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# **EDITORIAL TEAM**

## **EDITOR IN CHIEF**

Dr. Rupa Mishra, Assistant Professor

Dr. Nitin Kumar Kulkarni, Assistant Professor

## **STUDENT EDITORS**

Preetham (22BEE1006)

Anshika Acharya (22BEE1252)

Mukeshkumar V(22BEE1230)





# DECARBONIZATION TECHNOLOGIES

*By Akhila Deepak Kumar(22BEE1052)*

As the global push for sustainability gains momentum, decarbonization technologies have become critical in achieving net-zero carbon emissions. Central to this goal is the transformation of electrical systems, which account for a significant portion of global greenhouse gas emissions. Innovative solutions are reshaping the energy landscape, accelerating the transition to cleaner, more efficient, and more sustainable electrical systems. In this article, we will explore how cutting-edge technologies drive decarbonization in electrical systems and help achieve net-zero goals.

## **Renewable Energy Integration: A Clean Power Source**

The shift from fossil fuels to renewable energy sources like solar, wind, and hydropower has been one of the most transformative innovations in decarbonization. Renewable energy accounts for a growing share of electricity generation worldwide, reducing reliance on carbon-intensive power sources. This transition is facilitated by developing advanced technologies that enable better integration of intermittent renewables into the grid. One key innovation is smart grid technology, which enhances the efficiency, reliability, and resilience of electrical systems. Smart grids use sensors, advanced metering infrastructure, and AI driven analytics to optimize the balance between energy supply and demand. This allows for real time adjustments to renewable energy input, ensuring a stable grid even with fluctuating wind and solar output. Moreover, energy storage systems like lithium-ion batteries and emerging solid-state batteries are playing a pivotal role in overcoming the intermittency of renewables. These systems store excess electricity during periods of high renewable generation and release it when demand exceeds supply, ensuring continuous clean energy availability.

## **Electrification of Transportation: Driving the Future**

The transportation sector is another major contributor to carbon emissions. The electrification of vehicles (EVs) is one of the most promising decarbonization strategies, as it significantly reduces the demand for fossil fuels and shifts transportation to cleaner electricity sources. The widespread adoption of EVs is supported by the development of more efficient and affordable EV batteries, along with an expanding network of fast charging infrastructure. Breakthroughs in solid-state battery technology promise to revolutionize EV performance, offering greater energy density, faster charging times, and longer lifespans. Innovative vehicle-to-grid (V2G) technology is also emerging as a game-changer. V2G systems allow EVs to act as distributed energy resources, where parked vehicles can supply electricity back to the grid during peak demand. This two-way flow of energy improves grid resilience and enhances the overall efficiency of electricity usage.



## **Decentralized Energy Systems: Empowering Local Solutions**

Centralized power generation is gradually complemented by decentralized energy systems, which are particularly effective in reducing transmission losses and improving energy access in remote areas. Decentralized systems often rely on small-scale, renewable energy sources, such as rooftop solar panels, community wind farms, and micro-hydro projects. Microgrids are a key component of decentralized energy systems. They enable local communities, businesses, and industrial parks to generate, store, and distribute electricity independently from the larger grid. When integrated with renewable energy sources and energy storage, microgrids offer a highly efficient and resilient solution for decarbonization, particularly in areas prone to power outages or regions with limited grid infrastructure

# INNOVATIONS IN ELECTRICAL SYSTEMS FOR NET ZERO GOALS

*By Shreya Srivastava(22BEE1165)*

Peer-to-peer energy trading platforms, which use blockchain technology, further empower decentralized energy systems. These platforms allow individuals and organisations to buy and sell excess renewable energy directly from one another, promoting more efficient use of clean energy resources and reducing reliance on large, centralized power plants.

## **Energy Efficiency and Digitalization:**

**Smarter Energy Use** Improving the energy efficiency of electrical systems is an essential component of decarbonization. Digital technologies, such as the Internet of Things (IoT), machine learning, and big data analytics, are transforming how energy is consumed and managed. These technologies enable more intelligent control and monitoring of energy usage across industries, commercial buildings, and households, significantly reducing carbon footprints. For instance, smart meters and home energy management systems allow consumers to track their energy consumption in real-time, providing insights into how and when energy is used. This data can be used to optimize energy consumption patterns, reduce waste, and lower electricity bills. On a larger scale, industrial energy management systems (EMS) and artificial intelligence (AI) are helping factories and industrial plants minimize energy waste and improve operational efficiency. By predicting demand patterns and optimizing equipment usage, these systems enable substantial energy savings, reducing emissions from energy-intensive industries.

## **Hydrogen and Electrification of Industry: A Cleaner Future**

While renewable electricity and energy efficiency have made significant strides, certain industries, particularly those that rely on high-heat processes, need more time to electrify. This is where green hydrogen comes into play. Green hydrogen, produced through water electrolysis using renewable electricity, offers a zero-carbon alternative to traditional fuels in steel production, cement manufacturing, and chemical industries. Electrification of industrial processes is also advancing with the help of innovations like electric arc furnaces in steelmaking and electrified cement kilns.

These technologies allow industries to decarbonize by replacing fossil fuel-based heat with electricity from renewable sources.

## **Conclusion: Charting the Path to a Net-Zero Future**

Achieving net-zero carbon emissions will require a combination of innovative technologies, policy support, and international cooperation. The decarbonization of electrical systems lies at the heart of this effort, and the ongoing advancements in renewable energy integration, electrification, decentralized systems, energy efficiency, and industrial decarbonization offer a promising roadmap for the future. As these technologies continue to evolve, they will play a pivotal role in accelerating the transition to a more sustainable, low-carbon energy system bringing us closer to the realization of global net-zero goals. The future of electrical systems is bright, clean, and, most importantly, within reach.

