

NANDHA



COLLEGE OF TECHNOLOGY

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NANDHA TECHPULSE- 25

A TECHNICAL MAGAZINE

DEPARTMENT OF
ELECTRICAL AND ELECTRONICS ENGINEERING

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DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

ABOUT THE DEPARTMENT

Department of Electrical and Electronics Engineering was established in the year 2008 with an intake of 60. The department is always doing its best efforts to meet the objective of achieving technical excellence in the core areas of Power, Energy and control. Based on the infrastructure facilities and faculty strength the department was accorded approval by AICTE, New Delhi and Anna University Chennai. The department has well equipped laboratories through which creative ideas are sown in the minds of the students. Various laboratories are established with the wide range of equipment's for doing their regular laboratory experiments. Highly qualified and experienced faculty with specialization in Power Systems, Power Electronics & Drives, Applied Electronics, VLSI and Embedded System Technologies are looking after research and administration works besides teaching.



Dr.S.NANDAGOPAL
PRINCIPAL
NANDHA COLLEGE OF TECHNOLOGY

PRINCIPAL'S MESSAGE

I am pleased to extend my warm greetings to the Department of Electrical and Electronics Engineering for bringing out this edition of the *EEE Technical Magazine*. A technical magazine serves as an excellent platform for students to showcase their creativity, knowledge, and technical skills, and I am delighted to see the enthusiastic participation of both students and faculty in this endeavour. The field of Electrical and Electronics Engineering continues to evolve rapidly, influencing every sphere of modern technology—from power systems and automation to renewable energy and smart devices. It is encouraging to note that our department has consistently taken initiatives to keep pace with these advancements through seminars, workshops, industrial visits, and hands-on training activities. I congratulate the faculty members for their continuous efforts in providing quality education and guiding the students toward excellence. I also appreciate the students for their innovative contributions, achievements, and participation in various academic and co-curricular activities. This magazine is a reflection of teamwork, dedication, and the vibrant academic environment of the department. I am confident that such initiatives will inspire our students to think beyond the curriculum, develop their engineering skills, and prepare themselves for a successful professional career.

My best wishes to the editorial team, faculty members, and students for their continued growth and future accomplishments.



Dr.G.B.MOHANKUMAR

PROFESSOR AND HEAD / EEE

NANDHA COLLEGE OF TECHNOLOGY

HoD's MESSAGE

It gives me immense pleasure to present this edition of the *EEE Technical Magazine*, a platform that reflects the academic enthusiasm, innovative thinking, and technical capability of our students and faculty. The Department of Electrical and Electronics Engineering has consistently focused on providing quality education blended with practical exposure to meet the expectations of today's evolving industry. In the past academic year, our department has organized seminars, workshops, industrial visits, and hands-on training sessions that have enriched our students with real-time learning experiences. These activities have played a vital role in bridging classroom learning with industry practices. Our students have actively participated in project competitions, paper presentations, and technical events, bringing laurels to the department. I appreciate their dedication and congratulate them on their achievements. The sincere efforts of the faculty members in mentoring and guiding the students are also commendable. This magazine stands as a testimony to the creativity, knowledge, and teamwork of the editorial team and contributors. I am confident that the skills and values gained here will guide our students toward becoming competent engineers and responsible citizens.

I extend my best wishes to all students for a bright and successful future ahead.

VISION OF THE DEPARTMENT

- To be a Centre of Excellence in the field of Electrical and Electronics Engineering with Global Standards of Academic and Research for the need of Society and Industry.

MISSION OF THE DEPARTMENT

- To provide value based Electrical Engineering Education and Produce Innovative, Competent and High Quality Electrical and Electronics Engineering Professionals for the growing demand of Society and Industry.
- To facilitate the students for the constant up gradation of Technical Expertise and Perform Research Activities to Solve the Real-World Problems.

PROGRAMME OUTCOMES

1. **Engineering knowledge:** Apply knowledge of mathematics, basic science and engineering science
2. **Problem analysis:** Identify, formulate and solve engineering problems.
3. **Design/development of solutions:** Design an electrical system or process to improve its performance, satisfying its constraints.
4. **Conduct investigations of complex problems:** Conduct experiments in electrical and electronics systems and interpret the data.
5. **Modern tool usage:** Apply various tools and techniques to improve the efficiency of the system.
6. **The engineer and society:** Conduct themselves to uphold the professional and social obligations.
7. **Environment and sustainability:** Design the system with environment consciousness and sustainable development.
8. **Ethics:** Interacting industry, business and society in a professional and ethical manner.
9. **Individual and team work:** Function in a multidisciplinary team.
10. **Communication:** Proficiency in oral and written Communication.
11. **Project management and finance:** Implement Cost effective and improved system.
12. **Life-long learning:** Continue professional development and learning as a life-long activity.

PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO1: Foundation of Electrical Engineering: Ability to understand the principles and working of electrical components, circuits, systems and control that are forming a part of power generation, transmission, distribution, utilization, conservation and energy saving. Students can assess the power management, auditing, crisis and energy saving aspects.

PSO2: Foundation of Mathematical Concepts: Ability to apply mathematical methodologies to solve problems related with electrical engineering using appropriate engineering tools and algorithms.

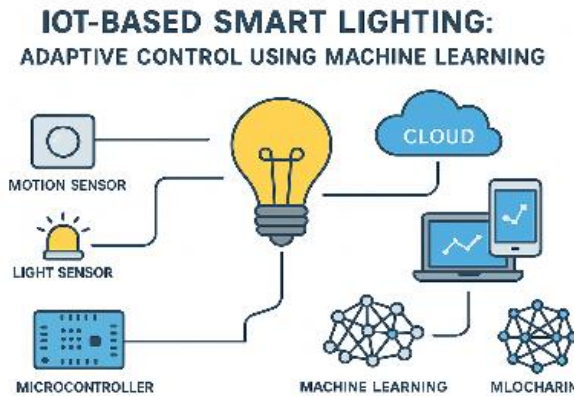
PSO3: Computing and Research Ability: Ability to use knowledge in various domains to identify research gaps and hence to provide solution which leads to new ideas and innovations.

TECHNICAL ARTICLES



IoT-Based Smart Lighting: Adaptive Control Using Machine Learning

The fast-growing domain of smart lighting systems, which includes devices that detect, regulate, and automate illumination, is becoming essential across homes, industries, and urban environments. The integration of IoT (Internet of Things) and Machine Learning (ML) has driven major advancements in lighting technologies, enabling systems that intelligently adjust brightness, reduce energy consumption, and enhance user comfort.



Recent advancements in smart lighting are significantly influenced by IoT-enabled sensors such as PIR motion detectors, Light Dependent Resistors (LDRs), ultrasonic sensors, and microcontrollers including ESP32 and Node MCU. These components allow continuous monitoring of environmental conditions. Machine learning algorithms further improve performance by enabling adaptive lighting through behavioural prediction, brightness optimization, and automated decision-making.

The image presents a visual overview of an IoT-Based Smart Lighting System enhanced with Machine Learning. At the centre, a light bulb symbolizes the smart light that responds to environmental conditions. On the left side, the motion sensor and light sensor gather real-time data such as human presence and ambient brightness. This information is sent to a microcontroller, acting as the processing unit, which interprets the sensor outputs and determines how the lighting should respond.

On the right, the diagram highlights IoT connectivity through the cloud, smartphone, and laptop, representing remote control, monitoring, and data storage. The bottom section showcases machine learning, where models analyze historical patterns, predict user behaviour, and adjust brightness automatically. Together, these components demonstrate how sensors, microcontrollers, cloud communication, and ML algorithms integrate to create an adaptive and energy-efficient smart lighting system.

Applications and Advancements:

Adaptive and Automatic Lighting: IoT-based sensors and ML models help create lighting systems that automatically adjust brightness based on natural light levels and room occupancy.

High-Performance Smart Devices: The unique combination of IoT and machine learning enables the development of advanced lighting solutions such as:

- High-response occupancy detection
- Energy-efficient dimming systems
- Personalized lighting control based on user habits

Next-Generation Smart Buildings: Smart lighting forms the core of modern buildings by integrating illumination systems with HVAC, security, and energy management platforms.

Bio-Integrated Systems: Adaptive lighting supports human well-being by adjusting colour temperature and brightness according to circadian rhythms and emotional states.

Wearable and Portable Lighting: Miniature IoT modules and ML-based brightness control help create portable smart lighting for safety and healthcare monitoring.

Image-Based Lighting Control: Cameras and ML-based vision algorithms detect gestures, presence, and activity patterns to control lighting without physical switches.

Challenges and Future Research:

Integration and Scalability: Implementing large-scale IoT lighting networks requires cost-effective integration and compatibility across diverse devices.

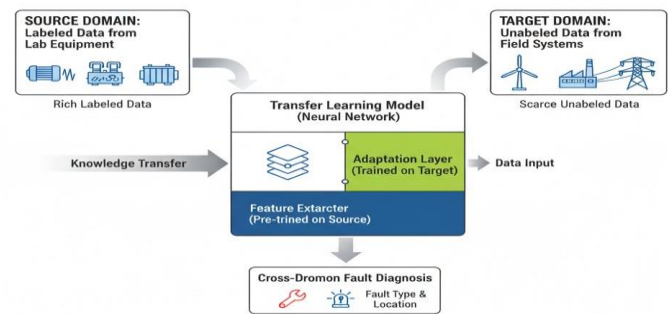
Stability and Longevity: Ensuring long-term reliability of IoT sensors and ML models is essential for continuous, automated lighting environments.

Fabrication and Optimization: Developing more efficient hardware, improving sensor accuracy, and creating low-power ML models remain ongoing research goals for the smart lighting industry.

BY**SUPRIETH N K, II EEE**

Transfer Learning for Cross-Domain Fault Diagnosis in Electrical Systems

In the modern era of intelligent manufacturing and smart grids, fault diagnosis in electrical systems has become a crucial task to ensure reliability, safety, and operational efficiency. Electrical machines and power electronic systems such as motors, generators, transformers, and converters are widely used in industrial, transportation, and energy applications. These systems operate continuously under varying loads, speeds, and environmental conditions, which can lead to mechanical wear, insulation degradation, and electrical faults. Detecting these faults at an early stage helps prevent system failures, reduce maintenance costs, and increase equipment lifespan. Traditionally, fault diagnosis methods relied on model based or signal processing techniques, where expert knowledge was required to extract features from signals such as current, voltage, vibration, or acoustic emissions. With the advent of artificial intelligence and deep learning, data driven approaches have revolutionized fault detection by automatically learning discriminative features from raw data. However, the success of these models depends heavily on large amounts of labeled data collected under consistent operating conditions. In real-world industrial environments, such data are scarce, and operating conditions differ significantly across machines or sites, making it difficult for models trained in one scenario to perform well in another.



TRANSFER LEARNING FOR CROSS-DOMAIN FAULT DIAGNOSIS IN ELECTRICAL SYSTEMS

Transfer learning offers a promising solution to this challenge by enabling knowledge learned from one domain to be reused in another related domain. In a typical scenario, a model is trained using data from a source domain such as a laboratory test rig or a specific motor under controlled conditions and then adapted to a target domain, such as a different machine or operating condition, where only limited or unlabeled data are available. This technique allows engineers to overcome the problem of domain dependency by transferring knowledge from previously learned tasks. The concept is similar to how humans apply prior experience to new situations. For example, an engineer familiar with diagnosing bearing faults in one motor can identify similar issues in another machine

without starting from scratch. Likewise, a neural network that has learned to detect faults in one system can be adapted to another, even if the working environment or sensor setup differs.

In electrical fault diagnosis, transfer learning has proven effective across a variety of systems and fault types. For induction motors, models trained on vibration or stator current signals at a particular speed or load can be reused for different operating conditions with minimal retraining. In rolling-element bearings and gearboxes, transfer learning techniques have shown high accuracy in transferring knowledge from laboratory datasets, such as the Case Western Reserve University (CWRU) bearing dataset, to real industrial machines where noise, load, and environmental variations are significant. In power converters, where faults such as switch failures or open circuit conditions occur, transfer learning helps in adapting diagnostic models trained on one converter topology to others, reducing the need for extensive retraining. This capability greatly enhances the scalability of predictive maintenance systems and facilitates deployment across multiple machines and locations.

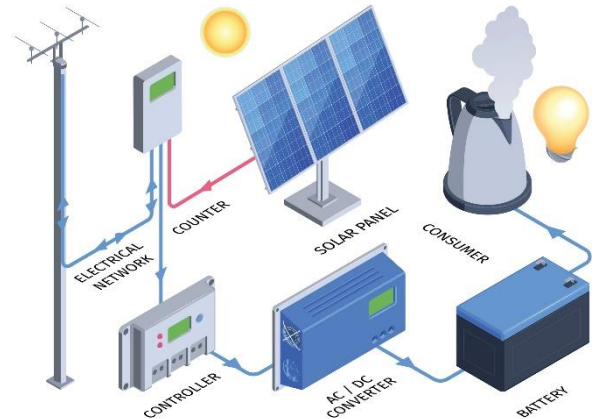
In conclusion, transfer learning represents a significant step forward in the evolution of intelligent fault diagnosis for electrical systems. By enabling cross domain knowledge transfer, it bridges the gap between controlled laboratory research and complex real world applications. It reduces data dependence, accelerates model deployment, and enhances diagnostic reliability under diverse operating conditions. As industries continue to adopt artificial intelligence, IoT, and digital twin technologies, transfer learning will serve as a cornerstone for building self-adaptive, intelligent, and resilient electrical systems. Its ability to continuously learn and generalize across domains promises a future where predictive maintenance becomes not just reactive or preventive but truly autonomous ensuring higher system uptime, lower costs, and safer industrial operations.

BY

GOKULPRASATH M, III - EEE

Neural Network-Based MPPT Controllers for Solar Power Converters

Harnessing solar energy efficiently remains one of the greatest challenges in renewable power generation. Solar panels produce electricity that fluctuates constantly due to changes in sunlight intensity, temperature, and shading. To extract the highest possible energy from a photovoltaic (PV) system, engineers employ a technique known as Maximum Power Point Tracking (MPPT). This method



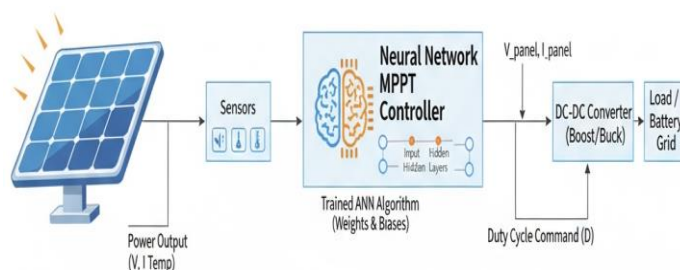
continuously adjusts the operating point of the solar panel to ensure it works at its optimal voltage and current combination, known as the Maximum Power Point (MPP). However, conventional MPPT algorithms such as Perturb and Observe (P&O) and Incremental Conductance (IncCond) often fall short under rapidly changing weather conditions, causing power losses and slower system responses. This limitation has led researchers to explore more intelligent control strategies, and one of the most promising among them is the Neural Network Based MPPT Controller.

Artificial Neural Networks (ANNs), inspired by the way the human brain processes information, have found growing applications in renewable energy systems due to their learning and adaptive capabilities. In the context of MPPT, a neural network is trained to understand the complex nonlinear relationships between key parameters such as solar irradiance, temperature, voltage, and current. Once trained, the ANN can instantly predict the ideal control signal such as the duty cycle of a DC-DC converter required to operate the PV system at its maximum efficiency. Unlike traditional algorithms that rely on fixed mathematical models or incremental adjustments, neural networks learn from historical and real-time data, allowing them to make rapid and intelligent decisions even under unpredictable environmental variations.

A Neural Network Based MPPT system typically consists of several functional blocks. The PV panel generates the initial power output, which is continuously measured by voltage and current sensors. These signals, along with temperature readings, are fed into the neural network controller. The network processes the inputs through multiple interconnected layers each containing neurons that apply learned weights and activation functions to determine the most efficient operating point. The controller then sends this optimized command to a DC-DC converter, such as a boost or buck

converter, which adjusts the panel's voltage and current to maintain the MPP. The output from the converter supplies energy to a load, a battery, or an inverter for grid connection. This closed-loop system ensures that the solar array consistently produces maximum power despite environmental fluctuations.

