in quantum computing research is the transition from simply increasing physical qubit numbers to developing reliable logical qubits. Physical qubits are highly sensitive to noise and decoherence, making them error-prone. Logical qubits combine multiple physical qubits with error correction techniques to form stable computational units. Roadmaps published by leading technology companies indicate that scalable, fault-tolerant systems will be built around logical qubits, signaling progress from experimental prototypes toward practical machines.

## Quantum Hardware Technologies

Several competing hardware platforms are under active development. Superconducting circuits, used by companies such as Google and IBM, offer fast gate operations but require cryogenic temperatures close to absolute zero. Trapped-ion systems provide excellent coherence and precision, while neutral-atom platforms offer promising scalability. Photonic quantum computers operate using light and can function at room temperature, though they face unique engineering challenges. Microsoft is pursuing topological qubits, which aim to achieve intrinsic error resistance through exotic quantum states. Each approach presents distinct advantages and trade-offs for electrical engineers.

## Impact on Electrical Engineering

Quantum computing places new demands on electrical engineering. Superconducting systems require advanced cryogenic engineering to operate below 0.1 kelvin while minimizing heat and noise. Microwave engineering plays a crucial role in generating precise control pulses for qubit operations. Complex control and synchronization systems are needed to manage thousands of signals with nanosecond accuracy. Signal processing techniques are essential for extracting qubit states from extremely weak measurement signals, while real-time classical processing supports quantum error correction.

## Security and Quantum Communication

The rise of quantum computing threatens conventional cryptographic systems. In

response, new post-quantum cryptographic standards finalized by NIST in 2024 aim to protect data against future quantum attacks. Electrical engineers are responsible for implementing these algorithms in hardware and communication systems. In parallel, quantum communication technologies such as quantum key distribution are being deployed in metropolitan-scale networks, requiring advanced photonic components and ultra-sensitive detectors.

## Outlook and Conclusion

Despite remarkable progress, significant challenges remain, including reducing error rates, extending qubit coherence times, scaling systems to millions of qubits, and lowering costs. While timelines vary, most experts agree that practical quantum advantage will emerge gradually over the next decade. Quantum computing is evolving from a scientific curiosity into an engineering discipline. Electrical engineers will play a central role in this transformation, making quantum literacy an essential skill for future professionals.

## Renewable Energy Grid Integration Challenges

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### Rupesh Shantaram Patil

Assistant Professor - EE

As renewable energy capacity expands worldwide, integrating large amounts of variable generation into electrical grids presents complex technical and operational challenges. Unlike conventional power plants, renewable sources such as solar and wind depend on weather conditions, requiring power system engineers to redesign grid planning, operation, and control strategies to maintain reliability and stability.

### Variability and Forecasting Challenges

Traditional thermal and hydro power plants can be dispatched according to demand, whereas solar and wind generation fluctuate with sunlight and wind speed. This variability introduces uncertainty in generation forecasting, forcing grid operators to maintain reserve capacity. Rapid changes in output, such as sudden drops in solar generation due to cloud cover, create steep ramping requirements for conventional generators. In regions with high solar penetration, this phenomenon leads to the “duck curve,” characterized by excess midday generation followed by sharp evening demand increases, challenging system flexibility and operational planning.

## Frequency Stability in Low-Inertia Systems

Maintaining grid frequency within tight limits is critical for system stability. Conventional power systems rely on the inertia of synchronous generators, whose rotating masses naturally resist sudden frequency deviations. Renewable energy sources are connected through power electronic inverters, which do not provide physical inertia. As renewable penetration increases, overall system inertia decreases, making frequency more sensitive to disturbances. To address this, modern inverters are designed to provide synthetic inertia by rapidly adjusting power output in response to frequency changes. Battery energy storage systems also provide fast frequency response, injecting or absorbing power within milliseconds. Grid-forming inverters represent a major advancement, as they can independently establish voltage and frequency, behaving similarly to traditional generators.

## Voltage Regulation and Distribution Networks

High levels of distributed solar and wind generation significantly affect voltage profiles, particularly in distribution networks. During periods of high renewable output, voltages may rise beyond permissible limits. Advanced inverter-based reactive power control helps regulate voltage locally. On-load tap changers in transformers adjust voltage dynamically, while energy storage systems absorb excess power during high-generation periods. Advanced distribution management systems coordinate these resources to maintain voltage stability across the network.

## Transmission Infrastructure Constraints

Renewable energy resources are often located far from major load centers, requiring extensive transmission expansion. High-voltage transmission projects face challenges related to cost, environmental permitting, and public acceptance. From a technical perspective, high-voltage direct current transmission offers lower losses over long distances and better controllability than conventional AC systems. Flexible AC transmission systems further enhance the utilization of existing infrastructure by actively controlling power flows.

## Role of Energy Storage

Energy storage plays a central role in mitigating renewable intermittency. Lithium-ion batteries dominate short-duration storage applications and are widely used for frequency regulation and peak shaving. Pumped hydro remains the most mature large-scale storage technology, while flow batteries and compressed air energy storage offer solutions for longer-duration applications. Thermal energy storage, particularly in concentrated solar power plants, allows electricity generation hours after sunset. Together, these technologies improve grid flexibility and reliability.