# SEMICONDUCTORS IN AUTONOMOUS VEHICLE TECHNOLOGY

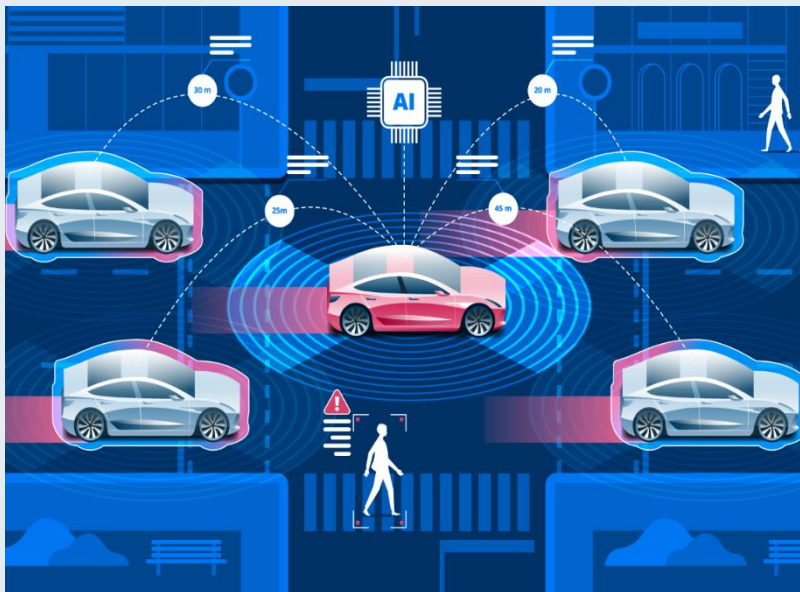
*By Arun R(22BEE1052)*

The Revolution Autonomous vehicles, once just a dream of the future, are now reshaping how we travel. At their core, these self-driving wonders rely on a sophisticated web of technologies, where semiconductors play a crucial role. These small yet powerful electronic components act as the vehicle's brain and nervous system, empowering them to sense their surroundings, analyse data swiftly, and make split-second decisions—all in real-time.

## What is Autonomous Vehicle Technology?

An autonomous vehicle is equipped with sensors and artificial intelligence (AI) that allows it to operate without human intervention. These vehicles use a combination of technologies, including cameras, radar, LiDAR (Light Detection and Ranging), and ultrasonic sensors, to gather information about their surroundings. This data is then processed by on-board computers, which use algorithms to make decisions about steering, acceleration, and braking.

Autonomous vehicles (AVs) are categorized into different levels based on the degree of automation:



Level 0: No automation, where humans control the vehicle entirely.

Level 1: Driver assistance systems, such as adaptive cruise control.

Level 2: Partial automation with features like lane-keeping and acceleration, but human intervention is required.

Level 3: Conditional automation, where the

vehicle handles all aspects of driving but still requires human attention.

Level 4: High automation, where the vehicle can operate independently in specific conditions.

Level 5: Full automation, where the vehicle requires no human involvement in any conditions.

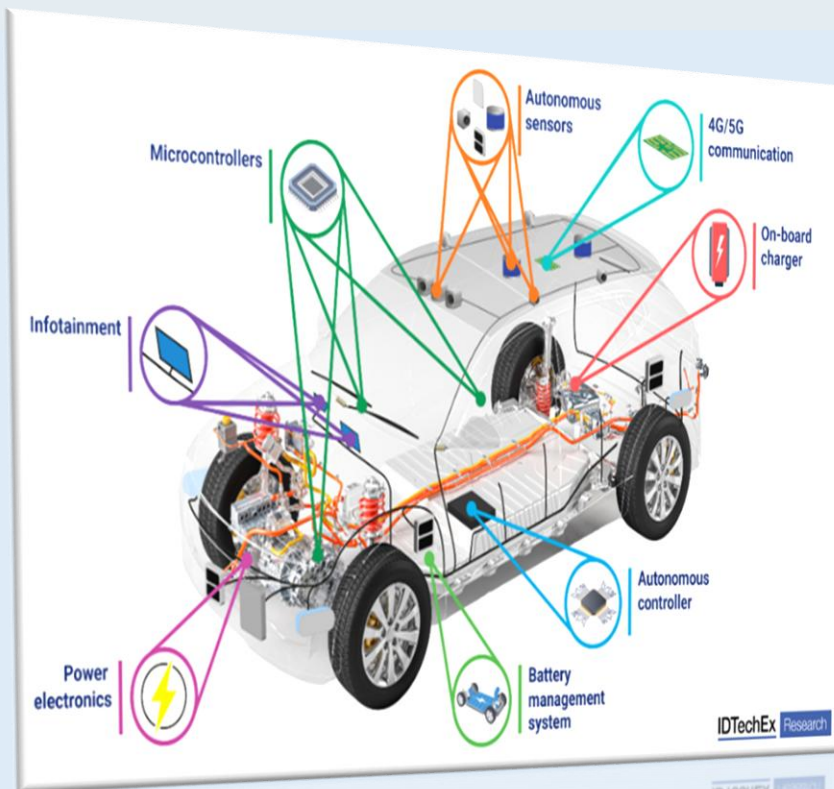
## Semiconductors: The Backbone

Semiconductors, primarily silicon-based integrated circuits (ICs), are the fundamental building blocks of modern electronics. They are used in various applications, from sensors and processors to communication systems and power management.

## Types & Applications

**Microcontrollers:** These are specialized microprocessors designed for embedded systems. They are used in autonomous vehicles to control various functions, such as motor control, sensor data acquisition, and communication with other systems. They are often chosen for their low power consumption, small size, and cost-effectiveness.

**Micro-processors:** More potent than microcontrollers, microprocessors are used for complex tasks like running AI algorithms, processing sensor data, and performing high-speed computations. They are often found in the central processing unit (CPU) of autonomous vehicles.



### Power

#### Semiconductors:

Power management is key for autonomous electric vehicles (EVs), with power semiconductors like MOSFETs and IGBTs playing vital roles in motor drives, battery management, and charging circuits. These devices efficiently convert and regulate power, ensuring smooth operation and minimizing losses.

#### Sensors and MEMS

#### (Micro-Electro-Mechanical Systems):

Sensors like radar, LIDAR, and cameras are essential for autonomous vehicles, gathering environmental data for processing. MEMS, tiny integrated mechanical and electrical systems, are used in accelerometers, gyroscopes, and pressure sensors for vehicle stability and positioning.

**FPGA (Field Programmable Gate Arrays):** FPGAs are reprogrammable semiconductor devices used in autonomous vehicles for high-computation tasks like sensor fusion and real-time data processing. They offer flexibility by adapting to new algorithms and sensor setups without hardware redesign.

