



R. C. PATEL

INSTITUTE OF TECHNOLOGY, SHIRPUR

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Technical Magazine

**DEPARTMENT OF
ELECTRICAL ENGINEERING**

JUNE 2025 – MAY 2026

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 delighted to witness the release of the Electrical Engineering Department Technical Magazine 2026. This publication stands as a remarkable reflection of our department's commitment to academic excellence, technological innovation, research, and collaborative learning.

Through its diverse sections—Student Corner, Faculty Corner, Best Project Abstracts, Converges Glimpse, Hackathon Glimpse, and other insightful contributions—the magazine effectively showcases the intellectual curiosity, creativity, and achievements of our students and faculty members. Each article, project, and accomplishment highlighted within these pages demonstrates the dedication and talent that continue to strengthen our academic community.

As we advance into an era driven by rapid technological transformation, platforms such as this magazine play a vital role in fostering critical thinking, encouraging innovation, and promoting the exchange of knowledge and ideas. Beyond celebrating achievements, it serves as a source of inspiration, motivating readers to explore new possibilities and contribute meaningfully to society through engineering excellence.

I extend my heartfelt appreciation to the editorial team, contributors, student coordinators, and faculty mentors whose hard work, enthusiasm, and vision have made this publication possible. Their collective efforts have created a valuable repository of knowledge and accomplishment that reflects the spirit of our department.

I congratulate everyone involved in bringing this edition to life and wish the magazine continued success in inspiring future generations of engineers. May it continue to grow as a beacon of learning, innovation, and excellence in the years ahead.



Dr. Jayantrao Patil

HOD'S MESSAGE

It gives me immense pleasure to present the Electrical Engineering Department Technical Magazine 2026. This publication is much more than a compilation of articles, projects, and achievements—it is a reflection of our department's collective vision, innovation, and dedication to academic and professional excellence.

The magazine brings together a diverse range of contributions through sections such as Student Corner, Faculty Corner, Best Project Abstracts, Converges Glimpse, Hackathon Glimpse, and other notable departmental activities. These pages showcase the enthusiasm, technical competence, research aptitude, and creative thinking of our students and faculty members, highlighting the vibrant academic environment that defines our department.

As the field of Electrical Engineering continues to evolve with emerging technologies, sustainable solutions, and interdisciplinary innovations, the importance of continuous learning and knowledge sharing becomes increasingly significant. This magazine serves as a valuable platform for exchanging ideas, celebrating achievements, and encouraging innovation among aspiring engineers and educators alike.

The accomplishments featured in this edition are a testament to the hard work, perseverance, and collaborative spirit of our department. They demonstrate our commitment to nurturing talent, promoting research, and preparing students to meet the challenges of an ever-changing technological landscape.

I extend my sincere appreciation to the editorial team, faculty mentors, student contributors, and all those whose dedication and efforts have made this publication possible. Your commitment to excellence has transformed this magazine into a meaningful source of knowledge and inspiration.



Dr. Shailaja Patil

MESSAGE BY EDITORIAL BOARD MEMBERS

We are delighted to present the 2026 edition of the Electrical Engineering Department's Technical Magazine—a platform that celebrates the creativity, innovation, and academic excellence flourishing within our community.

This magazine brings together diverse perspectives through the Student Corner, Faculty Corner, Best Project Abstracts, Converges Glimpse, and Hackathon Glimpse. 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, achievements, and experiences of our students and faculty has been a deeply rewarding experience. We envision this publication as more than an informative resource—it is a source of inspiration, encouraging readers to explore new ideas and push the boundaries of knowledge and innovation.

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

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FACULTY ARTICLES

AI-Native 6G Networks



Mr. Krunal Prakash Rane

Professor – EE

The evolution of wireless communication has continuously reshaped modern society, from voice-centric networks to broadband internet and intelligent connectivity. While 5G deployment continues worldwide, researchers and industry leaders are already developing sixth-generation (6G) communication systems. Unlike previous generations, 6G is being designed with Artificial Intelligence integrated directly into the network architecture. AI-native networks are expected to revolutionize communication by enabling intelligent, adaptive, and autonomous operation.

Beyond Traditional Connectivity

The primary objective of previous wireless generations was to increase data rates and network capacity. While these goals remain important, 6G introduces a broader vision that combines communication, computing, sensing, and artificial intelligence into a unified framework.

Future applications such as holographic communication, digital twins, autonomous transportation, smart factories, and immersive extended reality require networks capable of understanding and adapting to user requirements in real time. AI-native architectures are being developed to meet these demands while optimizing resource utilization and service quality.

AI-Driven Network Management

Modern communication networks generate enormous volumes of operational data. Managing this complexity using conventional rule-based approaches is becoming increasingly difficult. AI-native 6G networks utilize machine learning algorithms to analyze network conditions continuously and make intelligent decisions.

These systems can dynamically allocate spectrum resources, optimize transmission parameters, predict congestion, and improve energy efficiency. Self-optimizing network functions reduce operational complexity while improving reliability and performance.

As a result, communication networks become more responsive to changing user demands and environmental conditions.

Semantic Communication

One of the most promising innovations in 6G is semantic communication. Traditional communication systems focus on transmitting bits accurately from sender to receiver. Semantic communication aims to transmit meaning rather than raw data.

Artificial intelligence enables communication systems to understand context and prioritize information based on importance. This approach significantly reduces bandwidth requirements while improving communication efficiency. Applications such as autonomous vehicles and industrial automation can benefit from faster and more intelligent information exchange.

Integration of Communication and Sensing

Future wireless networks will perform both communication and environmental sensing simultaneously. Advanced radio systems can detect objects, measure distances, monitor movement, and gather environmental information while maintaining data transmission services.

Integrated sensing and communication capabilities support applications such as smart transportation, healthcare monitoring, industrial automation, and public safety systems. This convergence of functions represents a major advancement in wireless network design and functionality.

Distributed Artificial Intelligence

The growing demand for AI applications requires substantial computational resources. AI-native 6G networks support distributed intelligence by enabling processing at edge devices, base stations, and cloud platforms.

Edge intelligence reduces latency by processing data closer to users. This capability is essential for real-time applications including robotics, autonomous systems, and augmented reality. Distributed AI architectures also improve privacy by minimizing the need to transfer sensitive data to centralized servers.

Challenges and Research Opportunities

Several technical challenges must be addressed before large-scale deployment becomes feasible. AI models require significant computational power and energy consumption. Ensuring data privacy, cybersecurity, and model reliability remains a major concern.