In comparison to traditional MPPT methods, neural network controllers deliver superior performance under complex real-world conditions, especially in partially shaded PV arrays or installations with rapidly changing weather. While they require an initial training phase using experimental or simulated data, the operational benefits such as faster convergence, higher tracking accuracy, and reduced energy loss far outweigh the added complexity. Hybrid models that combine neural networks with fuzzy logic or genetic algorithms are also being explored to achieve even more robust and adaptive control systems.



Looking ahead, the fusion of deep learning and power electronics is expected to lead to even more advanced control architectures. Future solar converters may employ deep neural networks or reinforcement learning to not only track the MPP but also predict solar behavior, forecast energy yield, and coordinate storage usage. Such intelligent systems could revolutionize how solar power is integrated into the grid, making renewable energy systems more resilient and responsive.

In conclusion, Neural Network-Based MPPT Controllers represent a transformative leap in solar energy technology. By bringing artificial intelligence into the realm of power electronics, these controllers ensure that every photon of sunlight is converted into useful electrical power with unmatched precision. As AI continues to evolve, the synergy between neural networks and solar converters will play a crucial role in building a cleaner, smarter, and more sustainable energy future.

BY

MOHAMMED MEERAN S, III - EEE

WIRELESS POWER TRANSFER FOR ELECTRICAL

VEHICLE CHARGING

ABSTRACT

Wireless Power Transfer (WPT) technology enables efficient, contactless charging of electric vehicles (EVs), eliminating the limitations of plug-in charging systems. This article discusses the working principle, design elements, and performance characteristics of inductive and resonant coupling techniques used in WPT systems. The focus is on improving power transfer efficiency, maintaining coil alignment, and ensuring system safety. Recent advancements in dynamic charging are also highlighted, showing the potential of WPT to increase the convenience, automation, and adoption of electric vehicles.

INTRODUCTION

Electric vehicles play a vital role in reducing environmental pollution and dependence on fossil fuels. However, conventional plug-in charging systems present several drawbacks, including connector wear, safety hazards, and limited user convenience.

Wireless Power Transfer (WPT) offers a modern alternative, enabling energy transfer without direct electrical contact. The technology operates on the principle of electromagnetic induction between a transmitting coil embedded in the ground and a receiving coil mounted on the vehicle. This not only improves safety and comfort but also allows for automation of the charging process.

WORKING PRINCIPLE OF WPT

WPT for EV charging primarily works through inductive coupling, where alternating current in the transmitter coil generates a magnetic field that induces current in the receiver coil. In resonant coupling, both coils are tuned to the same resonant frequency to enhance efficiency and increase charging distance.

A high-frequency inverter converts DC power into AC, which energizes the transmitter coil. The received AC power on the secondary side is rectified to DC to charge the vehicle battery.

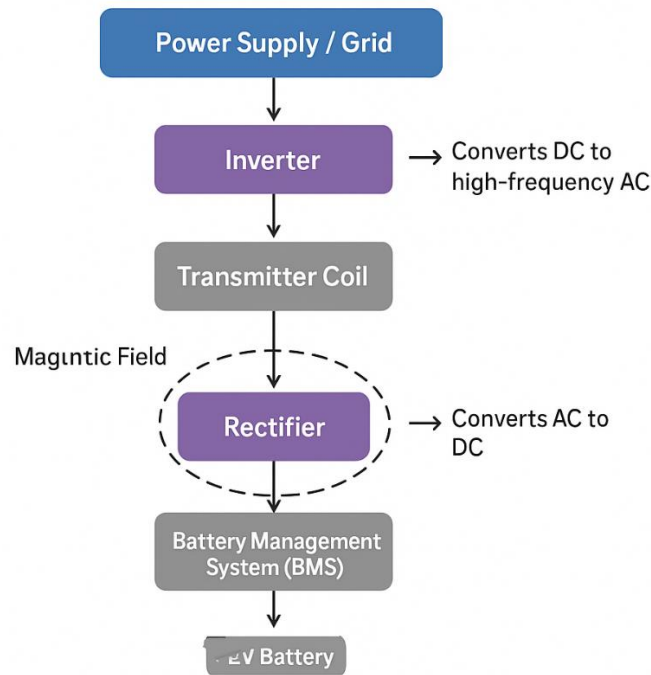


Figure 1: Basic block diagram of Wireless Power Transfer system for Electric Vehicle charging

FUTURE SCOPE

Future developments aim at achieving over 90% transfer efficiency, longer charging distances, and the integration of dynamic WPT systems into highways. The SAE J2954 standard is being developed to ensure compatibility among EVs and charging pads worldwide. Continued research in coil design and compensation topologies will further enhance performance and safety.

CONCLUSION

Wireless Power Transfer offers a promising solution for the next generation of EV charging systems. By enabling efficient and contactless power delivery, WPT can significantly improve the convenience and sustainability of electric transportation. With ongoing advancements in resonant technology and power electronics, WPT is expected to become a standard feature in future smart transportation networks.

BY

DHARSHANA T, III - EEE

Energy Storage Systems and Battery Technology

In today's modern world, energy storage systems (ESS) play a very important role in managing electricity and supporting renewable energy. As we move towards clean and green energy, the need for efficient energy storage becomes more important. Energy storage helps in saving electricity when it is not needed and supplying it when demand increases. This makes our power system more stable, reliable, and flexible.

An energy storage system is a setup that stores energy produced at one time and delivers it at another time. It helps in balancing supply and demand. When power generation is high but demand is low, the extra energy is stored. Later, when demand increases, the stored energy is released to the grid. This process reduces energy waste and improves the efficiency of the entire system.

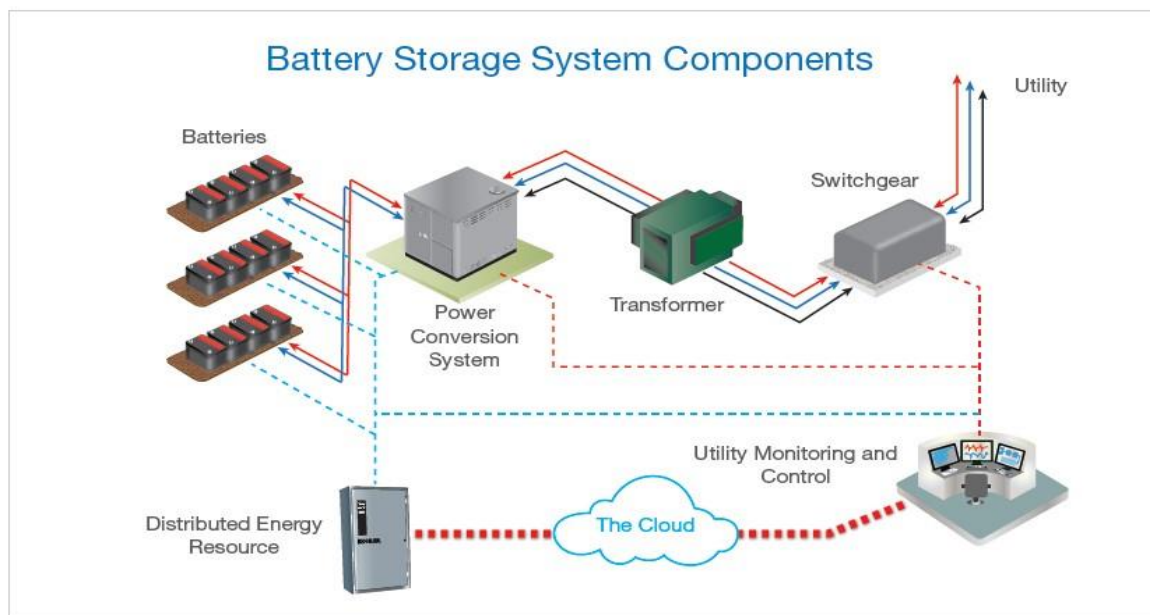
There are many types of energy storage systems, such as mechanical, thermal, electrical, and chemical. Among these, battery energy storage systems (BESS) are the most popular and widely used today. Batteries can quickly store and deliver energy, making them ideal for both small-scale and large-scale applications. They are used in homes, industries, electric vehicles, and even large power stations.

The most common type of battery used in energy storage is the lithium-ion battery. These batteries are lightweight, have high energy density, and can be charged and discharged many times. They are used in electric vehicles, solar systems, and portable devices. Other types of batteries include lead-acid, nickel-cadmium, sodium-sulfur, and flow batteries. Each type has its own advantages and is chosen based on the need, cost, and application.

Lithium-ion batteries are currently leading the market due to their high performance and long life. However, they also have some challenges like high cost, limited raw materials, and safety concerns. Researchers around the world are working to develop new battery materials that are cheaper, safer, and more sustainable. Some new technologies being developed include solid-state batteries and rechargeable metal-air batteries, which may replace lithium-ion in the future.

Battery energy storage is also a key part of renewable energy integration. Renewable sources like solar and wind do not produce power all the time. The sun does not shine at night, and the wind speed keeps changing. Batteries help to store the extra power generated during sunny or windy times and supply it when generation drops. This ensures a continuous and stable power supply to the grid.

In the future, energy storage systems will become a main part of smart grids and modern power systems. As technology continues to improve, we can expect batteries that charge faster, last longer, and are made from eco-friendly materials. This will not only make our



Energy use more efficient but also help protect the environment by reducing the use of fossil fuels. In simple words, energy storage systems and battery technology are the backbone of a sustainable energy future. They help in saving power, supporting renewable energy, and building a smarter and cleaner world for the coming generations.

Conclusion:

In conclusion, energy storage systems and battery technology are changing the way we produce and use electricity. They make our power systems more efficient, reliable, and eco-friendly. With the growing use of renewable energy sources like solar and wind, batteries have become essential for storing and managing energy when generation and demand do not match. Continuous improvements in battery design, materials, and performance are leading us toward a future with clean energy and sustainable power solutions. As technology advances, these systems will play a key role in creating a smarter, greener, and more energy-secure world.

BY

DHEENADHAYALAN B, III - EEE

Renewable Energy Integration

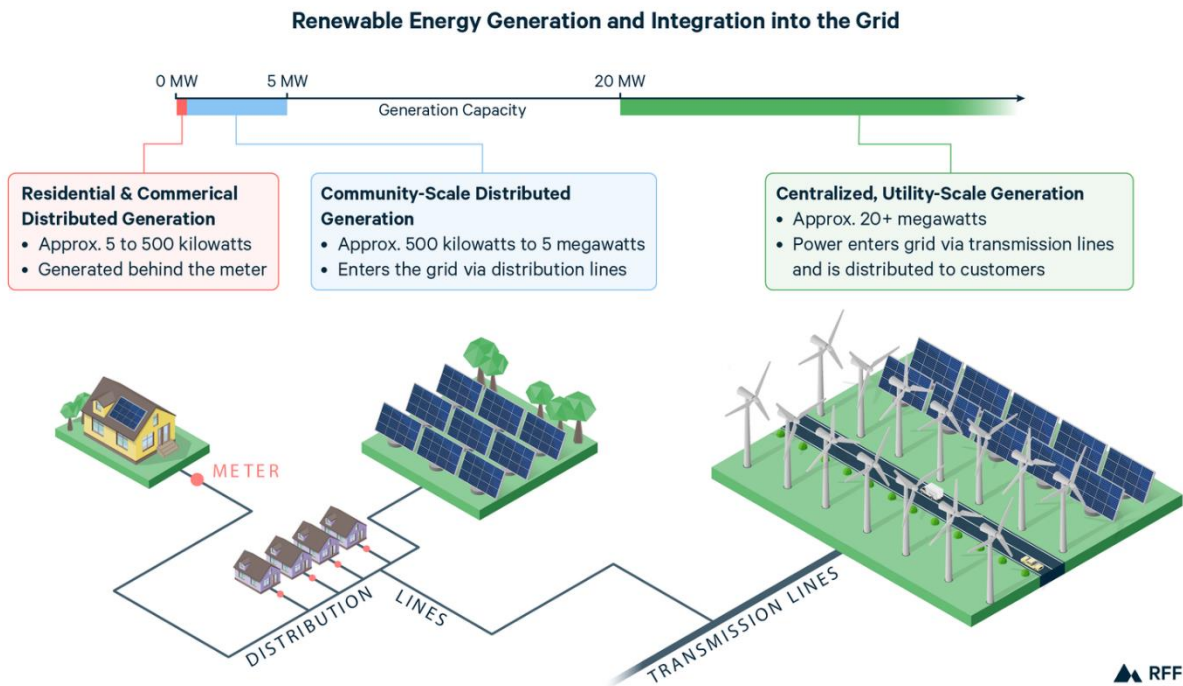
“Powering a Cleaner Future”

Today, the world is moving toward clean and green energy. The main reason for this change is that traditional energy sources like coal, oil, and gas are slowly getting reduced and also cause heavy pollution to the environment. To solve this problem, scientists and engineers are focusing more on renewable energy sources such as solar, wind, hydro, and biomass. But bringing all these clean energy sources together into our existing power system is not an easy task. This process is called Renewable Energy Integration, which means connecting renewable power with the main electricity grid so that both can work together efficiently and provide continuous power to everyone.

Renewable Energy Integration is an important step in creating a sustainable power system. It helps combine renewable energy with conventional power plants so that the total electricity supply remains stable and reliable. Since renewable energy depends on natural sources like sunlight and wind, it is not available all the time. For example, solar power can only be generated during the daytime, and wind turbines can produce power only when there is enough wind. Therefore, engineers use smart systems and energy storage devices to balance the power flow. This ensures that even when natural energy is low, electricity continues to reach homes and industries without interruption.

The integration of renewable energy is very important because it reduces pollution and protects the environment. It also saves natural resources like coal and oil, which are limited and take millions of years to form. By using more renewable energy, countries can produce their own power from sunlight and wind instead of depending on imported fuels. This improves energy security and supports the growth of clean industries. It also helps reduce greenhouse gases, which are one of the main causes of global warming. Thus, renewable energy integration plays a key role in creating a healthy and sustainable future for the next generations.

However, integrating renewable energy into existing power systems comes with many challenges. One of the major problems is power fluctuation, as solar and wind power change with the weather. When clouds cover the sun or wind speed drops, electricity generation also decreases suddenly, which can make the grid unstable. Another issue is the high cost of energy storage devices like batteries, which are needed to store extra power for later use. In addition, most of our electrical grids were built many years ago and are not designed to handle two-way communication and variable power flow. Engineers are now upgrading these systems into smart grids, which use sensors, automation, and artificial intelligence to balance supply and demand in real-time.



The future of renewable energy integration looks very promising. Many countries are now building large solar farms, offshore wind parks, and hybrid systems that combine different energy sources. New technologies like artificial intelligence (AI), Internet of Things (IoT), and advanced batteries are making renewable systems more intelligent and efficient. In the coming years, every home may become a small power station, producing and storing its own clean energy. This will make our power systems not only smarter but also self-sufficient and eco-friendly.

In conclusion, renewable energy integration is the key to building a cleaner and brighter future. It allows us to combine natural energy sources with modern technology to supply reliable electricity while protecting our planet. If we continue to invest in renewable energy and improve our systems, we can create a world that runs on pure, sustainable power. The future truly depends on how wisely we use our resources today — and renewable energy is the smartest and greenest choice for tomorrow.