**Neural Processing Units (NPUs):** NPUs are designed specifically for AI workloads, offering high efficiency and performance for deep learning tasks such as image recognition, object detection, and decision-making.

## Integration of AI and Deep learning

Integrating AI and Deep Learning in autonomous vehicles has led to the development of specialized chips designed to handle the complex computational tasks required for autonomous driving. Companies like Huawei and Cambricon are developing NPUs that can be integrated into autonomous driving systems, providing the necessary computational power for real-time processing.

**Graphics Processing Units (GPUs):** Initially designed for rendering graphics, GPUs have found a new role in autonomous driving due to their ability to handle parallel processing tasks. Nvidia's GPUs, particularly the Drive AGX platform, are widely used in autonomous vehicles to process large amounts of sensor data and run complex AI algorithms.

**Custom ASICs:** ASICs are custom-designed chips optimized for specific tasks, such as image processing or machine learning. They are used in autonomous vehicles for specialized tasks like lane detection, object recognition, and high-speed data processing. Tesla's Full Self Driving (FSD) chip is a prime example of a custom ASIC designed to handle the demanding requirements of autonomous driving.

## Technological Advancements in Autonomous Vehicles

Autonomous vehicles are rapidly evolving, driven by advancements in several key areas:

**Edge Computing:** Real-time decision-making is enhanced by processing data locally, reducing latency, and improving responsiveness.

**Neuromorphic Computing:** Inspired by the human brain, this technology promises more efficient and parallel processing, accelerating AI and machine learning.

**Wide-Bandgap Semiconductors:** Silicon Carbide and Gallium Nitride offer superior power efficiency, density, and thermal performance, leading to increased range and faster charging in electric vehicles.

**System-on-Chip (SoC) Solutions:** The automotive industry has increasingly adopted SoC designs, integrating multiple functionalities such as computing, graphics, networking, and AI processing into a single chip. Key players NVIDIA's Xavier and Orin platforms, part of its DRIVE series, are built for autonomous driving with integrated AI accelerators, GPUs, and CPUs, processing data from cameras, LIDAR, radar, and sensors. The Orin platform delivers up to 254 TOPS of AI computing power. Intel's Mobileye EyeQ chips excel in vision-based driver-assistance, handling tasks like lane detection and object recognition. Texas Instruments' TDA4VM processor, optimized for ADAS, combines an ARM-based CPU with AI accelerators for sensor fusion. Renesas R-Car H3 integrates ARM cores with a GPU and IPU, enabling real-time image recognition and vehicle control. Semiconductors are the foundation of autonomous vehicle technology, enabling advanced features like AI-driven decision-making, sensor fusion, and real-time data processing. Recent advances in AI accelerators, SoCs, wide-bandgap materials, and neuromorphic computing are pushing the boundaries of what autonomous vehicles can achieve.

As semiconductor technology continues to evolve, autonomous vehicles will become safer, more efficient, and capable of operating in increasingly complex environments.

# AUTOMATING DIAGNOSTICS IN OPHTHALMOLOGY USING DEEP LEARNING MODELS

*By Mradul Goyal(21BCE5393)*

In a world where technology is transforming all industries, the healthcare industry is not different. Perhaps the most promising advancement is the application of machine learning to detect diseases early. How deep learning models can be used to detect severe eye diseases such as glaucoma, diabetic retinopathy, and cataracts. This pioneering work seeks to offer a faster, more reliable, and less expensive means of diagnosing ocular diseases, particularly in areas with fewer medical resources. Vision-related illnesses afflict millions of people worldwide. If left undetected or untreated, they result in irreversible blindness. Conventional diagnosis is based on manual inspection by skilled ophthalmologists, which is time-consuming, subject to human error, and unavailable in remote locations. This research overcomes these drawbacks by employing cutting-edge deep learning methods to automatically classify retinal images.

Deep learning-based automated diagnostic systems can significantly alleviate the workload of ophthalmologists while improving the speed and accuracy of diagnosis. In areas of underserved availability of medical specialties, these systems can offer life-altering early diagnosis and treatment. As artificial intelligence continues to advance, the dream of medical diagnostics that are accessible, accurate, and efficient is within reach. As technology and medicine continue to converge, efforts like this point to the power of machine learning to revolutionize patient outcomes and global health equity.

## **Revolutionizing Eye Disease Diagnosis with Deep Learning**

In the rapidly evolving era of medical technology, deep learning has emerged as a revolutionary force in the diagnosis and treatment of diseases. A recent research study on computer-aided diagnosis of retinal images is pioneering new fronts in medical imaging with the help of advanced deep-learning models. This technology promises early detection and improved diagnosis of serious eye ailments such as cataracts, diabetic retinopathy, and glaucoma.

## **The Growing Need for Computerized Detection of Eye Disease**

Eye diseases are a major cause of visual disability globally. Cataracts and glaucoma develop silently and cause irreversible loss of vision if not diagnosed. Current diagnostic techniques, although effective, are time-consuming and rely on highly skilled medical knowledge. This research project hopes to fill this void by creating an automated eye disease detection system that is accurate and quick, thus improving patient outcomes and reducing the workload on medical professionals.

**Methodological Approach: In-Depth Investigation of Technology :** Leading the way in this project is the use of four state-of-the-art deep learning models: Convolutional Neural Networks (CNN), VGG16, Efficient Net, and Google Net (InceptionV3). All of these models have different strengths in medical image classification from each other:

- **CNN:** Ideal for basic image classification, with a simple architecture for learning spatial patterns.
- **VGG16:** Known for its deep structure, which captures intricate image features, though computationally intensive.
- **Efficient Net:** Designed for efficient scaling, balancing depth, width, and resolution for enhanced performance.
- **Google Net (InceptionV3):** Employs an inception module to capture multi-scale features, excelling in handling complex patterns.