Researchers are investigating new spectrum bands, advanced antenna technologies, intelligent radio access networks, and energy-efficient AI algorithms. International standardization efforts are also underway to define the technical framework for future 6G systems.

Future Outlook and Conclusion

AI-native 6G networks represent a paradigm shift in telecommunications engineering. By integrating artificial intelligence directly into network operations, future communication systems will become more intelligent, adaptive, and efficient than ever before. The convergence of communication, sensing, computing, and AI will create new opportunities across industries and society. For electronics and telecommunication engineers, 6G offers exciting prospects for innovation and research as the world moves toward a fully connected intelligent future.

Grid-Forming Inverters: Enabling the Next Generation of Renewable Power Systems



Dr. Yogesh Kalidas Kirange

Associate Professor - EE

As renewable energy penetration continues to increase across global power systems, maintaining grid stability without conventional synchronous generators has emerged as a major engineering challenge. Traditional power systems rely on large rotating generators to establish voltage and frequency references. However, solar photovoltaic systems, battery energy storage systems, and many modern wind turbines connect to the grid through power electronic converters. Grid-forming inverters have emerged as a transformative technology capable of supporting stable operation in power systems with high shares of renewable energy.

Transition from Grid-Following to Grid-Forming Control

Conventional renewable energy inverters operate in grid-following mode, where they synchronize with an existing voltage waveform before injecting power. These inverters depend on strong grid conditions and cannot independently regulate frequency or voltage. As renewable penetration increases and conventional generators retire, this approach becomes increasingly inadequate.

Grid-forming inverters operate differently. Instead of following the grid, they actively establish voltage magnitude and frequency references. This capability allows inverter-based resources to contribute to system stability in a manner similar to traditional synchronous machines. By creating a stable electrical waveform, grid-forming inverters support network operation even under weak-grid conditions.

Virtual Inertia and Frequency Support

One of the most significant challenges associated with renewable integration is the reduction of system inertia. Conventional generators possess large rotating masses that naturally resist sudden frequency changes. Inverter-based renewable systems do not provide physical inertia, resulting in faster frequency deviations following disturbances.

Grid-forming inverters address this issue through advanced control algorithms that emulate the behavior of synchronous generators. Virtual inertia functions enable rapid power adjustments in response to frequency variations. Battery energy storage systems equipped with grid-forming controls can inject power almost instantaneously, helping maintain frequency stability and reducing the risk of cascading failures.

Voltage Regulation and Reactive Power Control

Maintaining voltage stability becomes increasingly complex in power systems dominated by inverter-based resources. Grid-forming inverters provide dynamic reactive power support and voltage regulation capabilities. Through continuous monitoring of network conditions, these systems can adjust power output to compensate for voltage fluctuations.

In distribution networks with high rooftop solar penetration, voltage rise during peak generation periods can create operational difficulties. Grid-forming inverters help mitigate these issues by controlling reactive power flow and supporting local voltage regulation. This capability reduces dependence on traditional voltage-control equipment and improves overall system flexibility.

Black Start Capability

Power system restoration following large-scale outages traditionally depends on specially equipped thermal or hydroelectric generating stations. Grid-forming inverters are introducing new possibilities for black start operations. Energy storage systems equipped with advanced inverter controls can establish voltage and frequency without external support, enabling gradual restoration of electrical networks.

This capability is particularly valuable for remote microgrids, islanded systems, and renewable-dominated power networks. The ability to restore service quickly improves resilience and reduces outage impacts on consumers and critical infrastructure.

Applications in Microgrids and Renewable Energy Systems

Microgrids are increasingly being deployed in industrial facilities, campuses, military installations, and remote communities. These systems often operate with significant renewable energy penetration and require advanced control strategies to maintain stability.

Grid-forming inverters provide seamless transitions between grid-connected and islanded operation. They coordinate multiple distributed energy resources while maintaining voltage and frequency stability. As renewable deployment accelerates, these inverters are expected to become a fundamental component of future microgrid architectures.

Technical Challenges and Future Developments

Despite their advantages, several technical challenges remain. Coordinating multiple grid-forming inverters within large interconnected networks requires sophisticated control strategies. Protection systems must also evolve to accommodate inverter-dominated grids where fault current characteristics differ significantly from conventional systems.

Researchers are actively developing standardized control approaches, improved communication architectures, and advanced stability assessment techniques. Ongoing demonstration projects worldwide are validating the performance of grid-forming technologies under real operating conditions.

Future Outlook and Conclusion

Grid-forming inverters represent one of the most important innovations in modern power systems. Their ability to provide virtual inertia, voltage regulation, black start capability, and grid stability support makes them essential for future renewable-dominated electricity networks. As countries pursue decarbonization goals and renewable energy deployment continues to expand, grid-forming inverter technology will play a critical role in ensuring reliable, resilient, and sustainable power system operation.

Artificial Intelligence in Smart Grid Management: Revolutionizing Modern Power Systems



Mr. Krunalkumar Gandhi

Assistant Professor - EE

The electrical power sector is undergoing a significant transformation driven by the integration of renewable energy, digital technologies, and distributed energy resources. As power systems become increasingly complex, traditional methods of grid operation are no longer sufficient to ensure optimal performance. Artificial Intelligence (AI) has emerged as a powerful tool that enables utilities to manage modern power systems more efficiently, reliably, and sustainably. By leveraging machine learning, data analytics, and intelligent automation, AI is reshaping the future of smart grid management.

Growth of Data-Driven Power Systems

Modern power grids generate enormous amounts of data through smart meters, sensors, supervisory control systems, and communication networks. Managing and interpreting this data manually is both time-consuming and inefficient. AI algorithms can process vast datasets in real time, identifying patterns and trends that would be difficult for human operators to detect.

Machine learning models continuously analyze historical and real-time data to improve system performance. These capabilities allow utilities to make informed decisions, reduce operational costs, and enhance overall grid reliability.

Predictive Maintenance and Asset Management

One of the most valuable applications of AI in power systems is predictive maintenance. Conventional maintenance practices rely on fixed schedules or corrective actions after failures occur. AI-based systems monitor equipment conditions continuously using sensor data from transformers, circuit breakers, generators, and transmission lines.

Advanced algorithms can identify early signs of equipment deterioration and predict potential failures before they occur. This proactive approach reduces unplanned outages, extends equipment lifespan, and lowers maintenance costs. Utilities can allocate resources more effectively while improving service reliability.