BY

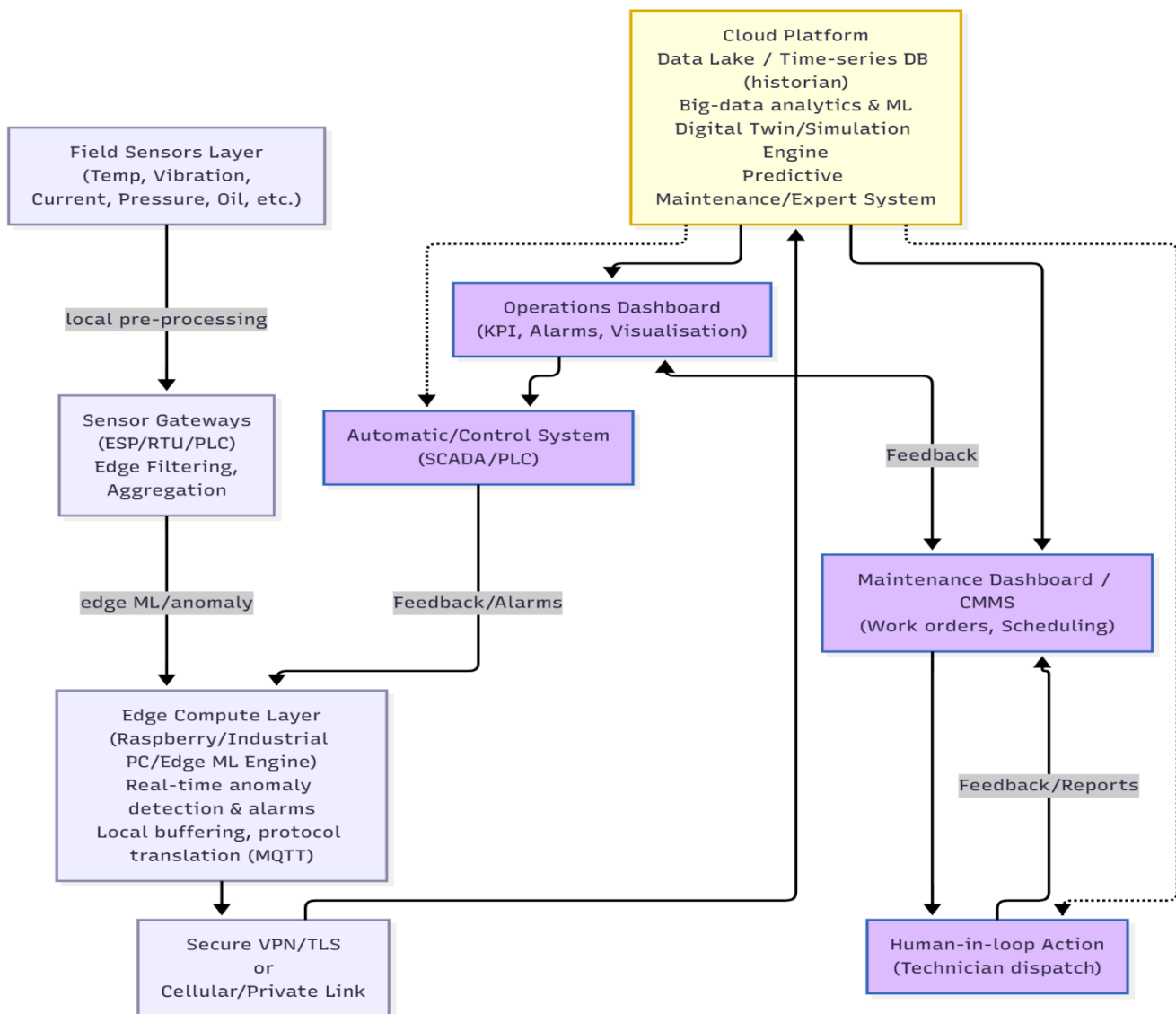
GEMINI P, III - EEE

How IoT Transformed a Legacy Power Plant into a Smart Facility

For decades, power generation facilities relied on manual inspections and reactive problem-solving, leading to inefficiencies, high costs, and unexpected equipment failures. The Internet of Things (IoT) has revolutionized this model by retrofitting legacy plants with sensor networks and remote monitoring capabilities, transforming them into intelligent systems that predict problems.

Sensor Networks and Real-Time Monitoring:

The transformation starts with comprehensive sensor deployment. Modern IoT systems use various sensors—temperature, vibration, and electrical sensors—across critical assets, enabling



real-time monitoring. These sensors communicate through a three-tier architecture, where local gateways process data and cloud-based platforms visualize operational telemetry. For instance, a

transformer monitoring system achieved a 95.6% fault detection rate, identifying issues that traditional inspections might overlook.

From Reactive to Predictive: Intelligent Maintenance Systems

IoT changes maintenance practices from reactive to predictive. Unlike traditional time-based maintenance, IoT allows for condition-based interventions based on asset health. This is achieved through expert systems, machine learning models, and digital twins that simulate asset behavior and forecast maintenance needs. IoT-enabled predictive maintenance has been shown to reduce unplanned downtime by 35-45% and maintenance costs by 25-30%. China Southern Power Grid's Smart Operation and Management System exemplifies these benefits, improving fault alarm accuracy and decreasing the need for physical inspections.

Data-Driven Decision Making: Analytics and Digital Twins:

The true strength of IoT lies in the analytics platforms that synthesize sensor data into actionable insights. Combining edge processing for anomaly detection with cloud data lakes for trend analysis and machine learning models for failure prediction enhances decision-making. Digital twins are at the forefront, offering real-time simulations of physical assets, allowing operators to test changes and optimize performance without jeopardizing equipment integrity. This capability ensures timely corrective actions and improves overall operational efficiency.

Conclusion:

The integration of IoT technologies into legacy power plants marks a significant shift in the operational landscape of power generation. By leveraging real-time monitoring, predictive maintenance, and advanced analytics, facilities can transform from reactive to proactive management approaches. This transition not only enhances asset performance and reliability but also drives down costs and improves efficiency. As power plants continue to adopt these smart technologies, they will be better equipped to face the challenges of today's energy demands, ensuring reliable and sustainable electricity generation for the future. The evolution towards intelligent, self-aware systems signifies a new era in the power industry, where data-driven decision-making becomes the norm rather than the exception.

BY

HEMA.M, III - EEE

AUTONOMOUS POWER GRID: POWERED BY AI

Artificial intelligence is revolutionizing power grid management by enabling self-healing systems, predictive load balancing, integration of renewables, and real-time response to consumer demand.

Generative AI has been a revolutionary tool in various regions to enhance grid operations into smart grid operations. Also, generative AI's ability to analyze data to make forecasts can be used for utility forecasting to predict the future of energy consumption, requirements, and generation rate.

The energy sector has been revolutionized by digital transformation, and generative AI has been the key technology among all. The energy sector is the most important sector to boost our daily operations efficiency. Electrical energy is the most used energy in daily life, which needs to be empowered with generative AI.

The first AI-powered self-healing grid in Shenzhen restored power in just 17 seconds after a simulated fault, showcasing 95% faster restoration compared to manual methods. The grid uses AI algorithms that automatically detect faults, generate restoration strategies, and shift to backup power



Smart Grid Management

AI enables decision-making at local levels, such as homes, businesses, and microgrids, coordinating distributed resources while sending valuable data to utility operators. This supports peak shaving and anticipates demand spikes, maximizing cleaner energy usage.

BY

INBATHAMILAN.E, III - EEE

SOLAR CHARGING VEHICLE: A STEP TOWARDS SUSTAINABLE TRANSPORTATION

The increasing global demand for clean and renewable energy has led to innovative solutions in transportation. One such emerging concept is the Solar Charging Vehicle, a vehicle that uses solar power to charge its batteries and operate efficiently with minimal environmental impact. This technology combines electric vehicles (EVs) and solar photovoltaic (PV) systems, offering an eco-friendly alternative to conventional fuel-based transportation.

Traditional vehicles powered by petrol or diesel release harmful pollutants such as carbon monoxide, nitrogen oxides, and particulate matter. This contributes significantly to air pollution and global warming. Electric vehicles reduce emissions, but they still rely on electricity from power plants, which may use coal or other non-renewable sources.

SOLAR CHARGING VEHICLE



CONCLUSION

Solar charging vehicles represent a major step toward a sustainable transportation system. By harnessing the power of the sun, these vehicles reduce dependence on fossil fuels, minimize pollution, and promote green mobility. With continuous technological improvements, solar vehicles are likely to become more efficient, affordable, and widely used in the near future. They truly symbolize the future of clean and smart transportation.

BY

NAGARAJ P, III - EEE

Smart Grid and the Future of Power Systems

“When the wires get wise, the power never dies”

Electricity plays a very important role in our daily life. It powers our homes, schools, hospitals, and industries. However, the old power grid that we use today has many problems such as power loss, overload, and poor monitoring. To overcome these issues, engineers have introduced a modern and intelligent system called the Smart Grid. It is a digital and advanced power network that makes electricity generation and usage more efficient, reliable, and eco-friendly.

A Smart Grid is an upgraded version of the traditional electricity system. It uses digital communication, sensors, and automation to control the flow of power. Unlike the old grid where electricity moves only from power stations to consumers, the Smart Grid allows two-way communication. This means electricity and data can flow in both directions. The system can automatically detect faults, balance power use, and even allow people with solar panels to send extra power back to the grid. This two-way feature makes the system more flexible and efficient.

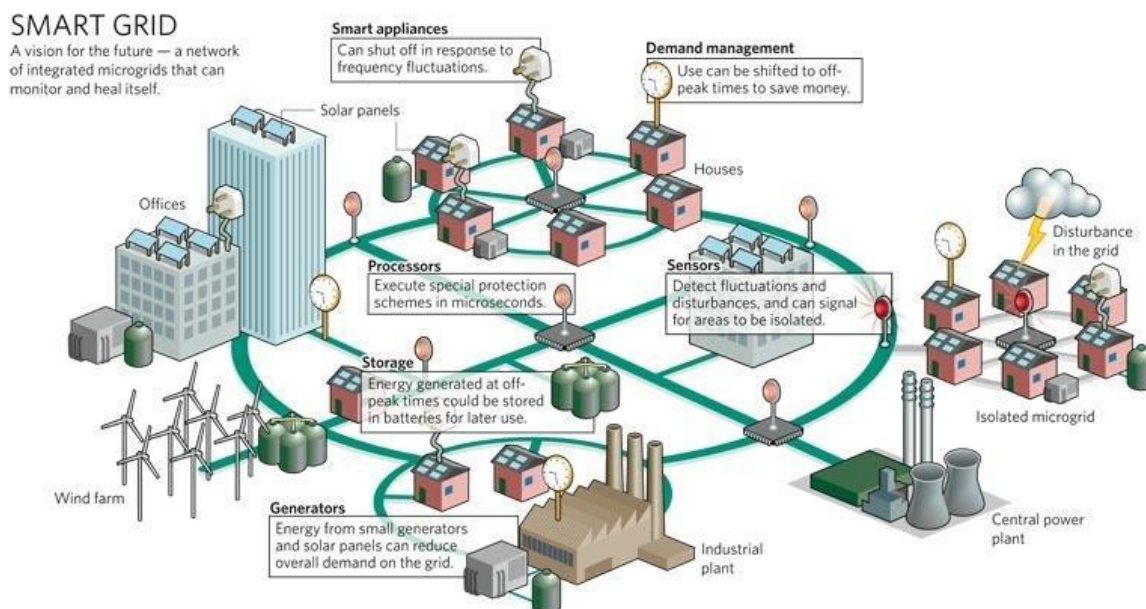
Smart Grids use several key technologies. One of the most important is the smart meter, which records energy use in real time and sends the data to both users and electricity companies. This helps in accurate billing and energy savings. Sensors and control systems monitor the grid and detect faults quickly, reducing power cuts. Communication networks connect all parts of the grid and allow real-time data transfer. Energy Management Systems analyze data and improve energy distribution. Renewable energy sources like solar panels, wind turbines, and battery storage are also part of Smart Grids, helping to make the system cleaner and more sustainable.

The need for Smart Grids is increasing because traditional grids are unable to handle growing energy demand. As our population grows and technology develops, the need for electricity also rises. At the same time, renewable energy like solar and wind is becoming popular, but their output changes with weather. The Smart Grid manages these variations by balancing supply and demand automatically using advanced software and communication systems. It reduces transmission losses, improves reliability, and maintains a steady flow of electricity even during faults.

Smart Grids also help to make better use of renewable energy. When more energy is generated than needed, it can be stored in batteries and used later during high demand. This makes the power system more stable and environmentally friendly.

Modern technologies such as the Internet of Things (IoT), Artificial Intelligence (AI), and Block chain are also used in Smart Grids. IoT connects different electrical devices so they can communicate and

manage energy use efficiently. AI predicts power demand and finds faults before they become serious problems. Block chain ensures safe and transparent energy transactions between producers and consumers. Smart Grids also support Electric Vehicles (EVs) by managing charging and even allowing vehicles to send energy back to the grid during high demand.



The benefits of Smart Grids are many. They improve energy efficiency, reduce power losses, and increase reliability. They help integrate renewable energy easily and reduce pollution. Consumers can monitor their energy use through smart meters and save money by managing their consumption. Power companies also benefit because automation reduces maintenance costs and improves service quality.

In the future, Smart Grids will become the foundation of modern Smart Cities. They will manage energy for homes, vehicles, and industries in a more intelligent way. With Artificial Intelligence, renewable energy, and storage systems working together, power systems will become self-sufficient, flexible, and green.

In conclusion, the Smart Grid is a major step forward in the development of electrical power systems. It combines technology and sustainability to create a more efficient and reliable energy future. By using Smart Grids, we can build a world where energy is used wisely, pollution is reduced, and electricity reaches everyone in a smarter way.

BY

NAVEEN S S, III - EEE

HVDC TRANSMISSION AND FACTS DEVICES

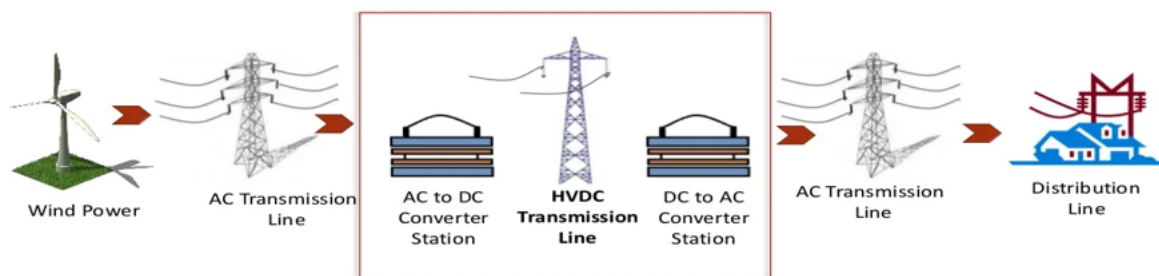
“THE FUTURE OF POWER FLOW”

In today's world, the demand for electrical power is increasing rapidly. Cities, industries, and rural areas all need a large and steady supply of electricity. To deliver this power efficiently over long distances, engineers are now using modern transmission technologies such as HVDC (High Voltage Direct Current) and FACTS (Flexible AC Transmission Systems) devices. These advanced systems have made power transmission more reliable, faster, and smarter compared to traditional methods.

HVDC Transmission stands for High Voltage Direct Current Transmission. It is a system where electrical power is transmitted in the form of direct current (DC) instead of alternating current (AC). In older power systems, most transmission lines used AC because it was easy to step up or step down voltage using transformers. However, when we try to send AC power over very long distances, energy losses become high due to the skin effect and line reactance. This is where HVDC technology plays a major role. In HVDC, power is converted from AC to DC at the sending end using a converter station, transmitted through DC lines, and then converted back to AC at the receiving end. This method reduces transmission losses and makes it possible to send large amounts of power over thousands of kilometres with higher efficiency.

The main advantage of HVDC transmission is that it is very efficient for long-distance and underwater power transmission. It can connect two power systems that operate at different frequencies, which is not possible with AC lines. HVDC also provides better control over power flow and reduces the chances of blackouts. For example, power from remote hydroelectric stations in mountains or offshore wind farms can be easily transmitted to cities using HVDC lines. It is also useful for interconnecting grids between countries because DC links can handle power exchange without disturbing the stability of each grid. Modern HVDC systems are now being used in countries like India, China, and Norway to transmit electricity over very long distances.

Along with HVDC, another important technology improving the power system is FACTS devices. The term FACTS stands for Flexible AC Transmission Systems. These are electronic devices used to control and stabilize the flow of AC power in transmission networks. Traditional AC systems have many problems like voltage drops, power losses, and instability due to changes in load and generation. FACTS devices help overcome these issues by using power electronics components such as thyristors and IGBTs to control voltage, current, and impedance in real-time.

HVDC transmission system

In the future, the use of HVDC and FACTS technologies will continue to grow as electricity demand increases. Engineers are working on advanced VSC-HVDC (Voltage Source Converter HVDC) systems that offer even better control and efficiency. These systems are compact, more reliable, and suitable for connecting offshore wind farms. FACTS controllers are also becoming smarter with the help of artificial intelligence and digital sensors that can automatically adjust power flow without human help. These innovations are leading us toward a more intelligent and self-controlled power network.