## Protection and System Modeling Challenges

Traditional protection schemes are designed for synchronous generators that supply high fault currents. Inverter-based resources limit fault current to protect power

electronic components, complicating fault detection and relay coordination. New adaptive protection strategies are required to ensure reliable operation. Additionally, accurate modeling of inverter-based resources demands advanced simulation tools that capture fast electromagnetic transients, supported by field validation data to ensure model accuracy.

## Market Operation and Curtailment

When renewable generation exceeds local demand or transmission capacity, curtailment becomes necessary, resulting in wasted clean energy. Improved forecasting, flexible market mechanisms, and demand response programs help minimize curtailment. Electricity markets must evolve to properly value flexibility, fast response, and reliability services provided by storage and advanced inverter technologies.

## Future Outlook and Conclusion

Integrating high levels of renewable energy requires a fundamental transformation of power system design and operation. Advanced inverter technologies, energy storage, expanded transmission networks, and improved control and protection strategies are essential. As renewable penetration continues to grow, electrical engineers with expertise in power systems, power electronics, and control engineering will play a critical role in building reliable, resilient, and sustainable electricity grids.

## Semiconductor Manufacturing for Power Devices

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### Amit Rajendra Mahire

Assistant Professor - EE

The manufacturing processes used for power semiconductor devices differ substantially from those used for integrated circuits. Power devices are designed to handle high voltages, large currents, and significant thermal stress, which requires specialized materials, device structures, and fabrication techniques. For electrical engineers working in power electronics, understanding these processes is essential for effective device selection, application, and innovation.

### Power Device Requirements

Power semiconductors must block high voltages, conduct large currents, dissipate heat efficiently, and switch at appropriate speeds.

High-voltage capability requires thick, lightly doped drift regions that can sustain strong electric fields without breakdown. High current handling demands large device areas, making power devices significantly larger than logic transistors. Thermal management is critical because power losses generate substantial heat that must be removed to ensure reliability. Switching speed must be optimized to reduce losses while limiting electromagnetic interference, leading to design trade-offs unique to power devices.

### **Silicon Power Device Fabrication**

Silicon remains widely used for power MOSFETs and IGBTs, but their fabrication involves additional steps compared to digital ICs. A key process is epitaxial growth, where a lightly doped layer is grown on a heavily doped substrate to form the voltage-supporting drift region. Power devices also require multiple ion implantation steps to form source, body, and gate regions. Modern silicon MOSFETs use trench gate structures, which are created through deep plasma etching and reduce on-state resistance. Electric field control at device edges is achieved through guard rings and field plates to prevent premature breakdown. Thick metallization layers are deposited to carry high currents with minimal resistive losses.

### **Silicon Carbide Device Manufacturing**

Silicon carbide offers superior breakdown strength, thermal conductivity, and high-temperature performance, but it is much more challenging to manufacture than silicon. High-quality SiC substrates are grown at temperatures above 2000°C using physical vapor transport, resulting in higher defect densities and higher costs. Chemical vapor deposition is used to grow epitaxial layers with precise doping control. Ion implantation in SiC requires much higher energies and is followed by annealing at extremely high temperatures to activate dopants. Forming reliable gate oxides is difficult due to interface defects, necessitating multiple oxidation and annealing steps. Low-resistance ohmic contacts and effective edge termination structures are critical for achieving high-voltage performance.

### **Gallium Nitride Processing**

Gallium nitride power devices rely on fundamentally different processing techniques. GaN layers are typically grown on foreign substrates such as silicon or silicon carbide using metal-organic chemical vapor deposition. Lattice mismatch introduces defects that must be carefully managed. GaN high-electron-mobility transistors exploit polarization effects to form a two-dimensional electron gas without traditional doping. For power switching, normally-off operation is essential and is achieved through advanced gate structures. Surface passivation is particularly important in GaN devices to ensure stability and long-term reliability.

### **Packaging Technologies**

Packaging plays a vital role in power device performance and reliability. Traditional wire bonding techniques use multiple aluminum or copper wires to handle high currents,

Die attach methods such as soldering and sintering provide mechanical support and thermal conduction. Advanced packages enable double-sided cooling, significantly improving heat removal. Embedded die technologies further reduce electrical parasitics and increase power density, making packaging an active part of device performance.

## Reliability and Testing

Power devices undergo extensive reliability testing to ensure long-term operation under harsh conditions. Temperature cycling and power cycling tests simulate thermal stresses during operation. High-temperature storage tests reveal long-term degradation mechanisms, while humidity testing verifies package integrity. Devices are also tested for short-circuit robustness and avalanche capability to ensure safe operation during fault conditions.

## Manufacturing Challenges and Future Directions

Wide bandgap devices face challenges related to substrate defects, complex processing, and smaller wafer sizes, all of which affect yield and cost. Industry efforts focus on improving crystal quality, scaling wafer diameters, and refining fabrication processes. Emerging materials such as gallium oxide, diamond, and vertical GaN structures offer promising performance but require further advances in manufacturing technology.

## Conclusion

Semiconductor manufacturing for power devices is a specialized discipline that integrates materials science, device physics, and advanced process engineering. As power electronics increasingly adopt wide bandgap semiconductors, expertise in SiC and GaN fabrication becomes increasingly valuable. Electrical engineers with knowledge of both device behavior and manufacturing processes are well positioned to contribute to the development of efficient, reliable, and sustainable power electronic systems.