Demand Forecasting and Load Management

Accurate demand forecasting is essential for maintaining the balance between electricity generation and consumption. AI models utilize weather conditions, historical consumption patterns, economic indicators, and consumer behavior data to predict future electricity demand with high accuracy.

Improved forecasting enables utilities to optimize generation scheduling and reduce operating reserves. During peak demand periods, AI-powered demand response programs encourage consumers to shift electricity usage, reducing strain on the grid and improving overall efficiency.

Renewable Energy Integration

The increasing adoption of solar and wind energy introduces variability and uncertainty into power system operation. AI plays a critical role in forecasting renewable energy generation by analyzing meteorological data and environmental conditions.

Accurate forecasting improves scheduling decisions and reduces the need for costly reserve generation. AI also supports real-time coordination of distributed energy resources, enabling greater penetration of renewable energy while maintaining grid stability.

Fault Detection and System Restoration

Power system faults can lead to widespread service interruptions if not detected and isolated quickly.

AI-based monitoring systems continuously analyze voltage, current, and frequency measurements to identify abnormal operating conditions. Machine learning algorithms can locate faults with high precision and recommend corrective actions. During outages, AI assists operators in restoring service efficiently by identifying optimal switching sequences and resource allocation strategies. These capabilities significantly improve system resilience and reduce downtime.

Cybersecurity and Grid Protection

As power systems become increasingly digitalized, cybersecurity has become a critical concern. AI-based security systems monitor network activity continuously and detect suspicious behavior that may indicate cyber threats.

Advanced anomaly detection algorithms identify unauthorized access attempts, malware activity, and communication irregularities. By responding rapidly to potential threats, AI helps protect critical infrastructure and maintain the integrity of power system operations.

Future Outlook and Conclusion

Artificial Intelligence is transforming the way modern power systems are designed, operated, and maintained. Applications such as predictive maintenance, renewable energy forecasting, demand management, fault detection, and cybersecurity demonstrate the immense potential of AI in smart grid environments. As electrical utilities continue their digital transformation journey, AI will become an indispensable tool for achieving greater efficiency, reliability, and sustainability. Future power engineers will play a crucial role in integrating intelligent technologies that enable smarter and more resilient electricity networks.

AI-Powered Humanoid Robots: Shaping the Future of Industry 5.0



Mr. Karan Ashok Jalwani

Assistant Professor - EE

Recent advancements in artificial intelligence, machine learning, computer vision, and robotics have accelerated the development of humanoid robots capable of performing increasingly sophisticated tasks. Unlike traditional industrial robots that operate within predefined environments, modern humanoid robots are designed to work alongside humans, adapt to changing conditions, and make intelligent decisions. As Industry 5.0 emphasizes human-centric automation and collaboration, AI-powered humanoid robots are emerging as a transformative technology across manufacturing, logistics, healthcare, and service sectors.

Evolution of Humanoid Robotics

Early humanoid robots were primarily research platforms with limited capabilities and restricted applications. Recent breakthroughs in artificial intelligence have dramatically improved robotic perception, mobility, and decision-making.

Modern humanoid robots use advanced sensors, cameras, force-feedback systems, and AI algorithms to interpret their surroundings. These systems enable robots to recognize objects, understand instructions, navigate complex environments, and interact safely with people.

Artificial Intelligence as the Driving Force

Artificial intelligence serves as the foundation of next-generation humanoid robots. Machine learning algorithms allow robots to learn from experience and improve performance over time. Computer vision systems enable real-time object recognition, environmental mapping, and obstacle avoidance.

Natural language processing allows robots to communicate with humans using conversational language. These capabilities make human-robot collaboration more intuitive and effective, particularly in dynamic workplace environments.

Applications in Manufacturing and Logistics

Manufacturing facilities increasingly require flexible automation capable of handling diverse tasks. Humanoid robots can perform assembly operations, material handling, quality inspection, and equipment support activities. Their human-like design enables them to utilize existing tools and operate within infrastructure originally designed for people.

In logistics environments, humanoid robots assist with inventory management, warehouse operations, package sorting, and transportation tasks. Their ability to adapt to changing workflows provides advantages over conventional automation systems.

Human-Robot Collaboration

Industry 5.0 focuses on combining human creativity with machine efficiency. Humanoid robots are designed to support workers rather than replace them entirely. Collaborative robots assist with repetitive, physically demanding, or hazardous tasks while allowing humans to focus on complex decision-making and innovation.

Advanced safety systems continuously monitor human presence and adjust robot behavior accordingly. This collaborative approach improves productivity while maintaining workplace safety.

Healthcare and Service Applications

Beyond industrial environments, humanoid robots are finding applications in healthcare and service industries. Robots assist medical personnel by transporting supplies, supporting rehabilitation programs, and providing patient interaction services.

In customer service environments, humanoid robots serve as information assistants, receptionists, and educational guides. Their ability to communicate naturally enhances user experience and expands potential applications.

Technical Challenges

Despite rapid progress, several technical challenges remain. Battery technology limits operating duration, while complex environments require highly reliable perception systems. Ensuring safe operation around humans remains a critical design consideration.

Researchers continue developing improved actuators, energy-efficient control systems, advanced AI models, and more capable sensing technologies. These advancements are expected to enhance performance and expand deployment opportunities.

Future Outlook and Conclusion

AI-powered humanoid robots represent a significant milestone in the evolution of intelligent automation. Their ability to learn, adapt, collaborate, and operate in human environments makes them a key technology for Industry 5.0. As artificial intelligence and robotics continue to advance, humanoid robots will become increasingly capable and accessible across diverse sectors. For engineers and researchers, this rapidly evolving field offers exciting opportunities to shape the future of automation, productivity, and human-machine collaboration.

Solid-State Transformers: Advancing the Future of Smart Power Distribution



Mr. Sachin Sayais

Associate Professor - EE

The modernization of electrical power systems requires technologies capable of supporting renewable energy integration, electric vehicle charging infrastructure, and intelligent grid operation. Conventional transformers have served power systems reliably for decades; however, they offer limited controllability and monitoring capabilities. Solid-State Transformers (SSTs) have emerged as a promising innovation that combines power electronics, digital control, and high-frequency transformers to create more flexible and efficient power distribution systems.

Limitations of Conventional Transformers

Traditional transformers perform voltage conversion through electromagnetic induction and operate at power-line frequencies. Although highly reliable, they are large, heavy, and unable to actively control power flow. Modern electrical networks require dynamic voltage regulation, bidirectional power transfer, and real-time monitoring capabilities that conventional transformers cannot easily provide.