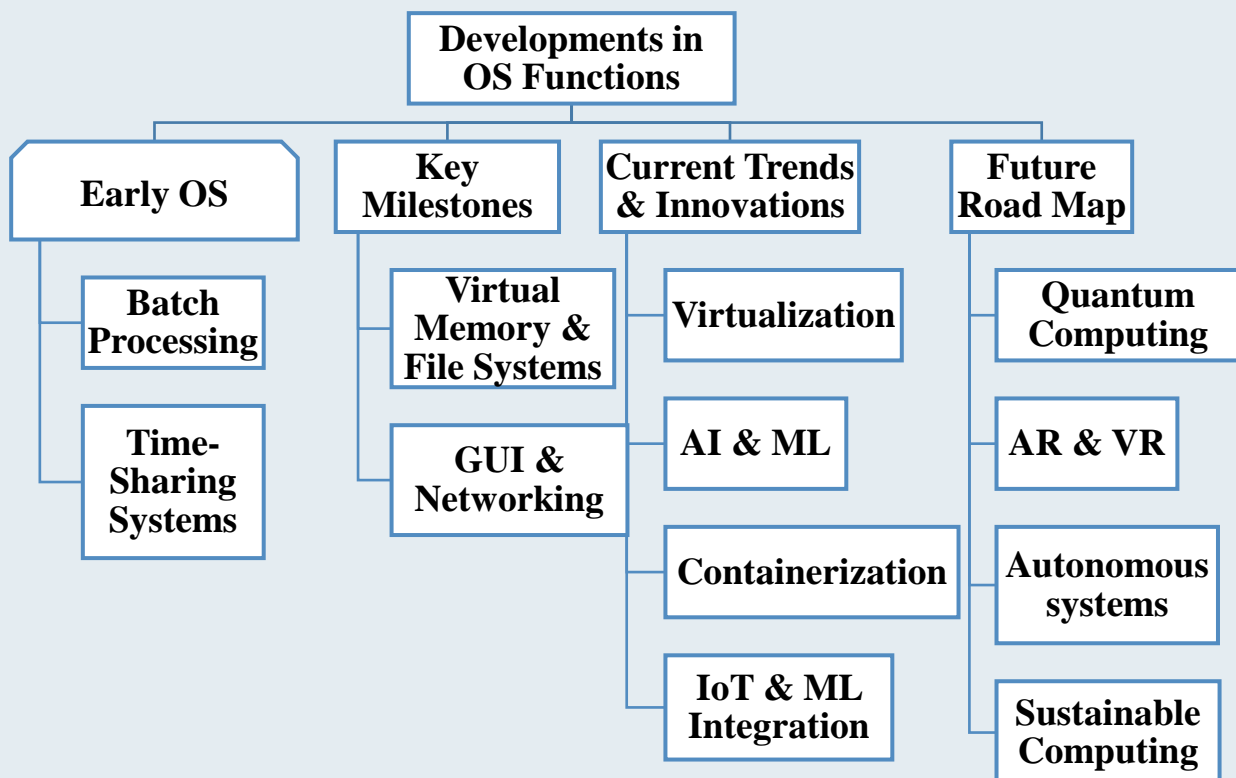
The preprocessing of the data through resizing, normalization, and applying data augmentation techniques for model resilience. Images were resized to the same resolution of 224x224 pixels for ensuring consistency in all the models. Rotation, flipping, and brightness adjustment-based data augmentation were employed for consideration of class imbalances and enhancement of generalizability.

# A GENERALISED FRAMEWORK OF OPERATING SYSTEMS

By Shashank Dwivedi (23BEL1049)

## Evolution of Operating Systems

It is amazing to note the rise of operating system operating from the mid-20<sup>th</sup> century until now. To note early computers made in the late 1940s until the middle of the 50s operated without any form of automatic system, hence the term ‘operating system’ would not apply for that time period. The period in the 60’s saw the introduction of automation into batch processing systems. The use of multi-programming in the 60’s enabled machines to run various programs simultaneously. With the existence of MS-DOS and Mac OS during the 80’s increased the rise of personal computers. Revamped enhancements such as advanced networking and virtualization started becoming a fixture in every computer during the 2000s. At present, the development of OS is all about AI inclusion, cloud computing and more up to date requirements.



## Functions of Operating Systems

Operating Systems are the backbone of modern computing, acting as a bridge between hardware and software. They handle:

- Process Management: Making multitasking possible by managing how programs run.
- Memory Management: Allocating memory to different programs and making sure it’s used efficiently.

- **File System Management:** Organizing data into files and directories and managing access.
- **Device Management:** Coordinating how hardware like printers and drives communicate with the system.
- **Security and Access Control:** Keeping data safe and controlling who can access it.
- **Networking:** Enabling communication between devices using network protocols.

## Features of Linux Operating System

Linux is a powerful, open-source operating system. Here's why it stands out:

- ✓ **Customizability:** You can tweak it to fit your exact needs.
- ✓ **Stability and Reliability:** It can run for long periods without crashing.
- ✓ **Security:** Built-in protection from malware thanks to its permission structure.
- ✓ **Community Support:** A huge community of developers keeps it up to date and solves issues quickly.
- ✓ **Lightweight Design:** Works well even on systems with limited resources.

## Opportunities in System Administration and OS Design

Careers in system administration and OS design are full of possibilities:

**System Administration:** Involves managing and maintaining IT infrastructure like servers and networks. Roles often focus on troubleshooting, securing systems, optimizing performance, and cloud management.

**OS Design and Development:** Focuses on creating and refining operating systems. This includes improving kernel functionality, ensuring compatibility with new technologies, and integrating cutting-edge innovations like AI and IoT.

### Developments in OS Functions

Over the years, operating system functions have become more sophisticated to meet the demands of modern technology. Key developments include:

1. **Virtualization:** Enabling multiple virtual machines to run on a single physical machine, improving resource utilization.
2. **Enhanced Security:** Incorporating advanced features like encryption, secure boot, and real-time threat detection.
3. **Cloud Integration:** Seamlessly connecting local devices to cloud services for storage and computing power.
4. **Support for AI and Machine Learning:** Integrating frameworks and tools that allow intelligent applications to run efficiently.
5. **Real-Time Processing:** Meeting the strict timing requirements of applications in robotics, automotive, and healthcare industries.

### Challenges in OS Design

- **Performance Optimization:** Balancing speed and efficiency with resource usage.
- **Security Threats:** Protecting against vulnerabilities and cyberattacks.
- **Scalability:** Making systems that can grow with user needs.

- **Compatibility:** Ensuring the OS works smoothly with various hardware and software.
- **Real-Time Processing:** Meeting the demands of time-critical applications like those in embedded systems.

