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COLLEGE OF ENGINEERING
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DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING
(NBA ACCREDITED)

TECHNICAL BULLETIN

VOLUME 5 | ISSUE 2



CHRIST COLLEGE OF ENGINEERING

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TECHNICAL BULLETIN

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CHRIST
COLLEGE OF ENGINEERING

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To excel in fostering competent Electrical and Electronics Engineering professionals with sound knowledge and practical skills for social upliftment

Mission of the Department

1. To impart the excitement of modern technology and problem-solving skill among students through the development of an inspiring teaching-learning environment.
2. To mould the young minds to provide cost-effective, innovative and sustainable solutions, for the challenges faced by the society, through fundamental research and training.
3. To develop ethical values, leadership skills and lifelong learning practices that leads the students to become responsible citizens.

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1. Transform students into skilled professionals in Electrical and Electronics Engineering with strong foundation in Mathematics, Basic Science and Management.
2. Mould the students to achieve and excel in their engineering profession or higher studies.
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Bi-directional Power Control using Constant Frequency Hysteresis with Reduced Switching Losses

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ABSTRACT

A simple control technique for the bi-directional power flow control between dc source and ac grid is presented. For each 60° of line cycle, the 3-phase bridge is considered as parallel-connected dual buck topology in inverter mode of operation and as a dual boost topology in rectifier mode of operation. Constant frequency hysteresis current control is proposed. Low current distortion and unity power factor are achieved. The magnitude of bi-directional current can be controlled. Simplicity of control circuit, considerable reduction in switching losses with excellent dynamic performance are the salient features of this control technique

KEY WORDS

Bi-directional power control, hysteresis control, buck topology, boost topology, power system control

1. Introduction

Bi-directional power flow control in a grid interfaced system would be necessary in several areas, the most common application being a regenerative drive system. The power flow in such systems reverses through the front-end grid interface when the machine is braking. In the context of alternative power sources (dc) connected to the grid, such requirements would arise when the dc loads need to be supplied from grid in the event of failure of the alternative source. Increased research efforts have been reported in this area focusing in both control techniques and circuit topologies.

The approach used in past was to employ back to back connected line frequency thyristor converters [1] in which one converter operates as a rectifier and the second one as an inverter to have bi-directional current flow. In this method the input current has a distorted waveform and power factor is low. Using switched mode converters the bi-directional power flow with unity power factor can be obtained by controlling the magnitude and phase of the converter voltage [1]. In [2], [3] the authors explain MINNESOTA interface method of 3rd harmonic current injection from the dc source to the neutral of the transformer to

obtain a sinusoidal current on ac side with low THD. The generation of the current reference involves calculation of 3rd harmonic and the power circuit contains two controlled switches operated using constant frequency PWM method and a 3-phase line commutated inverter.

Bi-directional power flow control using hysteresis control has been explained in [4]. In this control strategy all the six switches are controlled and the switching frequency is not constant. Using the instantaneous p-q theory, a control method for grid connected dc-ac converter for photovoltaic array, has been discussed [5]. This involves the calculation of instantaneous real and reactive power to generate the current references and the control is using hysteresis control in which all the six switches are controlled at any time instant. It is well known that the major disadvantage of hysteresis control is the high and variable switching frequencies involved and the consequent high losses.

Constant frequency hysteresis method by controlling all the six switches continuously has been explained for voltage source inverter control [6], [7]. While this makes the system switch at constant frequency, thereby making more efficient use of switching harmonic filters that may be used, losses associated with high switching frequency still persist. Unified constant frequency integration control based on one cycle control has been reported for inverter [8] and rectifier [9] operation of the converter connected between dc source and ac grid. Two switches are controlled at any time instant. The control structure derivation is, however, involved.

In this paper, constant frequency hysteresis control method is proposed for the bi-directional power flow control (Fig.1). It is shown that, from power flow considerations, the 3-phase bridge configuration may be considered as a dual buck or dual boost configuration, in every 60° interval. It is further shown that these configurations can be controlled simply in a constant frequency.

hysteresis mode. While control is simple, losses are reduced since only two switches are operated at high frequency at any time. The current on the ac side has low distortion and the system has a good dynamic response. The performance results are presented as simulation studies done using SABER simulator

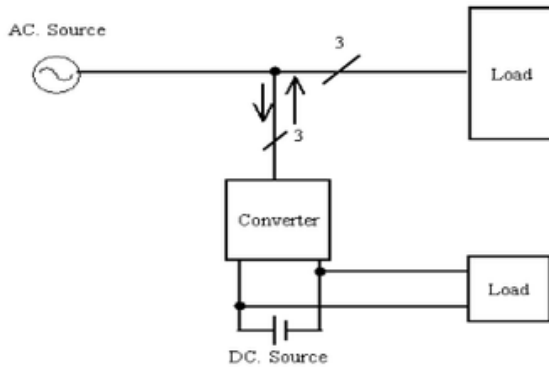


Fig. 1. Bi-directional Power Control

Dual buck and dual boost topologies and their switching patterns are explained in section 2. The proposed controller is presented in section 3 and results are analyzed. Finally conclusion is given in section 4.

2. Analysis of Three Phase Bridge Circuit in Inverter and Rectifier Mode of Operation

Dual buck and dual boost topologies and their switching patterns are explained in section 2. The proposed controller is presented in section 3 and results are analyzed. Finally conclusion is given in section 4.

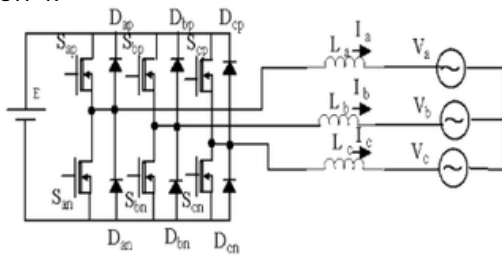


Fig. 2. Three-Phase Bridge Circuit

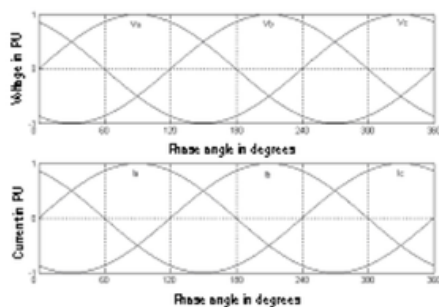


Fig.3 (a) Grid Voltage and injected Current for Inverter Operation

Figure 2 shows the standard 3-phase bridge circuit. The circuit is considered to operate as an inverter or a rectifier interacting with grid, which is represented as voltage source in series with an inductance. Grid interaction is desired at UPF. A three phase three wire system is considered, and current directions shown are reference directions for a positive value. When supplying power into the grid at UPF, the current and voltage waveforms (at voltage sources) are shown in Fig. 3(a). The following subsections describe how the topology of the circuit may be simplified to achieve this operation.

A. Inverter mode of Operation

From the grid voltage and injected current polarities, for a power factor angle of 0° (in phase) (Fig.3 (a)), it can be seen that, at any time instant the power flows from dc bus to ac grid in all the phases. For example, consider 60° of operation. It may be seen from Fig 3(a) that I_a and I_c are positive while I_b is negative. Controlling the trajectory of I_a and I_c would automatically control that of I_b since the system is 3-wire. Therefore, we may conclude that the switch S_{bn} be turned ON to allow for the flow of I_b . Since I_a and I_c are positive, their trajectory may be controlled using switches S_{ap} and S_{cp} alone. This leads to the circuit topology as shown in Fig.3 (b), which is nothing but dual buck converter. Control of the trajectory of I_a and I_c may be simply done using hysteresis control modified for constant frequency operation.

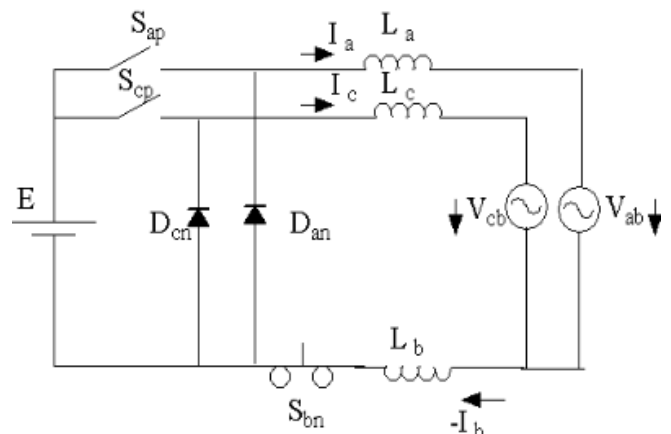


Fig.3 (b) Dual Buck Topology

Similar arguments may be presented for operation in the (60°-120°), (120°-180°), (180°-240°), (240°-300°), and (300°-360°) interval of line cycle and the final switching pattern that emerges is shown in Table 1. Thus we have a switching strategy where only two switches are switched at high frequency at any point of time. This brings down the losses.

Table 1. Switching table for Inverter Operation

Voltage Region	S_{ap}	S_{an}	S_{bp}	S_{bn}	S_{cp}	S_{cn}
(0° – 60°)	C	-	-	ON	C	-
(60° – 120°)	ON	-	-	C	-	C
(120° – 180°)	C	-	C	-	-	ON
(180° – 240°)	-	C	ON	-	-	C
(240° – 300°)	-	ON	C	-	C	-
(300° – 360°)	-	C	-	C	ON	-

C → Switch is Controlled, ON → Switch is ON,

- → Switch is OFF

B. Rectifier mode of Operation

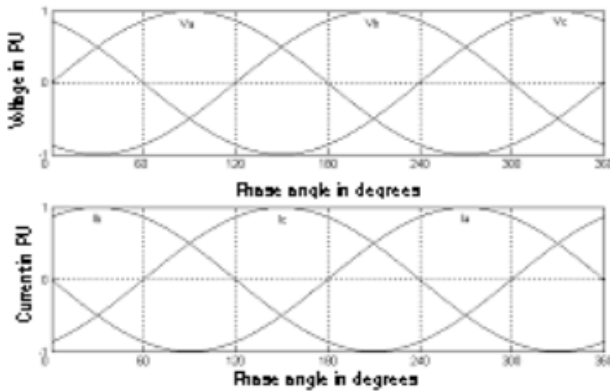


Fig.4 (a) Grid Voltage and injected Current for Rectifier Operation

From the grid voltage and current polarities, for a power factor angle of 180° (lag) Fig.4 (a), it can be seen that at any time instant the power flows from ac grid to dc bus in all the phases. For a 60° of line cycle, it may be seen from Fig 4(a) that Ia and Ic are negative while Ib is positive. Controlling the trajectory of Ia and Ic would automatically controls that of Ib since the system is 3-wire. Since Ia and Ic are negative their trajectory may be controlled using switches San and Scn alone. The return path for Ib is provided by the freewheeling diode. This leads to the circuit topology as shown in Fig.4 (b), which is called dual boost converter. Control of the trajectory of Ia and Ic may be done using hysteresis control modified for constant frequency operation.

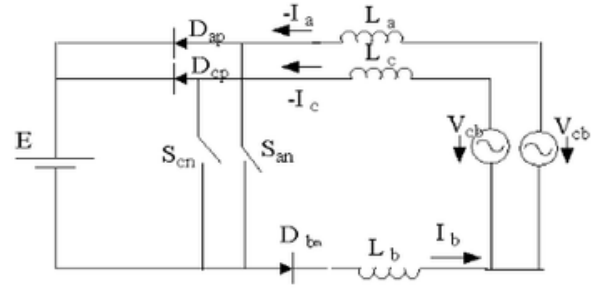


Fig.4(b) Dual Boost Topology

Similar arguments may be presented for operation in the (60°-120°), (120°-180°), (180°-240°), (240°-300°), and (300°-360°) interval of line cycle and the final switching pattern that emerges is shown in Table 2.

Table 2. Switching table for Rectifier Operation

Voltage Region	S_{ap}	S_{an}	S_{bp}	S_{bn}	S_{cp}	S_{cn}
(0° – 60°)	-	C	-	-	-	C
(60° – 120°)	-	-	C	-	C	-
(120° – 180°)	-	C	-	C	-	-
(180° – 240°)	C	-	-	-	C	-
(240° – 300°)	-	-	-	C	-	C
(300° – 360°)	C	-	C	-	-	-

C → Switch is Controlled, - → Switch is OFF

C. The Controlled Switching Algorithm

The switching algorithm for inverter and rectifier mode can be logically combined. Let t1, t2, t3, t4, t5, and t6 represent the region (0°-60°), (60°-120°), (120°-180°), (180°-240°), (240°-300°), and (300°-360°) interval the grid voltage respectively and x represents the mode of operation (x=1 /0=inverter/rectifier) which can be obtained by comparing the dc bus voltage with a reference voltage and 'x' represent the complement of 'x'.

Control equation for the switch Sap can be derived as given below.

$$S_{ap(c)} = x(t_1 + t_3) + x'(t_4 + t_6) \quad (1)$$

$$S_{ap(on)} = xt_2 \quad (2)$$

$$S_{ap} = S_{ap(c)} + S_{ap(on)} \quad (3)$$

Where Sap(c) is the enabling signal to control the switch Sap at high frequency and Sap (on) is the enabling signal to keep it ON. Final enabling signal to this switch is given by Sap. Similarly the enabling signals to all other switches are derived as follows.

$$S_{an(c)} = x(t_4 + t_6) + x'(t_1 + t_3) \quad (4)$$

$$S_{an(on)} = xt_5 \quad (5)$$

$$S_{an} = S_{an(c)} + S_{an(on)} \quad (6)$$

$$S_{bp(c)} = x(t_3 + t_5) + x'(t_2 + t_6) \quad (7)$$

$$S_{bp(on)} = xt_4 \quad (8)$$

$$S_{bp} = S_{bp(c)} + S_{bp(on)} \quad (9)$$

$$S_{bn(c)} = x(t_2 + t_6) + x'(t_3 + t_5) \quad (10)$$

$$S_{bn(on)} = xt_1 \quad (11)$$

$$S_{bn} = S_{bn(c)} + S_{bn(on)} \quad (12)$$

$$S_{cp(c)} = x(t_1 + t_5) + x'(t_2 + t_4) \quad (13)$$

$$S_{cp(on)} = xt_6 \quad (14)$$

$$S_{cp} = S_{cp(c)} + S_{cp(on)} \quad (15)$$

$$S_{cn(c)} = x(t_2 + t_4) + x'(t_1 + t_5) \quad (16)$$

$$S_{cn(on)} = xt_3 \quad (17)$$

$$S_{cn} = S_{cn(c)} + S_{cn(on)} \quad (18)$$

Output switching circuit is realized using these Boolean expressions.

3. Simulation Study

Simulation studies have been carried out using the SABER simulation package. AC grid voltage is taken as 120 V rms and dc source voltage is taken as 350 V. The triangular signal frequency is considered as 30 kHz and this decides the switching frequency, which is constant. Inductors La, Lb and Lc are selected as 2 mH. DC link capacitor is taken as 470 μ F. Hysteresis control technique is used. The system is made to work as inverter / rectifier by choosing appropriate switching algorithm, current reference and Vdc(ref). The injected currents in inverter mode and received currents in rectifier mode are at unity power factor

with the grid voltages with minimum distortion. The magnitude of the current can be changed by controlling Vdc(ref).

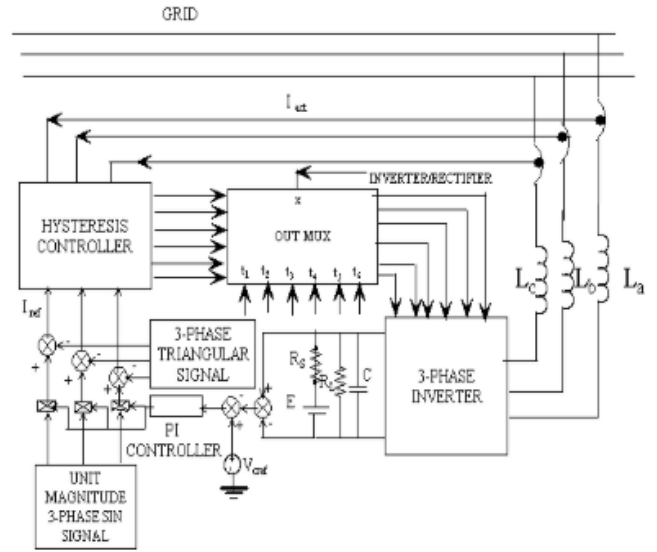


Fig .5. Control Schematic

The schematic of the control scheme is shown in Fig.5. The dc bus voltage is measured and compared with the reference value (Vdc (ref)) and the error is given to PI controller. The PI controller output is multiplied with unit magnitude 3-phase sinusoidal signal. 3-phase high

frequency triangular wave is subtracted from that to generate the reference current signal (Iref) [6]. Inverter output currents are sensed using current sensors. The Hysteresis controller generates the switching signals and 2% hysteresis band is used. The OUTMUX selects the switching signals based on the Boolean expressions of Sap, San, Sbp, Sbn, Scp, and Scn and these are used to control the switching devices. The system has been simulated using SABER. The results are presented in the following sections.

A. Simulation Results

Fig. 6(a), and (b) shows the grid voltages and injected currents from dc bus to ac grid for inverter and rectifier operation respectively. It may be noted that in both modes the operation is at UPF and distortion is minimum.