The growing adoption of distributed energy resources and electric vehicles further increases the need for advanced power conversion technologies capable of supporting intelligent grid operation.

Working Principle of Solid-State Transformers

Solid-State Transformers utilize power electronic converters and high-frequency isolation transformers instead of conventional low-frequency magnetic cores. Incoming AC power is first converted into DC, processed through high-frequency conversion stages, and then converted back to AC at the required voltage level.

This architecture enables precise control of voltage, current, and power flow. Advanced digital controllers continuously monitor operating conditions and optimize system performance in real time.

Enhanced Grid Flexibility

One of the primary advantages of SSTs is their ability to support bidirectional power flow. Traditional distribution systems were designed for one-way electricity transfer from generation sources to consumers. Modern grids increasingly require two-way power exchange as consumers install rooftop solar systems and energy storage devices.

Solid-State Transformers facilitate seamless integration of distributed generation by actively managing power flow between consumers and the grid. This capability improves system flexibility and supports the development of decentralized energy networks.

Voltage Regulation and Power Quality

Voltage regulation is becoming increasingly challenging as renewable energy penetration grows. SSTs provide fast and accurate voltage control through advanced power electronic converters. These systems can compensate for voltage fluctuations and improve overall power quality.

In addition, SSTs help mitigate harmonics, voltage sags, and other power quality disturbances. Improved power quality benefits industrial facilities, data centers, and sensitive electronic equipment that require stable electrical supply conditions.

Electric Vehicle Charging Applications

The rapid expansion of electric vehicle infrastructure presents new challenges for power distribution networks. High-power charging stations require efficient voltage conversion and flexible control capabilities.

Solid-State Transformers enable direct integration of DC charging systems while reducing conversion losses. Their compact design and intelligent control features make them particularly suitable for future fast-charging networks and transportation electrification initiatives.

Integration with Smart Grids

Modern smart grids require real-time monitoring and communication capabilities. SSTs incorporate advanced sensing, control, and communication functions that enable seamless integration with digital grid management systems.

Operators can remotely monitor transformer performance, detect abnormalities, and optimize power distribution using intelligent control platforms. These capabilities contribute to improved reliability and reduced maintenance requirements.

Challenges and Future Developments

Despite their advantages, widespread adoption of SSTs faces several challenges. High manufacturing costs, thermal management requirements, and power electronic reliability remain areas of ongoing research. Engineers are developing advanced semiconductor materials such as silicon carbide and gallium nitride to improve efficiency and reduce costs.

As technology matures, economies of scale and continued innovation are expected to accelerate commercial deployment across utility and industrial applications.

Future Outlook and Conclusion

Solid-State Transformers represent a major advancement in electrical power distribution technology. Their ability to provide intelligent control, bidirectional power flow, improved power quality, and seamless renewable energy integration makes them a key component of future smart grids. As electrical networks continue to evolve toward greater digitalization and sustainability, SSTs are expected to play a vital role in enabling reliable and efficient power delivery for next-generation energy systems.





STUDENT'S ARTICLES

Electric Vehicles and Their Impact on Modern Power Systems



Arti Balasaheb Patil

B. Tech EE IV-Year

The transportation sector is undergoing a major transformation with the rapid adoption of Electric Vehicles (EVs). Governments worldwide are encouraging electric mobility to reduce carbon emissions, decrease dependence on fossil fuels, and improve environmental sustainability. While EVs offer numerous benefits, their increasing penetration presents significant challenges and opportunities for electrical power systems. Engineers must develop innovative solutions to ensure reliable integration of EV charging infrastructure into existing electrical networks.

Growth of Electric Vehicle Adoption

Advancements in battery technology, government incentives, and growing environmental awareness have accelerated EV adoption across the world. Modern electric vehicles provide improved driving range, faster charging capabilities, and lower operating costs compared to conventional internal combustion engine vehicles.

As EV ownership continues to rise, electricity demand from charging stations is expected to increase significantly. This growing demand requires careful planning of generation, transmission, and distribution infrastructure to support future charging requirements.

Impact on Distribution Networks

Most EV charging occurs at residential and commercial locations connected to distribution networks. Simultaneous charging during peak hours can increase transformer loading and create voltage fluctuations. Local distribution systems designed for conventional load patterns may experience congestion if large numbers of EVs charge simultaneously.

Utilities are studying charging behavior to identify potential impacts on network performance. Smart charging strategies are being developed to distribute charging demand more evenly and reduce stress on electrical infrastructure.

Smart Charging Technologies

Smart charging systems use communication and control technologies to optimize charging schedules. These systems can adjust charging rates based on grid conditions, electricity prices, and renewable energy availability.

During periods of high demand, charging can be delayed or reduced to prevent overloading. Conversely, charging can be encouraged during off-peak periods when excess generation capacity is available. Smart charging improves grid efficiency while reducing electricity costs for consumers.

Vehicle-to-Grid Technology

One of the most promising innovations in electric mobility is Vehicle-to-Grid (V2G) technology. V2G systems allow electric vehicles to return stored energy back to the grid when required. EV batteries effectively become distributed energy storage resources capable of supporting grid operations.

During peak demand periods, connected vehicles can supply electricity to the grid. This capability improves system flexibility, supports renewable energy integration, and provides additional revenue opportunities for vehicle owners.

Renewable Energy Integration

Electric vehicles and renewable energy systems complement each other effectively. Solar and wind generation often produce excess energy during certain periods of the day. EV charging can utilize this surplus energy, improving renewable energy utilization and reducing curtailment.

Advanced charging management systems coordinate EV charging with renewable generation patterns. This integration contributes to cleaner transportation and more sustainable energy systems.

Challenges and Future Developments

Several challenges remain in large-scale EV integration. Fast charging stations require substantial power capacity and may create localized network stress. Battery degradation, charging infrastructure costs, and standardization issues also require attention.

Researchers are developing advanced battery technologies, wireless charging systems, and intelligent energy management solutions. Continued investment in charging infrastructure will support widespread EV adoption.

Future Outlook and Conclusion

Electric vehicles represent a major step toward sustainable transportation. Their successful integration into electrical power systems requires coordinated efforts in infrastructure development, smart charging, and energy management. As EV adoption continues to grow, electrical engineers will play a crucial role in designing efficient and reliable charging networks that support future mobility needs while maintaining grid stability and sustainability.



Piyush Chaudhari

B. Tech EE IV-Year

The Internet of Things (IoT) has emerged as one of the most influential technologies of the modern era. By connecting devices, sensors, and control systems through communication networks, IoT enables intelligent monitoring and management of various processes. In the energy sector, IoT plays a crucial role in improving efficiency, reducing wastage, and supporting smart grid development. The integration of IoT technologies is transforming the way electricity is generated, distributed, and consumed.