## **Inference**

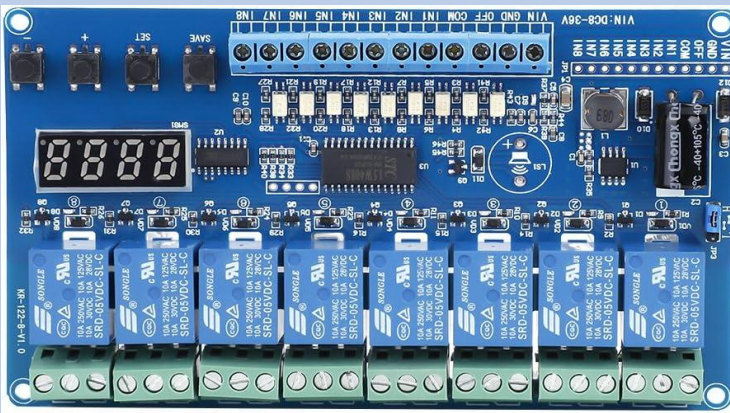
Operating Systems have grown and adapted over the decades to meet ever-changing demands. From their early beginnings to today's sophisticated platforms, they've enabled incredible technological advancements. Learning about OS features and functions opens doors to exciting careers in system administration and development. With trends like virtualization, AI, and cloud computing shaping the future, the journey of operating systems is far from over.

# MULTIFUNCTIONAL RELAY

By Aman Mishra(21BEE1010)

Protection mechanisms are of extreme importance in power systems engineering. A multifunctional relay is a critical component in modern power systems that ensure smooth and safe operation of electrical networks. It plays a pivotal role in safeguarding power systems from various electrical anomalies, including overcurrent, overvoltage, undervoltage, and differential faults.

Relays have been significantly evolving over the years to meet the increasing demands of complex electrical systems. The multifunctional relay, designed in adherence to IEEE standards, embodies this evolution by integrating multiple protective functions within a single, compact device. This integration enhances the reliability and efficiency of power systems while simplifying the overall protection scheme, reducing the need for multiple devices.



Each of the key functions of the multifunctional relay, namely overcurrent, overvoltage, undervoltage, and differential protection, serve a unique purpose in maintaining the stability and integrity of the power system.

Overcurrent protection is used to detect and isolate excessive current flow, which saves the equipment from damage and prevents accidents. Voltage protection guards against voltage fluctuations that disrupt the operation of sensitive electrical equipment's. Differential protection provides precise fault detection within specific zones of power system, allowing isolation of faults and minimizing its impact on the entire network. As power systems continue to expand and become more intricate, the need for advanced protection mechanisms like the multifunctional relay becomes increasingly critical. This article delves into the design and implementation of a multifunctional relay.

# SMART HOME ENERGY MANAGEMENT SYSTEM

By Gopika S (21BEE1241)

## What is a Smart Home Energy Management System?

A smart home energy management system is a technology that allows homeowners to manage the energy consumption of their home through an integrated network of devices. These systems use data from smart meters, sensors, and connected devices to track energy usage in real time and adjust settings to optimize efficiency. Smart home energy management systems (HEMS) are designed to monitor, control, and optimize the energy consumption of household devices and appliances.

## Current Technologies

**Smart Meters:** These digital meters measure the amount of electricity being used in real-time. Unlike traditional meters, they communicate usage data directly to your utility company and to the home's central management system, providing valuable insights into energy consumption.

**Smart Thermostats:** These devices, like the Nest Thermostat or Ecobee, learn your preferences over time and adjust heating and cooling settings automatically based on factors like occupancy, time of day, or weather conditions. They also provide remote control via apps.

**Sensors:** Sensors detect occupancy, temperature, light levels, and other factors that help optimize energy use. For example, motion sensors can turn off lights in rooms that are not in use, while temperature sensors adjust the thermostat when the room temperature changes.

**Energy Management Hubs:** These devices act as the central control unit for the home's energy system. They integrate all smart devices, allowing you to monitor and control energy consumption from a single platform or app.

**Renewable Energy Integration:** Homeowners increasingly incorporate solar panels and battery storage systems to generate and store energy, managed by SHEMS.

**AI-Based Energy Prediction Model:** To analyze and predict energy consumption, deep learning models such as LSTM (Long Short-Term Memory), GRU (Gated Recurrent Unit), and Bi-LSTM (Bidirectional LSTM) are employed. These models process time-series data to identify patterns and forecast future energy usage.



## Data Analytics

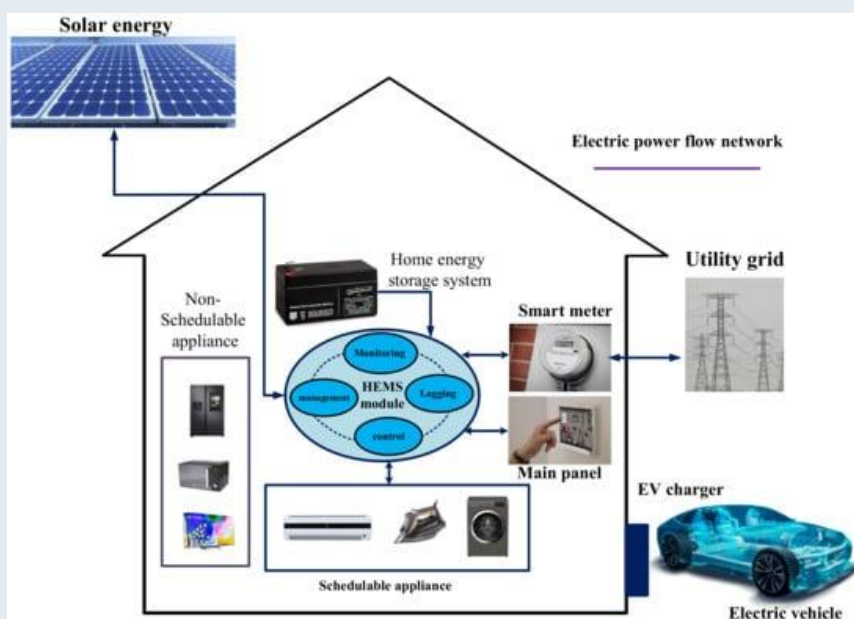
A significant feature of a smart home energy management system is its ability to gather data on energy consumption. This data is then analyzed to offer insights and recommendations.