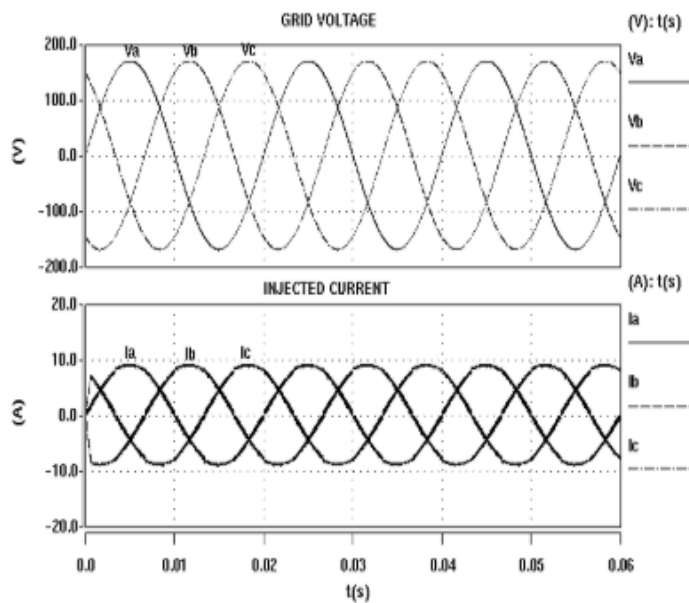


Fig.6 (a) Grid Voltage and injected Currents in Inverter mode

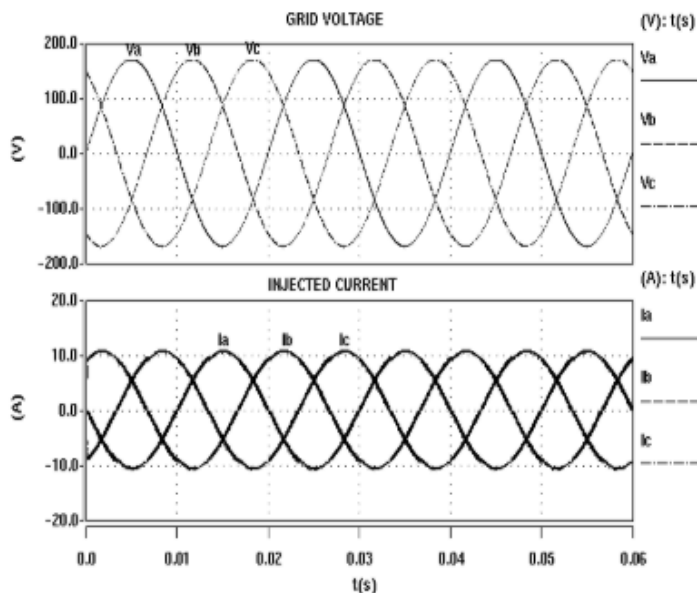


Fig.6 (b) Grid Voltage and injected Currents in Rectifier mode

The switching signal to the switch S_{ap} in inverter and rectifier modes are shown in the Fig. 7. In both cases the switch is controlled at high frequency only for 1/3 period of the line cycle unlike the conventional hysteresis control scheme in which all the six switches are controlled continuously. Thus, switching losses would be reduced.

Further it may also be noted that in the rectifier mode the switch is used only for 120° duration where it is switched at high (constant) frequency. During the remaining time the switch is OFF.

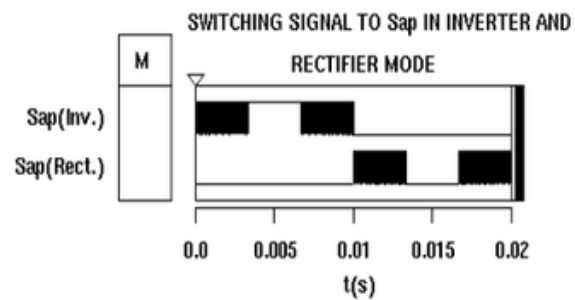


Fig. 7 Switching Signals to the Switch S_{ap} in Inverter and Rectifier mode of Operation.

The device losses for an injected current of 10A(max) in inverter and rectifier mode of operation for modified hysteresis control with constant frequency (proposed algorithm), conventional hysteresis control with constant frequency, and conventional hysteresis control without constant frequency are obtained by simulating the scheme in SABER. The IGBT used is BSP280. Table 3. shows the reduction in losses expressed as a percentage of the losses in conventional hysteresis control (81.6W for the inverter mode of operation and 124.2W for the rectifier mode of operation). While use of constant frequency switching itself increases efficiency, it can be seen that the proposed method further improves it.

Table 3. Reduction in Losses compared to Conventional Hysteresis Control (%)

Mode of operation	Modified hysteresis control with constant frequency	Conventional hysteresis control with constant frequency
Inverter	21.3	9.5
Rectifier	60.8	38.6

4. Conclusion

The proposed hysteresis control scheme demonstrates a strong balance between simplicity and efficiency in grid-interfaced systems. By restricting the operation to only two switches at a time, the converter achieves a notable reduction in switching losses, which directly translates to improved energy efficiency and longer device lifespan. This is particularly important in renewable energy applications, where maximizing the usable energy from sources such as solar PV or battery storage is critical. The constant switching frequency further enhances predictability in system behavior, simplifying the design of filters and ensuring smoother integration with the grid.

Equally significant is the ability of the system to maintain unity power factor in both inverter and rectifier modes. In inverter mode, the DC source can inject clean, sinusoidal current into the grid without reactive components, thereby improving grid stability and reducing penalties associated with poor power quality. In rectifier mode, the system draws current from the grid at unity power factor, ensuring efficient charging or energy absorption without burdening the grid with reactive power. This dual capability makes the scheme highly versatile, supporting both energy export and import seamlessly, which is essential for modern smart grids and distributed generation networks.

The controllability of current distortion through the hysteresis band adds another layer of flexibility to the design. By adjusting the band width, engineers can fine-tune the trade-off between switching frequency and harmonic distortion, ensuring compliance with international standards such as IEEE 519. This adaptability allows the system to be tailored for different operating conditions, whether prioritizing efficiency, current quality, or dynamic response. Moreover, the precise regulation of current magnitude enables accurate control of power flow, which is vital for applications like battery energy storage systems, electric vehicle charging, and renewable energy integration.

Overall, the combination of reduced switching losses, unity power factor operation, controllable distortion, and straightforward bi-directional power regulation makes this hysteresis-based scheme a promising candidate for next-generation grid-interfaced converters. With hardware implementation underway, practical validation will confirm its theoretical advantages and highlight its robustness under real-world conditions. Once proven, this approach could become a cost-effective and reliable solution for sustainable energy systems, contributing to the advancement of smart grids, renewable integration, and efficient power management technologies.

In summary, the hysteresis control scheme with constant switching frequency provides a practical and efficient solution for bi-directional power management in grid-interfaced systems.

Its ability to reduce switching losses, maintain unity power factor in both operating modes, and offer controllable current distortion makes it highly adaptable to modern energy applications. With hardware implementation underway, this approach is poised to demonstrate its effectiveness in real-world scenarios, paving the way for reliable, sustainable, and cost-efficient integration of renewable energy sources into the grid.

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Harnessing the Sun: The Importance of Domestic PV Panels in Kerala and Grid Connectivity Options

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Kerala is blessed with abundant sunshine for much of the year. Yet, a significant portion of its rooftops remains unutilized in terms of solar energy generation. As the world accelerates its transition toward clean, sustainable power, domestic photovoltaic (PV) systems emerge as a practical and economically sensible solution for households across Kerala.

Why Domestic PV Panels Matter in Kerala

1. Mitigating Rising Electricity Costs

Electricity prices in India have steadily increased in recent years. For households, this translates into larger monthly bills, especially with the growing use of appliances like air conditioners, heaters, and pumps. By generating electricity at the source, homeowners can significantly offset their grid consumption and lower their monthly expenses. Over the lifetime of the system, savings can be substantial.

2. Leveraging Kerala's Climatic Advantage

Kerala receives ample sunlight throughout the year, even during the monsoon season. Modern solar PV technology is designed to operate efficiently under diffuse light conditions, meaning that even cloudy days contribute to useful power generation. This climatic advantage makes solar rooftops a reliable source of clean energy in both urban and rural settings.

3. Reducing Carbon Footprint

Electricity in India is still largely generated from fossil fuels such as coal. By installing PV panels, households directly reduce their dependence on polluting energy sources. For environmentally conscious citizens, adopting solar power is a meaningful step toward lowering greenhouse gas emissions and combating climate change.

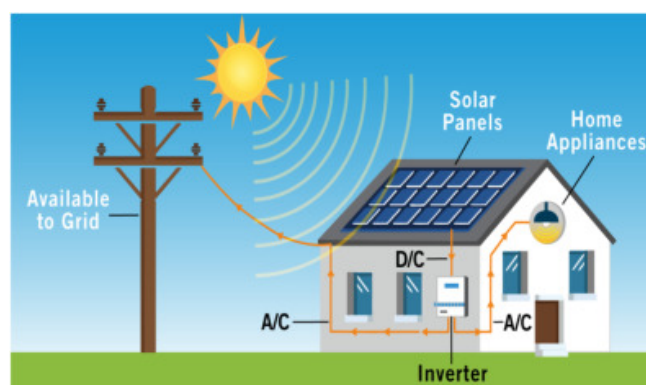
Grid Connectivity Options for Domestic Solar in Kerala

Kerala's solar policy framework allows homeowners multiple pathways to connect their PV systems with the electricity grid. Each option has unique benefits depending on lifestyle, electricity consumption, and financial goals.

1. Net Metering (Bi-Directional Metering)

Net metering is the most popular and financially advantageous method for grid connected rooftop solar.

- How it works: Excess solar electricity that is not immediately consumed in the home is exported to the grid. The energy meter runs backward, giving credit for the electricity sent to the utility.
- Benefit: You only pay the net balance; electricity consumed from the grid minus electricity exported.
- Ideal for: Homes that generate more solar power during the day than they use immediately.
- Example: If your system exports 100 kWh and imports 150 kWh in a billing period, you're billed only for the net 50 kWh.



2. Gross Metering (Feed-in Tariff)

In gross metering, all the solar power generated by your system is exported to the grid at a predetermined tariff, and all your household power needs are supplied by the grid.

- How it works: Your entire solar output is measured and credited separately (often at a feed-in tariff set by the utility/policy). You buy all your household electricity from the grid at regular retail rates.
- Benefit: Visibility of power generated and clear compensation per unit exported.
- Drawback: Less financial benefit for homeowners whose daytime consumption could have offset self-use.
- Ideal for: Those focusing on feed-in revenue rather than bill reduction through self-consumption.

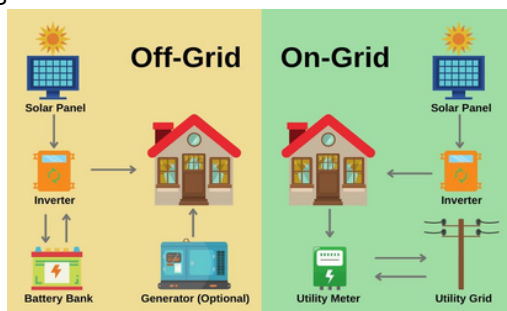
3. Grid Interactive Solar with Battery Backup

Grid interactive systems with battery storage combine solar generation, grid supply, and backup power in one setup.

- How it works: Solar power primarily feeds household loads. Excess charges batteries or feeds to grid. During outages, battery supplies critical loads.
- Benefits:
 - Uninterrupted power supply during outages.
 - Greater self-consumption of solar energy.
 - Demand load control to reduce peak tariffs (if applicable).
- Considerations: Higher upfront cost due to batteries; however, long-term value from resilience and energy savings.

Financial Incentives and Policy Support

Kerala, aligned with national renewable energy goals, encourages domestic solar adoption through:



- Subsidies for residential installations (often based on capacity and system type).
- Low-interest loans from banks under renewable energy financing schemes.
- Tax benefits and accelerated depreciation for solar investments.
- Net metering regulations that enable cost-effective power credits.

These policy incentives help reduce the payback period and improve return on investment.

Challenges and How to Overcome Them

Initial Investment Cost

Solar installations require upfront capital. However, declining panel prices and government incentives have made systems more affordable. Solution: Explore financing options, EMIs, and group purchase programs in your locality.

Space and Shading Constraints

Not all rooftops are ideally oriented or completely free of shade.

Solution: Conduct a professional site assessment to optimize panel placement or consider partial installation.

Awareness and Technical Knowledge

Some homeowners remain unaware of the options and benefits.

Solution: Engage with certified solar installers and participate in community awareness programs.

Conclusion: A Brighter, Greener Kerala

Domestic PV installation is more than an investment — it's a shift toward environmental stewardship, economic savings, and dependable power for families across Kerala. With progressive grid connectivity options, households can choose solutions tailored to their lifestyle and sustainability goals.

By embracing rooftop solar today, Kerala can light up homes, reduce carbon emissions, and contribute to India's clean energy future.

Power Electronics: A Gateway to Modern Energy Systems

Dhanush M V
S8EEE



I've always been interested in power electronics because it combines pure electrical theory with real-world use. As a student of electrical engineering and an electronics enthusiast, I find this field especially interesting because it deals with how electrical energy is changed, controlled, and used. Power electronics is all about controlling the conversion of electrical power using solid-state devices like diodes, thyristors, MOSFETs, and IGBTs. These devices are the building blocks of modern energy systems.

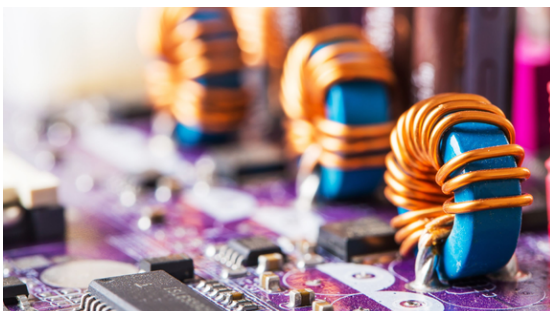
During my initial learning stages, I worked extensively on bridge rectifiers, converters, and inverters for single-phase and three-phase systems. While the circuits themselves seemed straightforward, analyzing their waveforms at different firing angles proved to be challenging. These experiences taught me the importance of strong fundamentals in circuit theory, control systems, and semiconductor physics, as load conditions often demand precise understanding and analysis.

One of the most crucial lessons I learned in this journey is the significance of efficiency. Unlike linear power circuits, where much of the energy is dissipated as heat, modern power supplies such as Switched-Mode Power Supplies (SMPS) achieve efficiencies greater than 92%. This remarkable improvement is made possible by power electronics, highlighting its relevance in today's energy-conscious world and its role in shaping sustainable technologies.

Simulation tools such as MATLAB/Simulink, LTSpice, and PSpice have also played a vital role in my learning. These platforms allow students to visualize waveforms, analyze harmonics, detect faults, and test control strategies without risking hardware damage. They bridge the gap between theoretical knowledge and practical implementation, preparing us for real-time projects involving PWM techniques and converters. Through simulations, I gained valuable insights into hardware implementation and developed confidence in tackling complex systems.

In the future, power electronics will train engineers for cutting-edge electrical systems, smart grids, and the integration of renewable energy. Power electronics is a key technology that promotes sustainability, efficiency, and innovation in each of these fields. It is one of the most influential fields in contemporary engineering since its uses go well beyond the classroom.

To sum up, power electronics is more than just a subject; it is a means of comprehending the operation of contemporary electrical energy systems. It rewards students with practical skills, problem-solving abilities, and exposure to cutting-edge technologies, but it also requires proficiency and clear conceptual understanding. In addition to expanding my technical knowledge, this field has helped me realize my goal of becoming a highly qualified engineer who can help shape the future of energy.



SMARTGRIDS AND AI IN MODERN POWER NETWORKS

Steev Sebastian
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The global demand for electricity is increasing rapidly due to population growth, urbanization, digitalization, and the widespread adoption of electric vehicles and renewable energy technologies. Traditional power grids, which were designed decades ago for one-way electricity flow from centralized power plants to consumers, are no longer sufficient to meet modern energy needs. These conventional grids struggle with inefficiencies, power losses, reliability issues, and the integration of renewable energy sources. To address these challenges, smart grids combined with artificial intelligence (AI) driven grid management have emerged as a transformative solution. Smart grids represent the future of electrical power systems by enabling intelligent, flexible, efficient, and sustainable energy management. This essay explores the concept of smart grids, the role of AI in grid management, their benefits, challenges, and their significance in shaping the future energy landscape.

Concept of Smart Grids

A smart grid is an advanced electrical power network that uses digital communication technologies, sensors, automation, and control systems to monitor and manage electricity generation, transmission, distribution, and consumption in real time. Unlike traditional grids, smart grids enable two-way communication between utilities and consumers, allowing better control, transparency, and responsiveness.

Key components of smart grids include smart meters, advanced sensors (such as phasor measurement units), automated substations, distributed energy resources (DERs), and communication networks. Smart meters provide real-time information about energy usage, enabling consumers to make informed decisions and utilities to manage demand more efficiently. Automated substations and intelligent switches help isolate faults and restore power quickly, improving grid reliability.

Smart grids are especially important for integrating renewable energy sources such as solar and wind power, which are intermittent by nature. By balancing supply and demand dynamically, smart grids ensure stability even when renewable generation fluctuates.

Role of Artificial Intelligence in Grid Management

Artificial intelligence plays a crucial role in enhancing the functionality of smart grids. AI driven grid management uses machine learning, deep learning, data analytics, and predictive algorithms to analyze massive volumes of data generated by grid sensors and devices. This enables utilities to make faster, more accurate, and automated decisions. One of the most significant applications of AI in smart grids is load forecasting. AI algorithms can predict electricity demand with high accuracy by analyzing historical data, weather conditions, consumer behavior, and economic trends. Accurate forecasting helps utilities optimize generation schedules, reduce operational costs, and prevent blackouts.

AI is also essential for fault detection and self-healing grids. Intelligent systems can identify abnormal patterns, detect equipment failures, and automatically reroute power or isolate faulty sections without human intervention. This significantly reduces outage duration and improves grid resilience.

Another critical application is renewable energy integration. AI helps manage the variability of renewable sources by predicting solar and wind output and coordinating energy storage systems. This ensures a stable and reliable power supply even with high renewable penetration.

Benefits of Smart Grids and AI-Driven Management

Smart grids with AI-driven management offer numerous advantages over traditional power systems. One of the most important benefits is improved efficiency. By minimizing transmission losses, optimizing power flow, and balancing demand and supply, smart grids reduce energy wastage and operational costs.

Reliability and resilience are also significantly enhanced. AI-enabled predictive maintenance allows utilities to detect potential failures before they occur, reducing equipment downtime and preventing large-scale blackouts. During natural disasters or cyber incidents, smart grids can adapt quickly and restore power faster than conventional systems.

Another major benefit is consumer empowerment. Smart grids allow consumers to actively participate in energy management through demand response programs, dynamic pricing, and rooftop solar integration. Consumers can reduce electricity bills by shifting usage to off-peak hours and even sell excess energy back to the grid.

From an environmental perspective, smart grids support sustainable development. By facilitating renewable energy integration and reducing dependence on fossil fuels, they help lower greenhouse gas emissions and combat climate change. AI optimization further enhances energy efficiency, contributing to global sustainability goals.