## Microgrid Technology and Distributed Energy Resources



### Dr. Bhushan Prataprao Patil

Associate Professor - EE

Microgrids represent a fundamental shift in the way electrical energy is generated, distributed, and consumed. Unlike traditional centralized power systems, microgrids are

localized networks that integrate distributed generation, energy storage, and controllable loads. They can operate either in coordination with the main utility grid or independently, offering improved resilience, higher efficiency, and enhanced integration of renewable energy sources.

## **Microgrid Architecture and Components**

A microgrid consists of distributed generators such as solar photovoltaic systems, wind turbines, diesel or gas generators, fuel cells, and combined heat and power units. Energy storage systems, most commonly batteries, play a critical role by storing excess generation and supplying power during peak demand or renewable intermittency. Controllable loads, including smart appliances, HVAC systems, and industrial processes, enable flexible demand management. The point of common coupling connects the microgrid to the utility grid, allowing seamless transitions between grid-connected and islanded operation. A central microgrid controller monitors system conditions, forecasts demand and generation, and coordinates all resources through the local distribution network.

## **Grid-Connected and Islanded Operation**

In grid-connected mode, the microgrid exchanges power with the utility grid, importing electricity during shortages and exporting excess generation when available. The utility grid provides the reference for voltage and frequency. In islanded mode, the microgrid disconnects from the main grid during outages or disturbances and operates autonomously. Local generation and storage maintain supply to critical loads. The transition between these modes must be rapid and smooth to avoid disrupting sensitive equipment, requiring advanced synchronization and control strategies.

## **Control Strategies and Protection**

Microgrid control is typically organized in hierarchical layers. Primary control provides fast, local voltage and frequency regulation using droop characteristics, enabling proportional load sharing without communication. Secondary control restores system frequency and voltage to nominal values after disturbances, while tertiary control optimizes economic operation based on fuel costs, electricity prices, and forecasts. Protection systems in microgrids are more complex than in traditional networks due to bidirectional power flow and variable fault currents. Adaptive protection schemes, directional relays, and reliable islanding detection mechanisms are essential to ensure safety and selectivity under both operating modes.

## **Communication and Energy Management**

Reliable communication infrastructure is vital for modern microgrids. Supervisory control and data acquisition systems collect real-time data on system performance, while standards such as IEC 61850 enable interoperability between devices from different manufacturers. Cybersecurity measures are increasingly important to protect microgrids from malicious attacks. Energy management systems use forecasting,

optimization, and demand response algorithms to minimize operating costs, reduce emissions, and ensure reliable supply by coordinating generation, storage, and loads.

## **Applications and Renewable Integration**

Microgrids are deployed across a wide range of applications, including military bases, university campuses, industrial facilities, hospitals, remote communities, and developing regions. They are particularly effective at integrating high levels of renewable energy by balancing variable generation locally through storage and flexible loads. This reduces curtailment, improves resilience during grid outages, and lowers dependence on distant power plants and transmission infrastructure.

## **Economic and Regulatory Considerations**

Microgrids offer economic benefits such as peak shaving, demand response revenue, ancillary service provision, and avoided outage costs. However, widespread deployment faces regulatory challenges related to interconnection standards, market access, permitting, and compensation for exported power. Accurately valuing resilience remains difficult, even though uninterrupted power supply can prevent significant economic losses and protect public safety during extreme events.

## **Future Trends and Research Directions**

Future microgrid development will be influenced by trends such as virtual power plants, DC microgrids, hydrogen-based energy storage, and vehicle-to-grid integration. Emerging concepts like blockchain-enabled peer-to-peer energy trading may further transform microgrid economics. Research opportunities include optimal system sizing, stability analysis with high inverter penetration, hierarchical control of interconnected microgrids, and the application of machine learning for forecasting and fault detection.

## **Conclusion**

Microgrids are reshaping power systems by enabling decentralized, intelligent, and resilient energy networks. While technical, economic, and regulatory challenges remain, their ability to integrate renewable energy and enhance reliability makes them increasingly important. Electrical engineers with expertise in power systems, control, communication, and optimization will play a crucial role in advancing microgrid technology and ensuring sustainable electricity systems in the future.



# STUDENT'S ARTICLES

## Solid State Batteries – The Future of Energy Storage



### Nilesh Magar

B. Tech EE III-Year

The year 2024 marked a significant milestone in battery technology with the advancement of solid state batteries. These next generation power storage devices are set to revolutionize electric vehicles and renewable energy systems.

### What are Solid State Batteries?

Traditional lithium ion batteries use liquid electrolytes to transport ions between electrodes. Solid state batteries replace this flammable liquid with solid materials, making them safer and more efficient. The solid electrolyte can be made from three main types of materials: sulfides, polymers, or oxides.

### Recent Breakthroughs

In early 2025, Mercedes Benz successfully integrated a lithium metal solid state battery into a production vehicle, the EQS model. This marked the first time a solid state battery powered car hit the road for testing. The company partnered with Factorial Energy to achieve this milestone.

BMW also tested solid state batteries in their i7 vehicle using sulfide based solid electrolytes. Meanwhile, research teams at the University of Texas at Dallas discovered that mixing small particles between two solid electrolytes creates unique channels for ion transport, potentially solving one of the biggest challenges in this technology.