## Operating Procedure

**Real-time Energy Monitoring:** The system continuously tracks energy use, offering detailed insights into which devices or appliances are consuming the most power. For instance, you can see how much energy your washing machine, refrigerator, or heating system uses in real time.

**Energy Usage Reports:** The system often generates daily, weekly, or monthly reports to help users understand their energy habits. These reports might break down energy usage by appliance or area of the home, helping homeowners identify areas where they could cut back on consumption.

**Usage Trends:** Advanced systems often use machine learning to analyze patterns over time. For example, the system might notice that you tend to leave lights on for longer than necessary or that your heating system is consuming more energy than expected. Based on this data, the



system may suggest behavioral changes or even automatically adjust settings.

**Smart Recommendations:** With the data collected, the system can offer personalized tips on how to improve energy efficiency. For example, it may suggest adjusting the temperature settings or changing the run times of energy-hungry appliances. In some cases, the system might also suggest upgrading to more energy-efficient devices.

In conclusion, smart home energy management systems are built around advanced technologies that provide real-time monitoring, control, and optimization of energy consumption across various devices. By utilizing sensors, smart meters, data analytics, and automation, these systems make it easier to reduce waste, lower energy bills, and promote sustainability in the home.

# OBSTACLE-FREE: A SMART WALKING STICK FOR A SAFER JOURNEY

*By Rohit Kumar Nonia(21BPS1208), Austin George Francis(21BLC1218)*

For visually impaired individuals, navigating the world independently can be incredibly challenging. Traditional aids like white canes and guide dogs have been invaluable in improving mobility and safety, but they often fall short in addressing the complexities of modern life. Limited awareness of obstacles, lack of contextual understanding, and dependence on caregivers can significantly affect their confidence and independence.

Thanks to rapid advancements in assistive technology, we are now seeing the integration of hardware innovations with intelligent software. From smart walking sticks and wearable devices to IoT-enabled systems and artificial intelligence, these technologies are redefining accessibility and empowering individuals to live safer, more autonomous lives.

## Challenges in Accessibility

Visually impaired individuals encounter numerous obstacles in their everyday lives. Whether navigating crowded streets, avoiding unexpected objects, or gathering information about their surroundings, these tasks can feel overwhelming without the right tools. While traditional walking sticks are helpful for detecting immediate obstacles, they lack the ability to differentiate between various types of objects or provide real-time situational awareness. As a result, many individuals still rely heavily on caregivers, which can limit their independence.

Moreover, traditional aids lack the flexibility to be customized or upgraded based on an individual's needs. Most do not incorporate modern features like GPS tracking, IoT connectivity, or real-time alerts—features that are crucial for safely navigating today's rapidly evolving urban environments. These limitations highlight the urgent need for more intelligent, adaptable mobility solutions

## Advancements in Assistive Technologies

The field of assistive technology has made remarkable progress in recent years, focusing on enhancing accessibility and independence through cutting-edge tools. Among the most impactful innovations are smart walking sticks, wearable assistive devices, and IoT-based solutions, all of which provide unique benefits to visually impaired individuals.

Smart walking sticks are a game-changer, transforming the traditional cane into an intelligent mobility aid. These devices come equipped with advanced sensors such as ultrasonic or infrared sensors that detect obstacles and measure their proximity. Real-time feedback is provided through buzzers, vibration motors, or auditory signals, ensuring users are alerted to any potential hazards in their path. Many of these sticks also feature fall detection and emergency panic buttons, further enhancing safety. Additionally, their modular design makes it easy to upgrade or replace components, making them more adaptable and cost-effective over time.

Wearable assistive devices, such as smart glasses and haptic feedback belts, add another layer of support. These technologies utilize AI-powered cameras to recognize objects, track paths, and even read out text to users. Haptic feedback systems provide discreet yet effective directional cues, helping users move confidently in unfamiliar environments. Mobile applications and IoT connectivity are expanding the scope of assistive technology. Specialized smartphone apps offer GPS navigation, voice commands, and machine learning-driven step-by-step instructions. Meanwhile, IoT-enabled solutions

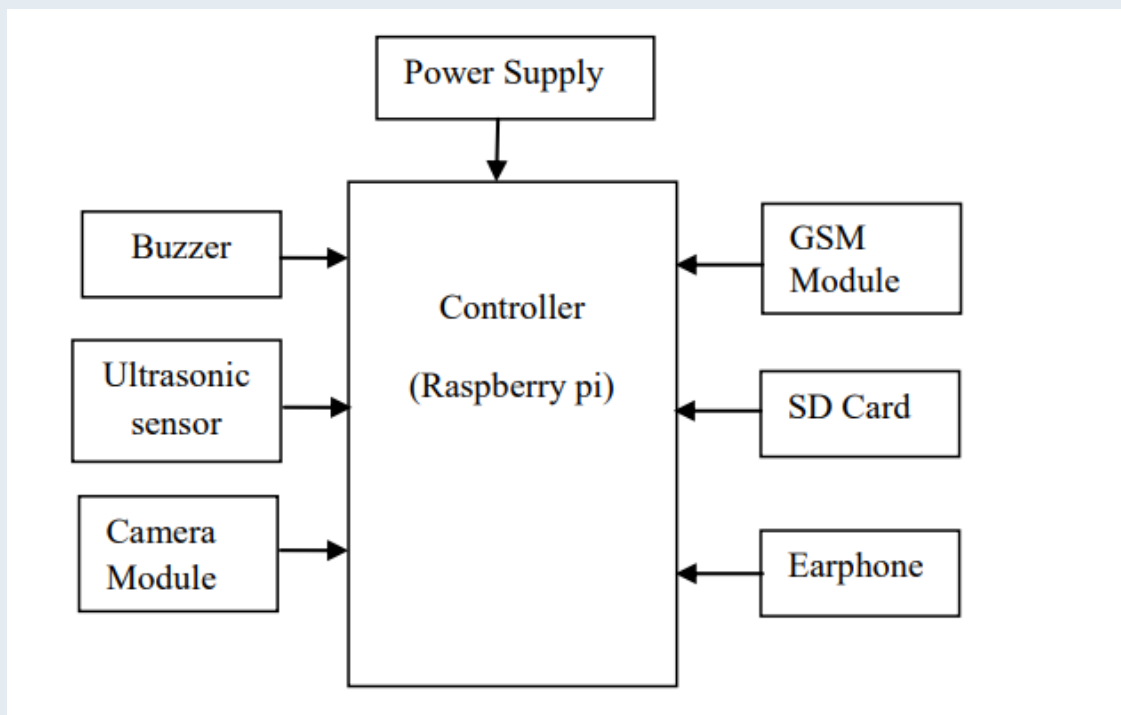
allow devices to seamlessly communicate with each other, providing location tracking, remote monitoring, and emergency notifications. For example, a smart walking stick can instantly alert family members or caregivers in case of a fall, ensuring rapid assistance.