Challenges and Limitations

Despite their advantages, smart grids and AI-driven grid management face several challenges. One major concern is cybersecurity. Since smart grids rely heavily on digital communication and internet connectivity, they are vulnerable to cyberattacks. Protecting critical infrastructure from hacking, data breaches, and system manipulation is a top priority for utilities and governments. Another challenge is high initial investment costs. Deploying smart meters, communication networks, sensors, and AI systems requires significant financial resources. Developing countries, in particular, may struggle to implement smart grid infrastructure due to limited funding and technical expertise.

Data privacy is also a growing concern. Smart grids collect detailed information about consumer energy usage, which could be misused if not properly protected. Strong regulations and data governance frameworks are necessary to ensure consumer trust.

Additionally, the successful implementation of AI-driven grids requires a skilled workforce capable of managing advanced technologies. The lack of trained professionals in power systems, data science, and cybersecurity can slow adoption.

Future Outlook and Global Impact

The future of smart grids and AI-driven grid management is highly promising. As renewable energy adoption increases and electric vehicles become more common, smart grids will be essential for managing complex energy ecosystems. The integration of energy storage systems, virtual power plants, and microgrids will further enhance grid flexibility and resilience.

AI technologies are expected to become more advanced, enabling autonomous grid operation with minimal human intervention. Digital twins of power systems, real-time simulations, and advanced optimization algorithms will allow utilities to test scenarios and improve decision-making.

On a global scale, smart grids will play a key role in achieving energy access, sustainability, and economic growth. Developing regions can benefit from decentralized smart grid solutions that provide reliable electricity to remote areas. International cooperation and policy support will be crucial for accelerating adoption and standardization.

Conclusion

Smart grids and AI-driven grid management represent a revolutionary shift in the way electrical power systems are designed and operated. By combining advanced communication technologies, automation, and artificial intelligence, smart grids address the limitations of traditional power networks and meet the demands of the modern world. They improve efficiency, reliability, sustainability, and consumer participation while enabling large-scale integration of renewable energy sources. Although challenges such as cybersecurity, cost, and workforce development remain, continued technological advancements and supportive policies will drive widespread adoption. In the future, smart grids powered by AI will form the backbone of a resilient, intelligent, and sustainable global energy system.

Online Parameter Identification for PMSMs

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To achieve high-performance Field Oriented Control (FOC) of Permanent Magnet Synchronous Motors (PMSMs), it is essential to perform online estimation of motor parameters (stator resistance (R_s), dq-axis inductances (L_d , L_q), and permanent magnet flux linkage (ψ_m)). By accurately identifying these parameters in real-time, the controller can ensure that the performance remains efficient, precise in torque output, and robust against changes to the environment and/or inverter nonlinear behaviour.

Different types of electronic user identification exist within four algorithm categories. One type is Model Reference Adaptive Systems (MRAS). With MRASs, comparison of information collected from a user's controls can be done easily by comparing real-time motor signal data to a reference model motor. The reference model is adjustable and is modified on a real-time basis through the application of adaptive laws to maintain convergence of the two models based on the principles of the Popov Hyperstability Theory. The Extended Kalman Filter (EKF) is also a recursive estimator, well-suited for nonlinear systems. Recent advances in the EKF, such as Multi-Innovation EKF (MIEKF) technology, have allowed for more dynamic responses and greater noise immunity in a variety of applications (e.g., Lunar Rover drives or marine propulsion systems). The Recursive Least Squares method (RLS) is simple to implement, converges quickly to a solution, and is commonly used to estimate resistance, and inductance along the a- and b-axes under steady-state conditions, but the RLS method is highly susceptible to noise in measured values. Swarm intelligence algorithms (e.g., Modified Fuzzy Particle Swarm Optimization MDFPSO, and Spider Monkey Optimization LSOSMO) consider the identification process as an optimization problem and attempt to find the optimal global minimum point of the fitness function to estimate parameters robustly.

Progress has been made; however, technical constraints remain. One technical constraint is the rank deficiency, which occurs because a single steady-state voltage equation cannot simultaneously identify all parameters. Typically, this is solved using two-stage parameter identification strategies: at high speed, identify inductances and flux linkages, and at low speed, identify resistance. In conjunction with this, the introduction of injected signals (i.e. negative -axis current) has increased observability of a lower-speed circuit or its equivalent through the elimination of dead-time effects from distortion caused by inverter switching. In addition, dead-time effects are another challenge; thus, compensation models can assist in aligning reference with actual voltage of the motor. Another challenge is that environmental influence changes the stator resistance through temperature; therefore, algorithms must be robust enough to detect slow environmental influences (i.e., temperature) while maintaining a stable control system.

For practical implementation, researchers typically validate algorithms using MATLAB/Simulink simulations before deploying them to real-time platforms such as dSPACE or DSP-based controllers. These platforms allow experimental verification under realistic operating conditions, bridging the gap between theoretical development and industrial application. Current research trends emphasize hybrid approaches that combine methods like EKF and RLS to balance noise immunity with fast convergence, signal injection techniques to improve low-speed observability, and AI-driven optimization strategies for handling nonlinearities. Additionally, temperature-adaptive models are being developed to enhance long-term reliability in harsh environments, making PMSM drives more robust and efficient in real-world applications.

Battery Electric Vehicles

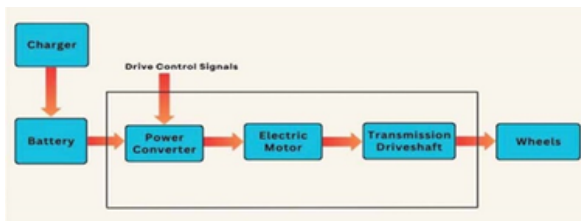
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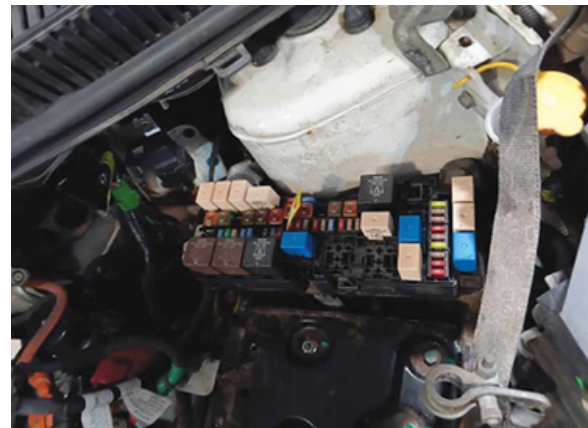
A Battery-operated Electric Vehicle (BEV) runs entirely on electricity stored in rechargeable batteries—no petrol or diesel needed. It uses an electric motor, produces zero tailpipe emissions, and is recharged through home or public charging stations.

These next-generation cars are quiet, smooth, and low-maintenance because they don't have traditional engine parts like clutches or fuel systems. Even without regenerative braking, BEVs still deliver quick acceleration and a typical driving range of 250–400 km per charge, making them a clean and practical choice for city and medium-distance travel.

Electric Motors



BEVs use electric motors to turn battery power into motion. The most common types are Permanent Magnet Synchronous Motors (PMSMs), Induction Motors, and Switched Reluctance Motors. PMSMs are the most widely used because they are compact, highly efficient, and deliver strong torque at low speeds, giving smooth and quick acceleration. These motors are precisely controlled by inverters and usually connect directly to the wheels through a simple gear system, eliminating traditional transmissions. Thermal management systems keep the motor cool and reliable during operation.



Various Types of Sensors Used in Battery Electric Vehicles and Permanent Magnet Synchronous Motor for BEV

Electrical Sensors

Electrical sensors monitor voltage, current, speed, and position in real time to ensure safe battery operation, efficient motor control, and vehicle stability. They play a key role in protection, performance optimisation, and safety systems.

Gearbox

Most BEVs use a single-speed transmission or direct drive instead of multi-speed gearboxes. This simplifies the drivetrain, reduces losses, and improves overall efficiency.

Actuators

Actuators convert electrical signals into mechanical movement. They control motor operation and other systems, ensuring smooth response and accurate vehicle functions.

Traction Inverter

The traction inverter converts DC power from the battery into AC power for the electric motor. It precisely controls motor speed and torque for smooth, efficient acceleration.



Electric Vehicle Battery Charging Infrastructure

DC-DC Converter

The DC-DC converter steps down high-voltage battery power to low voltage for auxiliary systems such as lighting and infotainment. The onboard charger safely converts grid AC power into DC for battery charging.



Large Lithium-Ion Battery Pack for BEVs

Battery System

The lithium-ion battery stores energy and determines vehicle range. A Battery Management System (BMS) monitors voltage, current, temperature, and state of charge, while thermal management maintains safe operating conditions.

Battery Charging Unit

BEVs support AC charging for everyday use and DC fast charging for rapid energy replenishment. Smart charging features improve efficiency, battery health, and convenience.

Major Issues and Solutions in BEVs

Battery Electric Vehicles face challenges such as limited driving range, long charging times, high initial costs, battery degradation, and sensitivity to extreme temperatures. These issues are being addressed through high-energy-density batteries, fast-charging infrastructure, advanced Battery Management Systems, thermal management, cost reductions through mass production, and improved recycling methods. Expanding charging networks and government incentives further support wider adoption.

Conclusion

Battery-operated Electric Vehicles represent a key step toward sustainable transportation. Despite existing challenges, continuous technological advancements, improved infrastructure, and supportive policies are making BEVs more efficient, affordable, and practical. As innovation continues, BEVs are expected to play a major role in reducing emissions and shaping the future of mobility.

Electric Vehicle Integration into Modern Power Systems

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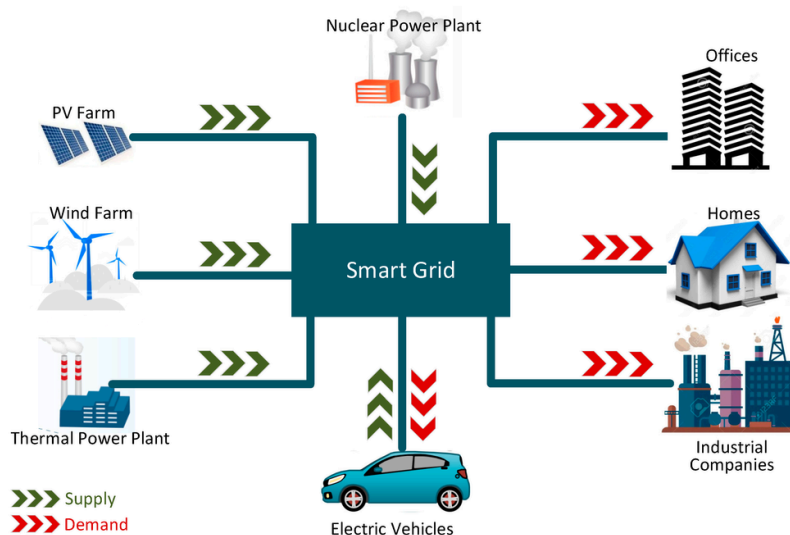
The increasing penetration of electric vehicles (EVs) is transforming conventional power systems into highly dynamic and electronically interfaced networks. From an electrical engineering standpoint, EVs function as nonlinear, high-power loads connected through power electronic converters, making their large-scale integration a critical technical challenge for modern distribution systems.

EV charging introduces significant variability in load demand, particularly during peak hours. Fast charging stations draw high current within short time intervals, which can lead to voltage drops, feeder congestion, and transformer overloading. Since EV chargers employ rectifiers and DC-DC converters, they inject harmonic currents into the grid, affecting power quality and increasing system losses. If uncoordinated, widespread EV charging can accelerate insulation aging of distribution equipment and exceed permissible harmonic limits.

Power electronics plays a central role in enabling efficient EV operation and grid compatibility. On-board and off-board chargers are designed with power factor correction and advanced control techniques to minimize total harmonic distortion and improve efficiency. Recent advancements in wide-bandgap semiconductor devices such as silicon carbide have enhanced switching performance, thermal stability, and power density of EV chargers, making high-power fast charging more feasible.

To mitigate grid stress, smart charging strategies are employed to regulate charging time and power levels based on system conditions. By aligning EV charging with off-peak periods and renewable energy availability, smart charging improves load balancing and grid reliability. An emerging concept, Vehicle-to-Grid (V2G), further extends EV functionality by enabling bidirectional power flow, allowing EV batteries to act as distributed energy storage units that support peak load reduction and frequency regulation.

The integration of EVs also demands careful attention to protection and safety. Issues such as ground fault detection, isolation monitoring, protection coordination, and cybersecurity become increasingly important in converter-dominated networks. These challenges highlight the need for updated standards and intelligent protection schemes.



Powering the Future: The Magic of AC Single-Phase Alternators

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Imagine flipping a switch during a Kerala monsoon blackout, and lights flicker on thanks to a humble single-phase alternator humming away. These compact powerhouses convert mechanical energy into alternating current (AC) that lights our homes and powers everyday gadgets, making them the unsung heroes of electrical engineering.

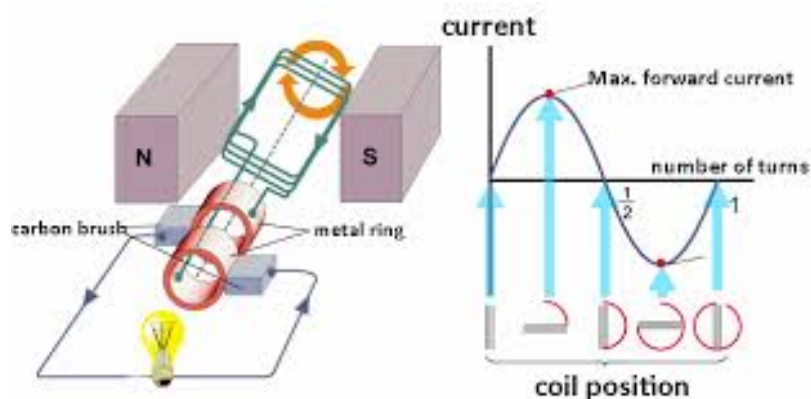
The alternator generates electrical energy through electromagnetic induction as given in Faraday's Law. An electric motor, turbine, or other source provides mechanical power to the rotor to allow it to rotate within the stationary stator. When the rotor rotates, it creates an AC voltage with a sinusoidal shape. In India, this system is typically designed to produce a frequency of 50 cycles per second (Hz) via a single revolution of the rotor in a standard two-pole configuration.

Every component inside the machine has an important function. The stator's outer-shell-like shape contains laminated iron cores and coiled windings. When alternating current voltage travels through these conductors, magnetic fields are created.

The rotor is the rotating portion located inside the stator and generally contains salient poles powered by direct current (DC) through sliprings that generate alternating north-south polarities. The exciter and brushes supply steady DC voltage to the rotor to generate a strong and stable magnetic field, providing a dependable power source. The combination of these elements results in a 230-volt single-phase supply, capable of powering loads up to 10 kW without requiring the added complexities of a three-phase system.

Single-phase alternators are ideal for practical purposes and provide the advantages of being reliable and easy to use. You can find single-phase alternators in many different places, including portable generators used by colleges, refrigeration applications in farming, and everywhere else you can think of where electricity is needed. Imagine a diesel system powering a town festival—cost-effective, scalable, and capable of meeting the needs of student projects such as wind turbine prototypes.

When single-phase alternators are properly tuned, they can reach an efficiency level exceeding 85%. Therefore, they will help improve efficiency by limiting the amount of copper loss and eddy current produced. As a way to gain first-hand experience of how alternators work, the aspiring engineer can build a model, hand-crank the rotor and observe what the oscilloscope produces as a pure sine wave trace. On the horizon, the potential of pairing alternators with solar inputs to create hybrid green energy solutions will add an exciting component to the energy landscape of Kerala in the years to come.

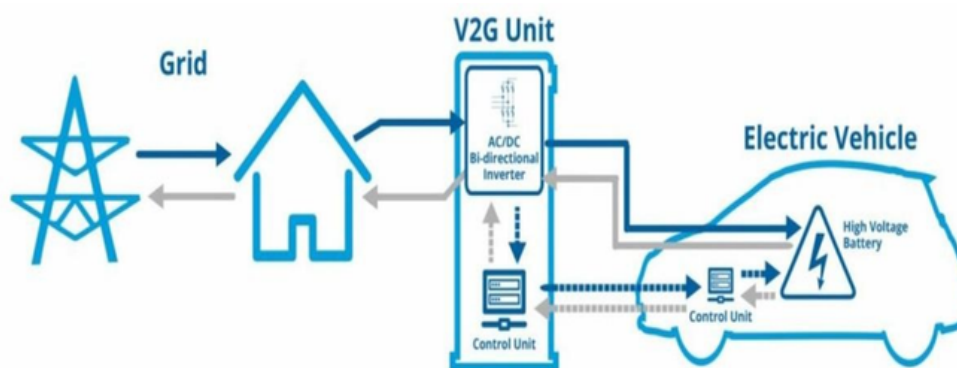


Vehicle-to-Grid (V2G) Technology

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The rapid adoption of electric vehicles (EVs) is transforming not only the transportation sector but also the conventional power system. One of the most promising innovations emerging from this transition is Vehicle-to-Grid (V2G) technology. V2G enables electric vehicles to exchange electrical energy with the power grid, allowing them to function as mobile energy storage units. This bidirectional interaction opens new possibilities for grid stability, renewable energy integration, and efficient energy management. Unlike traditional charging systems where electricity flows only from the grid to the vehicle, V2G allows power to flow in both directions. During periods of low demand or high renewable energy generation, EVs can be charged from the grid. Conversely, during peak demand conditions, stored energy in EV batteries can be supplied back to the grid. This capability makes EVs active participants in the power system rather than passive loads.