### Advantages Over Conventional Batteries

- **Energy Density:** Solid state batteries can store 300 to 900 Wh per kg compared to 150 to 300 Wh per kg for lithium ion batteries.
- **Safety:** Non flammable operation eliminates fire risks associated with liquid electrolytes.

- **Charging Speed:** Potential charging times of 3 to 15 minutes versus 30 to 60 minutes for current batteries.
- **Lifespan:** Expected to last 10,000 to 100,000 charge cycles compared to 1,000 to 3,000 cycles.
- **Temperature Range:** Can operate from negative 50 degrees Celsius to 125 degrees Celsius.

## Current Challenges

The main obstacle is cost. Solid state batteries currently cost between 400 to 800 dollars per kWh, while lithium ion batteries dropped to 115 dollars per kWh in 2024. Manufacturing these batteries at scale requires new production techniques and equipment.

Another challenge is interfacial resistance, which occurs at the boundary between solid materials. Poor physical contact between electrodes and electrolytes creates resistance that limits performance.

## Timeline for Commercial Availability

Industry experts predict the following timeline:

- **2025 to 2027:** Initial integration into premium and specialized electric vehicles with improved safety features.
- **2027 to 2028:** Toyota and Samsung plan commercial deployment with initial production facilities.
- **2028 to 2030:** Full scale manufacturing begins, leading to cost reduction and mainstream adoption.
- Chinese company WeLion New Energy reported achieving 824 Wh per kg in laboratory tests and aims to break the 1,000 Wh per kg barrier. They plan mass production around 2027.

## Applications Beyond Electric Vehicles

While electric vehicles receive the most attention, solid state batteries will also transform:

- Consumer electronics with longer lasting devices
- Renewable energy storage systems for solar and wind power
- Medical devices requiring safe, reliable power
- Aerospace applications where weight and safety are critical

## Conclusion

Solid state battery technology represents one of the most exciting developments in electrical engineering. As manufacturing techniques improve and costs decrease, these batteries will enable electric vehicles with over 600 miles of range and charging times comparable to filling a gas tank. For engineering students, this field offers tremendous opportunities for research and career development in materials science, electrochemistry, and power systems.

# Smart Grids – Intelligence Meets Power Distribution

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## Dhiraj Ravandale

B. Tech EE III-Year

Traditional electrical grids are undergoing a transformation. Smart grids use digital communication and automation to create an intelligent power distribution network that benefits both utilities and consumers.

### Understanding Smart Grids

A smart grid is an evolved electricity network that uses telecommunications and automation to monitor, forecast, and optimize energy usage. Unlike traditional grids that deliver power in one direction from power plants to consumers, smart grids enable two way communication between producers and users.

### Key Components

- **Smart Meters:** Digital devices that record electricity consumption in real time and communicate this information back to utilities. They replace traditional meters that require manual reading.
- **Sensors and Monitors:** Distributed throughout the grid to detect faults, measure power quality, and track system performance.
- **Communication Networks:** Connect all components using wireless or fiber optic technology to enable data exchange.
- **Automation Systems:** Automatically respond to changes in demand, reroute power around failures, and optimize distribution.
- **Energy Management Software:** Analyzes data from all components to make intelligent decisions about power distribution.

### How Smart Grids Work

When you turn on an appliance, smart meters instantly record the power consumption and send this data to the utility company. Advanced software analyzes consumption patterns across thousands of homes and businesses. If demand starts exceeding supply in one area, the system can automatically reroute power from other sources or activate backup generators.

During power outages, smart grids can isolate the affected section and restore power to unaffected areas within minutes instead of hours. Sensors detect the fault location, and automated switches redirect power flow around the problem area.

## Benefits of Smart Grid Technology

- **Reduced Power Losses:** Traditional grids lose 8 to 15 percent of electricity during transmission and distribution. Smart grids reduce these losses through optimized routing and voltage management.
- **Faster Outage Recovery:** Automated fault detection and isolation restore power much faster than manual processes.
- **Integration of Renewable Energy:** Smart grids can handle the variable output from solar panels and wind turbines by balancing supply from multiple sources.
- **Peak Demand Management:** By monitoring consumption patterns, utilities can encourage users to shift energy intensive activities to off peak hours through time based pricing.
- **Improved Power Quality:** Continuous monitoring ensures voltage and frequency remain within acceptable ranges, protecting sensitive electronic equipment.
- **Real World Applications**

India has been implementing smart grid projects in several cities. The Smart Grid Pilot Project covered areas in states like Rajasthan, Gujarat, and Karnataka. These projects demonstrated how smart grids reduce distribution losses and improve service reliability.

Many residential areas now have smart meters that show real time consumption. Some utilities offer mobile apps where consumers can track their usage hour by hour and identify which appliances consume the most power.

## Challenges in Implementation

- **High Initial Investment:** Installing smart meters, sensors, and communication infrastructure requires substantial capital.
- **Cybersecurity:** Connected systems are vulnerable to hacking. Protecting grid infrastructure from cyber attacks is essential.
- **Data Privacy:** Smart meters collect detailed consumption data. Ensuring this information remains private is important.
- **Technical Expertise:** Operating and maintaining smart grids requires skilled personnel with knowledge of both electrical engineering and information technology.