## Applications in Daily Life

Assistive technologies are revolutionizing various aspects of everyday life for visually impaired individuals. **Urban navigation** is now significantly safer and more manageable with devices that provide auditory or tactile feedback on nearby obstacles. In crowded environments such as markets or public transport, these tools help users maintain awareness and move more smoothly through the space.

Even **indoor environments**, which have traditionally been challenging for visually impaired individuals, are becoming easier to navigate. RFID-based systems, combined with smart navigation aids, help users find their way around large spaces like malls or airports. Moreover, wearable devices equipped with health monitoring features, such as heart rate sensors and fall detection, add an extra layer of security by notifying caregivers of potential emergencies.

By integrating communication technologies like GSM and GPS modules, assistive devices are also helping bridge the gap between users and their caregivers. Real-time location tracking, emergency alerts, and voice-guided instructions give both users and their families peace of mind, enabling greater independence.



## Future Trends in Assistive Technologies

Looking ahead, the future of assistive technology is being shaped by rapid advances in artificial intelligence, IoT, and robotics. AI-powered systems will soon be capable of interpreting complex environments and providing even more precise feedback. Imagine a voice-controlled AI assistant that can offer real-time updates about traffic conditions, identify obstacles in the user's path, or suggest the safest route based on live data.

Machine learning algorithms will also play a crucial role in **personalizing** assistive technologies, allowing devices to adapt to an individual's unique habits and preferences over time. Instead of simply reacting to environmental conditions, future assistive tools will **anticipate user needs**

and improve their functionality based on past interactions. Additionally, the integration of assistive devices with **smart city infrastructure** is expected to create a seamless experience for visually impaired individuals. Smart walking sticks and wearable devices will be able to connect directly with public transport systems, traffic signals, and smart home automation tools, fostering a fully interconnected world for those with visual impairments.

Advanced sensing technologies like **LiDAR and deep learning-based vision systems** are also on the horizon. These technologies promise unparalleled accuracy in detecting and recognizing obstacles, ensuring safer and more reliable navigation.

## Summary

Assistive technology for visually impaired individuals has moved far beyond the traditional white cane. Innovations such as smart walking sticks, wearable devices, and IoT-integrated systems are transforming accessibility and independence. By tackling long-standing challenges like obstacle detection, situational awareness, and emergency communication, these tools provide users with the confidence to navigate their world with ease.

As artificial intelligence, IoT, and robotics continue to evolve, the future of assistive technology holds limitless possibilities. The focus on developing personalized, intelligent, and connected systems ensures that visually impaired individuals can achieve greater autonomy and inclusion, fostering a world where everyone has the freedom to move without limitations.

# POWER ELECTRONICS IN CRI HAVELLS: INNOVATIONS AND APPLICATIONS

*By Vismaya Remesh(21BEE1044)*

Power electronics is an important subject in modern electrical engineering because it allows for efficient energy conversion, control, and distribution. CRI Havells, a major manufacturer in the electrical industry, has produced considerable advances in power electronics. Their breakthroughs benefit a variety of applications, including motor drives, power supplies, lighting systems, and renewable energy integration. This article looks at the important technologies, products, and future prospects in power electronics at CRI Havells.

## Detailed Description:

### CRI Havells and Its Power Electronics Expertise

CRI Havells is known for its experience in electrical technology and power electronic systems. The company specialises in designing energy-efficient motor drives, smart control systems, and superior power conversion solutions for a wide range of applications, providing peak performance with little power loss.

### Key Innovations in CRI Havells

CRI Havells uses

- Variable Frequency Drives (VFDs) in pump control and industrial automation systems to optimise energy consumption based on real-time demand.
- Smart Motor Controllers: These controllers include features like soft-start, overload protection, and remote monitoring to improve performance.
- Renewable Energy Integration: CRI Havells' solar-powered solutions rely on power electronics to efficiently harvest and convert solar energy for a variety of applications, including water pumping and industrial use.



### Major Power Electronics Applications in CRI Havells

- ✓ UPS and Inverters: CRI Havells produces high-efficiency uninterruptible power supplies (UPS) and inverters for residential and industrial applications.
- ✓ LED Drivers and Smart Lighting: Advanced power electronic circuits in CRI Havells'
- ✓ Smart Switchgear and Protection Devices: CRI Havells integrates digital control and monitoring features into switchgear products, improving reliability and safety.

## Havells Centre for Research and Innovation

CRI Havells has established a dedicated Centre for Research and Innovation (CRI) to drive technological advancements in power electronics and smart energy solutions. This center focuses on developing high-performance electrical products, energy-efficient solutions, and next-generation power management technologies.

### Key Focus Areas of CRI Havells

1. **Advanced Power Semiconductors:** Research in SiC and GaN devices for improved efficiency and performance in power conversion.
2. **Smart IoT-based Solutions:** Integration of IoT and AI to enhance real-time monitoring, predictive maintenance, and remote control of power systems.
3. **Energy Storage and Electrification:** Development of sustainable energy storage solutions and EV charging infrastructure to support electrification initiatives.
4. **Green and Renewable Energy Technologies:** Innovations in solar inverters, microgrid systems, and energy-efficient lighting solutions to reduce carbon footprints.

## Emerging Trends in Power Electronics at CRI Havells

CRI Havells is actively investing in research and development to stay ahead in the power electronics industry. Key trends include:

✓ **Wide Bandgap Semiconductors:** The use of SiC (Silicon Carbide) and GaN (Gallium Nitride) devices significantly improves efficiency, reduces heat dissipation, and enables compact designs. These materials offer higher switching frequencies and lower losses compared to traditional silicon-based devices, making them ideal for applications such as high-performance motor drives, power converters, and renewable energy systems.