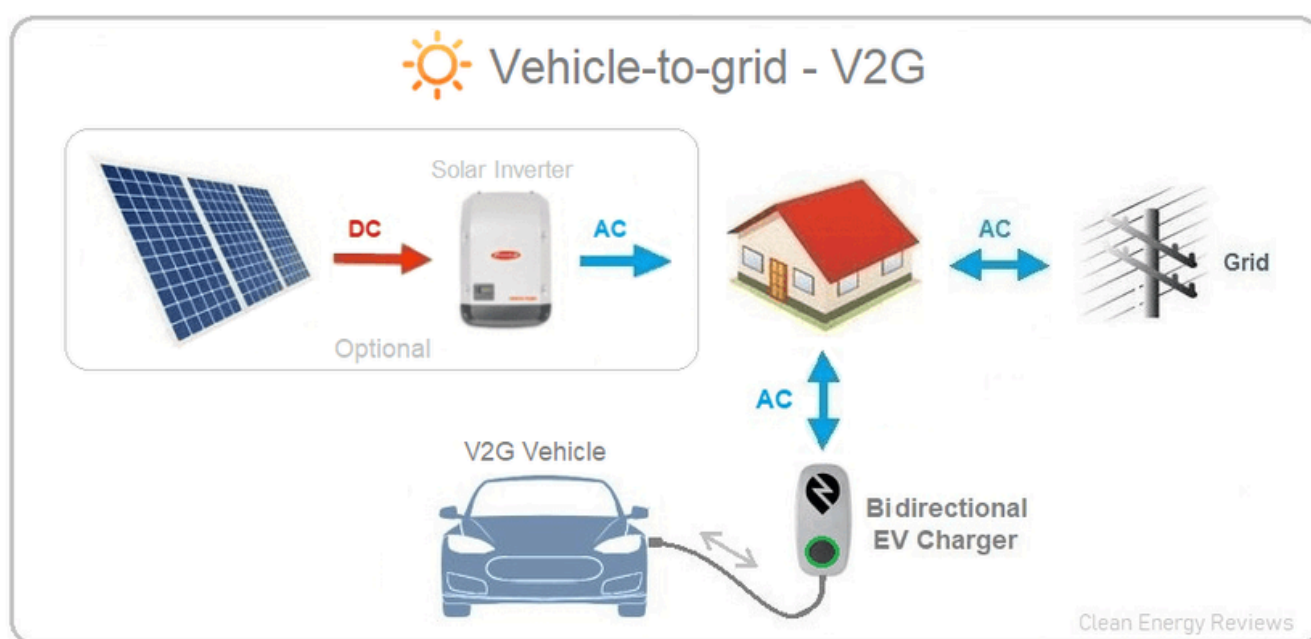
The working principle of V2G technology is based on controlled bidirectional power flow enabled by advanced power electronics and smart communication systems. When an EV is connected to a V2G-enabled charging station, the grid operator or energy management system continuously monitors parameters such as grid load, voltage, frequency, and battery state of charge (SoC). Based on these parameters and user-defined preferences, the system decides whether the vehicle should charge or discharge. User requirements such as minimum battery level and departure time are always given priority to ensure mobility is not affected. A typical V2G system consists of several key components. The EV battery, usually a lithium-ion battery, acts as the primary energy storage unit. A bidirectional charger enables conversion between AC and DC power, allowing both charging and discharging operations. Power electronic interfaces such as inverters and DC-DC converters regulate voltage and current during power transfer. The Battery Management System (BMS) ensures safe operation by monitoring battery voltage, current, temperature, and SoC. In addition, smart grid communication systems enable real-time data exchange between vehicles, aggregators, and grid operators.

From a technical perspective, the power exchanged between the EV and the grid can be expressed as $P = V \times I$, where P represents power, V is the battery voltage, and I is the current. A positive value of power indicates that energy is being supplied from the vehicle to the grid, while a negative value represents charging. The state of charge of the battery is defined as the ratio of the current charge to the rated capacity of the battery, expressed as a percentage. These simple equations form the basis for energy management and control strategies in V2G systems. Vehicle-to-Grid technology has several important applications in modern power systems. One major application is peak shaving, where EVs supply power during peak load conditions, thereby reducing stress on the grid. V2G also plays a crucial role in frequency regulation due to the fast response capability of EV batteries.

. Furthermore, it supports renewable energy integration by storing excess energy generated from solar and wind sources. In addition, V2G enables related concepts such as Vehicle-to-Home (V2H), where EVs provide backup power to homes during outages. The advantages of V2G technology are significant. It improves grid reliability and stability, reduces peak power demand, and enhances the utilization of renewable energy resources. EV owners can benefit economically by participating in energy markets or receiving incentives for supplying power back to the grid. Moreover, V2G supports the development of smart grids and contributes to a cleaner and more sustainable energy ecosystem. Despite its advantages, V2G technology faces several challenges. Frequent charging and discharging may lead to battery degradation if not properly managed. The high cost of bidirectional chargers and lack of standardized communication protocols remain major barriers. Cybersecurity concerns and regulatory limitations also pose challenges to large-scale implementation. Addressing these issues is essential for the widespread adoption of V2G systems.

In the Indian context, V2G technology has immense potential due to the rapid growth of electric vehicles and increasing penetration of renewable energy sources. V2G can support peak load management, enhance solar energy utilization, and improve energy access in both urban and rural areas. With appropriate policies, infrastructure development, and technological advancements, V2G can play a vital role in India's transition toward a smart and sustainable power grid. Looking ahead, the future of Vehicle-to-Grid technology is closely linked to advancements in battery technologies, artificial intelligence-based energy management systems, and smart city initiatives. Large-scale deployment of V2G in commercial EV fleets such as buses and delivery vehicles is expected to further strengthen grid support services.

In conclusion, Vehicle-to-Grid technology represents a paradigm shift in the way electric vehicles interact with the power system. By enabling bidirectional power flow, V2G transforms EVs into valuable energy assets that enhance grid stability, support renewable energy integration, and provide economic benefits. Although technical and regulatory challenges remain, continued research and development will make V2G a cornerstone of future intelligent power systems.



The Silicon Revolution: Solid-State Transformers and the Future of the Grid

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For more than a century, the backbone of our power grid has been the conventional iron-core transformer, a device rooted in Faraday's Law of Induction. These machines, though reliable, are passive in nature—shifting voltages without intelligence or adaptability. In today's era of renewable energy, distributed generation, and bidirectional power flow, such "dumb" components have become a bottleneck. Solid-State Transformers (SSTs) represent a radical departure from this legacy, replacing bulk copper and iron with silicon-based power electronics. Instead of relying solely on magnetism, SSTs employ advanced semiconductor devices such as MOSFETs and IGBTs to actively manage and condition electricity, making them far more versatile than their predecessors.

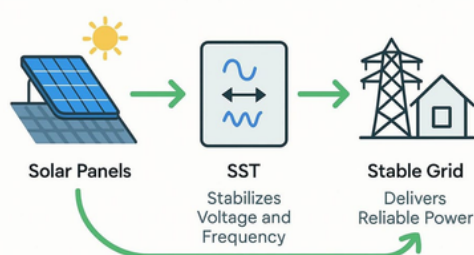
At the heart of an SST lies a three-stage architecture designed for maximum control and flexibility. The first stage is AC/DC rectification, where incoming high-voltage AC from the grid is converted into a regulated DC bus. This process incorporates active power factor correction, ensuring that the grid remains stable and free from harmonic pollution. The second stage, often implemented as a Dual Active Bridge (DAB), provides galvanic isolation and efficient energy transfer through a compact high-frequency transformer. By increasing the operating frequency from the traditional 60 Hz to around 20 kHz, the physical size of magnetic components shrinks dramatically, enabling lighter and more compact designs. Finally, the DC/AC inversion stage reconstructs the desired AC output for end-users or delivers direct DC taps for applications such as electric vehicle charging stations and data centers.

Beyond simple voltage stepping, SSTs introduce a suite of advanced functionalities that conventional transformers cannot provide. They can dynamically inject or absorb reactive power, stabilizing grid voltage without the need for bulky capacitor banks. Their semiconductor-based switching allows for fault isolation within microseconds, vastly outperforming mechanical circuit breakers in protecting both the grid and connected loads. Moreover, SSTs inherently support bidirectional power flow, a critical capability in modern grids where homes and businesses act as "prosumers," simultaneously consuming and producing electricity through solar panels, batteries, and other distributed resources.

Despite these advantages, widespread adoption of SSTs faces significant engineering hurdles. Thermal management remains a pressing challenge, as semiconductors generate concentrated heat that must be dissipated effectively to ensure long-term reliability. Designing cooling systems—whether liquid-based or advanced heatsinks—that can match the 30-year lifespan of traditional transformers is an ongoing area of research. Additionally, the cost of silicon carbide (SiC) devices, though steadily declining, still makes SSTs more expensive upfront compared to conventional iron-core units. This higher capital expenditure has slowed their deployment, even as pilot projects demonstrate their transformative potential.

Looking ahead, the trajectory of SSTs is clear. As material costs fall and cooling technologies mature, these devices are poised to move from experimental installations into mainstream grid infrastructure. Solid-State Transformers are not merely smaller or faster—they represent a fundamental shift in how electricity is managed, enabling a smarter, more resilient, and more sustainable power system. The transition from copper to silicon is not just an upgrade; it is the cornerstone of the digital, decarbonized grid of the future.

How SSTs Stabilize Solar Power



Electric Vehicles and Charging Infrastructure in India

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Electric vehicles (EVs) are reshaping India's transportation sector, driven by environmental concerns, rising fuel costs, and strong government support. The country views electric mobility as a cornerstone of its sustainable development strategy, but the success of this transition depends not only on the vehicles themselves but also on the charging infrastructure that sustains them.

India's EV market has seen remarkable growth in recent years, with adoption spreading across two-wheelers, three-wheelers, passenger cars, and commercial fleets. This momentum is fueled by consumer awareness of cost savings, reduced maintenance, and the broader push to cut carbon emissions and reduce oil imports. The government has set ambitious targets for 2030: 30% of private cars, 70% of commercial vehicles, and up to 100% of two- and three-wheelers sold should be electric. These goals are designed to reduce greenhouse gases while boosting domestic manufacturing of batteries and EV components.

Charging infrastructure forms the backbone of this transition. It consists of slow chargers, typically used in homes and workplaces for overnight charging, and fast chargers, which deliver high power for quick recharging—essential for public stations and long-distance travel. A robust charging network reduces “range anxiety” and makes EV ownership more practical and appealing.

India's charging infrastructure has expanded rapidly, with public charging stations growing from a few thousand in 2022 to tens of thousands by 2025. Yet, the ratio of chargers to vehicles remains low—currently about one public charger for every 200 EVs, compared to one for every 10–20 EVs in many developed countries. Moreover, infrastructure is unevenly distributed: metro cities and states like Maharashtra, Delhi, Karnataka, and Uttar Pradesh lead the way, while smaller towns and rural areas remain underserved.

Government initiatives are central to bridging this gap. The FAME India Scheme provides subsidies for EV purchases and charging infrastructure, while the PM E-Drive Scheme focuses on accelerating nationwide charger deployment. State-level policies further encourage private investment, and parallel efforts in battery manufacturing and securing critical minerals aim to strengthen India's EV ecosystem and reduce import dependence.

Despite progress, challenges persist. The number of charging stations is still insufficient to meet projected demand, especially for highway networks. Technology and standards also pose hurdles, as varying connector types and outdated chargers reduce efficiency and compatibility. Finally, the urban-rural divide in infrastructure access risks slowing adoption outside major cities.

India's EV journey is well underway, but scaling charging infrastructure will be the decisive factor in achieving its ambitious 2030 targets. With continued policy support, private investment, and technological standardisation, the country can build a charging network that matches its vision of a cleaner, smarter, and more sustainable mobility future.



Solar Power System – Harnessing Energy from the Sun

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Solar energy has emerged as one of the most vital renewable energy sources in the modern world. It is harnessed directly from the sun and converted into usable electrical energy through solar panels. With the rising demand for electricity and the environmental damage caused by fossil fuels, solar power offers a clean, sustainable, and long-term solution for power generation.

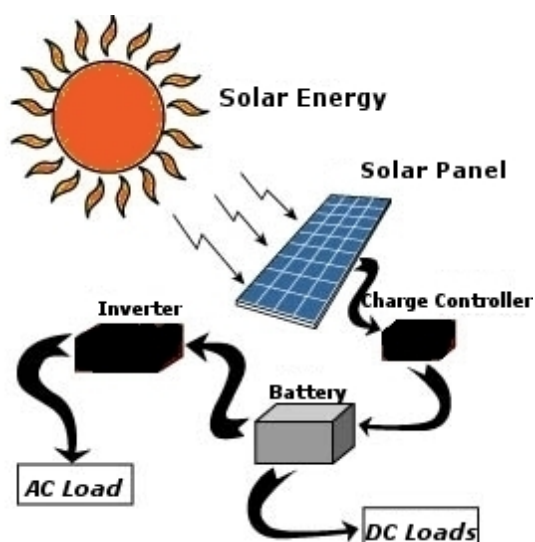
At the core of a solar power system lies the solar panel, which is composed of numerous solar cells. These cells are typically made from silicon, a semiconductor material. When sunlight strikes the cells, it excites electrons, generating direct current (DC) electricity through the photovoltaic effect. Since most household appliances and industrial equipment operate on alternating current (AC), this DC power is converted into AC using an inverter. The inverter plays a crucial role in ensuring that the electricity produced is compatible with everyday usage in homes, offices, and industries.

To enhance reliability, solar power systems often include batteries for energy storage. During the day, when sunlight is abundant, excess energy is stored in these batteries. This stored energy can then be used at night or during cloudy weather, ensuring a continuous and dependable supply of electricity.

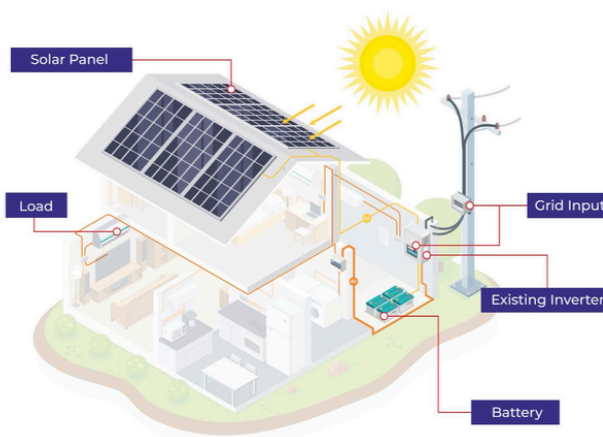
Solar energy offers several advantages. It is renewable and inexhaustible, unlike coal or oil. It produces no pollution, thereby protecting the environment. Once installed, the operating costs are minimal since sunlight is free. These benefits make solar power an attractive option for sustainable energy production.

However, solar power systems also face certain limitations. The initial installation cost is relatively high, which can be a barrier for widespread adoption. Power generation is dependent on sunlight, meaning output decreases during rainy seasons or at night. Additionally, large areas of land or rooftops are often required to install solar panels, which may not always be feasible.

In conclusion, solar power systems represent a promising technology for the future of electricity generation. With ongoing advancements in solar panel efficiency and battery storage, solar energy is expected to play a major role in meeting global energy needs. It stands as a clear example of how electrical engineering can drive innovation toward a cleaner, greener, and more sustainable world.



How Solar Solution Works



Smart Grid Technology – The Future of Power Distribution

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Smart grid technology represents the future of power distribution by transforming traditional one-way electricity transmission into a dynamic, two-way communication system between utilities and consumers. Unlike conventional grids that only deliver electricity from power plants to users, smart grids enable interaction, making the system more intelligent, flexible, and responsive.

Equipped with sensors, smart meters, and digital control devices, smart grids continuously monitor voltage levels, power flow, and energy consumption. The collected data is sent to control centers where engineers can analyze the system in real time and make quick decisions to prevent failures, optimize performance, and improve efficiency.

One of the key advantages of smart grids is better power management. During peak demand, the system can automatically balance loads by reducing unnecessary usage or shifting power from low-demand areas. This helps avoid blackouts and ensures a stable and reliable electricity supply. Smart grids also play a vital role in integrating renewable energy sources such as solar and wind. Since these sources are intermittent and weather-dependent supply.

Smart grids also play a vital role in integrating renewable energy sources such as solar and wind. Since these sources are intermittent and weather-dependent, the smart grid, the smart grid adjusts power flow adjusts power flow and storage systems and storage systems to handle fluctuations smoothly, ensuring to handle fluctuations smoothly, ensuring continuous supply continuous supply and supporting sustainability and supporting sustainability goals.

Another major benefit is major benefit is energy conservation energy conservation. With smart meters. With smart meters, consumers can track, consumers can track their real-time their real-time electricity usage electricity usage, encouraging efficient, encouraging efficient consumption and consumption and reducing wastage reducing wastage. Utilities can also. Utilities can also detect faults and detect faults and power theft quickly power theft quickly, saving both energy, saving both energy and money.

Despite these benefits, smart grid technology requires significant these benefits, smart grid technology requires significant investment, advanced cybersecurity measures investment, advanced cybersecurity measures to protect sensitive to protect sensitive data, and skilled data, and skilled engineers to design engineers to design and maintain the system. These challenges and maintain the must be addressed system. These challenges must be addressed to ensure successful to ensure successful implementation. implementation.

In conclusion, smart grid technology, smart grid technology is a transformative is a transformative step toward modern step toward modernizing electricalizing electrical power systems. By power systems. By improving reliability improving reliability, efficiency, and, efficiency, and renewable energy renewable energy integration, smart integration, smart grids will play grids will play a crucial role in a crucial role in meeting growing meeting growing electricity demand electricity demand and building a sustainable and building a sustainable, intelligent energy, intelligent energy future. future.

AI in the Field of Electrical Engineering

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S2EEE



Electrical and Electronics Engineering (EEE) has always been at the forefront of technological innovation, driving advancements that shape our everyday lives. With the rapid evolution of Artificial Intelligence (AI), the field is entering into a new era. The scope of EEE spans over multiple subfields, including power systems, control systems, signal processing, communication systems etc. Smart grids, autonomous vehicles, and Internet of Things (IoT) applications all depend heavily on EEE principles and technologies.

The fusion of AI and EEE represents one of the most transformative developments in engineering today. Electrical engineering is a highly specialized branch, it requires the use of expert systems in order to solve problems by employing decision making, archiving knowledge, and solving problems by the help of reasoning, judgement and heuristics. Artificial neural networks can be used in improving the performance of the transmission lines. It is pretty evident how much of an impact artificial intelligence can have on power systems. Several problems in power systems cannot be solved by conventional methods. A few broad areas that artificial intelligence can possibly be used are operation of power system, autonomous vehicles, embedded systems.