## Internet of Things and Smart Grids

The integration of IoT devices with smart grids creates even more possibilities. Smart thermostats, solar inverters, and electric vehicle chargers can communicate with the grid to optimize energy usage. For example, EV chargers can automatically charge vehicles during off peak hours when electricity is cheaper and more abundant.

## Career Opportunities

Smart grid technology creates demand for electrical engineers with skills in:

- Power systems analysis
- Communication protocols and networking
- Data analytics and software programming
- Cybersecurity for critical infrastructure
- Renewable energy integration

## The Future of Smart Grids

As technology advances, smart grids will become even more intelligent. Artificial intelligence will predict demand patterns and optimize distribution in real time. Blockchain technology might enable peer to peer energy trading, where homeowners with solar panels sell excess power directly to neighbors.

Energy storage systems, including batteries and pumped hydro storage, will integrate with smart grids to store excess renewable energy and release it during peak demand.

## Conclusion

Smart grid technology represents the convergence of electrical engineering, telecommunications, and computer science. As India and other nations modernize their power infrastructure, electrical engineers who understand smart grid systems will be in high demand. This technology is essential for integrating renewable energy sources and building a sustainable energy future.

## Wireless Power Transfer – Cutting the Cord

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### Yukta Badgujar

B. Tech EE III-Year

Wireless power transfer (WPT) is transforming the way electrical energy is delivered to electronic devices by eliminating the need for physical cables. From smartphones and wearable electronics to electric vehicles, this technology promises greater convenience, improved durability, and safer power delivery. By using electromagnetic fields instead of conductors, wireless power transfer is steadily moving from a niche innovation to a mainstream solution.

## Fundamentals of Wireless Power Transfer

Wireless power transfer refers to the transmission of electrical energy from a source to a load without direct electrical contact. The system relies on time-varying electromagnetic fields to carry energy through space. The fundamental operating principle is electromagnetic induction, first discovered by Michael Faraday in 1831. In a typical system, alternating current flows through a transmitter coil, generating a changing magnetic field. When a receiver coil is placed within this field, an electrical current is induced, enabling battery charging or direct device operation.

## Methods of Wireless Power Transfer

Several methods of wireless power transfer have been developed to address different distance and power requirements. Inductive coupling is the most widely used approach and operates over very short distances, usually a few centimeters. It is commonly found in smartphone charging pads, electric toothbrushes, and wearable devices. Resonant inductive coupling improves upon this method by tuning both transmitter and receiver coils to the same resonant frequency, allowing energy transfer over greater distances with higher efficiency. Radio frequency power transfer converts electrical energy into radio waves that propagate through space and are then converted back into electricity at the receiver, enabling longer-range power delivery but at lower efficiency.

## Present-Day Applications

Wireless power transfer is already part of everyday life. Smartphone wireless charging based on the Qi standard has become widely adopted, allowing users to charge devices simply by placing them on a charging pad. Medical devices such as pacemakers benefit greatly from wireless charging, as it eliminates the need for invasive procedures to replace batteries. Wearable electronics use wireless charging to maintain sealed designs that resist moisture and corrosion. In industrial environments, wireless charging supports automated guided vehicles and robots by reducing downtime and maintenance caused by mechanical connectors.

## Recent Technological Developments

Recent research has demonstrated significant advancements in wireless power capabilities. Experimental systems developed by researchers have successfully powered devices such as light bulbs across room-scale distances, demonstrating the feasibility of mid-range wireless power. In the automotive sector, wireless charging for electric vehicles is rapidly progressing. Ground-mounted charging pads installed in garages can transfer power wirelessly to vehicles parked above them, with power levels reaching 11 kilowatts or more. These systems offer charging performance comparable to wired solutions while improving convenience and safety.

## Advantages of Wireless Charging

Wireless power transfer offers several compelling advantages. It enhances convenience by removing the need for cables and connectors, reducing clutter and user effort. The absence of physical contacts improves durability by eliminating wear and corrosion. Safety is also enhanced because there are no exposed electrical connections, reducing the risk of electric shock. Standardized wireless charging systems allow interoperability between devices and chargers, further improving usability.

## Challenges and Limitations

Despite its benefits, wireless power transfer faces technical challenges. Efficiency remains lower than wired charging, with some energy lost as heat during transmission. Effective operation typically requires precise alignment between transmitter and receiver coils, particularly in inductive systems. Charging distance is limited, as efficiency decreases rapidly with separation. Wireless charging systems also tend to be more expensive due to additional components and control circuitry. Thermal management is critical, as excess heat can degrade battery performance and reduce system lifespan.

## Future Outlook

The future of wireless power transfer is promising. Researchers are working to extend transmission range, improve efficiency, and reduce sensitivity to alignment. Concepts such as rooms equipped with embedded wireless power transmitters could allow devices to charge automatically. For electric vehicles, wireless charging may be integrated into parking areas and roadways, enabling stationary or dynamic charging. Pilot projects for wireless bus charging are already underway in several cities.

## Engineering Considerations and Conclusion

Designing wireless power systems requires careful attention to operating frequency, electromagnetic compatibility, safety standards, and thermal management. Engineers must ensure that wireless power systems do not interfere with communication networks or exceed exposure limits. Wireless power transfer represents a major step toward seamless energy delivery. As the technology matures, it will play a key role in shaping the future of consumer electronics, transportation, and smart infrastructure, making it an important area of study for electrical engineering students.