In conclusion, HVDC transmission and FACTS devices are two of the most powerful tools in modern electrical engineering. They improve the way electricity is transmitted, making it faster, safer, and more stable. HVDC helps in carrying large amounts of power across long distances with minimal losses, while FACTS ensures smooth and flexible operation of AC networks. Together, they are shaping the future of energy systems — creating a world where power flows more efficiently, reliably, and sustainably.

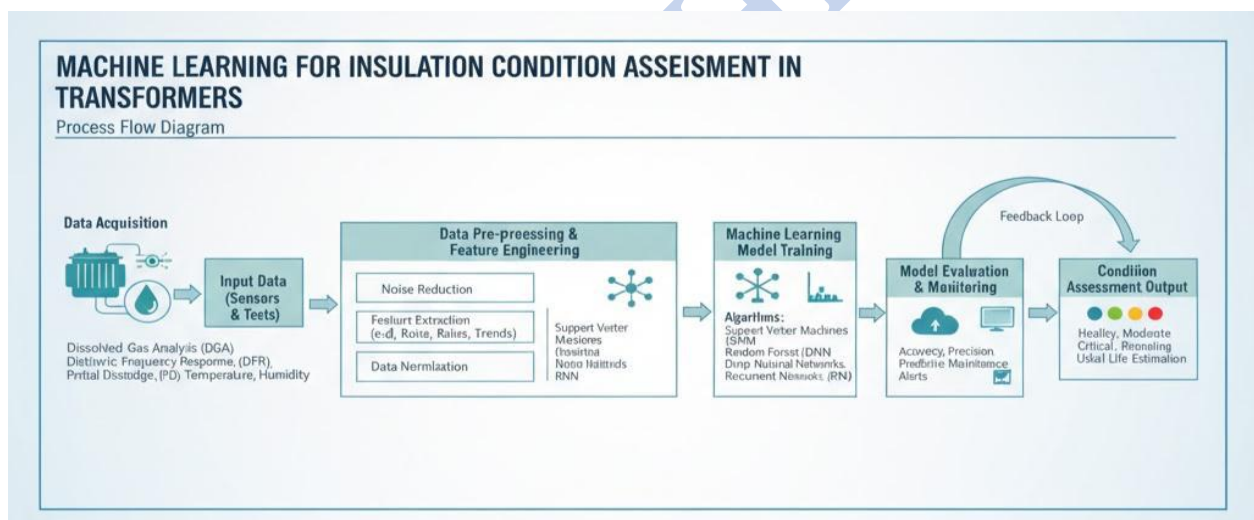
BY

RUBACHANDRAN G, III - EEE

MACHINE LEARNING FOR INSULATION CONDITION

ASSESSMENT IN TRANSFORMERS

Transformers are vital components in electrical power systems, serving as the backbone for efficient voltage regulation and energy transmission. Their reliability directly affects the stability and performance of the entire power network. One of the most critical aspects of transformer health is the condition of its insulation system. Over time, insulation materials deteriorate due to electrical, thermal, mechanical, and environmental stresses. This degradation can lead to partial discharges, moisture accumulation, and ultimately catastrophic failures. Traditional diagnostic techniques, while effective, are often time-consuming, require expert interpretation, and may not detect early signs of insulation failure. In recent years, machine learning (ML) has emerged as a transformative tool for intelligent condition monitoring and predictive maintenance, offering faster, more accurate, and data-driven assessments of transformer insulation health.



Machine learning enables systems to learn from historical and real-time data to identify complex patterns that human experts might overlook. For transformer insulation, various diagnostic data such as dissolved gas analysis (DGA), partial discharge (PD) signals, oil quality parameters, dielectric frequency response (DFR), and thermal measurements are used as input features. ML algorithms can analyze these data points to predict insulation degradation levels, detect anomalies, and even estimate the remaining useful life (RUL) of the transformer. Techniques such as artificial neural networks (ANNs), support vector machines (SVMs), decision trees, random forests, and deep learning models have shown remarkable accuracy in classifying insulation conditions and forecasting future failures.

Among these, Dissolved Gas Analysis has traditionally been one of the most important diagnostic methods. It involves monitoring gases such as hydrogen (H_2), methane (CH_4), ethylene (C_2H_4), and acetylene (C_2H_2) dissolved in transformer oil, which serve as indicators of different fault types like overheating, arcing, or corona discharge. Machine learning enhances this process by automating fault classification. Instead of relying solely on traditional ratio-based methods (like the Duval Triangle or Rogers Ratios), ML models can use multi-dimensional gas concentration data to classify faults with higher precision. Similarly, Partial Discharge (PD) analysis benefits significantly from ML integration. PD signals are complex, non-linear, and often obscured by noise, making manual interpretation difficult. Machine learning algorithms, particularly convolutional neural networks (CNNs) and recurrent neural networks (RNNs), can extract meaningful features from PD waveforms or images to identify discharge types and locate insulation defects. These models can distinguish between surface discharge, corona discharge, and internal void discharges, which helps utilities plan targeted maintenance and avoid unnecessary transformer downtime.

However, challenges remain in deploying ML-based insulation assessment systems. Data quality and availability are major concerns; transformers operate in diverse conditions, and collecting large, labeled datasets for training robust models is often difficult. Moreover, model interpretability and trustworthiness are crucial for engineers who rely on these systems for high-stakes maintenance decisions. Future research is focusing on explainable AI (XAI) techniques that make ML predictions more transparent, allowing engineers to understand why a model predicts a certain fault type or insulation condition.

In conclusion, machine learning is revolutionizing the way transformer insulation conditions are assessed. By harnessing the power of data analytics and intelligent algorithms, it is now possible to detect insulation degradation earlier, classify fault types more accurately, and predict transformer lifespan with unprecedented precision. As the energy sector moves toward digitalization and smart grid implementation, the adoption of ML-based condition monitoring systems will continue to grow. These technologies not only enhance operational reliability but also contribute to sustainability by reducing unplanned outages and extending the service life of critical power assets. The fusion of data science and electrical engineering is paving the way for a new era of intelligent transformer diagnostics—where machines learn to protect the very infrastructure that powers modern society.

BY

SANJEEV RAJ R, III - EEE

WIRELESS POWER TRANSFER AND INDUCTIVE CHARGING

In today's modern world, technology is growing faster than ever, and one of the most exciting developments is Wireless Power Transfer (WPT). It means transferring electrical energy without using any physical wires. This technology is now used in many areas like charging mobile phones, electric vehicles (EVs), and even medical devices. The main idea behind wireless power is to make charging and energy transfer easier, safer, and more convenient.

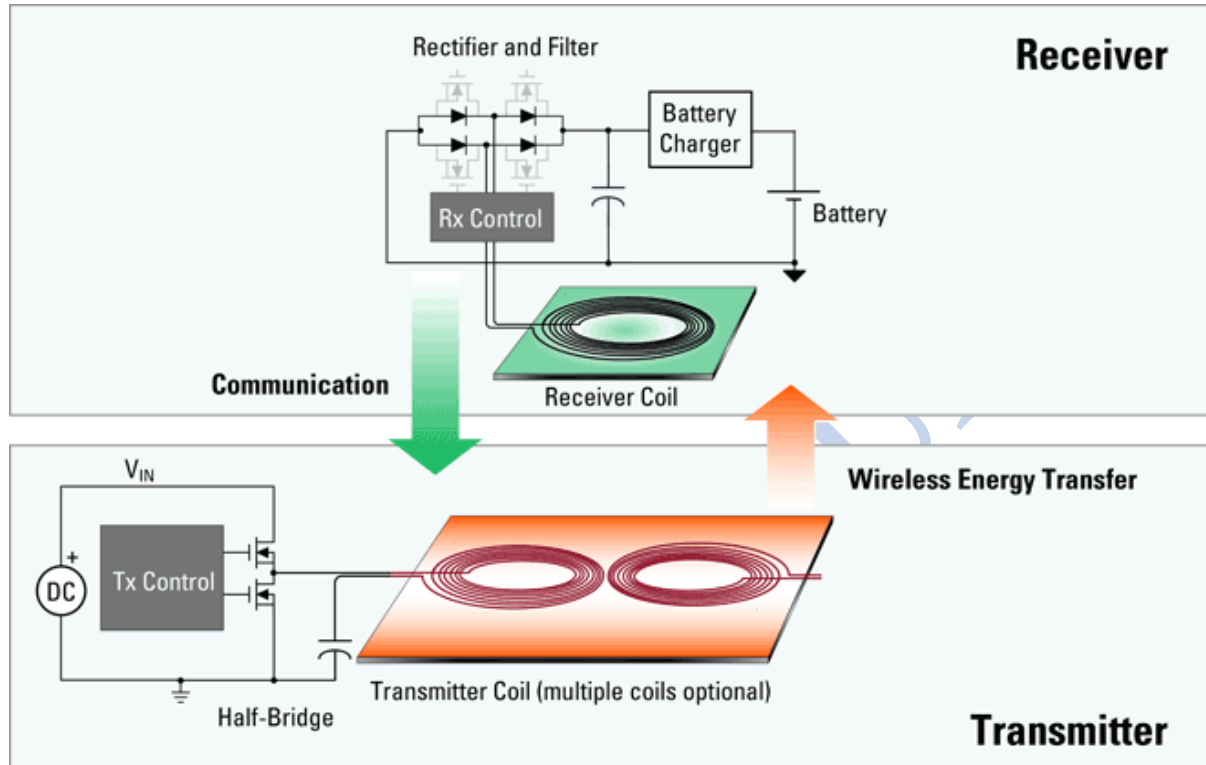
Wireless power transfer works on a simple principle — energy can move through a magnetic or electric field from one coil to another. In this system, there are mainly two parts: a transmitter coil and a receiver coil. The transmitter coil, which is connected to a power source, creates an alternating magnetic field. The receiver coil, placed close to it, captures that energy and converts it back into electrical power. This method of transferring energy through magnetic fields is known as Inductive Charging.

Inductive charging is most commonly used in smartphones, smartwatches, and electric toothbrushes. When you place your phone on a wireless charging pad, the pad acts as the transmitter and your phone's coil acts as the receiver. Because there is no need to plug in cables, the system reduces wear and tear, and it is also safer in wet or dusty conditions. For example, electric toothbrushes often use this technology because they are used in water environments where metal connectors could cause problems.

One of the biggest advantages of wireless power transfer is convenience. You simply place your device near a charger and it begins charging automatically. It also helps in reducing cable clutter and increasing device safety. In the case of electric vehicles, inductive charging can be used to charge the battery just by parking the car over a special charging pad. This not only makes charging easier but also helps promote the use of clean electric transportation.

However, there are also some challenges with this technology. The energy transfer efficiency in wireless systems is usually lower than in wired systems, meaning that some power is lost as heat. Also, the distance between the transmitter and receiver coils must be small for effective charging. If the coils are too far apart or misaligned, the charging speed becomes slower. Another issue is the cost — wireless charging systems are more expensive to build than traditional ones.

To overcome these problems, researchers are developing resonant inductive coupling and magnetic resonance technologies, which can transfer power over longer distances and with better efficiency. Future versions of wireless power transfer may allow charging of multiple devices at once, even while they are in motion. For example,



a car could charge while driving on a road equipped with wireless charging coils — this idea is already being tested in some countries.

In conclusion, Wireless Power Transfer and Inductive Charging are changing the way we think about energy. This technology offers a clean, simple, and smart way to power our devices without depending on wires. Although it still faces challenges like distance limits and efficiency, continuous research and innovation are improving it every day. In the future, we can expect to see more wireless power systems in homes, offices, and even entire cities, making our world truly wireless and connected.

“Innovation is the spark that lights the future.”

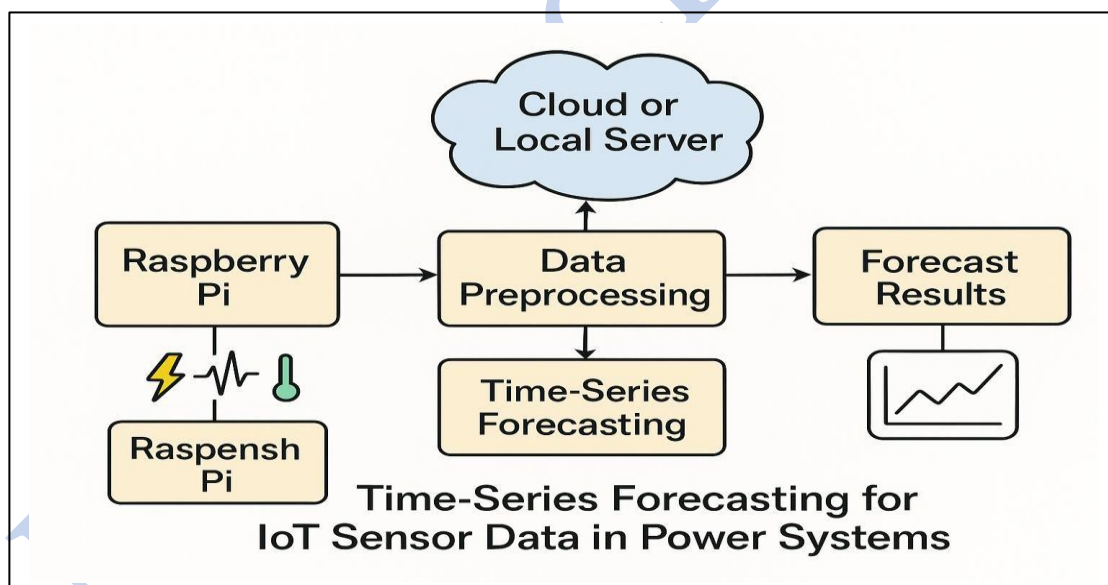
BY

SRI AJAY J M, III - EEE

TIME-SERIES FORECASTING FOR IOT SENSOR DATA IN POWER SYSTEMS

In today's rapidly evolving energy sector, the integration of Internet of Things (IoT) technology with power systems has opened a new chapter in intelligent grid management. The research and technical sources reviewed on this topic show how forecasting models, IoT sensors, and edge computing together form the backbone of modern smart grids. Each study offers a unique viewpoint on how time-series forecasting improves reliability, efficiency, and sustainability in power distribution networks.

The study by R. Kumar et al. highlights how IoT devices can be used to gather continuous sensor data and apply machine learning techniques to predict load patterns. Their approach demonstrates that even low-cost systems, when combined with well-structured algorithms such as ARIMA or Linear Regression, can generate accurate short-term forecasts. This idea supports the growing trend of using affordable embedded systems like the Raspberry Pi for real-time data analytics and grid monitoring.



C. Hu et al. provided an extensive overview of time-series data generation challenges in IoT environments. They pointed out that many researchers lack access to continuous and high-quality datasets. To overcome this, synthetic data generation methods such as GANs and statistical modeling are used to simulate realistic patterns. This insight is valuable for academic and student projects where real-world utility data is limited, ensuring that model development remains practical and reliable.

The framework proposed by H. A. Selmy and team focuses on predictive analytics for streaming sensor data. Their model integrates cloud computing and machine learning to process live IoT inputs, showing how real-time retraining of forecasting models can adapt to changing conditions in the grid. This directly relates to the goal of achieving dynamic load management in smart distribution networks.

S. Suryavansh et al. presented another interesting finding — forecasting can also help save energy. By performing local predictions within sensor nodes, the number of wireless data transmissions can be reduced, extending the life of IoT devices. This demonstrates how forecasting not only enhances accuracy but also contributes to sustainable power system operation by minimizing resource consumption.

Across these studies, a common vision emerges: data-driven decision-making is transforming power systems into intelligent networks. IoT sensors act as the data source, forecasting algorithms serve as the analytical engine, and communication technologies bridge them together in real time. The combination allows the grid to respond before issues occur, not after. While deep learning methods such as LSTM and Prophet improve long-term predictions, classical models remain practical for smaller implementations where data and computational power are limited. In conclusion, the analysis of multiple research papers clearly shows that time-series forecasting is not just a technical concept but a strategic necessity for the future of smart power systems. By integrating IoT, analytics, and automation, engineers can create an ecosystem that predicts, adapts, and sustains. The future of power engineering lies in foresight — the ability to anticipate tomorrow's demand today.