Understanding IoT Technology

The Internet of Things refers to a network of interconnected devices capable of collecting, transmitting, and processing data. Sensors installed in electrical equipment continuously monitor parameters such as voltage, current, temperature, and energy consumption.

This data is transmitted to centralized platforms where it is analyzed and used to make informed decisions. Real-time visibility into system performance enables better management of electrical resources.

Smart Metering Systems

One of the most common applications of IoT in power systems is smart metering. Smart meters automatically record electricity consumption and communicate data to utilities without manual intervention.

Consumers gain access to detailed information regarding their energy usage patterns. This awareness encourages efficient electricity consumption and supports energy conservation initiatives. Utilities benefit from improved billing accuracy and enhanced demand forecasting capabilities.

Energy Monitoring and Control

IoT-based energy management systems allow continuous monitoring of energy consumption in residential, commercial, and industrial facilities. Smart sensors identify inefficient equipment and unnecessary energy usage.

Automated control systems can switch off unused loads, regulate lighting, and optimize HVAC operation.

These capabilities significantly reduce electricity consumption while improving operational efficiency.

Role in Smart Grids

Smart grids rely heavily on IoT technologies to facilitate communication between various components of the electrical network. Sensors installed throughout the grid monitor equipment condition and system performance.

Real-time information enables rapid fault detection, voltage regulation, and load balancing. Utilities can respond quickly to disturbances and maintain reliable service. IoT also supports integration of distributed energy resources such as solar panels and battery storage systems.

Predictive Maintenance Applications

— Electrical equipment failures can lead to costly outages and operational disruptions. IoT sensors continuously monitor equipment health and detect abnormal conditions before failures occur.

Predictive maintenance systems analyze collected data to identify potential issues and recommend maintenance actions. This proactive approach reduces downtime, lowers maintenance costs, and improves system reliability.

Challenges and Security Concerns

Despite numerous advantages, IoT deployment introduces cybersecurity challenges. Connected devices may become vulnerable to unauthorized access or cyberattacks. Ensuring secure communication and data protection is essential for reliable operation. Other challenges include interoperability, data management, and infrastructure investment requirements. Engineers must address these concerns while developing scalable IoT solutions.

Future Outlook and Conclusion

The Internet of Things is revolutionizing energy management by enabling intelligent monitoring, automation, and decision-making. Applications such as smart metering, predictive maintenance, and smart grid operation demonstrate its growing importance in the electrical sector. As technology continues to advance, IoT will play an increasingly significant role in creating efficient, reliable, and sustainable energy systems. Future electrical engineers will be at the forefront of implementing these technologies and shaping the next generation of smart energy networks.



Rutuja Mali

B. Tech EE IV-Year

The global transition toward clean energy has increased interest in alternative fuels capable of reducing greenhouse gas emissions. Among various emerging technologies, green hydrogen has gained significant attention as a promising solution for decarbonizing power generation, transportation, and industrial processes. Produced using renewable energy sources, green hydrogen offers the potential to store energy, support grid stability, and contribute to a sustainable energy future.

Hydrogen as an Energy Carrier

Hydrogen is the most abundant element in the universe and possesses a high energy content per unit mass. Unlike conventional fuels, hydrogen does not emit carbon dioxide during utilization. When used in fuel cells, hydrogen combines with oxygen to produce electricity, water, and heat.

Hydrogen serves as an energy carrier rather than a primary energy source. It must be produced using various methods before it can be utilized in practical applications.

Production of Green Hydrogen

Hydrogen can be produced through several techniques. Green hydrogen is generated by electrolysis, where water is split into hydrogen and oxygen using electricity derived from renewable sources such as solar and wind power.

Because renewable electricity powers the process, green hydrogen production generates minimal environmental impact. This characteristic distinguishes it from grey and blue hydrogen production methods that rely on fossil fuels.

Energy Storage Applications

One of the major challenges associated with renewable energy is intermittency. Solar and wind generation fluctuate depending on weather conditions, creating difficulties in balancing supply and demand.

Green hydrogen provides a solution by storing excess renewable energy during periods of high generation. The stored hydrogen can later be converted back into electricity using fuel cells or gas turbines when demand increases. This capability supports grid flexibility and long-term energy storage.

Industrial and Transportation Applications

Several industrial sectors require high-temperature processes that are difficult to electrify directly. Green hydrogen offers a clean alternative for industries such as steel manufacturing, chemical production, and refining.

The transportation sector is also exploring hydrogen-powered vehicles, particularly for heavy-duty applications where battery-based solutions may face limitations. Fuel-cell vehicles provide long driving ranges and rapid refueling capabilities.

Challenges in Hydrogen Deployment

Despite its potential, green hydrogen faces several challenges. Electrolysis systems remain relatively expensive, and large-scale production requires substantial renewable energy capacity. Transportation and storage of hydrogen also present technical difficulties due to its low volumetric energy density.

Researchers are working to improve electrolyzer efficiency, reduce production costs, and develop safer storage technologies. Government support and industrial investments are accelerating progress in this field.

Future Outlook and Conclusion

Green hydrogen is emerging as an important component of future sustainable energy systems. Its ability to store renewable energy, support industrial decarbonization, and enable clean transportation makes it a versatile energy carrier. As technological advancements continue and production costs decline, green hydrogen is expected to play a significant role in achieving global climate and energy goals. Electrical engineers will contribute to the development of hydrogen infrastructure and renewable energy systems that support a cleaner and more sustainable future.

Digital Twins in Smart Power Systems: A New Era of Intelligent Grid Management



Bhagawat Girase

B. Tech EE IV-Year

The rapid digitalization of the power sector has introduced innovative technologies that enhance the planning, operation, and maintenance of electrical systems. Among these advancements, Digital Twin technology has emerged as a powerful tool for improving the reliability and efficiency of modern power networks.

A digital twin is a virtual representation of a physical asset, system, or process that continuously receives real-time data from the actual system. By combining simulation, data analytics, and artificial intelligence, digital twins enable utilities to monitor performance, predict failures, and optimize decision-making.

Understanding Digital Twin Technology

A digital twin creates a dynamic digital model of physical equipment such as transformers, generators, substations, transmission lines, or even entire power systems. Sensors installed on physical assets collect operational data including voltage, current, temperature, vibration, and loading conditions.