# Electric Vehicle Charging Infrastructure

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## Puja Marathe

B. Tech EE IV-Year

The rapid growth of electric vehicles (EVs) has created a strong demand for reliable and efficient charging infrastructure. As transportation systems transition toward electrification, understanding the electrical engineering principles behind EV charging becomes essential. EV charging systems combine power electronics, communication protocols, and grid integration technologies to safely and efficiently deliver energy to vehicle batteries.

### Types of EV Charging Systems

EV charging is generally classified into three levels based on power output and charging speed. Level 1 charging uses standard household AC outlets and provides very slow charging, typically adding only a few kilometers of range per hour. This method relies on the vehicle's onboard charger and is mainly suitable for overnight residential charging. Level 2 charging operates at higher voltage and current, delivering significantly more power and enabling faster charging. It is widely used in homes, workplaces, and public parking areas and requires dedicated electrical installation. DC fast charging delivers direct current to the battery at much higher power levels, enabling rapid charging suitable for highways and commercial charging stations.

### Working Principle of EV Chargers

EV batteries store energy in direct current form, while electrical grids typically supply alternating current. In Level 1 and Level 2 charging, AC power is supplied to the vehicle, where the onboard charger converts it into DC. The power rating of this onboard charger limits charging speed. DC fast chargers perform AC-to-DC conversion externally and supply DC power directly to the battery. Because these chargers are not constrained by vehicle size or weight, they can deliver very high power. Continuous communication between the charger and vehicle ensures correct voltage, current, and thermal limits are maintained during charging.

### Role of Power Electronics

Power electronics are the core of EV charging systems. Rectifiers convert grid AC power to DC, while power factor correction circuits ensure efficient power draw and minimize

harmonic distortion. DC-DC converters regulate voltage levels according to battery requirements and state of charge. Advanced control systems monitor battery temperature, voltage, and current to maximize charging speed while preserving battery life and safety.

## **Charging Standards and Grid Integration**

Multiple charging standards exist worldwide, including CCS, CHAdeMO, Tesla connectors, and regional AC standards such as Type 2 and Bharat DC. These standards define electrical characteristics, communication protocols, and safety requirements. Integrating EV chargers with the electrical grid introduces challenges such as increased peak demand, transformer overloading, and power quality issues. Smart charging systems help mitigate these challenges by balancing loads, shifting charging to off-peak hours, and maintaining acceptable power factor and harmonic levels.

### **Vehicle-to-Grid and Renewable Integration**

Vehicle-to-grid technology enables bidirectional power flow between EVs and the grid. When connected, EV batteries can supply power back to the grid during peak demand, effectively acting as distributed energy storage. This approach enhances grid stability and can provide economic benefits to vehicle owners. Many charging stations are also integrated with renewable energy sources such as solar panels, allowing vehicles to be charged with clean energy while reducing stress on the grid.

## **Smart Charging and Installation Considerations**

Modern EV charging infrastructure incorporates smart features such as mobile applications for locating chargers, scheduling charging sessions, and managing payments. Dynamic load management adjusts charging power based on grid conditions and local demand. Proper installation requires careful assessment of electrical capacity, dedicated circuits, grounding, and weatherproofing, particularly for outdoor installations.

## **Future Trends and Career Opportunities**

Future developments in EV charging include wireless charging, ultra-fast chargers delivering hundreds of kilowatts, and battery swapping systems. These innovations aim to reduce charging time and improve user convenience. The expansion of EV charging infrastructure creates significant career opportunities for electrical engineers in charger design, power electronics, grid integration, software development, and system maintenance.

## **Conclusion**

EV charging infrastructure is a critical component of the global transition to electric transportation. Through advanced power electronics, smart grid integration, and emerging technologies, electrical engineers play a key role in enabling efficient and reliable EV charging. As adoption accelerates, expertise in this field will be increasingly valuable, offering strong prospects for innovation and professional growth.



**Pratiksha Patil**

B. Tech EE IV-Year

Artificial intelligence is rapidly transforming electrical power systems, enabling smarter, more efficient, and more reliable operation. Modern power grids are highly complex, consisting of thousands of generators, transmission lines, substations, and loads operating simultaneously. Managing this complexity exceeds human capability alone, making AI an essential tool for power system planning, operation, and control. For electrical engineering students, understanding AI applications in power systems has become increasingly important.

## Fundamentals of AI and Machine Learning

Artificial intelligence refers to computational techniques that allow machines to perform tasks such as learning, pattern recognition, prediction, and decision making. Machine learning, a major branch of AI, enables systems to improve performance by learning from data rather than relying on fixed rules. Supervised learning uses labeled historical data to predict outcomes such as equipment failures. Unsupervised learning identifies hidden patterns or anomalies in data, which is useful for detecting abnormal consumption or system behavior. Reinforcement learning allows systems to learn optimal control strategies through trial and error, making it suitable for dynamic power system control problems.

## Applications in Power Generation

AI plays a critical role in power generation through predictive maintenance and forecasting. Sensors installed on generators, transformers, and auxiliary equipment continuously measure vibration, temperature, and electrical parameters. AI algorithms analyze these signals to detect early signs of degradation and predict failures before they occur. This approach reduces maintenance costs and prevents unplanned outages. AI is also widely used for load forecasting by analyzing historical demand, weather conditions, and economic activity. Accurate demand forecasts enable utilities to schedule generation efficiently and maintain system reliability. For renewable energy sources such as wind and solar, AI improves generation forecasting by combining meteorological data with historical output patterns, helping operators manage variability.