BY

NAMACHIVAYAN.G, IV - EEE

Smart City Electric Vehicle Charging via Renewable-Enabled On-Road Wireless Systems

Introduction

While cities across the world begin to adopt EVs and renewable energy, the real transportation revolution is surely to come: an intelligent, integrated wireless charging infrastructure within the roads of smart cities. Teaming the clean energy of renewables with the on-road convenience of a wireless system opens up all sorts of new dimensions in mobility, sustainability, and efficiency.

The Vision of Renewable-Powered Smart Cities

Think of a city where electric vehicles charge themselves while in motion: no plugs, no waiting in line at charging stations. Roads embedded with wireless charging coils powered by solar photovoltaic panels and battery energy storage systems are an enabling platform for this innovation. As vehicles pass over these roads, they draw power through electromagnetic induction, keeping batteries charged and range anxiety at bay.

How On-Road Wireless Charging Works

The system uses resonant inductive coupling, where power is transferred wirelessly between charging coils embedded in the road and receiver coils installed under EVs. Smart sensors communicate vehicle position, speed, and energy demand in real time to ensure optimal efficiency. The whole network is monitored and managed through the city's digital grid, which integrates IoT, AI, and renewable energy forecasting.

Environmental and Economic Benefits

Wireless EV charging via renewables contributes greatly to lessening carbon emissions, improving air quality, and offering energy independence. Economically, it cuts fuel costs, reduces downtime, and creates green jobs both in manufacturing and maintenance. When powered by solar or wind energy stored in BESS, the system ensures 24/7 availability—even during low sunlight or grid outages.

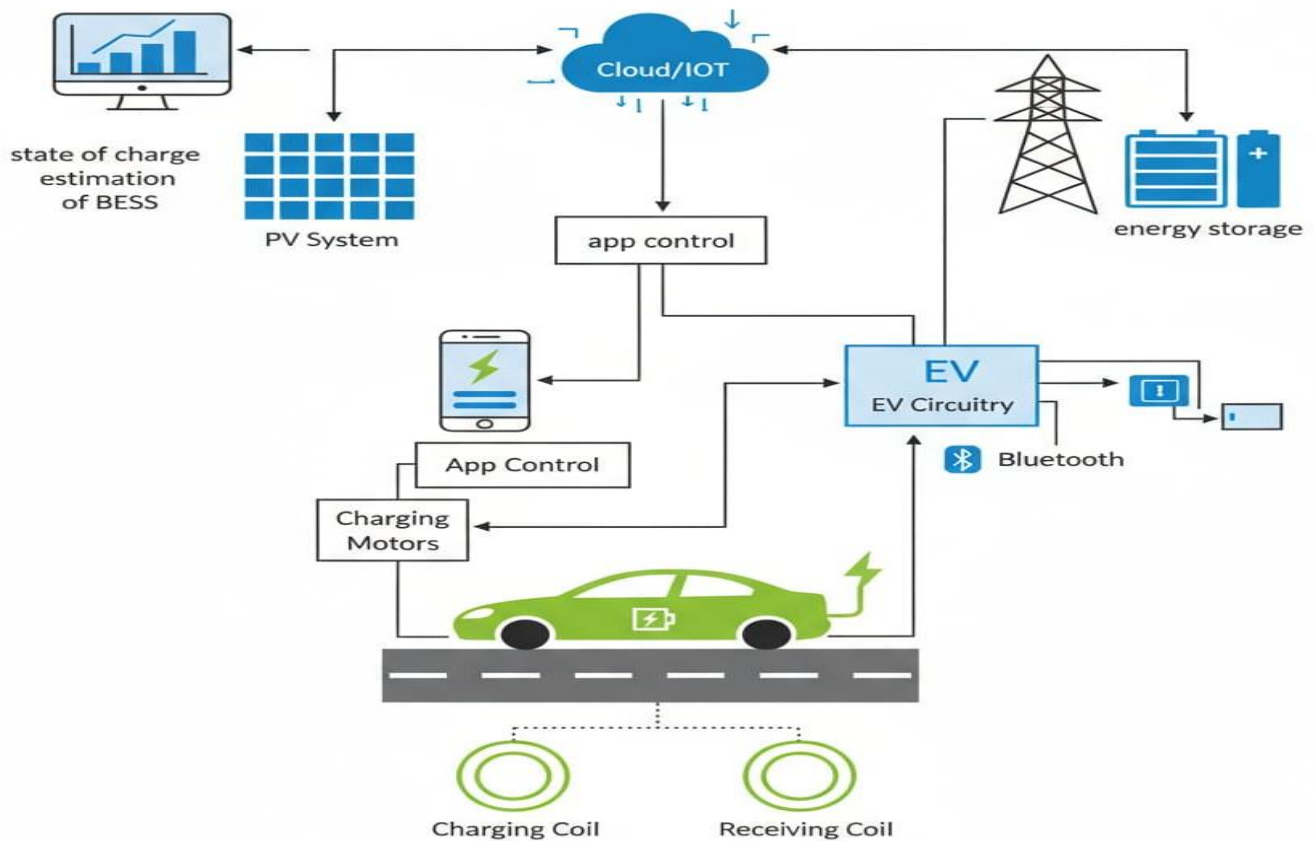


Fig 1.1 On-Road Wireless Charging design.

Challenges and Future Outlook

While the vision is compelling, challenges persist: high infrastructure costs, standardization of charging protocols, and ensuring road durability under heavy traffic. The transition to renewable energy and smart wireless charging infrastructures represents the next generation in the world of sustainable transport. It is not only a question of vehicle electrification but rather the electrification of the city itself. In the move to carbon-neutral futures, these will be the intelligent systems that turn roads from passive surfaces into dynamic, energy-sharing ecosystems.

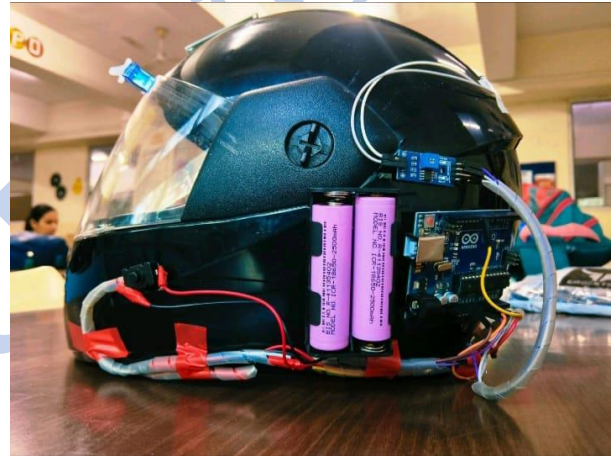
BY

P M KARTHIKEYAN, IV - EEE

Smart Helmet with Automatic Rain Detection and Wiper System

Introduction

Road safety is one of the most important concerns in today fast-paced world. Two-wheeler riders, in particular, face several challenges when it comes to safety and comfort. Helmets are mandatory for protection, but traditional helmets only serve the purpose of shielding the head during accidents. They do not assist the rider in handling real-world environmental difficulties especially rain. When it rains, the water droplets collect on the helmet's visor, significantly reducing the rider's visibility. Many riders attempt to wipe the visor with their hands or gloves, which can be risky while driving. To overcome this, engineers have introduced a Smart Helmet with an Automatic Rain Detection and Wiper System, which merges electronic automation with mechanical functionality to improve rider safety and convenience. This smart helmet is designed to automatically detect rain using sensors and activate a miniature wiper to clean the visor without requiring any manual intervention. The result is a safer, more comfortable, and technologically advanced riding experience.



Need for the System

In many countries, motorbikes are the most common mode of transport. Riders frequently face sudden weather changes, and rainfall poses a particular challenge. The primary issues include reduced visibility, manual effort, increased risk of accidents, and discomfort. Hence, there is a strong need for an intelligent helmet that can automatically detect rain and instantly clear the visor, ensuring continuous visibility and safety without distracting the rider.

Overview

The Smart Helmet with Automatic Rain Detection and Wiper System operates on a simple but effective concept detect, decide, and act. The rain sensor acts as the detection component, the microcontroller serves as the decision-maker, and the wiper system performs the action. When rainwater touches the sensor mounted on the helmet, the change in electrical conductivity or light reflection triggers the microcontroller, which then sends a command signal to a miniature DC motor

that drives a small wiper blade attached to the helmet visor. Once the rain stops, the motor is switched off automatically, ensuring automation and hands-free operation.

Applications

This system is ideal for daily commuters, delivery personnel, police officers, and long-distance riders who often encounter unpredictable weather conditions.

Future Improvements

Future enhancements may include IoT and Bluetooth connectivity, automatic speed control integration, fog detection systems, voice command operation, and solar charging options for eco-friendly use.

Conclusion

The Smart Helmet with Automatic Rain Detection and Wiper System represents a forward-thinking innovation that merges electronics, automation, and human safety. By automatically responding to rain, it helps maintain clear visibility and allows riders to focus completely on the road. Such innovations remind us that even simple inventions like a helmet can be made smarter for the benefit of human lives. Ultimately, this project is not just about adding comfort it is about saving lives through intelligent design.

BY

MUGUNTH M R, IV - EEE

AI-POWERED DEMAND RESPONSE SYSTEMS FOR SUSTAINABLE ENERGY DISTRIBUTION

In the age of smart grids and intelligent energy systems, Artificial Intelligence (AI) plays a vital role in balancing electricity demand and supply. As renewable energy sources grow and load patterns become more variable, AI-powered Demand Response (DR) systems have emerged to make traditional grids adaptive and sustainable.

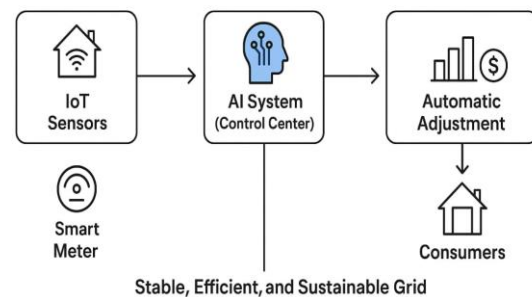
Recent studies show that DR systems let consumers shift energy use during peak hours in response to price signals or grid status. When enhanced with AI and Machine Learning (ML), these systems forecast demand fluctuations and automate control decisions efficiently. Modern algorithms, including Neural Networks, Reinforcement Learning, and Support Vector Machines, can predict energy usage and manage distributed resources far better than manual approaches.

One key advantage of AI-driven DR systems is their ability to handle data from IoT-enabled devices, smart meters, and sensors. This information helps AI models find trends, detect problems early, and suggest ways to save energy, making the system highly responsive. Fast processing through cloud and edge computing enables fast decisions for load balancing and energy dispatch.

Reinforcement Learning is becoming popular for policy optimization in these systems. AI agents learn from feedback such as power consumption, voltage changes, and market signals to make adaptive decisions, improving energy efficiency and reliability. This helps utilities save costs, cut emissions, and extend equipment life.

In summary, AI-powered Demand Response systems are the next big step in sustainable energy distribution. They combine data analytics, IoT connectivity, and automation to create smarter, adaptive grids. The future of power engineering lies in this combination, where AI makes electricity networks efficient, responsive, and greener.

AI-POWERED DEMAND RESPONSE SYSTEMS FOR SUSTAINABLE ENERGY DISTRIBUTION



BY

DHARSHINI K, IV - EEE

EMBEDDED SYSTEM FOR TRANSFORMER LOAD

BALANCING

Abstract

In modern electrical distribution networks, load imbalance among transformers is a critical issue that affects the efficiency, reliability, and lifespan of the power system. Traditional methods of monitoring and controlling load distribution rely heavily on manual intervention, which is time-consuming and less accurate. This paper presents the concept of an embedded system-based automatic load balancing system for transformers. The proposed system continuously monitors the load on multiple transformers and redistributes power intelligently using microcontroller-based control circuits and sensor feedback, ensuring optimal performance and reduced losses.

Introduction

The demand for electrical energy has increased drastically in recent years due to industrialization and urbanization. In power distribution systems, distribution transformers play a vital role in supplying electricity to residential and industrial areas. However, when the load connected to different transformers becomes unequal, it causes an unbalanced system, leading to excessive heating, increased copper losses, voltage fluctuations, and reduced transformer life. To overcome these challenges, an automatic load balancing system using embedded technology can be developed. The embedded system continuously measures the load on each transformer and automatically transfers the load from overloaded transformers to lightly loaded ones using intelligent control logic. This not only improves efficiency but also enhances the stability of the power distribution system.

Need for Load Balancing

When a transformer is overloaded, its temperature rises beyond safe limits, causing insulation damage and reducing operational lifespan. On the other hand, under loaded transformers waste available capacity, leading to inefficient utilization of network assets. Unequal loading can also cause voltage unbalance, which negatively affects sensitive equipment connected to the grid. Hence, load balancing ensures proper utilization of all transformers, prevention of overloading and overheating, improved voltage regulation, and reduction of system losses and maintenance costs.

System Design and Working Principle

The system typically consists of three distribution transformers connected in parallel to a common load network. Each transformer output is monitored by a current sensor and fed into a microcontroller. The controller compares the measured current values with the reference limit. If any transformer is overloaded, the controller identifies a lightly loaded transformer and shifts part of the load to balance the system. This automatic process maintains load balance dynamically without manual supervision.

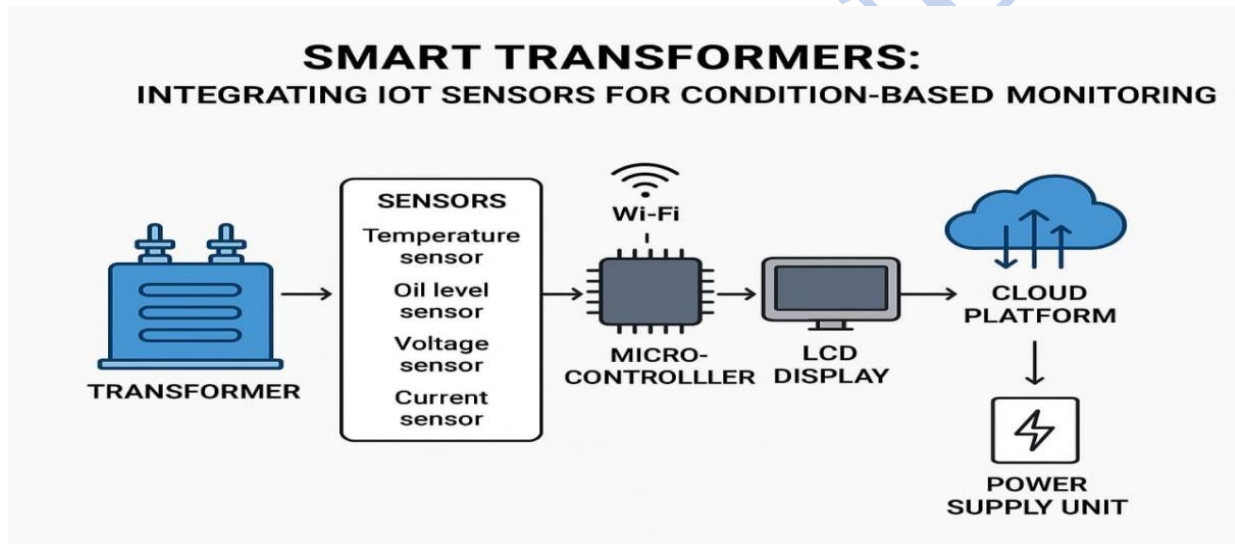
Conclusion

The implementation of an embedded system-based transformer load balancing system represents a significant step toward intelligent power distribution management. The system's ability to monitor and balance loads automatically ensures efficient utilization of transformers, extends their lifespan, and enhances the overall reliability of the electrical network. Future developments may include IoT and AI integration for predictive balancing, leading to a smarter and adaptive power system.