This information is transmitted to the digital model, where advanced algorithms continuously analyze system behavior. Unlike conventional simulation models, digital twins update in real time, accurately reflecting the current operating state of the physical system.

Applications in Power Generation

Power generation facilities require continuous monitoring to maintain efficiency and reliability. Digital twins enable operators to assess equipment performance under various operating conditions without disrupting actual operations.

For example, a digital twin of a turbine generator can predict performance degradation, identify maintenance requirements, and optimize operating parameters. By analyzing historical and real-time data, operators can improve efficiency while reducing unexpected downtime and maintenance costs.

Smart Grid Monitoring and Control

Modern smart grids contain numerous interconnected components that require constant supervision. Digital twin technology provides a comprehensive view of grid operation by integrating data from substations, renewable energy sources, energy storage systems, and consumer loads.

Operators can simulate different scenarios, evaluate network responses, and implement corrective actions before problems occur. This capability improves grid reliability and enhances the management of increasingly complex power systems.

Predictive Maintenance and Asset Management

One of the most valuable benefits of digital twins is predictive maintenance. Traditional maintenance approaches often rely on fixed schedules that may not accurately reflect equipment condition.

Digital twins continuously assess asset health using real-time operational data. Machine learning algorithms identify abnormal behavior and estimate remaining useful life. Maintenance activities can therefore be scheduled based on actual equipment condition, reducing costs and preventing unexpected failures.

Renewable Energy Integration

Renewable energy sources introduce variability and uncertainty into power system operation. Digital twins help utilities manage renewable integration by simulating generation patterns, forecasting system performance, and optimizing resource utilization.

For solar and wind farms, digital twins monitor environmental conditions and equipment performance simultaneously. These capabilities improve energy forecasting accuracy and enhance operational efficiency.

Role of Artificial Intelligence

Artificial intelligence significantly enhances the capabilities of digital twins. AI algorithms analyze large volumes of operational data, identify trends, and generate predictive insights.

Advanced machine learning models can detect hidden patterns that may indicate future equipment failures or operational inefficiencies. The combination of AI and digital twins enables intelligent decision-making and automated system optimization.

Challenges and Future Developments

— Despite its advantages, implementing digital twin technology requires substantial investment in sensors, communication infrastructure, and data management systems. Cybersecurity is another important concern, as digital twins depend heavily on continuous data exchange.

Researchers are developing more sophisticated modeling techniques, cloud-based platforms, and AI-driven analytics to improve digital twin performance. As computing capabilities continue to advance, adoption across the power industry is expected to increase significantly.

Future Outlook and Conclusion

Digital twin technology is transforming the management of modern power systems by enabling real-time monitoring, predictive maintenance, and intelligent decision-making. Its applications in generation, transmission, distribution, and renewable energy integration demonstrate its immense potential. As electrical networks become increasingly digital and interconnected, digital twins will play a crucial role in improving efficiency, reliability, and sustainability. For future electrical engineers, understanding digital twin technology will be essential for developing and operating next-generation smart power systems.

Artificial Intelligence and Machine Learning for Predictive Maintenance in Electrical Utilities



Kamini Rajput

B. Tech EE IV-Year

Electrical utilities manage extensive networks of power generation equipment, substations, transformers, transmission lines, and distribution systems. Ensuring reliable operation of these assets is critical for maintaining uninterrupted electricity supply. Traditional maintenance practices are often based on fixed schedules or reactive repairs after failures occur. Recent advancements in Artificial Intelligence (AI) and Machine Learning (ML) have enabled predictive maintenance strategies that improve reliability, reduce operational costs, and enhance asset performance.

Evolution of Maintenance Strategies

Maintenance approaches have evolved significantly over the years. Corrective maintenance involves repairing equipment only after a failure occurs, often resulting in service interruptions and increased costs. Preventive maintenance reduces risk by scheduling inspections and repairs at regular intervals, regardless of equipment condition.

Predictive maintenance represents the next stage of development. By continuously monitoring equipment health and analyzing operational data, utilities can identify potential failures before they occur. This approach enables timely intervention and more efficient resource utilization.

Role of Artificial Intelligence

Artificial Intelligence provides the capability to process large volumes of operational data collected from electrical assets. Sensors installed on transformers, circuit breakers, generators, and transmission equipment continuously measure parameters such as temperature, vibration, insulation condition, oil quality, and electrical loading.

AI algorithms analyze this information to identify abnormal patterns that may indicate equipment deterioration. The ability to detect subtle changes in operating behavior allows utilities to respond proactively to emerging issues.

Machine Learning Techniques

Machine Learning enables systems to learn from historical data and improve prediction accuracy over time.

Supervised learning algorithms are trained using records of past equipment failures and operating conditions. These models can then predict the likelihood of future failures based on current data.

Unsupervised learning techniques identify unusual behavior without requiring labeled datasets. This capability is particularly useful when failure records are limited or when new types of equipment are introduced into the network.

Transformer Health Monitoring

Power transformers are among the most critical and expensive assets in electrical networks. Unexpected transformer failures can result in significant financial losses and service disruptions.

AI-powered monitoring systems analyze dissolved gas analysis results, temperature trends, and loading conditions to assess transformer health. Predictive models estimate remaining equipment life and provide early warning of potential failures, allowing utilities to plan maintenance activities effectively.

Transmission and Distribution Applications

Transmission lines and distribution networks cover vast geographical areas, making manual inspection challenging and costly. AI-assisted monitoring systems utilize sensors, drones, and image-processing techniques to assess equipment condition.

Machine learning algorithms can detect damaged insulators, conductor defects, vegetation encroachment, and structural abnormalities. These technologies improve inspection efficiency and enhance system reliability.

Benefits of Predictive Maintenance

Predictive maintenance offers numerous advantages for utilities. Early fault detection reduces equipment failures and minimizes service interruptions. Maintenance activities can be scheduled efficiently, reducing labor and operational costs.

Improved asset utilization extends equipment lifespan while enhancing overall system reliability. Predictive maintenance also supports better investment planning by providing accurate information regarding asset condition and replacement requirements.

Challenges and Future Directions

Successful implementation of AI-based predictive maintenance requires high-quality data, reliable communication systems, and robust cybersecurity measures. Developing accurate predictive models for diverse operating conditions remains a significant challenge.

Researchers continue to improve machine learning algorithms, sensor technologies, and data analytics platforms. Integration with digital twins and advanced smart grid systems is expected to further enhance predictive maintenance capabilities.