## Smart Meter and Demand-Side Analytics

The widespread deployment of smart meters has created massive datasets that AI can effectively process. Machine learning algorithms detect electricity theft by identifying abnormal consumption patterns and potential meter tampering. Customer usage data is also analyzed to classify consumers into distinct segments, enabling utilities to design tailored tariffs and energy services. AI-driven demand response programs automatically shift flexible loads to off-peak periods, reducing peak demand and improving grid efficiency.

## Grid Stability and Energy Management

Maintaining grid stability requires continuous balancing of generation and load. AI systems assist with frequency regulation by automatically adjusting generator outputs and controlling energy storage systems. Voltage stability is enhanced through coordinated reactive power control, while transient stability is supported by rapid AI-based responses to disturbances such as faults or generator trips. At the consumer level, AI-based energy management systems optimize HVAC operation, industrial production schedules, and battery usage to minimize energy costs while maintaining comfort and productivity.

## Implementation Challenges

Despite its benefits, integrating AI into power systems presents challenges. High-quality, reliable data is essential for effective AI performance, requiring accurate sensors and robust data infrastructure. Cybersecurity is a major concern, as AI systems may be vulnerable to data manipulation or cyber attacks. Additionally, many AI algorithms operate as “black boxes,” making it difficult for operators to interpret decisions. Ensuring safe integration with existing control systems requires careful validation and engineering.

## Future Outlook and Conclusion

The future of power systems will increasingly rely on AI-driven automation. Autonomous grids capable of self-healing and real-time optimization are emerging as a realistic goal. As distributed energy resources such as rooftop solar, batteries, and electric vehicles proliferate, AI will be essential for coordinating millions of small assets. Electrical engineers who combine power system expertise with AI and data analytics skills will be well prepared for the evolving energy industry. Artificial intelligence is not replacing traditional power engineering knowledge but enhancing it, making AI literacy as important as fundamental circuit and power system theory.



# BEST PROJECT ABSTRACT

## Fighting Robotic Vehicle With Night Vision Camera

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Gaurav More, Nishant Patil, Sachin Lohar, Hariom Patil, Jayant Patil

Firefighting is a hazardous occupation that often requires human firefighters to enter dangerous environments to extinguish fires and conduct rescue operations. To enhance safety and efficiency, the development of firefighting robotic vehicles equipped with advanced technologies has become a focus of research and innovation. This paper presents a firefighting robotic vehicle integrated with a night vision camera, designed to operate in low-visibility conditions and high-temperature environments. The robotic vehicle is equipped with fire detection sensors, thermal imaging, and an autonomous navigation system to locate and extinguish fires effectively. The night vision camera enhances the vehicle's capability to operate in darkness or smoke-filled environments, providing realtime video feedback to operators. The vehicle's design incorporates robust materials and cooling systems to withstand intense heat, ensuring operational continuity during firefighting missions. Through field tests and simulations, the performance of the firefighting robotic vehicle is evaluated, demonstrating its potential to significantly reduce the risks faced by human firefighters and improve the efficiency of fire suppression efforts. This innovation represents a significant advancement in firefighting technology, offering a safer and more effective solution for combating fires in challenging conditions.

# Portable Electric Scooter: An Eco-Friendly Alternative for Urban Transportation

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Patil Sanika, Wagh Divyeshvari, Bhosale Ashwini, Patil Pratiksha, Thakare Manasi

The growth of urban areas and the resulting increase in traffic congestion have prompted the need to investigate sustainable transport options. This research focuses on portable electric scooters as an environmentally friendly alternative for city travel, tackling the issue of excessive greenhouse gas emissions and dependence on fossil fuels in urban settings. The main goal is to assess the efficacy, practicality, and environmental effects of electric scooters in comparison to conventional transportation methods. To accomplish this objective, the study utilized a combination of quantitative and qualitative research methods. Researchers gathered numerical data from user surveys and usage statistics, as well as qualitative insights through interviews with urban commuters. The investigation involved measuring the scooters' energy usage, reduction in carbon footprint, and levels of user satisfaction. Results revealed that portable electric scooters substantially decrease emissions compared to automobiles and motorcycles, while providing a versatile and efficient means of travel for short-distance trips. Moreover, user feedback emphasized the benefits of portability, user-friendliness, and cost-effectiveness as major advantages. Portable electric scooters are becoming a significant eco-friendly alternative for urban transportation, addressing the challenges of traffic congestion and environmental pollution in cities.

These scooters are designed to be lightweight, foldable, and easy to carry, making them highly convenient for urban commuters. They operate on electric power, producing zero emissions, which contributes to cleaner air quality and reduced carbon footprints. Additionally, the cost-effectiveness of electric scooters—lower operational costs compared to traditional vehicles—makes them an attractive option for daily travel. However, their widespread adoption requires the development of supportive infrastructure, such as dedicated lanes and charging stations, as well as effective regulations to ensure safety for both riders and pedestrians. Overall, portable electric scooters present a promising solution for enhancing urban mobility while promoting sustainability.