BY**BHARATH M, IV - EEE**

Smart Transformers: Integrating IoT Sensors for Condition-Based Monitoring

Smart transformers are advanced electrical transformers equipped with IoT (Internet of Things) sensors that continuously monitor key parameters such as temperature, oil level, moisture, load, voltage, and current. These sensors collect real-time data and transmit it to a central monitoring system using wireless communication technologies. The collected data is analyzed using cloud-based analytics or AI algorithms to detect abnormalities or faults before they lead to failures. This process, known as condition-based monitoring (CBM), helps in predicting maintenance needs and improving the reliability and efficiency of power distribution systems.



In the future, smart transformers will play a crucial role in smart grids and renewable energy integration. With advancements in IoT, artificial intelligence, and edge computing, these transformers will become more autonomous and capable of self-diagnosis and automatic fault correction.

In conclusion, smart transformers represent a significant step toward sustainable, reliable, and intelligent power systems. Their integration with IoT and AI technologies will not only reduce maintenance costs and downtime but also enhance grid flexibility, energy efficiency, and environmental sustainability.

BY

MALINI M, IV - EEE

OVERLOAD PROTECTION SYSTEM FOR INDUSTRIAL

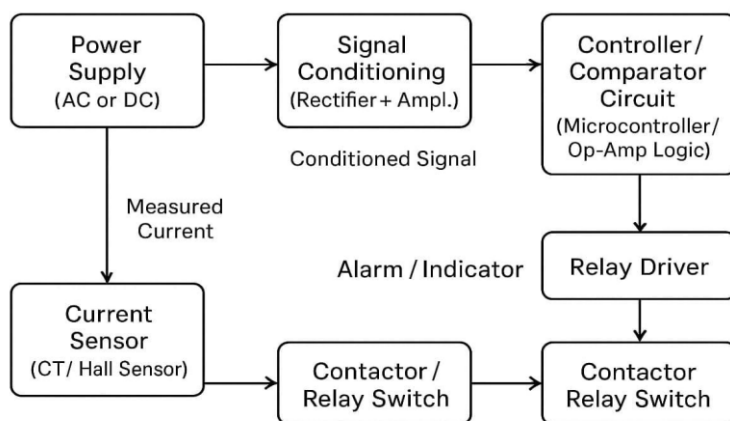
MOTOR

Electric motors are very important in every industry. They are used to run machines like pumps fans and conveyors. In many factories these motors work for long hours without any break. When a motor works with a heavy load it starts to draw more current from the power supply. If this continues for a long time the motor becomes very hot and may get damaged. Sometimes the winding inside the motor burns and this causes a big loss to the industry. To stop this problem an overload protection system is designed. It helps to protect the motor from damage due to extra current and overheating.

The main idea of this project is to create a system that can automatically turn off the motor when the current goes beyond the safe level. This system uses a current sensor, a microcontroller a relay and an indicator. The current sensor measures the current that is flowing through the motor. The microcontroller checks this current and compares it with a fixed limit. If the current is normal the motor keeps running smoothly. But if the current becomes higher than the set limit the microcontroller sends a signal to the relay to cut off the power to the motor. This quick action helps to save the motor from burning. At the same time a buzzer or light glows to show that an overload has happened. When the problem is fixed the motor can be switched on again safely.

This system works in a very simple way but gives a big benefit. It helps to protect the motor saves maintenance cost and increases the life of the equipment. In industries where many motors are used even a single motor failure can stop the whole process. So having a small protection system like this is very useful. The project can be easily made using low-cost electronic components. It can also be fitted into old motor control panels without much change.

The working of the overload protection system can be explained step by step. First, the current sensor continuously checks how much current the motor is using. This value is sent to the microcontroller. The microcontroller compares this value with the safe current limit already stored in its memory. If the value is normal the motor keeps running. But when it crosses the safe value the microcontroller sends a command to the relay to disconnect the motor supply. A small buzzer sound or light signal alerts the user. After reducing the load or checking the fault the motor can be restarted. This simple process avoids damage and ensures smooth operation.



The system can also be improved in the future. For examples sensors can be added to check motor temperature phase failure or voltage drop. The project can also be connected with IoT technology to send alerts to a mobile phone when a fault happens. This makes it a smart and advanced version for future industries.

In conclusion the overload protection system for industrial motors is a simple useful and cost-effective project. It helps to protect motors save energy and improve the safety of machines. The project shows how electrical and electronic engineering can be used to solve real industrial problems in an easy way. By applying such protection systems industries can avoid breakdowns save money, and maintain smooth production. It is a great example of how small innovations can make a big change in daily industrial work.

BY

BRINDHA R M, IV - EEE

RECLAIMING YOUR TIME: THE POWER OF DIGITAL DISCIPLINE

Today, almost everyone spends a lot of time on phones, social media and online entertainment. Technology has made our lives easy, but it has also made us forget how to spend time wisely. Many students now find it hard to focus on studies or personal goals because of constant digital distractions.

Digital discipline means using technology in a smart and controlled way. It doesn't mean avoiding phones or the internet completely. It means knowing when to use them and how much to use them. Just like food, technology is good in the right amount, but too much can cause problems.

When we limit screen time and avoid unnecessary scrolling, we get more time to study, read and do the things we love. Our minds become calmer, and we start feeling more confident and productive. Small habits like keeping the phone away while studying or turning off notifications can make a big difference.

Reclaiming your time is not about losing connection with the world it's about reconnecting with yourself. Every minute you save from mindless scrolling is a minute you can use to build your dreams.

So, take control of your digital life. Be the master of your phone, not the other way around. In the end, true success comes not from being constantly online, but from being fully present in your own life.

BY

MUKUNDHAN.M, IV - EEE

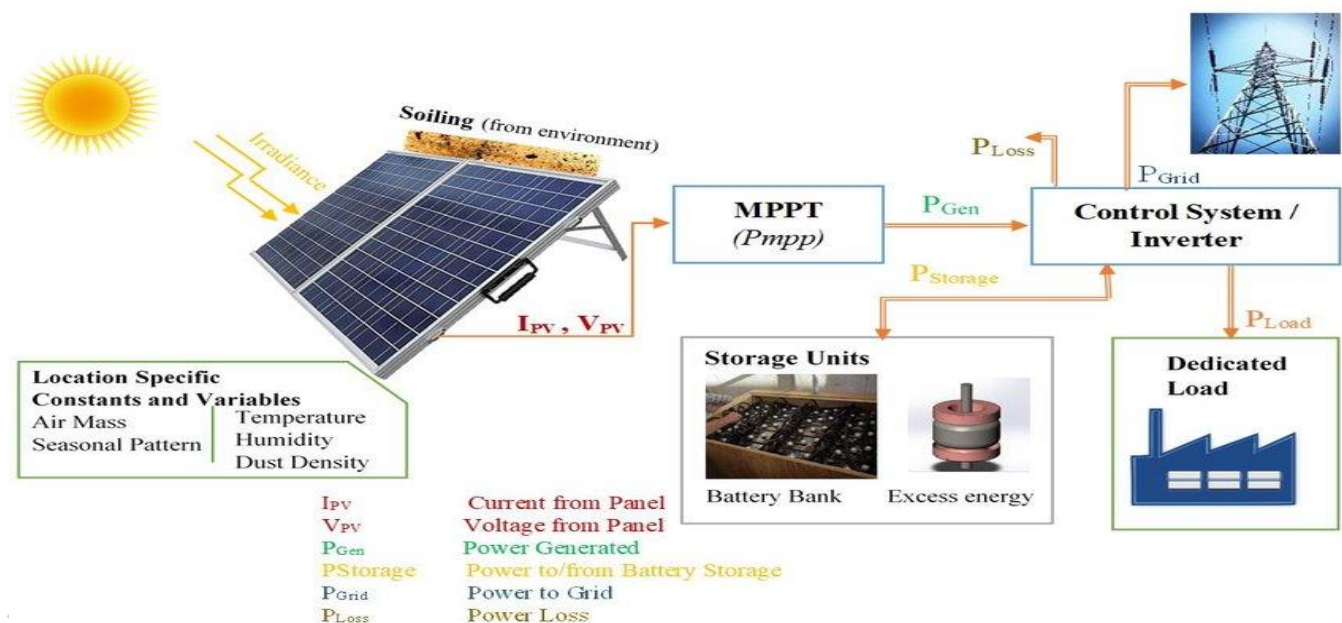
SOLAR PV: THE ENERGY OF THE FUTURE

Abstract

Solar Photovoltaic (PV) technology has become one of the fastest-growing renewable energy sources worldwide. By directly converting sunlight into electricity, PV systems provide a clean, sustainable, and cost-effective solution to meet global energy demands. This article discusses the working principle of solar PV, its types, performance factors, applications, and its vital role in shaping a greener and more energy-secure future.

Introduction

The 21st century is witnessing a global shift toward renewable energy, with solar power leading the transformation. Solar energy is abundant, inexhaustible, and environmentally friendly. Among various solar technologies, Photovoltaic (PV) systems stand out due to their ability to convert sunlight directly into electrical energy using semiconductor materials. As concerns about fossil fuel depletion and climate change grow, Solar PV has emerged as a key technology for sustainable energy generation.



Types of Solar PV Technologies

There are several types of PV cells based on the material and structure used:

Monocrystalline Solar Cells made from a single crystal of silicon, these panels have high efficiency (15–22%) and excellent durability but are more expensive. Polycrystalline Solar Cells composed of multiple

silicon crystals, these are less costly but slightly less efficient (13–17%). Thin-Film Solar Cells Made from materials like cadmium telluride (CdTe) or amorphous silicon, they are lightweight and flexible but have lower efficiency. Emerging Technologies Next-generation materials such as perovskite and organic solar cells are being developed for higher efficiency and lower cost.

Future Outlook

The future of solar PV is bright and dynamic. Emerging technologies such as bifacial panels, perovskite-silicon tandem cells, and floating solar farms promise higher efficiencies and new applications. Integration with smart grids, Internet of Things (IoT), and artificial intelligence (AI) will enable intelligent energy management and predictive maintenance. Moreover, as countries commit to achieving Net-Zero emissions, solar PV will play a central role in the global energy transition.

Conclusion

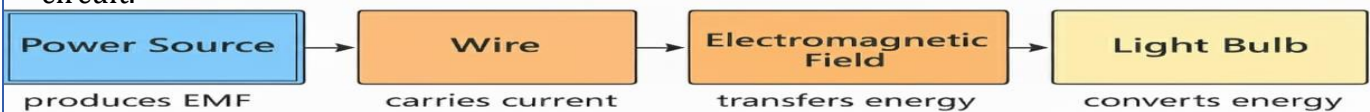
Solar PV technology stands as a symbol of hope in the fight against climate change and energy scarcity. With continuous research, innovation, and policy support, it is poised to become the backbone of the world's clean energy future. Harnessing the power of the sun not only ensures sustainability but also empowers communities with reliable and affordable electricity. Truly, Solar PV is not just an energy source — it is the energy of the future.

BY

BARATH M, IV - EEE

THE HIDDEN PATH OF ELECTRICITY

When we turn on a fan or switch on a light, we naturally believe that electric energy rushes through the wires and powers our devices. But in truth, energy does not flow inside the wires it flows around them. This may sound strange, but it's one of the most fascinating realities of how electricity truly works. Inside the wire, electrons do move, but very slowly only a few millimetres per second. If energy really travelled with those electrons, our light bulbs would take several minutes to glow. What actually happens is that when we apply voltage, an electric field is instantly created throughout the circuit.



This field, together with the magnetic field, transfers energy through the space surrounding the wire at nearly the speed of light. To understand this better, think of the wire not as a pipe carrying energy, but as a guide or pathway that directs energy flow through the surrounding electromagnetic field. The great physicist James Clerk Maxwell first revealed this idea through his equations of electromagnetism. Later, John Henry Poynting explained it more clearly using what we now call the Poynting vector a concept showing that energy flows through the electric and magnetic fields outside the conductor. In simple terms, the wire itself carries electric charge, but the energy the useful work that powers your fan or charges your phone flows through the invisible electromagnetic field around it. The wire only helps shape and guide this field. Understanding this concept changes our everyday perception of electricity. It teaches us that the visible wire is only part of the story the real action happens in the invisible space around it. This is the elegant beauty of electromagnetism: energy silently moves through the surrounding field, bringing light and life to our modern world.

So, the next time you flick a switch, remember the light glows not because energy flows in the wire, but because it flows around it.

BY

AUSTIN JONATHAN H, IV - EEE

Energy-Efficient Battery Thermal Management in Electric Vehicles Using Artificial Neural Network-Based Predictive Control

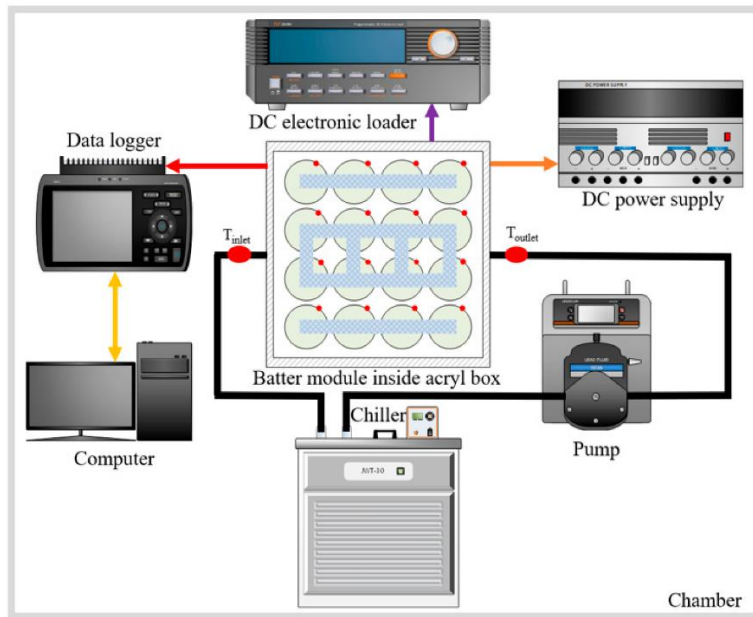
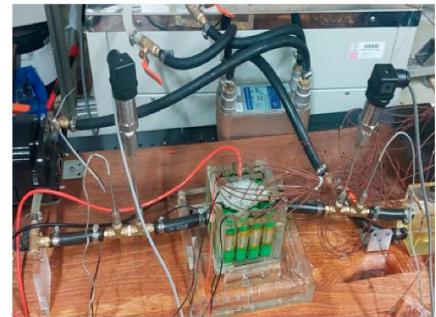
Abstract

This study proposes an Artificial Neural Network (ANN)-based Model Predictive Control (MPC) strategy for the Battery Thermal Management System (BTMS) in Electric Vehicles (EVs) to achieve optimal energy efficiency while rigorously maintaining the battery's temperature within its safe and optimal operating range. The inherent complexity of BTMS dynamics necessitates a computationally efficient yet accurate predictive model. Therefore, an ANN-based model is developed and utilized to provide high-fidelity predictions with significantly reduced computational load compared to high-order physical models. This enhanced model is integrated within an MPC framework. The resulting controller leverages the ANN's predictive capabilities to proactively optimize the BTMS actuator operations (e.g., pump/fan speeds, cooling/heating power) over a defined horizon. This proactive approach minimizes the energy consumption of the thermal system, a major factor affecting EV driving range, while preventing temperature-induced degradation and ensuring battery safety.

Simulations confirm that the proposed ANN-MPC strategy substantially reduces energy consumption across various ambient temperatures and driving conditions (e.g., reductions of 27.8% to 78.9% in different thermal environments), simultaneously improving the stability and longevity of the thermal actuators. These findings highlight the potential of intelligent, predictive control to enhance the overall performance, range, and lifespan of EV battery system.

EV Battery Thermal Management

The global shift toward Electric Vehicles (EVs) hinges on the performance and lifespan of their lithium-ion batteries, which are critically sensitive to temperature; a $^{\circ}\text{C}$ increase above the optimal range can significantly accelerate battery degradation. Consequently, the Battery Thermal Management System (BTMS) is vital for safety and longevity, yet it often consumes substantial vehicle auxiliary power, thereby reducing the driving range. Due to the battery system's inherent non-linear, time-varying, and coupled electrochemical-thermal dynamics, traditional control methods struggle. Neural Networks present an ideal solution by leveraging their ability to accurately approximate these complex non-linear functions from operational data, offering a more efficient alternative to computationally demanding physical models.