Other possible examples are Smart Grid Technology and Renewable Energy Sector. AI applications in smart grid technologies facilitate the management of large volumes of data from various sources, including renewable energy sources. This helps in improving efficiency, reducing energy waste, and enhancing the reliability of the system. As India moves towards greener energy solutions, there is a significant demand for EEE professionals who can integrate AI with renewable energy systems to enhance their efficiency and reliability.

Integrating AI into Electrical and Electronics Engineering marks a transformative leap in system design, operation, and maintenance. The future will be shaped by with renewable energy, autonomous systems, and other useful technologies—delivering smarter, more efficient solutions that redefine the technological landscape for decades to come.



If Electricity Disappeared for One Day

KIRAN CHIRAMEL
S2EEE

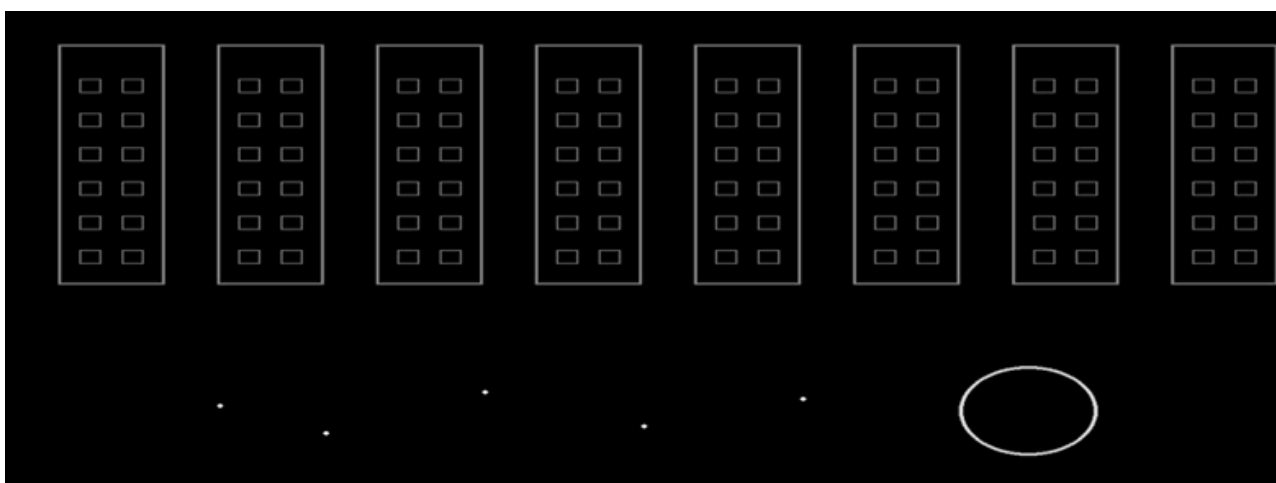


Waking up to a world without electricity would feel surreal. The absence of alarms, mobile notifications, and the quiet hum of fans would immediately unsettle us. What we often take for granted—the invisible current that powers our lives—would suddenly vanish, leaving behind an eerie silence. In those first few hours, confusion would dominate. Traffic signals would freeze, communication networks would collapse, and hospitals would struggle to function with only emergency systems. Everyday tasks like withdrawing money, cooking food, or calling for help would become unexpectedly difficult, reminding us how deeply electricity is woven into our routines.

As the day unfolds, the impact would ripple across society. Industries would grind to a halt, classrooms would fall silent, and cities would slow down to an unfamiliar rhythm. Yet, amidst the inconvenience, something profound might emerge. People would talk more, spend time outdoors, and reconnect with the natural world beyond screens. The sudden darkness would remind humanity of the true value of light, not just as a utility but as a symbol of progress and comfort.

For an electrical engineering student, this scenario is more than a thought experiment—it is a reflection of responsibility. Electricity is not merely energy; it is trust. It ensures that homes remain lit, machines operate safely, and lives are protected. The disappearance of electricity, even for a single day, would reaffirm its irreplaceable importance.

The world would survive such a day, but it would never overlook electricity again. For engineers, this realization carries a powerful truth: their work is not just technical—it is the heartbeat of modern civilization. It is what keeps the world awake, alive, and connected.



How Electrical Engineering is Digitizing Human Thought

Athul P Liju
S2EEE



A world where keyboards are obsolete and thoughts flow directly into text feels like stepping into the future of human-machine interaction. Brain-to-Text (BTT) technology in 2026 represents not just an engineering marvel but a profound shift in how we communicate.

The engineering challenge lies in the nature of the brain itself. Our neurons generate signals in the range of (10-100 μ V), far weaker than most electrical systems we deal with. Capturing these signals requires precision tools. Invasive Brain-Computer Interfaces (BCIs), such as micro-electrode arrays placed on the motor cortex, provide high-definition data but involve surgical risks. On the other hand, non-invasive methods like EEG rely on wearable caps or earbuds, using high-gain amplifiers and filters to detect faint signals through the skull. Both approaches highlight the delicate balance between accuracy and practicality.

The 2026 breakthrough is remarkable. Researchers have achieved typing speeds of 90 words per minute—faster than most smartphone users—by decoding the electrical signature of imagined handwriting. This is possible through advanced Digital Signal Processing (DSP) combined with AI models that translate neural patterns into ASCII text with 95% accuracy. What was once science fiction is now a functional reality, opening doors for both accessibility and efficiency.

The final frontier of BTT lies in refining hardware to eliminate interference, such as the electrical noise from heartbeats or muscle activity. As engineers push toward cleaner signal acquisition, the boundary between thought and digital execution grows thinner. For patients with paralysis, this technology is already life-changing, restoring communication and independence. But beyond medicine, the "API-fication" of the mind hints at a future where human intent seamlessly integrates with digital systems—where thinking could directly control devices, write code, or even collaborate across networks without physical input.

This vision underscores the responsibility of electrical engineers. BTT is not just about speed or convenience; it is about trust, ethics, and redefining the human-digital interface. The disappearance of keyboards may be symbolic, but the emergence of thought-driven communication marks a new era where engineering keeps the world not just awake, but deeply connected.



Mobile Microgrids: How EEE is Steering the Future of Transportation

GEESAC ANTONY
S2EEE



For decades, the automotive world was defined by pistons and gears. But as we move toward Electric Vehicles (EVs), the focus has shifted entirely. To an Electrical and Electronics Engineer (EEE), an EV isn't just a car - it is a sophisticated, high-power mobile microgrid.

In this new era, the 'roar' of an engine has been replaced by the silent switching of semiconductors, and the mechanical gearbox has been replaced by the elegant logic of control software.

The Power Heart: The Traction Inverter

In the EEE worldview, the most important component is the Inverter. While the battery provides steady Direct Current (DC), the motor needs precise Alternating Current (AC) to run efficiently. Modern engineers are now replacing traditional silicon switches with Silicon Carbide (SiC). These advanced semiconductors work faster and stay cooler. For an engineer, this is the ultimate win: less energy wasted as heat means more miles for the driver. We are essentially using 'smart switches' to replace the heavy, oily parts of the past.

The Virtual Transmission: Software-Driven Torque

Mechanical engineers once spent years perfecting physical gears to control a car's speed. In an EV, we do this with Control Theory. Using a method called Field Oriented Control (FOC), we use math and sensors to tell the motor exactly how much magnetic force to create at any microsecond. This is why EVs feel so fast; the 'gearing' is happening at the speed of electricity, managed entirely by a Digital Signal Processor (DSP).

The Digital Chemist: The Battery Management System (BMS)

An EV battery is a complex chemical environment. The EEE's job is to act as a 'Digital Chemist' through the Battery Management System (BMS). A battery pack is made of thousands of individual cells, and they don't all behave the same way. The BMS acts like a conductor in an orchestra, ensuring every cell charges and discharges equally. It monitors the State of Charge (SoC) to prevent the battery from dying and ensures the pack stays in a 'safe zone' so it doesn't overheat. This is high-level embedded systems engineering in action.

The Grid Connection: A Battery on Wheels

The most exciting part of EEE in this field is Vehicle-to-Grid (V2G) technology. We no longer view the car as a standalone machine, but as a part of the city's power grid. With bi-directional chargers, an EV can actually 'give back.' During the day, your car can power your home or help stabilize the local grid during a blackout. For an electrical engineer, the EV is the missing piece of the puzzle for a sustainable energy future.

The Verdict: A Software-Defined Future

Mobile Microgrids: How EEE is Steering the Future of Transportation

The transition to EVs has 'electrified' the career path for EEE graduates. We are no longer just supporting the drivetrain; we are the drivetrain. From the high-power challenges of fast-charging stations to the low-power precision of the car's internal computers, the EV is the new frontier for electrical innovation.

ROLE OF POWER ELECTRONICS IN ELECTRIC VEHICLES

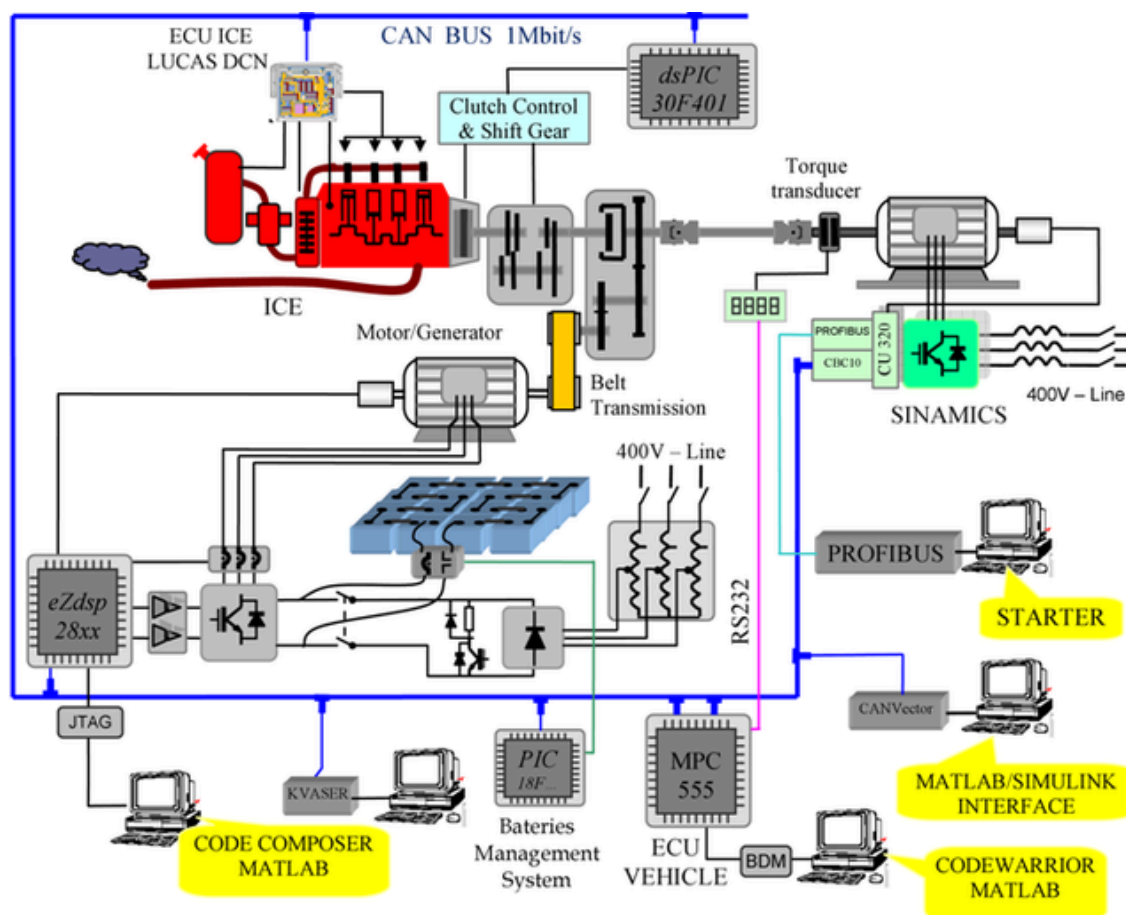
SANDESH K SAN
S2EEE



Power electronics are at the heart of modern electric vehicles, acting as the invisible force that ensures efficiency, safety, and reliability. Their primary role lies in energy conversion, where DC-DC converters regulate voltage levels for various onboard systems like infotainment, lighting, and sensors, while inverters transform DC power from the battery into AC power for propulsion motors. This seamless conversion allows precise motor control, directly improving vehicle performance and efficiency.

Beyond conversion, power electronics are crucial in battery management. Advanced chargers enable fast charging and bidirectional power flow, paving the way for vehicle-to-grid (V2G) and vehicle-to-home (V2H) applications. Energy management systems further enhance efficiency by coordinating regenerative braking, monitoring battery health, and extending battery life—all of which contribute to longer driving ranges and reduced operating costs.

The impact of power electronics on EVs is profound. By enabling efficient energy conversion and intelligent management, they not only improve performance but also reduce environmental footprints, making electric mobility more sustainable. As technology advances, innovations in semiconductor devices, thermal management, and control algorithms will continue to push EVs toward greater efficiency, affordability, and widespread adoption. In essence, power electronics are not just components—they are the backbone of the electric transportation revolution.



Internet of Things (IoT) in Daily Life

STEVEN BAIJU
S2EEE



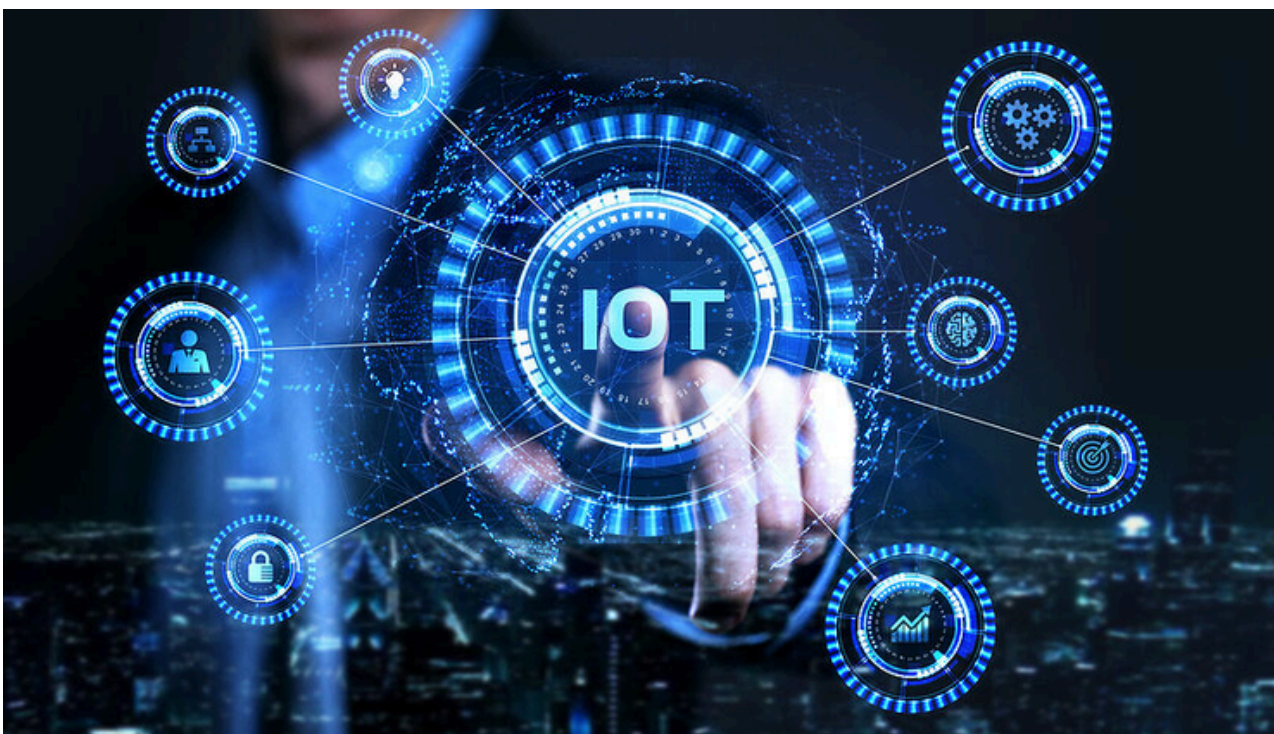
The Internet of Things (IoT) is a transformative technology that connects everyday physical devices to the internet, enabling them to collect, share, and act on data. These devices range from sensors and home appliances to vehicles and wearable gadgets, all working together to make life smarter, easier, and more efficient.

In smart homes, IoT allows users to control lights, fans, air conditioners, and security systems directly from their smartphones. Devices can operate automatically to save energy and enhance safety—for instance, lights switching off when a room is empty or cameras sending alerts during emergencies.

In healthcare, wearable devices such as smartwatches track heart rate, steps, and sleep patterns. Doctors can remotely monitor patients using this data, which is especially beneficial for elderly individuals and those with chronic illnesses. This remote care improves convenience and reduces the need for frequent hospital visits.

IoT also plays a vital role in transportation, where GPS tracking and smart traffic systems help reduce congestion and fuel consumption. Meanwhile, in agriculture, IoT sensors monitor soil conditions, weather patterns, and crop health, allowing farmers to optimize yields and minimize wastage.

In conclusion, IoT is deeply integrated into daily life, enhancing comfort, safety, and efficiency. With continuous advancements, it will further drive the development of smart living and future technologies, shaping a world where connectivity and intelligence are seamlessly embedded into our surroundings.



The Silent Pulse: How EEE is Architecting the Modern World

VISHNU PRAVEEN
S2EEE



Electrical and Electronics Engineering (EEE) is often described as the art of mastering the invisible, and your reflection captures that beautifully. Every time we flip a switch or swipe a screen, we are engaging with a vast, unseen symphony of energy conversion, signal processing, and electron flow. What makes EEE so fascinating is its scale—stretching from megawatt power systems that sustain entire nations to nanometre-level microelectronics that manipulate individual electrons for lightning-fast data processing.

The green revolution has placed EEE at the center of humanity's survival blueprint. Engineers are no longer confined to centralized power plants; instead, they are designing smart grids that integrate solar, wind, and IoT technologies. These hybrid systems balance intermittent energy sources with remarkable precision, ensuring sustainability while reshaping how homes and industries consume and produce energy.