Future Outlook and Conclusion

Artificial Intelligence and Machine Learning are transforming maintenance practices within electrical utilities. By enabling early fault detection, condition-based maintenance, and intelligent asset management, these technologies improve reliability and reduce operational costs. As power systems become increasingly digitalized, predictive maintenance will become a fundamental component of utility operations. Future electrical engineers will play a key role in developing and implementing intelligent maintenance solutions that ensure the efficient and reliable operation of modern electrical networks.





BEST PROJECT ABSTRACT

Modeling and Integration of Microgrid Based on V2G/G2V Methodology

Marathe Anjali, Mali Rutuja, Nevad Karan, Patil Arti, Mali Bhumika

The concept of the project Modeling and Integration of Microgrid based on V2G-G2V Methodology is that electric cars will no longer be utilized only in transport. However, as a storage mechanism of energy also. In the modern world, where the consumption of renewable is taking place, with the increasing use of alternative sources of energy like solar and wind, the traditional power grid is becoming problematic as fluctuation in power, wastage of energy and lack of proper storage. To solve these problems, our project is devoted to the development of the system that will enable the flow of power in two directions – the grid to the vehicle (G2V) and vice versa, the vehicle to the grid (V2G).

Under this system EVs will be charged in the off-peak hours or when renewable energy is available, and they can inject power back to the grid or domestic loads during power cuts or peak demand. Such elements as the bidirectional charger are used in the model, along with a BMS, inverters and smart controller which controls safe and efficient flow of energy.

The project will assist in sustaining grid stability, lowering cost of electricity and making more effective use of renewable energy. It also demonstrates that EVs can be used as mobile energy banks to help communities and homes in case of an emergency. All in all, our system supports clean energy, smart power management, and contributes to India's vision of sustainable and green energy solutions.

Vital Vault: The Smart Blood Storage System

Bhagawat Girase, Dipali Potdar, Om Sonawane, Nikita Girase, Jayesh Patil

Wastage of blood is a perennial issue in health facilities due to inadequate stock control and the lack of real-time monitoring systems. These inefficiencies tend to lead to expiry or mismanagement of blood units, resulting in shortages and higher operational costs. This paper presents Vital-Vault, a smart, compact blood storage unit that incorporates RFID-based tracking, real-time monitoring, and automated expiry notifications. The designed system improves traceability, enhances blood resource efficiency, and reduces wastage with timely alerts. This paper focuses on the pitfalls of conventional storage of blood, outlines the Vital-Vault system architecture, and evaluates its feasibility to improve patient care and health system efficiency.



Design and Development of a Portable 3-Lead ECG Device with Mobile Integration for Cardiac Monitoring and Early Detection of Cardiovascular Diseases

Ravandale Dhiraj, Waswani Sumit, Sonawane Nishant, Patil Nayan

Electrocardiography (ECG) is the basic foundation tool in diagnosis and detection of cardiovascular disease. From the last couple of decades, the ECG world has been frequently developing from bulky, medical grade machines towards portable, pocket-friendly, wearable and AI-assisted devices.

This paper marks the journey of all the major advancements in ECG devices and cardiovascular disease diagnosis and detection technology, centering on innovations in wearable technologies, with advancement in analog circuits. This also has the flavors of AI and ML integration with the devices.

This paper reviews recent developments in ECG technology, analyzes the strengths and shortcomings of existing approaches, and highlights research gaps. The findings indicate that although modern ECG devices are more accessible and cost-effective, several issues - such as motion artifacts, electrode stability, long-term data reliability, and embedded AI performance - remain unsolved.



IOT-Based Automatic Power Factor Correction System

Badgujar Yukta, Pranav Jagtap, Dinesh Wadile, Mahendra Mahajan,
Nilesh Magar

In modern industrial and commercial systems, maintaining a high power factor is crucial for efficient energy utilization and reducing electricity costs. This project presents an IoT-based Automatic Power Factor Correction (APFC) method that continuously monitors the power factor of a system in real-time and dynamically corrects it by switching appropriate capacitor banks.

The integration of IoT technology enables remote monitoring, data logging, and performance analysis through a cloud-based platform. Using sensors to measure voltage and current parameters, a microcontroller calculates the power factor and automatically activates correction mechanisms. The system improves energy efficiency, minimizes penalty charges due to low power factor, and provides real-time access to data for proactive energy management.

The proposed solution is cost-effective, scalable, and highly beneficial for industries, commercial establishments, and large residential buildings aiming for smart and sustainable energy solutions.



Multifunctional Mini E-Farming Vehicle

Nikumbh Vaishnavi, Shisode Gaurav, Sutar Shivam, Nikam Mahesh,
Sonawane Vaishnav

India's agricultural sector continues to face persistent challenges, including outdated farming methods, labor shortages, expensive machinery, and heavy reliance on diesel fuel. Conventional diesel-powered tractors not only increase operational costs but also contribute to soil compaction, degradation, and inefficient energy consumption.

Additionally, farmers often endure physical strain from manually transporting heavy water containers for fertilizer application, which can lead to health problems and added financial stress. A promising solution is the development of a multifunctional mini electric vehicle (EV) tractor, an affordable and versatile system that integrates seed sowing, ploughing, and fertilizer spraying into a single platform.

This innovation reduces fuel dependency, minimizes environmental impact, and alleviates farmers' physical workload. Compared with diesel tractors, the electric-powered system offers lower operating costs, zero emissions, and reduced soil compaction. Designed to support farmers of all economic levels, from smallholders to commercial producers, this technology promotes sustainable and efficient farming practices.

By improving productivity, reducing expenses, and enhancing farmers' overall well-being, the multifunctional mini EV tractor represents a transformative step toward a resilient and sustainable agricultural future in India.



CONVERGES GLIMPSE

The Department of Electrical Engineering successfully organized two exciting events during Converges'26 on 06th and 07th March 2026, providing students with a platform to showcase their knowledge, creativity, and technical skills.