✓ **Internet of Things (IoT) and AI Integration:** The adoption of IoT and AI-driven analytics enhances the monitoring, predictive maintenance, and automation of power electronic systems. Smart sensors, cloud computing, and AI algorithms allow real-time data processing, improving efficiency and reliability in industrial and residential applications. CRI Havells is incorporating these technologies into their smart switchgear and energy management solutions to optimize performance and reduce downtime.

✓ **Electrification and Sustainable Solutions:** As industries transition toward electrification, power electronics play a crucial role in enabling sustainable energy solutions. CRI Havells is investing in electric vehicle (EV) charging infrastructure, energy storage solutions, and grid modernization projects. These initiatives contribute to reducing carbon footprints and increasing the adoption of renewable energy sources like solar and wind power.

# ML BASED FAULT ANALYSIS IN PV SYSTEM

By Ved Khandeparkar(21BEE1016), Shreshtha(21BEE1198), Saurabh Kashyap(21BEE1338)

As global interest in clean energy grows, solar power has emerged as a key component of the renewable energy landscape. Nonetheless, ensuring the efficiency and reliability of photovoltaic (PV) systems presents considerable difficulties. Various faults may occur during operation, resulting in power losses, shorter system lifespans, and possible safety risks. To tackle these issues, effective fault detection methods are crucial. Conventional manual inspections and electrical assessments are frequently slow and ineffective. However, advancements in simulation tools like MATLAB and data-driven methods such as Machine Learning (ML) enable real-time monitoring of solar power systems for enhanced performance and dependability. This article examines typical faults in PV systems and the contemporary strategies employed for effective detection and resolution.

## Detailed Description:

Photovoltaic (PV) systems may encounter various faults, ranging from slight inefficiencies to severe breakdowns. It is essential to identify and address these issues to ensure optimal performance of the system. Frequently encountered PV system faults include:



- Open-Circuit Faults – Disruptions in the circuit caused by damaged connections, corroded terminals, or module failures hinder current flow.
- Short-Circuit Faults – Unintentional direct connections between terminals result in excessive current, potentially harming system components.
- Ground Faults – Failures in insulation lead to leakage currents, which can create electrical risks.
- Mismatch Faults – Variations in module characteristics, such as aging, dirt buildup, or shading, lead to power discrepancies.

Detecting these faults in real-time is vital for maintaining the long-term efficiency and dependability of PV systems.

**Traditional Fault Detection Methods:** Traditional methods for detecting faults depend on manual evaluations and conventional electrical testing methods. Some typical strategies consist of:

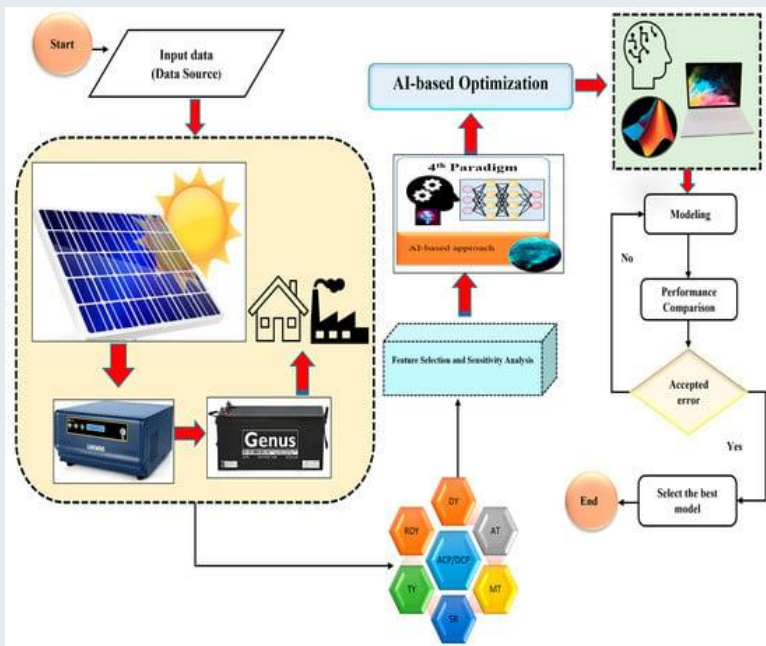
- ✓ Thermal Imaging – Detects hotspots using infrared cameras.
- ✓ I-V Curve Tracing – Analyses voltage-current characteristics to identify abnormalities.

- ✓ Electroluminescence Imaging – Reveals hidden defects in PV cells.

Although these approaches yield important information, they require significant manual effort, take a lot of time, and do not facilitate real-time monitoring. This is why simulations based on MATLAB and Machine Learning present more effective alternatives.

**MATLAB Simulations for Fault Analysis:** By examining fluctuations in voltage, current, and power, engineers can foresee possible malfunctions and create more reliable systems. Simulations in MATLAB offer:

- ✓ Realistic modelling of electrical faults.
- ✓ Analysis of power fluctuations due to shading, aging, and environmental factors.



- ✓ Insights into fault propagation and its impact on system efficiency.

## Machine Learning for Automated Fault Detection

The incorporation of ML in fault detection is revolutionizing the solar sector. ML algorithms have the capability to evaluate extensive real-time data sets, enabling predictive maintenance and automated classification of faults.

How ML Enhances Fault Detection:

1. **Data Collection** – Sensors installed in PV systems continuously record voltage, current, temperature, and irradiance data.
2. **Feature Extraction** – Advanced signal processing techniques such as Fast Fourier Transform (FFT) and Wavelet Transform extract critical performance indicators.
3. **Model Training** – ML algorithms, including Decision Trees, Support Vector Machines (SVM), Random Forest, and Neural Networks, learn from historical fault data to detect anomalies.
4. **Fault Classification** – Trained ML models categorize faults, enabling precise troubleshooting and maintenance.
5. **Real-Time Monitoring** – Automated alerts and predictive maintenance schedules ensure minimal system downtime.

By leveraging ML, PV systems can detect faults early, reducing maintenance costs and enhancing system longevity.