Meanwhile, the digital nervous system of our world is powered by electronics. Every 5G tower, every semiconductor breakthrough, and every high-frequency circuit design represents a leap in communication and connectivity. Here, electronics serve as the "brain," orchestrating the muscle of electrical systems to create the backbone of the digital age.

Looking ahead, the path of EEE is one of convergence. Electric Vehicles rely on advanced battery management systems, robotics and automation demand precise control systems, and biomedical engineering depends on life-saving devices like pacemakers and neural interfaces. These intersections highlight how EEE is no longer a single discipline but a bridge across multiple domains of innovation.

Ultimately, to be an Electrical and Electronics Engineer is to refine the raw power of nature into something purposeful—lighting homes, powering industries, and connecting people across the globe. As the world transitions into a new energy era, the "Silent Pulse" of EEE resonates louder than ever, reminding us that the invisible forces we harness are the very ones keeping civilization alive and advancing.



PROJECT REPORTS

Analog Soil Moisture Controlled Irrigation System

Team Members

- Irine Paul Anthikadan
- Carmel Shaju
- Saniya Jos K

Guide

Ms.Anjana Somasundaran, Assistant Professor

This project demonstrates an automatic irrigation system that waters plants based on soil moisture levels using analog electronics. The system uses a soil moisture sensor, comparator module, relay, and water pump to maintain optimal soil moisture. When the soil dries, the pump automatically turns ON, and it turns OFF once the soil is sufficiently moist. This method conserves water, reduces manual labor, and ensures efficient irrigation.

Background of the Problem:

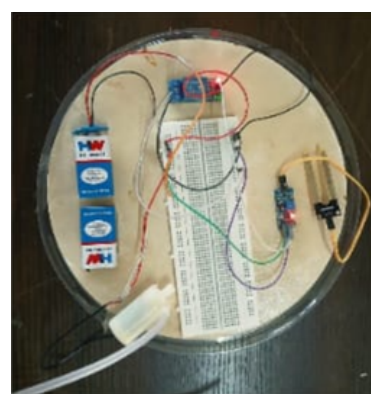
Manual irrigation can lead to overwatering or underwatering, wasting water and affecting crop growth. With increasing water scarcity, automatic irrigation systems are necessary for efficient water usage.

Background of the Problem:

Manual irrigation can lead to overwatering or underwatering, wasting water and affecting crop growth. With increasing water scarcity, automatic irrigation systems are necessary for efficient water usage.

Relevance of Study:

This project is relevant for farmers, gardeners, and anyone looking to optimize water use. It demonstrates a fully analog solution, avoiding complex programming and microcontrollers.



Analog TDS Water Tester

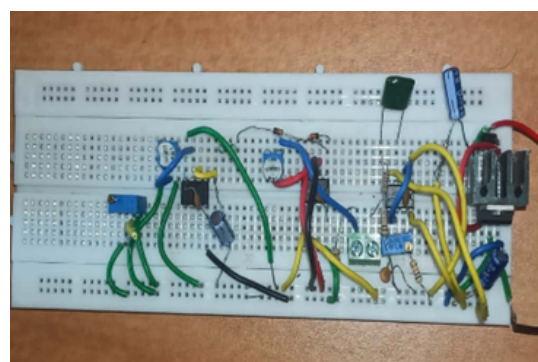
Team Members

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- Krishnanunni TB
- Jishnu S Menon

Guide

Dr. Needhu Varghese, Associate Professor

This project presents a low-cost analog water quality detector designed to measure the Total Dissolved Solids (TDS) level of water and indicate its suitability for drinking. The device uses a 555 timer to generate a 1 kHz AC signal, which is applied to stainless-steel electrodes immersed in water. The resulting current, proportional to the water's conductivity, is converted to a DC voltage using an LM358 op-amp, amplified, and compared against preset thresholds with an LM393 comparator. A three-LED system (green, yellow, red) indicates safe, moderate, or unsafe water quality. Powered by a 9V battery regulated to 5V, the device is portable, energy-efficient, easy to assemble, and cost-effective, making it suitable for household and community water monitoring.



Conclusion

- The project successfully developed a low-cost, portable analog water quality detector.
- It provided accurate and reliable readings using a 555 timer, op-amp, and comparator.
- The three-LED system made it easy to interpret water safety levels.
- Trimmer potentiometers allowed calibration to meet local water standards.
- The design is energy-efficient, user-friendly, and practical for household and community water monitoring.

Cold Box

Team Members

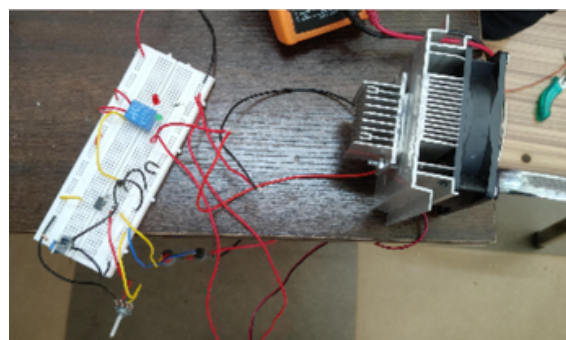
- Devika Mukundan
- Ajsal P N
- Darsana U R

Guide

Dr. Vishnu P Madhanmohan, Associate Professor

Vaccines and many critical medicines must be stored within a specific temperature range to remain effective. In many rural or remote areas, maintaining a stable cold chain is a major challenge due to unreliable electricity and high refrigeration costs. The proposed Smart Cold Box addresses this issue by providing a compact, electronically controlled cooling solution powered by a Peltier module. The DS18B20 temperature sensor ensures precise temperature monitoring, and its digital interface improves accuracy and reliability. By combining digital sensing with efficient thermal management, this project presents a viable alternative to bulky refrigeration systems, offering a scalable and sustainable design.

The Smart Cold Box using the DS18B20 sensor effectively addresses the problem of maintaining stable temperatures for vaccine and medicine storage in rural or mobile healthcare scenarios. The design ensures accuracy, energy efficiency, and affordability. The system's modular structure allows future integration of IoT-based monitoring and solar power options, improving adaptability for field use. This project demonstrates how simple electronic components can solve real-world healthcare challenges.



3-Channel Audio Equalizer

Team Members

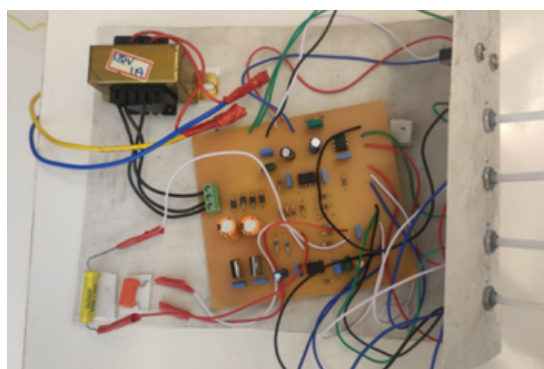
- Ajo R Mechery
- Hrishikesh C P
- Abil Mohammed

Guide

Mr. Vipin Padmanabhan, Assistant Professor

The 3-Channel Audio Equalizer is designed to enhance audio quality by allowing independent control over three frequency bands: bass, midrange, and treble. This project demonstrates the implementation of an active equalizer using operational amplifiers and film capacitors for superior audio fidelity. It aims to deliver clean sound output, suitable for both educational and practical audio applications.

The circuit employs a quad operational amplifier (TL074 or LM324) for processing the three bands. Each band consists of a frequency-selective RC network controlled by a potentiometer. Film capacitors are used due to their stability and low noise characteristics, making them ideal for audio applications where signal clarity is critical.



The 3-Channel Audio Equalizer project successfully demonstrates the principles of frequency-based audio control using active filters. Although the breadboard version exhibited noise issues, the PCB implementation is expected to provide cleaner performance. Proper grounding, component selection, and layout design play crucial roles in achieving high-quality sound output.

Temperature Controlled Fan

Team Members

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- Alan Biju
- Hemin Paul

Guide

Dr. Eugene Peter, Associate Professor

In this article, we are going to discuss making a temperature-controlled fan using Arduino. With this circuit, we will be able to change the fan speed in our home or any place according to the room temperature and also display the temperature and fan speed changes on a 16x2 LCD display. To do this we will be using an Arduino UNO Board, LCD, DHT11 sensor Module, and DC fan. Let's get started.

The design includes an Arduino UNO board connected to a DHT11 sensor for temperature and humidity measurement, a 16x2 LCD to display temperature readings, and a 5V DC fan controlled via a 2N222 transistor. A potentiometer is used for contrast adjustment in the LCD. The Arduino reads temperature data and adjusts fan speed accordingly.



In this article, we learned about how we can make a temperature-controlled fan circuit using an Arduino, DHT11, and a few other components. It can be used in any place where temperature needs to be maintained at specific levels like in some industries or houses. We checked how it actually works and also learned how to code for a temperature-controlled fan..



Fire Exist Direction Indicator

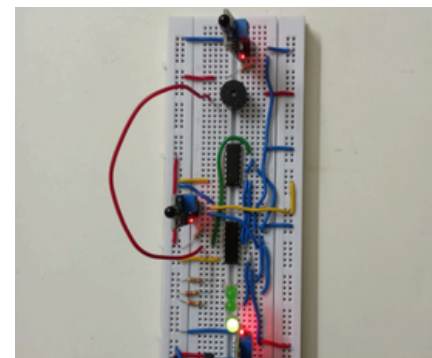
Team Members

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Guide

Mr. Febin Raju , Assistant Professor

The Fire Exit Direction Indicator is a safety system designed to guide people quickly and safely toward the nearest exit during a fire or emergency. The system uses sensors and LED indicators to detect fire and automatically display the correct escape direction. It ensures efficient evacuation, reduces panic, and improves safety in public buildings such as schools, offices, and malls. This project highlights the importance of combining electronics, sensors, and safety design to protect lives during emergencies



The Fire Exit Direction Indicator enhances building safety by providing a clear, automatic guide during emergencies. The system demonstrated reliable performance in detecting fire and indicating safe exits.

Dark Sensor using LDR

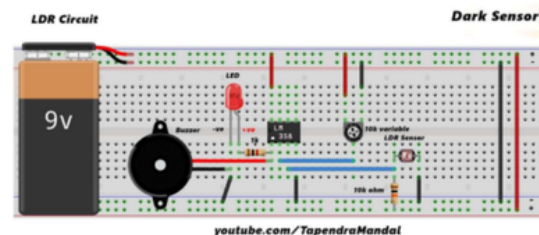
Team Members

- Aadithya Sreejith
- Ajosh C J
- Nikhil Paul Olakkengil

Guide

Dr. Ravishankar A N, Professor

This project aims to design and implement a simple and efficient dark sensor circuit using a Light Dependent Resistor (LDR). The system automatically turns ON a light when the surrounding brightness falls below a certain level, and turns it OFF when sufficient light is present. The LDR is used as a light-sensitive element whose resistance varies inversely with light intensity. An operational amplifier (op-amp) is used as a voltage comparator to detect light level changes and control a transistor switch that drives an LED or lamp. The project demonstrates the practical application of basic electronic components in creating an automatic lighting system that conserves energy and reduces human intervention. The prototype successfully operates with quick response and stability under various light conditions.



The dark sensor using LDR is a simple yet effective application of basic electronic components for automation and energy conservation. It eliminates manual effort and ensures lights operate only when needed. The project demonstrates the use of sensors and comparators in practical automation systems. Future improvements could include using microcontrollers for intelligent light control, integrating solar power, or employing relay drivers to control high-power lamps.



Voltage Regulated Buck-Booster

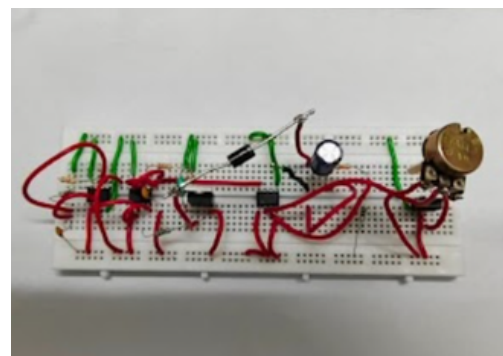
Team Members

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- Eric Paul Biju
- Irena Mary Baspin

Guide

Dr. Needhu Varghese, Associate Professor

The Voltage Regulated Buck-Boost Converter is a DC-DC converter designed to provide a constant output voltage despite variations in the input voltage. It can both step up and step down voltage, making it suitable for variable sources such as batteries and solar panels. The circuit uses a PWM-controlled switching device along with an inductor, diode, and capacitor to ensure efficient energy transfer. A feedback mechanism maintains voltage regulation under changing input and load conditions. This project highlights the practical application of power electronics in providing efficient and reliable power for modern electronic systems.



The Voltage Regulated Buck-Boost Converter was successfully designed and tested to provide a constant DC output regardless of variations in the input voltage. The project demonstrated the effective integration of switching, control, and feedback mechanisms to achieve efficient voltage regulation. The converter proved capable of operating in both buck and boost modes, maintaining stable output with minimal ripple and high efficiency.

Active Noise-Cancelling Circuit

Team Members

- Joel Robin
- Parvathi Dilip
- Devsankar Bose

Guide

Mr. Nithin K S, Assistant Professor

The Active Noise-Cancelling Circuit is designed to reduce unwanted background noise and enhance audio clarity in applications such as headphones, microphones, and communication systems. The circuit works on the principle of destructive interference by generating an inverse waveform to cancel external noise. It aims to improve the quality of the desired audio signal while minimizing ambient disturbances. The design focuses on simplicity, portability, and cost-effectiveness, ensuring reliable performance under different acoustic conditions. This project demonstrates the practical application of electronics and basic signal processing in creating a quieter and more comfortable listening experience.



The Active Noise-Cancelling Circuit effectively reduces background noise and improves audio clarity using destructive interference. Demonstrates practical use of electronics and signal processing in modern audio applications.

IoT Based Smart Grid Monitoring System

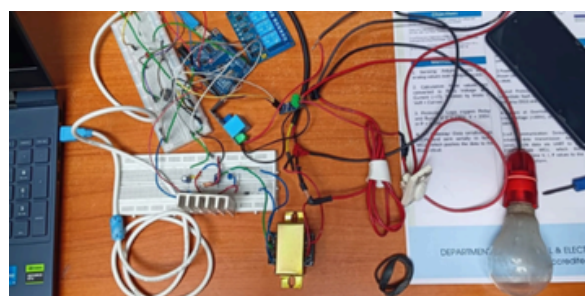
Team Members

- Sidan M S
- Alan B Antony
- Adit C Anand

Guide

Mr. Febin Raju, Assistant Professor

This project presents an IoT-based system for real-time monitoring and protection of the AC power grid. It uses an Arduino UNO with ZMPT101B voltage and ACS712 current sensors to measure AC parameters and compute RMS voltage, RMS current, and true power. A relay and buzzer provide local protection by disconnecting the load during conditions such as over/under-voltage and overloading. The measured data is formatted in JSON and transmitted via an ESP32 (NodeMCU) to the Blynk IoT platform for remote monitoring. The system offers a cost-effective solution for improving power reliability and supporting smart metering applications.



The developed IoT-Based Smart Grid Monitoring System is a functional, low-cost solution that reliably measures AC power parameters and provides essential automated load protection. This system validates the approach for future smart metering applications.

5 band Audio Equalizer

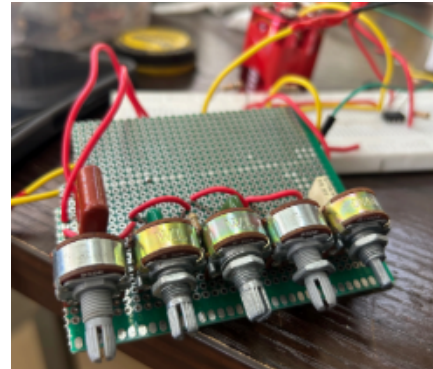
Team Members

- Athin Jophy
- Nistil Rooy A J
- Shalwin Shaji

Guide

Mr. Nithin K S, Assistant Professor

This project demonstrates the design and implementation of an active audio equalizer using operational amplifiers and high-quality film capacitors to achieve superior audio fidelity. The equalizer allows precise control over different frequency bands, enabling enhancement or attenuation of bass, midrange, and treble components of an audio signal. The design focuses on delivering clean, low-distortion sound output while maintaining stability and efficiency. This project is suitable for both educational purposes and practical audio applications, showcasing the effective use of analog electronics in audio signal processing and sound quality improvement..



The 5-band audiobook equalizer improves the overall listening experience by making voices clearer and more distinct. Users can adjust the bass, mid, and treble frequencies to suit their preferences, which helps reduce background noise and uneven tones. This leads to a balanced and comfortable sound, making long audiobook sessions easier on the ears. Overall, the equalizer allows listeners to enjoy personalized, high quality audio tailored to their needs



HEARTBEAT SENSOR

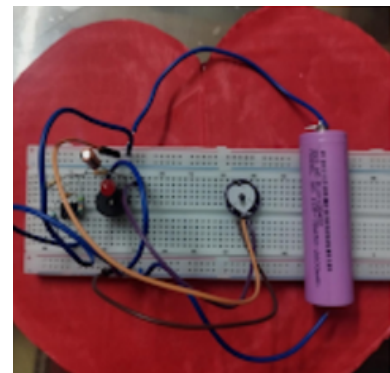
Team Members

- K P Nayanthara
- Sana Rose K A
- Magna T V

Guide

Ms. Anjana Somasundaran, Assistant Professor

This project presents a simple and low-cost heartbeat monitoring system using the LM358 operational amplifier. It detects heartbeats through an IR LED and photodiode placed on a fingertip, sensing changes in blood flow. The weak signals are amplified using the LM358 and used to trigger an LED or buzzer for each heartbeat. The project provides an affordable health-monitoring solution and offers hands-on experience in analog electronics, signal processing, and sensor interfacing, with scope for future upgrades using microcontrollers and digital displays.



This project presents a simple and cost-effective heartbeat monitoring circuit using basic analog components, making it suitable for educational use. However, the circuit is sensitive to noise and finger placement. Future improvements include Arduino-based BPM calculation, LCD display, Bluetooth connectivity, and wearable applications for continuous health monitoring.