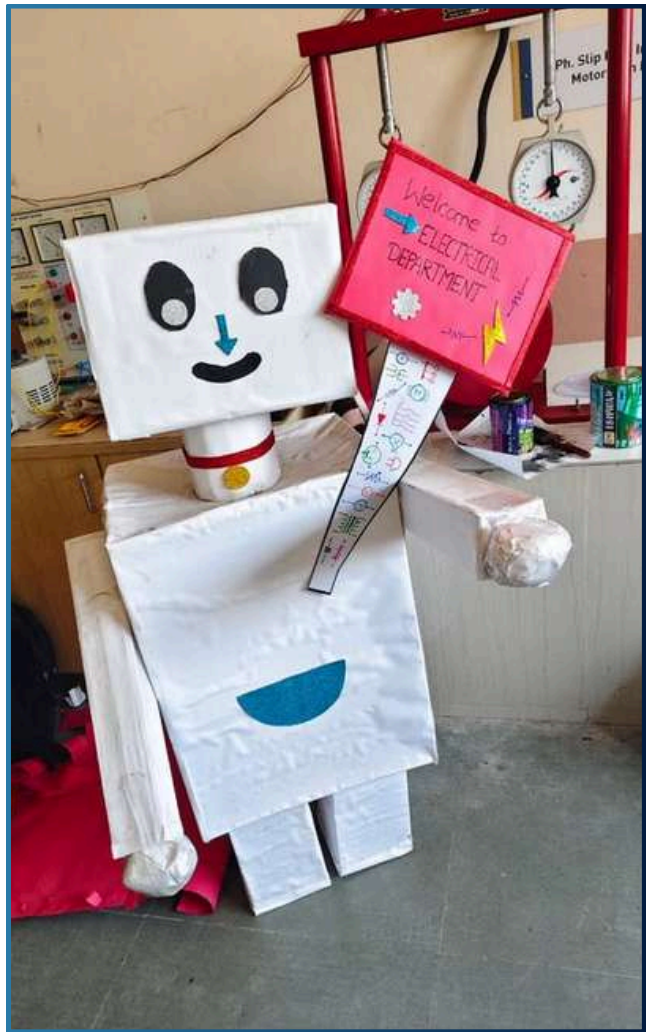
BrainCharge (06 March 2026) – An engaging quiz competition inspired by the popular format of Kaun Banega Crorepati (KBC), where participants tested their knowledge of electrical engineering, science, technology, and current affairs. The event witnessed enthusiastic participation, intense competition, and active audience involvement throughout the rounds.

ElectroToy (07 March 2026) – A hands-on toy-making competition that encouraged participants to combine creativity with engineering concepts. Students designed and developed innovative toys incorporating electrical principles, demonstrating their imagination, practical skills, and problem-solving abilities.

Both events received an overwhelming response from participants and spectators alike, reflecting the enthusiasm and innovative spirit of budding engineers. The competitions not only enhanced technical knowledge and teamwork but also encouraged creative thinking and practical application of engineering concepts.

Converges'26 proved to be a grand success, fostering innovation, healthy competition, and experiential learning while inspiring students to explore new ideas and challenges in the field of engineering.







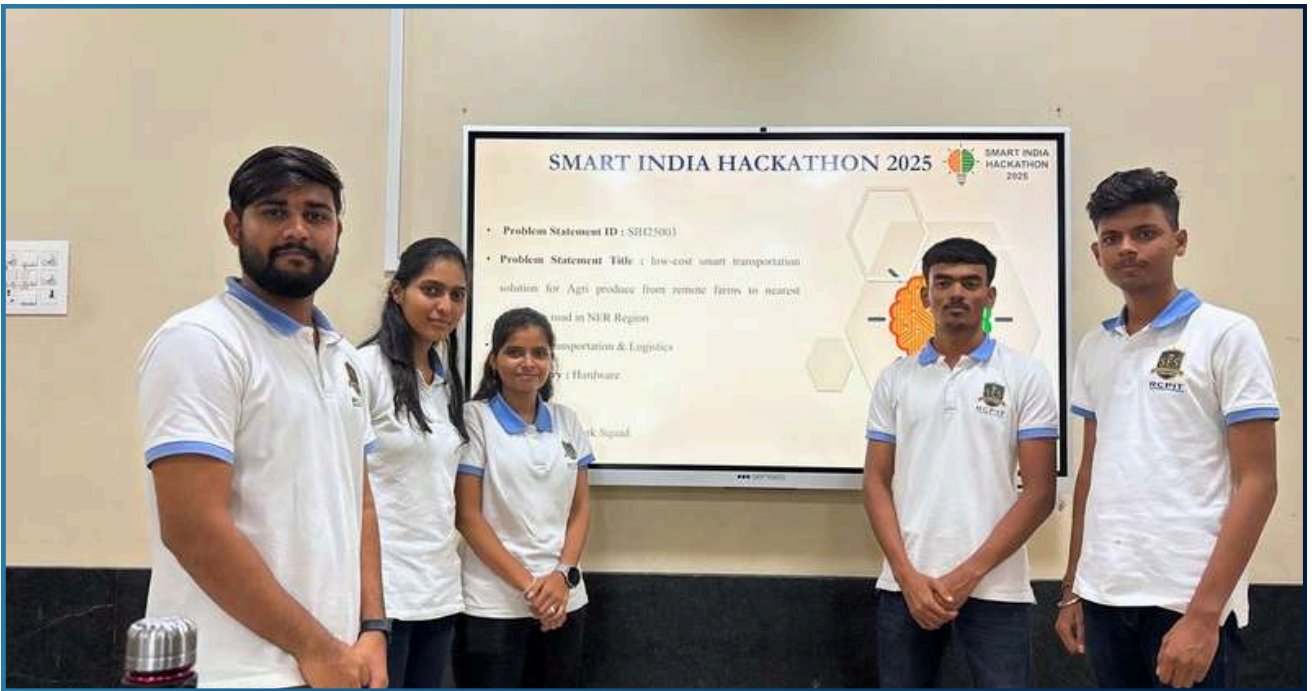
HACKATHON GLIMPSE

The Smart India Hackathon (SIH) 2025 Internal Hackathon was organized by the Department of Electrical Engineering, R. C. Patel Institute of Technology, Shirpur, on 13th September 2025. The event served as a dynamic platform for students to showcase their innovative ideas, technological solutions, and problem-solving capabilities aligned with real-world challenges and national priorities.

Participants demonstrated remarkable creativity, technical expertise, and teamwork through their project presentations. The proposed solutions reflected a strong understanding of engineering concepts, emerging technologies, and practical implementation strategies. Students effectively addressed complex problem statements by integrating innovation, research, and design thinking into their projects. The quality of ideas, originality of approach, and clarity of presentation highlighted the participants' ability to develop impactful and sustainable solutions. Their projects showcased not only technical proficiency but also entrepreneurial thinking and a commitment to addressing societal and industrial challenges.

The Smart India Hackathon 2025 Internal Hackathon successfully fostered a culture of innovation, collaboration, and experiential learning among students. The event encouraged participants to think beyond conventional boundaries, develop industry-relevant skills, and contribute towards building technology-driven solutions for a better future.







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