Role of Neural Networks in BTMS

Neural Networks, particularly **Artificial Neural Networks (ANNs)**, are deployed in BTMS for two primary applications:

Thermal Modelling and State Estimation Surrogate Modelling: A high-fidelity battery thermal model (e.g., a 1D or 2D finite element model) is computationally expensive. An ANN (often a Recurrent Neural Network (RNN) or Long Short-Term Memory (LSTM) network for time-series prediction) is trained on data from this model or from experimental results. The trained ANN can then predict battery temperature, heat generation, or thermal distribution with high accuracy but with computational speeds orders of magnitude faster.

Physics-Informed Neural Networks (PINNs): A more advanced approach where the neural network is trained not only on data but also on the governing partial differential equations (like the heat equation), ensuring the predictions adhere to the laws of physics.

CONCLUSION

The integration of Neural Networks into BTMS is transitioning from theoretical research to practical application. ANNs provide the necessary speed and accuracy to enable sophisticated, predictive control strategies like MPC, moving beyond reactive control. The resulting energy savings directly translate to a greater driving range for the EV, making the technology a key enabler for the next generation of high-performance and reliable electric vehicles.

BY

MONASRI S, II - EEE

IoT Security in Smart Home Electrical Networks

“Enhancing Safety and Intelligent Living”

Introduction

The Internet of Things (IoT) has transformed smart home electrical networks by enabling remote control, automation, and real-time monitoring of appliances. However, the same network connectivity that improves convenience also creates security risks. Many IoT devices have limited built-in protection, making them vulnerable to unauthorized access, data leakage, and system manipulation.

To ensure safe operation, smart homes must implement strong security practices such as encrypted communication, secure passwords, firmware updates, and proper network configuration. Artificial Intelligence (AI) further strengthens protection by learning normal device behavior, detecting suspicious activity, and responding to potential threats automatically. By combining secure network design with AI-based monitoring, smart home systems can remain reliable, private, and resilient.



Figure 1: Smart Home, IoT Devices, and AI Security — Overview

Attackers may attempt to control appliances, access camera feeds, or steal personal information. To reduce risk, users should:

- 1) Change default credentials and use strong unique passwords.
- 2) Enable WPA3 or at least WPA2 encryption on routers.
- 3) Keep device firmware up to date and segment the home network so IoT devices are isolated from personal computers.

Artificial intelligence improves protection by learning normal device behavior and alerting on anomalies. For example, if a plug suddenly contacts an unknown server or a camera streams at odd hours, the monitoring system can flag or block it. Automated responses may quarantine

the device, notify the user, and enforce updates. With responsible configuration and continuous monitoring, IoT systems can remain safe, private, and dependable.

In a typical smart home, multiple devices such as lights, smart TVs, cameras, smart plugs, refrigerators, and voice assistants are interconnected. These devices communicate through a shared network which can be accessed locally or remotely via mobile applications. However, if the communication is not securely encrypted, attackers can intercept the data and gain control over the devices. Therefore, implementing end-to-end encryption is crucial to ensure data privacy and device safety.

Conclusion

In summary, the integration of IoT devices in smart home electrical networks brings significant advantages in terms of convenience, automation, and energy efficiency. However, these benefits also introduce security challenges that must be addressed with proper network configuration, strong authentication methods, and continuous monitoring. By incorporating Artificial Intelligence, smart homes gain the ability to detect unusual behavior and respond to threats in real time, strengthening overall system reliability. As technology continues to advance, the adoption of adaptive security models and blockchain-based authentication will further enhance the safety and efficiency of automated living environments.

BY

BARATH S, II - EEE

V2G Communication: IoT Protocols for Vehicle-to-Grid Integration

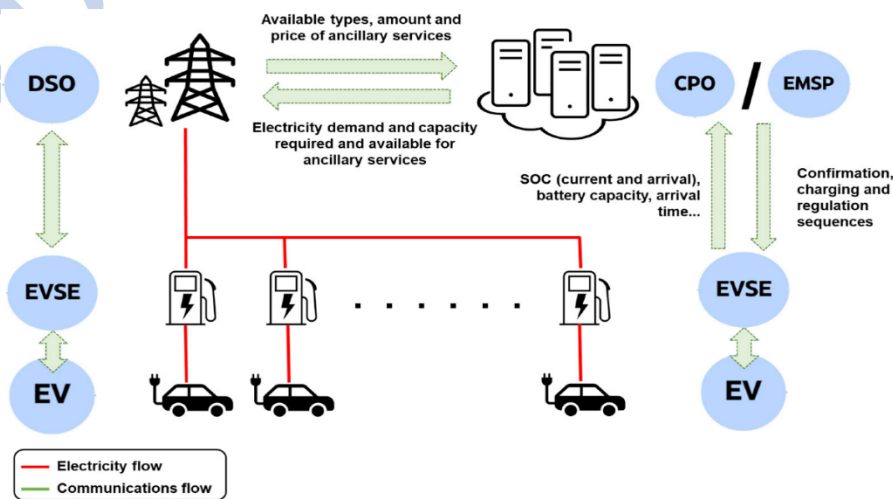
Abstract

The rapid growth of Electric Vehicles (EVs) presents new opportunities for energy management through Vehicle-to-Grid (V2G) systems. V2G technology enables bidirectional power flow between electric vehicles and the electrical grid, allowing EVs to function as distributed energy storage units. The Internet of Things (IoT) plays a crucial role in facilitating efficient communication and coordination within V2G networks. This article explores the fundamentals of V2G communication, highlights key IoT protocols used for integration, and discusses challenges and future perspectives in achieving seamless interoperability between vehicles and smart grids.

Introduction

The transition from conventional vehicles to electric vehicles is transforming the global energy and transportation sectors. As EV adoption accelerates, so does the demand for smart energy management systems capable of balancing electricity supply and demand. Vehicle-to-Grid (V2G) technology offers a solution by enabling EVs to discharge stored energy back into the power grid during peak demand periods and recharge during off-peak times.

However, achieving this coordination requires real-time, secure, and reliable communication between EVs, charging stations, and the grid — a task made possible through IoT-based communication protocols. IoT serves as the backbone of V2G integration, providing connectivity, data management, and interoperability across heterogeneous systems.



V2G systems operate on the principle of bidirectional power and information flow. In traditional grid-to-vehicle (G2V) charging, electricity flows only from the grid to the vehicle. In contrast, V2G systems allow reverse energy flow, enabling EVs to supply power back to the grid when needed. The Internet of Things (IoT) enables intelligent interaction between vehicles, charging stations, and grid operators through sensors, communication devices, and cloud-based platforms. IoT provides the connectivity and data exchange framework required for V2G coordination. IoT protocols define how data is exchanged within the V2G ecosystem.

Future trends include the integration of 5G/6G networks, blockchain-based energy transactions, edge intelligence, and AI-driven energy forecasting to enable autonomous, secure, and efficient V2G ecosystems.

Conclusion

IoT-based communication is the foundation of modern Vehicle-to-Grid systems. Through standardized protocols such as OCPP, ISO 15118, and MQTT, IoT enables seamless, real-time interaction between electric vehicles and the power grid. The fusion of IoT, AI, and smart energy systems will lead to a future where EVs not only consume energy but actively contribute to a more resilient, efficient, and sustainable power infrastructure.

BY

BIRUNDHA S, II - EEE

PREDICTIVE ANALYTICS FOR HOME BATTERY

STORAGE SYSTEMS

In recent years, the integration of renewable energy sources such as solar power has grown rapidly, driving the need for efficient energy storage solutions. Home battery storage systems play a crucial role in storing excess energy and supplying it during peak demand periods. However, the efficiency and longevity of these systems depend greatly on how intelligently they are managed. Predictive analytics has emerged as a transformative technology that enhances the performance, reliability, and cost-effectiveness of home battery storage systems. Predictive analytics involves using data, statistical algorithms, and machine learning techniques to forecast future events based on historical data. When applied to home battery systems, it enables homeowners and energy providers to anticipate power demand, optimize charging and discharging cycles, and predict potential system failures. This proactive approach helps maximize energy savings while minimizing wear on battery components.

One of the key benefits of predictive analytics is its ability to forecast energy consumption patterns. By analyzing data from smart meters, weather forecasts, and user behavior, predictive models can determine when electricity demand will rise or fall. This allows the battery system to charge during periods of low energy cost or high solar generation and discharge when demand or prices are high. As a result, homeowners can reduce their electricity bills and make better use of renewable energy. Furthermore, predictive maintenance is another valuable application. Instead of relying on fixed maintenance schedules, predictive analytics identifies early signs of battery degradation or faults. This enables timely interventions, preventing costly breakdowns and extending the lifespan of the storage system. In addition, the collected data can support continuous improvement of battery design and performance through feedback analysis.

Overall, predictive analytics is revolutionizing how home battery storage systems operate. By transforming raw data into actionable insights, it enhances energy efficiency, reliability, and sustainability. As technology continues to advance, predictive analytics will become an integral part of the smart energy ecosystem, empowering homeowners to achieve greater energy independence and contribute to a greener future.

BY

DEEPAN S, II - EEE

CYBERSECURITY & RELIABILITY: BLOCKCHAIN -

ENABLE SECURE IOT COMMUNICATION IN

ELECTRICAL NETWORKS

Abstract

Industrial automation demands continuous operation of electrical equipment. Traditional maintenance often fails, causing expensive downtime and failures. This article introduces a robust framework that integrates Wireless Sensor Networks (WSN), the Internet of Things (IoT), and Machine Learning (ML) for real-time condition monitoring. By analyzing distributed sensor data (e.g., vibration, temperature) with ML algorithms, this system enables accurate predictive maintenance. This proactive solution significantly boosts system reliability, extends asset lifespan, and moves industry closer to the zero-downtime goal of Industry 4.0.

Introduction

Electrical networks are becoming increasingly digitized and intelligent with the use of Internet of Things (IoT) devices such as smart meters, sensors, relays, and controllers. These devices continuously collect and exchange data related to energy usage, voltage levels, equipment conditions, and fault detection.

While IoT brings automation and real-time monitoring, it also exposes the system to cybersecurity threats such as data theft, false data injection, and device spoofing. Therefore, maintaining data integrity, confidentiality, and trust is a major challenge. Block chain technology provides a decentralized and tamper-proof mechanism to secure communication among IoT devices in electrical networks.

Need for Blockchain in IoT-Based Electrical Systems

Traditional security methods (like centralized servers) are not suitable for IoT systems because: They can become a single point of failure, they cannot handle massive real-time data securely and device authentication and access control are often weak.

Blockchain can solve these by:

- Enabling decentralized control,
- Ensuring secure data storage,
- Providing transparent device identity management.

Conclusion and Future Need

Blockchain technology plays a vital role in ensuring secure, transparent, and reliable

communication among IoT devices in electrical networks. It prevents unauthorized access, protects data integrity, and enables decentralized control. Thus, Block chain serves as a powerful foundation for the development of secure and intelligent power systems.

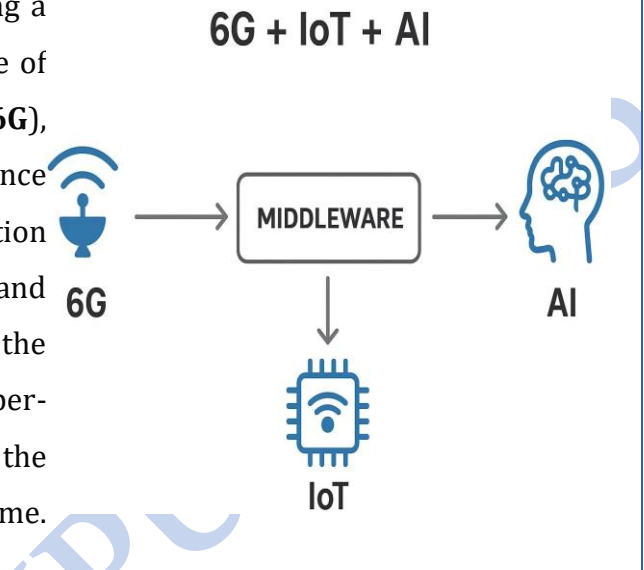
In the future, there is a need to design lightweight, energy-efficient block chain models compatible with IoT devices. Research should focus on reducing computational load, improving transaction speed, and integrating AI-based predictive systems for smarter decision-making. Standardized frameworks and policies will also be essential for large-scale

BY

KOUSHIKA S, II - EEE

THE CONVERGENCE OF 6G, IoT, AND AI IN NEXT-GENERATION ELECTRICAL SYSTEMS

The world's electrical systems are undergoing a profound transformation, driven by the convergence of the sixth generation of wireless communication (6G), the Internet of Things (IoT), and Artificial Intelligence (AI). This synergy is paving the way for next-generation smart grids that are efficient, reliable, autonomous, and sustainable. This article explores how 6G provides the necessary infrastructure, how IoT creates a hyper-connected environment, and how AI leverages the resulting data to optimize electrical systems in real time.



The Accelerator: 6G Connectivity

For this deluge of IoT data to be useful, it must be transmitted and processed with speed and reliability that current networks struggle to provide. This is where 6G technology becomes the essential communication backbone. 6G networks promise a paradigm shift over 5G, offering ultra-high data transfer rates (potentially up to 1 Tbps), incredibly low latency (as low as 0.1 ms), and massive device connectivity.

These features are critical for next-generation electrical systems:

- **Ultra-Reliable Low-Latency Communication (URLLC):** This capability enables real-time monitoring and control of critical infrastructure. In the event of a fault in the power grid, the ultra-low latency of 6G can ensure a fault detection and reaction time of less than 1 ms, preventing blackouts and minimizing downtime.
- **Massive Machine-Type Communication (MMTC):** 6G is designed to support a hundred times more connected devices per square kilometer than 5G, enabling the seamless integration of billions of IoT devices into the grid ecosystem.
- **Ubiquitous Connectivity:** Through the integration of non-terrestrial networks (like LEO satellites) and traditional terrestrial networks, 6G will ensure coverage even in remote locations, which is vital for managing sprawling energy infrastructure.

The Intelligence: AI-Driven Optimization

AI and Machine Learning (ML) are the "brains" of this converged system, transforming raw IoT data transmitted over 6G networks into actionable intelligence. AI algorithms analyze the vast datasets to identify patterns, predict future demands, detect potential issues, and make autonomous decisions without human intervention.

Key AI applications in next-generation electrical systems include:

Demand Forecasting and Load Optimization: AI models analyze historical consumption data, weather forecasts, and economic indicators to predict energy demand patterns with high accuracy. This enables utilities to optimize load scheduling and manage supply and demand dynamically.

Predictive Maintenance: Instead of routine inspections, AI analyzes data from IoT sensors embedded in infrastructure to detect early signs of equipment degradation and predict failures before they occur. This proactive approach minimizes downtime and reduces operational costs.

Renewable Energy Integration: The intermittent nature of renewable sources like solar and wind can destabilize the grid. AI algorithms help forecast renewable energy generation and optimize the use of energy storage systems to balance power fluctuations and ensure a steady, reliable supply.

Synergies and Future Outlook

The synergy between these three technologies creates a feedback loop of continuous improvement: IoT provides the data, 6G provides the transport and ultra-low latency, and AI provides the intelligence to optimize the entire system.

Challenges remain, including ensuring data privacy and security, addressing interoperability issues, and managing significant infrastructure investment costs. Policymakers and industry stakeholders must collaborate to develop harmonized frameworks and standards.

Ultimately, the convergence of 6G, IoT, and AI is set to revolutionize electrical systems, making them more resilient, sustainable, and efficient, paving the way for smarter cities and a more interconnected, automated world.

BY

SANJANA S, II - EEE

THE RISE OF GaN TECHNOLOGY IN E-MOBILITY

POWER SYSTEMS

Abstract

The rapid evolution of electric mobility has intensified the demand for high-efficiency, compact, and reliable power electronic systems. Traditional silicon-based devices are increasingly reaching their performance limits, paving the way for advanced semiconductor materials. Among these, Gallium Nitride (GaN) has emerged as a transformative technology in electric vehicle (EV) power systems. This article explores the rise of GaN technology, its advantages, applications, challenges, and its future role in shaping sustainable transportation.