High Efficiency Micro Power Inverter

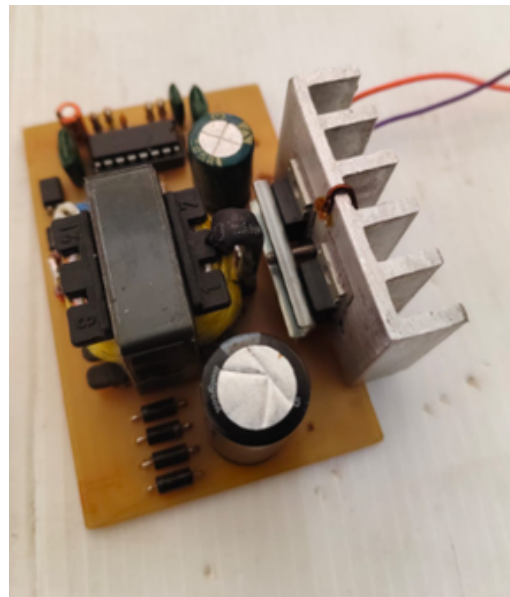
Team Members

- Herschel Son
- Chrisvin Savio
- Adith Krishna

Guide

Mr. Jinu K T, Assistant Professor

Portable and backup power solutions are widely used in households, laboratories, and remote installations where mains supply is unavailable or unreliable. A compact, efficient inverter minimizes energy losses, reduces heat generation, and extends battery runtime. This project aims to design a 250 W inverter that is: Efficient (target overall efficiency $\geq 88\text{--}92\%$ under typical loads)



As the operating frequency increases, the transformer size decreases while power density increases and losses are reduced. A high-frequency push-pull MOSFET driver controls the MOSFETs using PWM generated from an internal comparator with a 2.5 V reference and a triangle wave generator. The inverter maintains a stable output voltage under both no-load and load conditions, achieving 99.5% efficiency at no load and 90% efficiency at a 100 W load, with the transformer remaining cool even under heavy loads and voltage spikes.



RythmWear

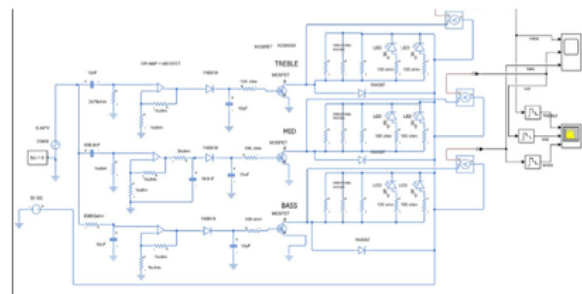
Team Members

- Noel Joby
- Ansal Mohammed
- Albin Paul

Guide

Dr. Ravishankar A N, Professor

This project aims to develop a wearable analog wristband that enables hearing-impaired individuals to experience music through vibrations and visual feedback. The system captures audio signals and processes them into different frequency bands, which are then converted into tactile vibrations and LED responses to represent rhythm and intensity. Emphasis is placed on simplicity, low cost, and portability, making the device suitable for everyday use. By translating sound into alternative sensory feedback, this project promotes inclusivity and provides an engaging way for the hearing-impaired community to connect with music.



This project presents a simple and cost-effective heartbeat monitoring circuit using basic analog components, making it suitable for educational use. However, the circuit is sensitive to noise and finger placement. Future improvements include Arduino-based BPM calculation, LCD display, Bluetooth connectivity, and wearable applications for continuous health monitoring.

SMART GLOVES FOR BLIND

Team Members

- Anugrah Sojan
- Arun V B
- Jitto Jeesson

Guide

Ms. Geena Kurian, Assistant Professor



This project presents the design and development of Smart Gloves for the Blind, an assistive wearable device aimed at improving mobility and independence for visually impaired individuals. The glove is powered by an ESP32 microcontroller and uses ultrasonic sensors to detect nearby obstacles, providing haptic feedback through vibration alerts. Additional features include voice feedback via a Bluetooth-connected mobile application and location tracking using Wi-Fi/GPS for improved navigation. The system is compact, low-cost, and easy to use, offering a reliable and practical solution for safe and independent movement through sensor technology and IoT integration.

The Smart Gloves for the Blind based on ESP32 proved to be an effective and intelligent assistive technology. The glove enhanced user safety and mobility through vibration and voice-based feedback, while remaining portable, power-efficient, and cost-effective. However, sensor performance may be affected by uneven surfaces or high ambient noise. Future improvements could include AI-based object recognition, rechargeable Li-ion batteries, and water-resistant materials to increase reliability and user comfort.

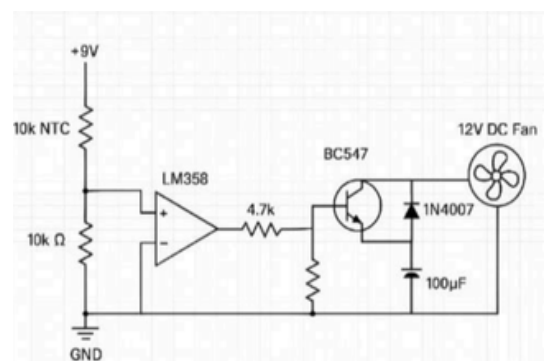
TEMPERATURE CONTROLLED DC FAN

Team Members

- Navaneeth Krishnan
- Athul krishna
- Krishnalal

Guide

Ms. Emilin Thomas Kangappadan, Assistant Professor



The thermistor and the 10 kΩ resistor form a voltage divider that generates a temperature-dependent voltage V_{tV_tVt} . As the temperature increases, the thermistor's resistance decreases, causing V_{tV_tVt} to increase, while a decrease in temperature raises the thermistor resistance and lowers V_{tV_tVt} . This voltage is applied to an LM358 op-amp, which compares V_{tV_tVt} with a fixed reference voltage $V_{refV_ref}V_{ref}$ set using a resistor or potentiometer. When V_{tV_tVt} exceeds $V_{refV_ref}V_{ref}$, the op-amp output goes HIGH (close to the supply voltage), and when V_{tV_tVt} is lower than $V_{refV_ref}V_{ref}$, the output goes LOW. The op-amp output drives a BC547 transistor

through a 4.7 kΩ base resistor; a HIGH output turns the transistor ON, allowing current to flow from collector to emitter and power the fan, while a LOW output turns the transistor OFF, stopping the fan. A 1N4007 diode is connected across the fan to protect the transistor from damage due to back EMF generated when the motor is switched OFF. Overall, at low temperatures the thermistor resistance is high, the op-amp output remains LOW, the transistor stays OFF, and the fan does not run, whereas at high temperatures the thermistor resistance drops, the op-amp output goes HIGH, the transistor turns ON, and the fan operates.

ELECTRONIC STETHOSCOPE

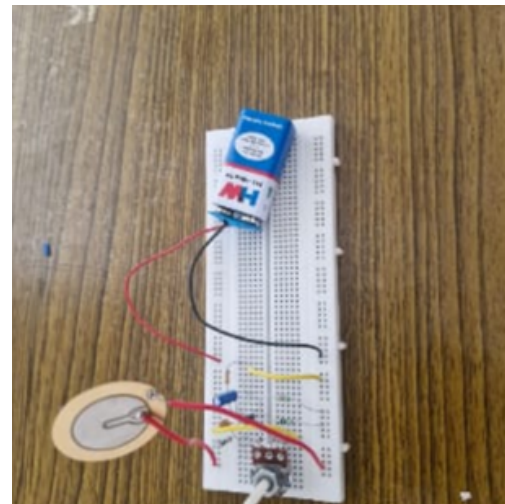
Team Members

- Anagha K S
- Anora Faria
- Hridya Sanalkumar

Guide

Ms. Emilin Thomas Kangappadan, Assistant Proffesor

An electronic stethoscope is an advanced diagnostic tool designed to overcome the limitations of traditional acoustic stethoscopes. It converts body sounds such as heartbeats and lung sounds into electrical signals that can be amplified, filtered, and analyzed. This project aims to design and develop a low-cost, high-sensitivity electronic stethoscope using a microphone sensor, preamplifier, signal processing circuit, and audio output stage. The processed signal can also be interfaced with a smartphone or computer for recording and real-time visualization. The system enhances diagnostic accuracy, supports telemedicine applications, and allows storage of patient data for future reference. The outcome demonstrates a reliable and affordable medical instrument suitable for rural and clinical healthcare settings.



The electronic stethoscope prototype achieved the desired performance in amplifying and analyzing body sounds. Its affordability and ease of use make it suitable for healthcare workers and telemedicine. Future enhancements include digital signal processing for noise reduction, wireless data transmission, and cloud-based health monitoring integration.

Water Level Indicator Using Transistors

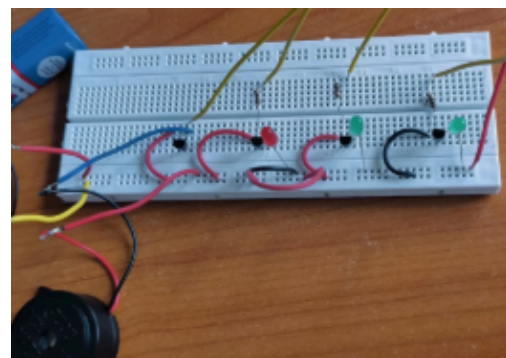
Team Members

- Alfin Tony
- Adheendhra Jayanandhan
- Pius Jake

Guide

Dr. Eugene Peter, Associate Professor

This project presents the design and implementation of a Water Level Indicator using analog electronic components such as transistors, resistors, LEDs, and a buzzer. The system monitors the water level in a storage tank and provides both visual and audible indications as the water level rises. The circuit operates purely on analog principles without using any microcontroller, making it cost-effective, reliable, and easy to construct. The working is based on the conductivity of water, which triggers different transistor stages corresponding to low, medium, and full levels. When the tank reaches the full level, a buzzer is activated to alert the user. This project helps prevent water overflow and wastage, offering an efficient and practical solution for domestic and industrial applications.



The Water Level Indicator using transistors is a simple, cost-effective, and reliable solution to monitor water levels. It enhances understanding of transistor switching and analog circuit design. While performance may vary with water conductivity, the circuit can be improved by integrating automatic motor control or upgrading to a microcontroller-based smart monitoring system. Future Scope: - Integration of motor control via relay. - Smart system upgrade with IoT integration.

Solar Based Smart Aqua Purifier

Team Members

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- Devath Sailesh
- Krishnendu C P

Guide

Dr Vishnu P Madhanmohan, Associate Professor

SolarSmart AquaPurifier is a solar-powered intelligent water purification system designed for rural and remote areas. It uses renewable solar energy and UV technology for efficient purification. Sensors such as LDR, photodiode, and IR modules monitor water turbidity and level, allowing an Arduino-based controller to automatically select the appropriate purification mode. During daytime, natural solar UV is used, while at night a solar-charged UV lamp ensures continuous operation. The prototype demonstrated accurate turbidity detection, automatic mode switching, and effective purification, highlighting its potential as an eco-friendly and portable solution.



The SolarSmart AquaPurifier effectively provides clean and safe drinking water using solar and UV-based purification technology. While the system performs reliably, its efficiency may reduce during prolonged cloudy conditions or when treating water with very high turbidity. In the future, the system can be scaled for rural and remote communities, integrated with IoT for real-time monitoring and control, and adapted for larger water supply and community-level purification systems.



Automatic Solar Panel Cleaning System using Arduino

Team Members

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- Malavika KM
- Anamika PK

Guide

Mr. Nithin KS, Assistant Professor

The project titled “Automatic Solar Panel Cleaning System using Arduino” was developed to address the problem of dust accumulation on solar panels, which can reduce power generation efficiency by up to 30 percent. Manual cleaning is often expensive, labor-intensive, and impractical for large or remote solar installations. This project proposes an automated cleaning solution using an Arduino microcontroller to control a servo-driven wiper and a water pump. Cleaning can be initiated either automatically through an LDR sensor when reduced sunlight indicates dust accumulation, or through scheduled operation using a real-time clock (RTC) module. The system is powered by a rechargeable battery charged directly from the solar panel, making it energy-efficient and self-sustaining.

The system was designed using components such as an Arduino Uno, MG996R servo motor, 12V water pump, Li-ion battery, and L298N motor driver. A brush assembly attached to the servo motor provides mechanical cleaning, while the water pump ensures uniform wetting of the panel surface. PWM control was used for precise servo operation, and the motor driver ensured stable pump performance. Software logic coordinated sensor inputs, timing control, and actuator movement. Testing showed that the automated cleaning mechanism effectively removed dust and improved panel output by approximately 10 to 15 percent in dusty conditions. The battery-supported operation allowed multiple cleaning cycles without external power. While the system is scalable and suitable for large installations, performance depends on brush design, water flow, and periodic maintenance.

Overall, the Automatic Solar Panel Cleaning System provides a low-cost, eco-friendly solution for maintaining solar panel efficiency. By reducing manual intervention and operational costs, the system is well suited for remote and large-scale solar applications. Automated cleaning ensures consistent panel performance, improves energy yield, and enhances the long-term return on investment in solar energy systems.

AUTOMOTIVE BLACKBOX

Team Members

- Aashna Nazeer
- Agnes Elizabeth Joshy
- Abinik Biju

Guide/Mentor

Dr Vishnu P Madhanmohan, Associate Professor

The Automotive Blackbox project involves the development of an Event Data Recorder (EDR) for vehicles to record critical parameters before, during, and after accidents. The system captures data such as vehicle speed, acceleration, braking status, GPS location, engine condition, vibration, temperature, smoke, and alcohol presence using an ESP32 microcontroller and multiple sensor. This data helps in accurate accident reconstruction, driver behavior analysis, insurance verification, and legal investigations by providing reliable and unbiased evidence.

The system was tested under simulated driving and accident conditions and successfully recorded real-time and event-based data, including pre- and post-crash information. Results showed effective identification of unsafe driving behaviors such as overspeeding and sudden braking while

maintaining a compact and cost-effective design. Although challenges like data security, long-term storage, and privacy remain, the automotive blackbox proves to be a practical and valuable safety tool with strong potential for future enhancements through AI, IoT, and intelligent vehicle integration.



AUTOMATIC WHITEBOARD ERASER ROBOT

Team Members

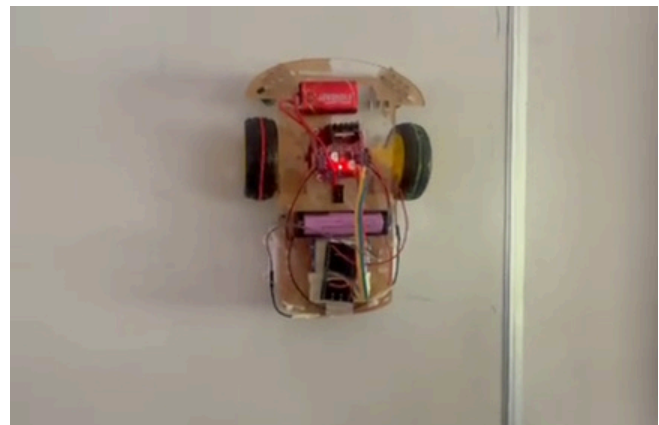
- Henry Bastian V
- Sania Maria Johnson
- Jaffrin Shaju

Guide/Mentor

Dr. Eugene Peter, Associate Professor

The “Automatic Whiteboard Eraser Robot” automates the cleaning of whiteboards used in classrooms and offices, addressing the inefficiency and inconsistency of manual erasing. The system uses a mobile robotic mechanism with erasing pads or rollers that move across the board under automated control. An ESP32 microcontroller manages motor movement and sensor inputs to ensure full surface coverage. The design focuses on simplicity, portability, low cost, and uniform erasing quality, making it practical for everyday use. The prototype was built using motors, microfiber pads, guiding frames, sensors, and a rechargeable power supply, with control software developed using the Arduino IDE.

Testing on different board sizes and marker types showed that the robot erased content uniformly and reduced cleaning time by 50 to 70 percent compared to manual wiping. It consumed low power, operated smoothly, and required minimal user effort. The project demonstrates how basic automation and intelligent control can improve routine tasks. Future improvements may include vision-based selective cleaning, IoT connectivity, automated scheduling, eco-friendly materials, and adaptation for other flat surfaces such as glass boards and walls.



Wild Animal Deterrent System

Team Members

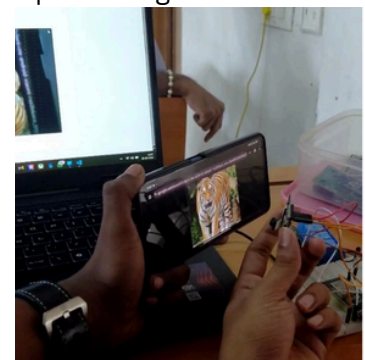
- Jovial Joyson
- Yadhuraj M
- Aaroh A
- Harris Diyu

Guide/Mentor

Mr. Vipin Padmanabhan, Assistant Professor

The “Wild Animal Deterrent System” addresses human-wildlife conflict by replacing non-selective deterrents with an AI-based, species-specific approach. Conventional systems trigger false alarms and cause animal habituation due to indiscriminate activation. This system integrates machine learning to classify animals and trigger targeted deterrents, such as customized audio alerts, ensuring humane and effective intervention. The hardware consists of an ESP32-CAM, PIR sensor, relay module, speaker, LED, and SD card, with firmware developed using Arduino IDE. Image classification is performed using a TensorFlow/Keras model trained via Google Teachable Machine, while a Python Flask server manages decision logic and communication. A web dashboard enables real-time monitoring of detections and system status.

Testing showed reliable end-to-end operation, with an average response time of 3–5 seconds from detection to deterrent activation. The AI model accurately distinguished humans and background scenes, significantly reducing false alarms, and correctly triggered species-specific deterrents for target animals. The system demonstrated practical feasibility for real-time wildlife deterrence. Current limitations include reliance on stable Wi-Fi, continuous power, and limited model scope. Future enhancements include edge-based AI processing, solar power integration, cloud-based analytics, and advanced deterrent mechanisms. The project demonstrates the effectiveness of AI-driven, selective deterrence in promoting safer human-wildlife coexistence.