## Solar Powered Plug-In Electric vehicle

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Rajput Prajakta, Neve Aaditya, Bagad Sanket, Gayatri Girase, Pawar Nayan

A solar powered battery charger is presented, where a photovoltaic (PV) panel is used to convert solar power into electricity and a DC/DC converter is used to control the output power of the PV panel and the charging current for the battery. In the software, an optimal control algorithm is applied to obtain the maximum available power from the sunshine. The simulation and experimental results are presented and compared. The applications of this technique can be light electrical vehicles such as golf carts, scooters, airport utility vehicles, as well as other renewable power stations where batteries are used for energy storage. This presents the design and implementation details of the embedded system to design photovoltaic based battery charger for lead-acid battery. The battery is charged in float charging mode as well as in bulk charging mode. In bulk charging mode perturb and observe maximum power point tracking algorithm is used to charge the battery. Hardware realization of the V-based battery charger has been carried out and is tested in real time scenario. These scooters are designed to be lightweight, foldable, and easy to carry, making them highly convenient for urban commuters. They operate on electric power, producing zero emissions, which contributes to cleaner air quality and reduced carbon footprints. Additionally, the cost-effectiveness of electric scooters—lower operational costs compared to traditional vehicles—makes them an attractive option for daily travel. However, their widespread adoption requires the development of supportive infrastructure, such as dedicated lanes and charging stations, as well as effective regulations to ensure safety for both riders and pedestrians. Overall, portable electric scooters present a promising solution for enhancing urban mobility while promoting sustainability.

# Liquid Cooling System In EV Battery For Fast Charging

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More Vicky, Rajput Devesh, Bachhav Bhavesh, Mujavar Sohel

In order to overcome the thermal management issues related to high-speed charging, this project focused on creating a liquid cooling system for EV charging. Effective heat dissipation is essential for preserving the durability, safety, and efficiency of the battery and the charging infrastructure as EVs continue to grow in popularity.

In order to absorb heat and avoid overheating, the suggested liquid cooling system circulates coolant through the EV charger and battery pack while charging. The method guarantees quicker, more effective charging while lowering the possibility of battery deterioration or charger damage by controlling temperatures within ideal ranges. With a focus on system integration and practical testing, the research investigates important elements such as coolant selection, flow path design, and heat exchange processes. The ultimate goals of this liquid cooling technology are to boost EV performance overall, speed up charging, and improve safety—all of which will contribute to the further expansion of environmentally friendly electric vehicles.



# Cloud Based Electrical Vehicle Battery Monitoring System

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Jaykumar Chavhan, Ankush Karankale, Ganesh Ishi, Sakshi Salunke,  
Trupti Kothavade

The Cloud-Based Electric Vehicle (EV) Battery Monitoring System with Fire Protection and Cooling enhances the safety, performance, and lifespan of lithium-ion phosphate ( $\text{LiFePO}_4$ ) batteries. To maintain ideal conditions, this sophisticated system continually monitors important battery metrics, including voltage, temperature, state of charge (SoC), and state of health (SoH). Equipped with a smart cooling fan, it dynamically manages battery temperature, preventing overheating and mitigating thermal stress. Integrated fire protection mechanisms detect early signs of thermal runaway, ensuring high safety standards. Leveraging cloud technology, real-time data is securely transmitted for remote diagnostics, advanced analytics, and predictive maintenance, enabling early anomaly detection and proactive action. This cloud-enabled system supports efficient energy management, cost savings, and reliable EV performance by delivering critical insights that are accessible anytime, anywhere.





# CONVERGES GLIMPSE

The Electrical Engineering Department successfully hosted three exciting events during Converges'25 on February 27-28, 2025, showcasing innovation, knowledge, and creativity.

**Greenovation (Feb 27)** – A platform where budding innovators presented groundbreaking ideas in green energy. The event witnessed remarkable solutions aimed at shaping a sustainable future.

**BrainCharge (Feb 27)** – A thrilling quiz show inspired by Kaun Banega Crorepati (KBC), where participants put their electrical and general knowledge to the test. The competition was intense, keeping both contestants and the audience engaged.

**ElectroToy (Feb 28)** – A hands-on toy-making competition, where participants showcased their creativity and technical skills by building innovative toys with electrical concepts.

The events saw enthusiastic participation and highlighted the spirit of innovation and technical excellence. Converges'25 was a grand success, leaving participants inspired and motivated for future challenges.







# HACKATHON GLIMPSE

The Department Level Research Convention – Avishkar 2024 was conducted under the Engineering and Technology theme by the Department of Electrical Engineering, R. C. Patel Institute of Technology, Shirpur, on 18th October 2024. The event provided a platform for students and researchers to present their innovative ideas, research outcomes, and technological solutions addressing contemporary engineering challenges.

Participants demonstrated a high level of technical competence, creativity, and analytical thinking through their research work. Their projects reflected strong theoretical understanding combined with practical implementation, highlighting their ability to apply engineering principles to real-world problems. The quality of research, originality of ideas, and clarity of presentation distinguished their work from others.

Their outstanding research contribution and innovative approach set them apart in the competition, showcasing exceptional problem-solving skills and technical excellence. The convention successfully fostered a spirit of research, innovation, and academic excellence among participants, reinforcing the importance of research-driven learning in engineering education.







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