Introduction:

The global shift toward electric mobility is driven by environmental concerns, energy efficiency, and advancements in power electronics. Electric vehicles rely heavily on power electronic converters such as inverters, onboard chargers, and DC-DC converters. Conventional silicon (Si) devices, though widely used, suffer from limitations such as switching losses, large size, and thermal constraints. Wide Bandgap (WBG) semiconductors, particularly Gallium Nitride (GaN), are revolutionizing power electronics by offering superior electrical and thermal properties. With a bandgap of approximately 3.4 eV, GaN enables high-frequency, high-efficiency operation, making it highly suitable for modern EV applications.



Properties of GaN Technology

GaN is a wide bandgap semiconductor with remarkable characteristics that outperform conventional silicon devices. High Electron Mobility which enables faster switching speeds, High Breakdown Voltage which Supports high-power applications, Low On-State Resistance which Reduces conduction losses, Zero Reverse Recovery Loss which Improves efficiency and High Thermal Stability which Suitable for high-temperature operation. These properties allow GaN devices to operate at significantly higher switching frequencies, leading to smaller passive components and improved system performance.

Role of GaN in E-Mobility Power Systems

GaN technology is increasingly integrated into various EV subsystems:

On-Board Chargers (OBC)

GaN-based chargers enable Faster charging speeds, reduced energy losses and Compact and lightweight designs. GaN chargers can significantly improve charging efficiency and reduce charging time compared to silicon-based systems

DC-DC Converters

In EVs, DC-DC converters are used to step down high-voltage battery power to low-voltage auxiliary systems. GaN enhances Power density, Conversion efficiency and Thermal performance

Traction Inverters

Although still emerging in high-power traction systems, GaN shows promise due to High switching frequency, Reduced switching losses and Improved motor drive efficiency

Wireless Charging Systems

GaN-based inverters are being explored for wireless EV charging, offering high-frequency operation and reduced harmonic distortion, improving overall system efficiency.

Advantages of GaN in EV Applications

The adoption of GaN technology provides several advantages like High Efficiency, Faster Charging, Reduced Weight, Improved Thermal Management, and Challenges in GaN Adoption

Despite its advantages, GaN technology faces several challenges like Limited high-voltage capability compared to SiC, Complex gate driving requirements, Reliability concerns in harsh automotive environments, higher initial cost compared to silicon, however, ongoing research and industrial advancements are addressing these issues.

Future Scope

The future of GaN technology in e-mobility is highly promising Integration with **fast-charging infrastructure**, Use in **high-frequency wireless charging systems**, Development of **high-voltage GaN devices**, Adoption in **next-generation EV platforms**, As manufacturing processes mature, GaN is expected to become a mainstream technology in EV power electronics.

Conclusion

Gallium Nitride technology is playing a pivotal role in transforming e-mobility power systems. Its superior efficiency, compact size, and high-speed switching capabilities make it an ideal choice for modern electric vehicles. Although challenges remain, continuous advancements in GaN technology are expected to overcome existing limitations. The rise of GaN marks a significant step toward more efficient, sustainable, and high-performance electric mobility systems.

By

BALAMURUGAN L, II EEE

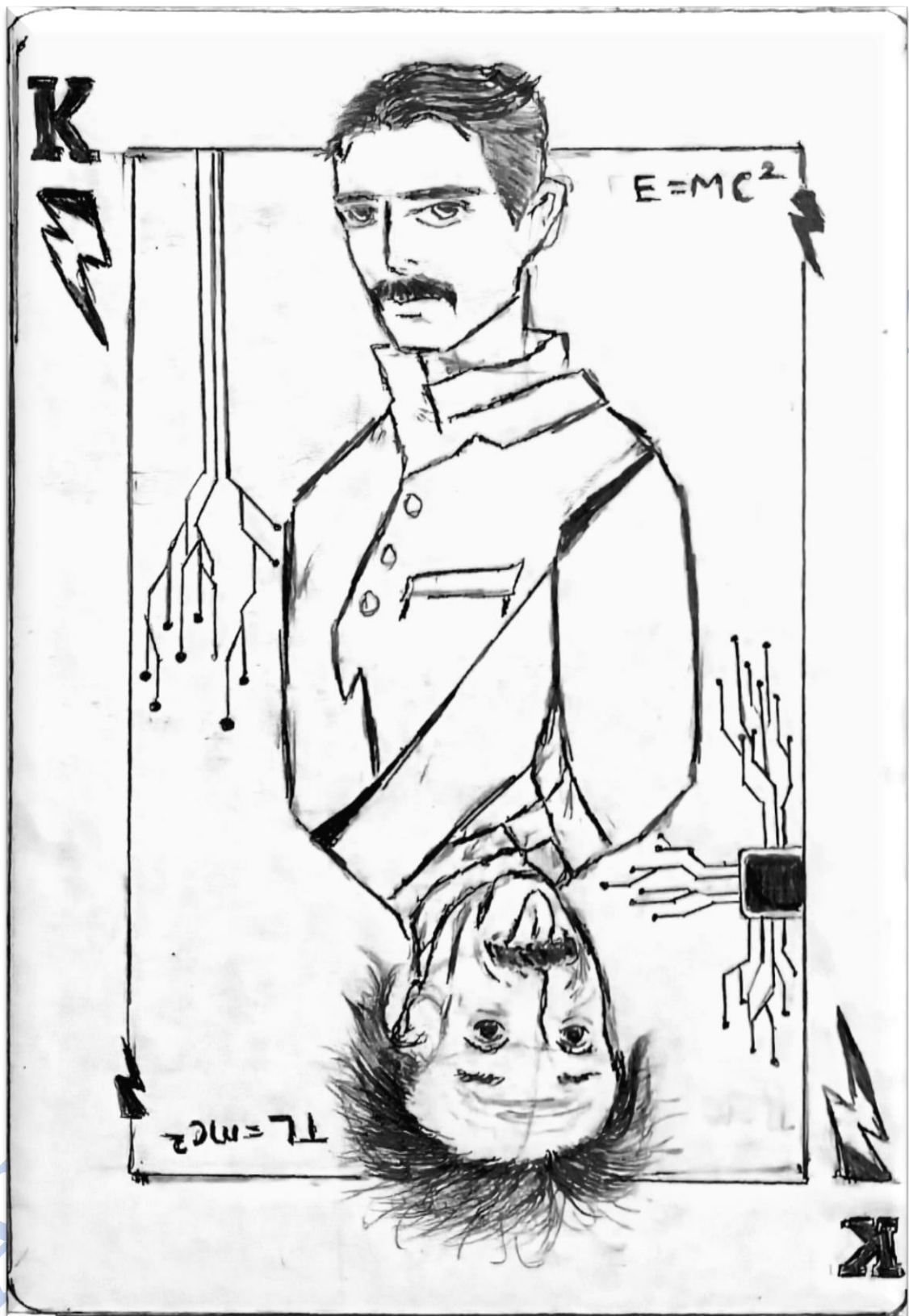
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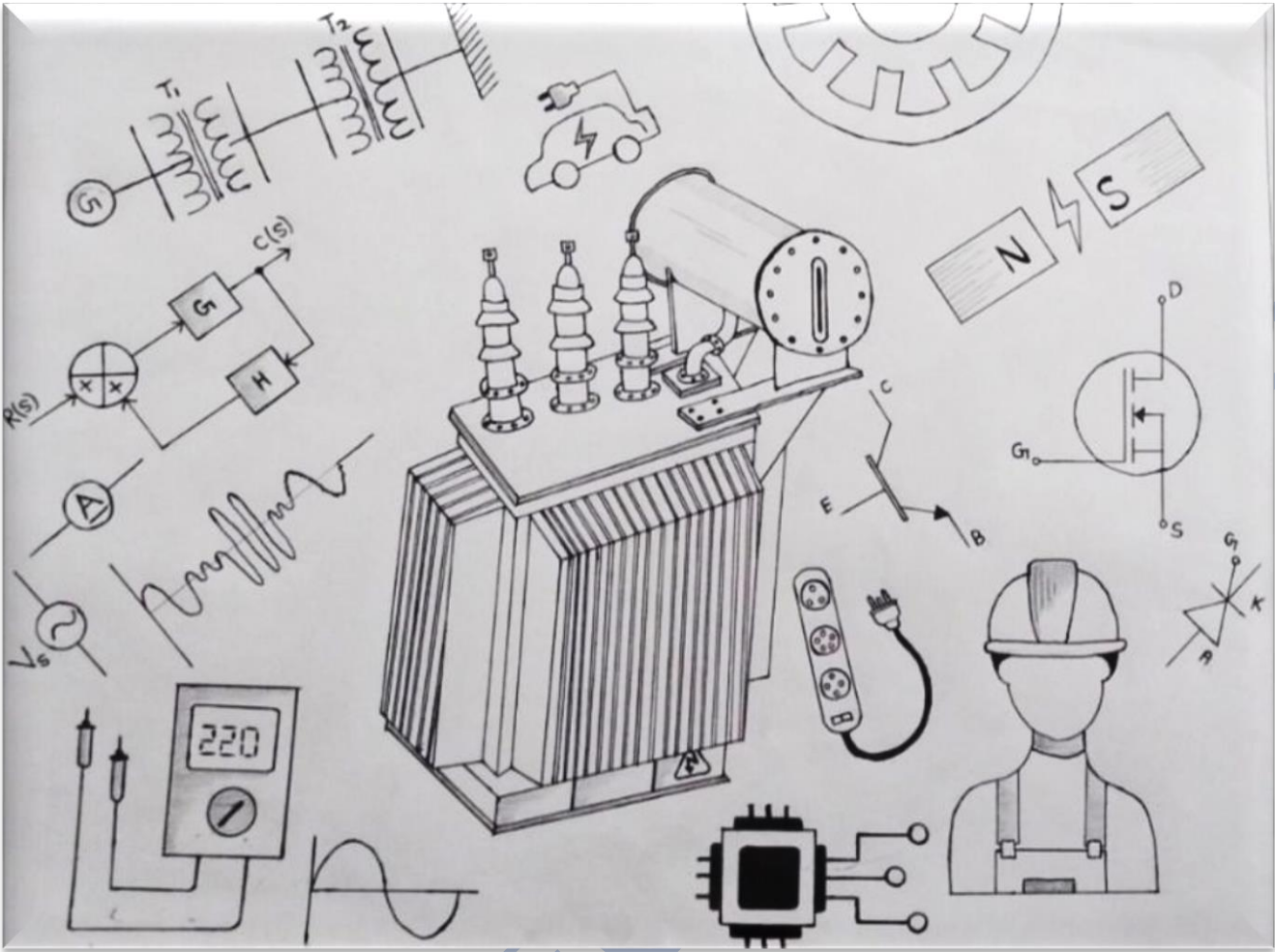
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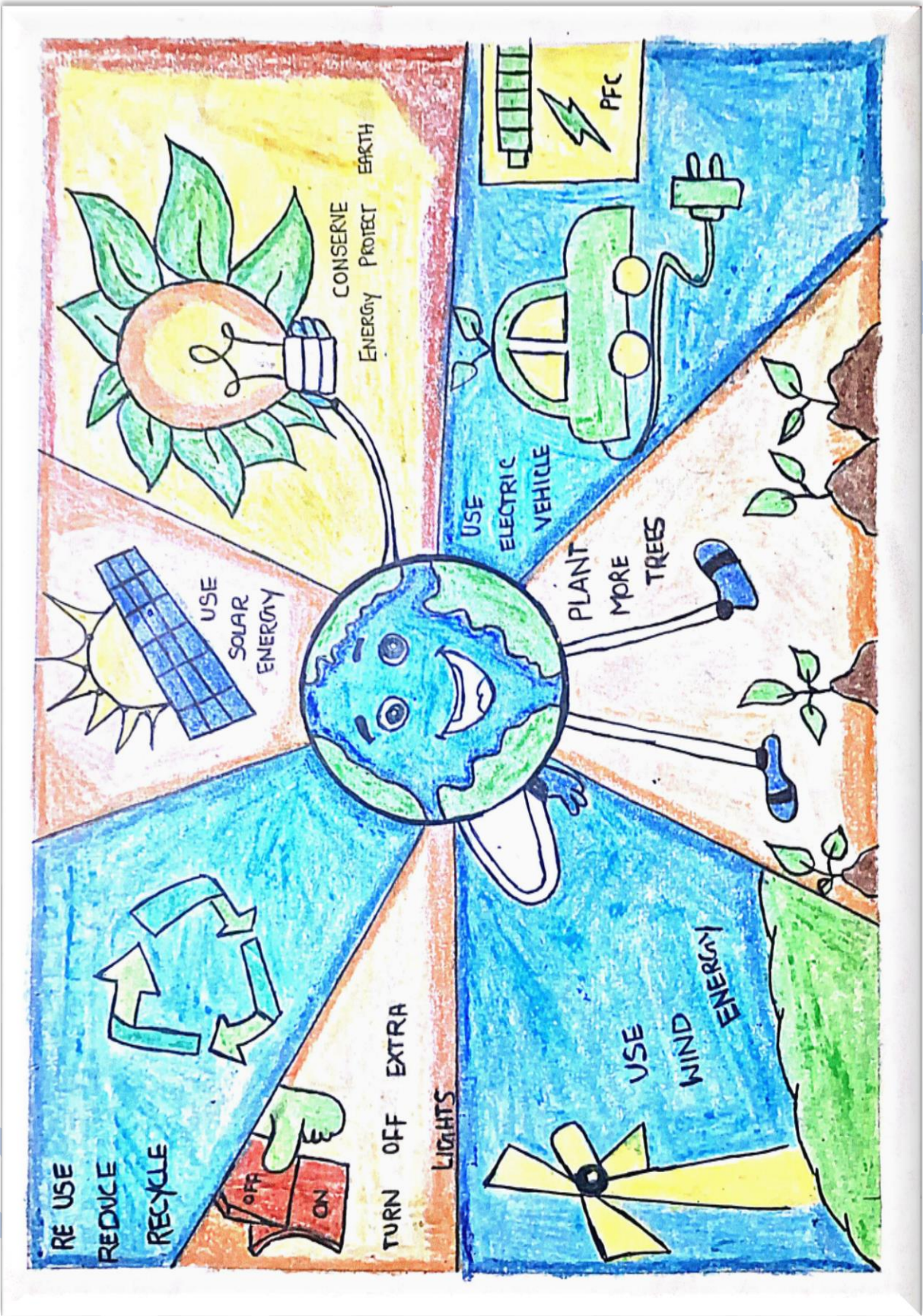
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கியத்திரம்

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 உருவான கியத்திரமீ...
 கியத்தைய மறைத்து
 செயற்கையில் நகரச் செய்கிறாய்!...
 காணம் கட்டித் தவறாமையும்
 காணம் செய்கு
 பிரமிப்பைக் காட்டினாய்...
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 பிரபஞ்சத்தையும் உள்படக்கி
 எண் திசையில் திகழும்
 கியத்திரமீ!...
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-ச. சிமானாஸ்
 II - EEE.

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MONASRI S, II - EEE



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SHEELA M, IV - EEE



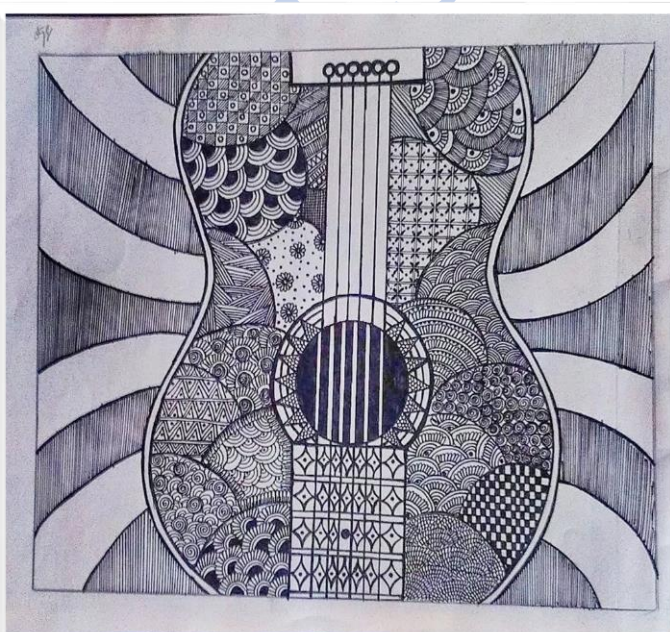
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