SMART AQUATIC SYSTEM (SMARTFEED PRO)

Team Members

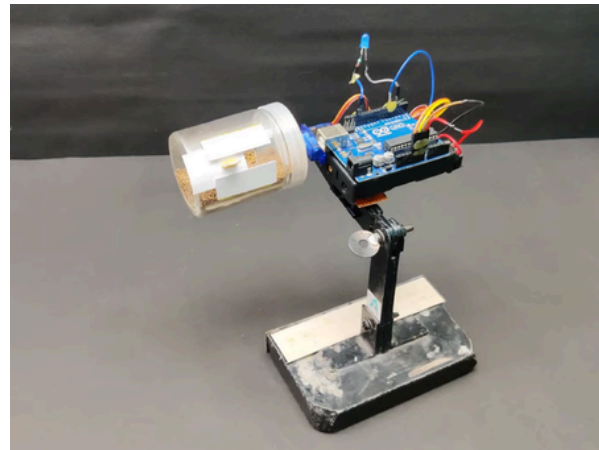
- Chrysler Marshal
- Criswin Saju
- Benedict K R

Guide/Mentor

Ms. Emilin Thomas Kangappadan, Assistant Professor

The “Smart Aquatic System (SmartFeed Pro)” is an IoT-based automatic fish feeding solution designed to ensure consistent and controlled feeding for aquarium and pond fish. It uses an ESP32 microcontroller, a servo motor for precise food dispensing, and a Flutter-based mobile application for remote scheduling and control. Feeding schedules and commands are synchronized through Firebase Realtime Database, allowing users to manage feeding intervals reliably from anywhere. The system addresses common issues such as irregular feeding, overfeeding, and neglect caused by busy routines, while also reducing food waste and water contamination through portion control.

The system was implemented using Arduino-based firmware with Wi-Fi and NTP time synchronization, along with a mobile app that communicates via HTTP requests. Testing confirmed accurate timing, reliable dispensing, and effective remote operation with minimal manual intervention. While minor mechanical issues such as food jamming were observed, overall performance was stable and efficient. The project demonstrates a practical and low-cost application of IoT in pet care and aquaculture. Future improvements may include water quality sensors, live video monitoring, and solar-powered backup to enhance reliability and scalability.



Scribe Assist – HID Joystick Based Assistive Device

Team Members

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- Pavithra Vinod
- Kiran P S
- Shravan Rubesh N

Guide/Mentor

Mr. Nithin KS, Assistant Professor

The “Scribe Assist – HID Joystick Based Assistive Device” was developed to improve computer accessibility for individuals with physical disabilities who experience difficulty using conventional input devices such as a mouse or trackpad. Many assistive solutions currently available are either expensive, complex, or poorly suited to users with limited and inconsistent motor control. This project focuses on providing a simple, affordable, and ergonomic alternative that converts small, intentional physical movements into complete mouse functionality. By reducing the physical effort required for cursor movement, clicking, and scrolling, the device enables users to interact with computers more comfortably and independently. The design prioritizes ease of use, reliability, and compatibility with standard computer systems, making it suitable for educational, professional, and personal computing environments.

The system uses an ESP32-S3 microcontroller with a joystick, rotary encoder, and push switches to control cursor movement, scrolling, and mouse clicks. Input signals are calibrated and transmitted using the USB HID protocol, allowing plug-and-play operation. Testing confirmed smooth cursor control and reliable performance. Future enhancements may include wireless operation and adjustable sensitivity to support a wider range of user needs.



RFID-Based Smart Lock Using ESP32, PN532 and Servo Motor

Team Members

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- Ashish JK
- Sooraj Christy Raj

Guide/Mentor

Dr. Needhu Varghese, Associate Professor

The project titled “RFID-Based Smart Lock Using ESP32, PN532 and Servo Motor” was developed to provide a secure, reliable, and modern access control solution for residential, commercial, and institutional environments. Traditional mechanical locking systems are prone to issues such as key loss, unauthorized duplication, and limited control over access, which can compromise safety. This project addresses these shortcomings by implementing Radio Frequency Identification (RFID) technology, which enables contactless and user-specific authentication. By replacing physical keys with RFID cards or tags, the system ensures that only authorized users are granted access. The design integrates an ESP32 microcontroller as the central control unit, a PN532 RFID reader for tag detection, and a servo motor to physically control the locking mechanism. Additional components such as LEDs and a buzzer are included to provide clear visual and audio feedback to users, improving usability and system transparency.

The system operates by reading the unique identifier (UID) of an RFID card or tag through the PN532 module and comparing it with a list of pre-authorized UIDs stored in the ESP32. When a valid tag is detected, the microcontroller activates the servo motor to unlock the door and signals successful authentication through a green LED and buzzer tone. Unauthorized access attempts are rejected, with the lock remaining engaged and the user notified through a red LED and alert sound. Testing demonstrated reliable RFID detection, accurate access control, and smooth servo motor operation. The system is practical, cost-effective, and easy to implement. Owing to the flexibility of the ESP32, the design can be extended to include features such as Wi-Fi or Bluetooth-based access logging, mobile application control, cloud monitoring, or multi-factor authentication, making it suitable for future smart security applications.



Reading Aid for Visually Impaired Using Raspberry Pi

Team Members

- Norah Els John (CCE23EE046)
- Angelin K P (CCE23EE018)
- Abel Thomas (CCE23EE05)

Guide/Mentor

Dr. Needhu Varghese, Associate Professor,

The project titled “Reading Aid for Visually Impaired Using Raspberry Pi” was developed to provide an accessible and cost-effective solution that enables visually impaired individuals to read printed documents independently. Reading physical text is a major challenge for visually impaired users and often requires external assistance. This system addresses that limitation by converting printed text into audible speech using a portable and affordable platform based on the Raspberry Pi 4. The device captures text from physical documents using a webcam and processes the images through Optical Character Recognition (OCR) to extract readable content. OpenCV is used for image pre-processing to improve clarity and recognition accuracy, while the Tesseract OCR engine performs text extraction. The extracted text is then converted into speech using the pyttsx3 Text-to-Speech library, allowing users to listen through headphones for a private and convenient reading experience.

The methodology involves integrating hardware components such as the Raspberry Pi 4, webcam, push buttons, headset, and power supply, with the Raspberry Pi acting as the central processing unit. Software implementation is carried out using Raspberry Pi OS and Python, along with supporting libraries for OCR and speech synthesis. Testing showed that the prototype accurately captured printed text and delivered clear audio output, enabling independent reading with minimal user interaction. The system proved to be portable, user-friendly, and reliable for use in homes, schools, and workplaces. Future enhancements may include multilingual support, wireless connectivity, and cloud-based processing to further expand functionality and usability.

Microprocessor Based Robotic Leg Control System

Team Members

- Adith Shine
- Athul Krishnan
- Alen Saji

Guide/Mentor

Mr. Febin Raju, Assistant Professor

The project titled “Microprocessor Based Robotic Leg Control System” focuses on the design and development of a robotic leg prototype using an Arduino-controlled stepper motor to achieve precise and repeatable leg-like motion. The primary objective is to demonstrate a low-cost and efficient motion control system that can be used as a foundational model for applications such as prosthetics, automation, and robotics education, where complex and expensive systems limit accessibility. The design emphasizes simplicity in both hardware and software while maintaining accurate movement control. A mechanical frame was developed to support the motor assembly and provide stability during operation, allowing the system to simulate lifting and supporting actions similar to a basic robotic leg.

The methodology involved interfacing an Arduino microcontroller with a stepper motor and a suitable motor driver to enable controlled angular displacement, speed regulation, and repeatable motion patterns.

Control algorithms were implemented using the Arduino IDE to manage step sequencing and timing. Experimental testing was conducted under different operating conditions, and results showed that the prototype could lift and support a load of up to 250 g without loss of stability or accuracy.

The system exhibited smooth motion, consistent performance, and reliable load handling. This project confirms that stepper motor-based control combined with microcontrollers is an effective and economical approach for simulating robotic leg movement, making the design suitable for further development in educational platforms, prosthetic research, and scalable robotic applications.



IoT-Based Energy Monitoring System

Team Members

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- Francis Lalu Maliyackel
- Gokul Kishan KD

Guide/Mentor

Ms.Preethi T.I, Assistant Professor

The project titled “IoT-Based Energy Monitoring System” was developed to address the growing demand for efficient, real-time monitoring and management of electrical energy consumption. With increasing electricity costs and rising energy demand, conventional energy meters that provide only monthly readings are inadequate for identifying power wastage, inefficient appliances, or abnormal usage patterns. This project introduces an IoT-enabled monitoring solution that allows continuous tracking of voltage, current, and power consumption in real time. By integrating sensing hardware with cloud-based visualization, the system enables users to analyze usage trends, identify high-energy-consuming devices, and take corrective action to optimize load distribution. The approach supports informed decision-making and promotes sustainable energy usage in residential, commercial, and small industrial environments.

The system uses current and voltage sensors, specifically the ACS712 current sensor and a voltage sensing module, interfaced with an ESP32 microcontroller equipped with built-in Wi-Fi. The ESP32 processes sensor data and transmits real-time energy metrics to the Blynk cloud platform, where users can monitor consumption through a mobile or web dashboard. Firmware development and system integration were carried out using the Arduino IDE. Testing demonstrated accurate real-time monitoring and effective detection of abnormal consumption patterns, such as sudden power spikes caused by faulty or overloaded devices. Alert notifications enabled users to respond quickly and reduce unnecessary energy loss. Although the prototype was evaluated on a limited scale and measurement accuracy depends on sensor calibration, the system proved reliable and practical. The design is scalable and can be extended with machine learning algorithms for predictive analysis, historical data analytics, and deployment in larger residential, office, or industrial power systems.

Carbon Monoxide and Gas Leak Detector using GSM Module

Team Members

- Jithin Joy
- Hari Shyam R
- Suryadev K S

Guide/Mentor

Ms. Anjana Somasundaran, Assistant Professor

The project titled “Carbon Monoxide and Gas Leak Detector using GSM Module” was developed to enhance safety in domestic and industrial environments by providing early detection and instant notification of hazardous gas leaks. Leakage of gases such as carbon monoxide and LPG poses serious health and fire risks, and delayed awareness can lead to severe accidents. Conventional gas detectors are often limited to local alarms, which are ineffective if occupants are away from the site. This project addresses that limitation by integrating a GSM communication module with a microcontroller-based detection system, enabling real-time alerts through SMS and phone calls. The objective is to ensure immediate user awareness regardless of location, thereby reducing response time and potential damage

The system continuously monitors the surrounding environment using an MQ-2 gas sensor capable of detecting carbon monoxide and other combustible gases. Sensor data is processed by an Arduino Uno microcontroller, which evaluates gas concentration levels against predefined safety thresholds. When leakage is detected, the system activates a buzzer and displays warning messages on an LCD to alert nearby individuals. Simultaneously, a GSM module (SIM800L) sends SMS notifications and initiates call alerts to predefined mobile numbers, ensuring remote warning. The entire system is programmed and tested using the Arduino IDE, emphasizing simplicity, low cost, and ease of deployment.

Testing demonstrated reliable detection of carbon monoxide and LPG leaks, with alert responses generated within seconds. The combination of local audio-visual alerts and remote GSM-based notifications proved effective in improving overall safety and reliability. The system is suitable for homes, kitchens, gas storage areas, laboratories, and industrial facilities. While the current design operates as a standalone safety device, future enhancements could include IoT-based cloud monitoring, mobile app integration, automatic shutoff of gas supply, and exhaust fan control, further strengthening preventive safety measures.

Electricity Theft and Power Loss Alert System Using Arduino

Team Members

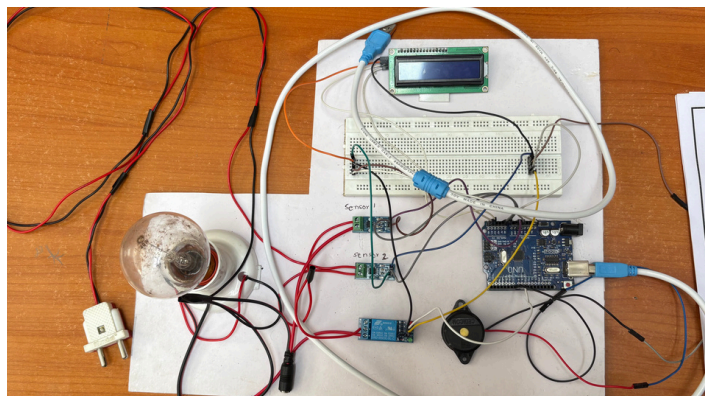
- Jesty Baiju
- Alwin Lawrance
- Godwin Francis

Guide/Mentor

Ms. Anjana Somasundaran, Assistant Professor

The project titled “Electricity Theft and Power Loss Alert System Using Arduino” was developed to detect electricity theft and sudden power loss in a simple and cost-effective manner. Electricity theft and unexpected outages cause financial loss, energy wastage, and safety risks, especially in domestic and small-scale distribution systems. This project uses an Arduino Uno with ACS712 current sensors to continuously monitor power flow and identify abnormal conditions in real time.

Two ACS712 current sensors are used to measure supply and load currents, which are compared by the Arduino. Any mismatch indicates theft or power loss and triggers immediate alerts through a buzzer and LCD display. A relay module disconnects the load automatically during abnormal conditions to prevent misuse and improve safety. Testing confirmed reliable detection of theft and power loss, along with effective alerting and load isolation. The system provides an affordable and practical solution, with future scope for IoT or GSM-based remote monitoring and expansion to larger power networks.



E-Braille Reader using Arduino (Model)

Team Members

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- Adhithya V S
- Saniya Soby

Guide/Mentor

- Dr. Sudha Balagopalan, Professor

The project titled “E-Braille Reader using Arduino (Model)” was developed as a low-cost and modular assistive technology prototype aimed at supporting visually impaired learners. Conventional Braille systems are often limited in terms of storage, flexibility, and scalability, which restricts their use in modern educational environments. This project overcomes those limitations by combining an Arduino UNO microcontroller with external driver circuits and an SD card module, allowing Braille patterns to be stored, retrieved, and displayed dynamically. The system is designed to demonstrate how digital storage and microcontroller control can enhance traditional Braille learning tools while keeping the overall design simple and affordable.

The system uses MOSFET-based driver circuits consisting of six NMOS transistors to control LEDs or solenoids that represent Braille dot patterns. The Arduino UNO generates control signals based on data retrieved from the SD card, which is interfaced using the SPI protocol. Push buttons are provided to navigate between different stored Braille patterns, enabling user interaction without reprogramming the controller. Protective components such as current-limiting resistors for LEDs and fly-back

diodes for solenoids were incorporated to ensure safe operation. The design was initially simulated using Tinkercad before hardware implementation, reducing errors and improving reliability.

Testing verified that the system correctly displayed Braille patterns using LEDs or solenoids based on data stored on the SD card. Pattern navigation through push buttons worked smoothly, and the modular wiring made the system easy to modify and debug. The project demonstrates a functional and scalable approach to Braille representation using microcontroller-based control. While the Arduino UNO's limited I/O pins restrict expansion, the design provides clear scope for future improvements such as larger driver arrays, wireless communication, and battery-powered standalone operation, making it a strong foundation for assistive and educational applications.



Color Sorting Machine

Team Members

- Alaina K L
- Amrutha Ramachandran
- Anjana Ajay K

Guide/Mentor

- Dr. Ravishankar A N, Professor

The project titled “Color Sorting Machine” was developed to automate the sorting of objects based on color using an Arduino Nano microcontroller. Manual sorting in industries such as packaging, recycling, agriculture, and food processing is often slow, inconsistent, and labor-intensive. This project demonstrates how low-cost components can be combined to create an efficient and reliable automation system capable of identifying and separating objects by color. The design focuses on simplicity, affordability, and ease of implementation, making it suitable for small-scale industrial use as well as educational demonstrations.

The system operates by moving objects to a sensing station where a TCS3200 color sensor detects RGB values. The Arduino Nano processes this data and compares it with predefined threshold values to determine the object's color.

Based on the detected color, servo motors direct the object into the appropriate collection bin. The mechanical structure was built using lightweight plastic corrugated sheets, and jumper wires and a servo controller were used for wiring and calibration. Testing showed that the machine successfully sorted objects with good accuracy, though performance was slightly affected by lighting conditions and surface reflections. Despite these limitations, the project validated the effectiveness of a low-cost color sorting system. Future enhancements could include improved lighting control, conveyor belt integration, and advanced sensors to increase accuracy and scalability for wider applications.



HANDWRITING DETECTION USING CONVOLUTIONAL NEURAL NETWORKS

By

NAVNEETH C MANOJ

Guide/Mentor

Dr.Nitha C Velayudhan



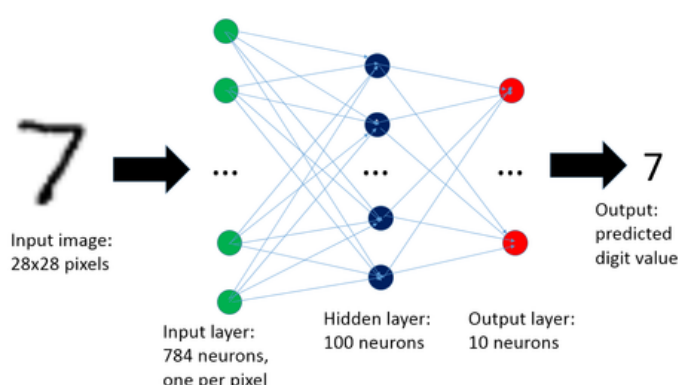
Handwriting detection is a branch of computer vision that helps interpret handwritten text from scanned documents, digital tablets, or images. With digitization becoming more important, this project focuses on building a system using convolutional neural networks (CNNs) to recognize handwritten characters accurately.

Earlier methods used feature extraction and classifiers like k-NN and SVM, but they struggled with complex handwriting. Modern deep learning approaches, especially CNNs and transfer learning models such as VGGNet and ResNet, perform much better. Datasets like MNIST, EMNIST, and IAM are commonly used to train and test these systems.

The system works by preprocessing handwriting samples to remove noise and normalize images, segmenting characters, extracting features through CNN layers, and classifying them with a softmax output.

Tools like Python, OpenCV, and TensorFlow/Keras are used, with optional GUI support for user interaction.

Future improvements include multilingual recognition, mobile applications, signature verification, and digitization of documents. Overall, CNNs provide a reliable and scalable solution for handwriting recognition, bridging analog and digital data while enabling practical applications in accessibility and archiving.



Water Quality Prediction System

By

Neetha John

Guide/Mentor

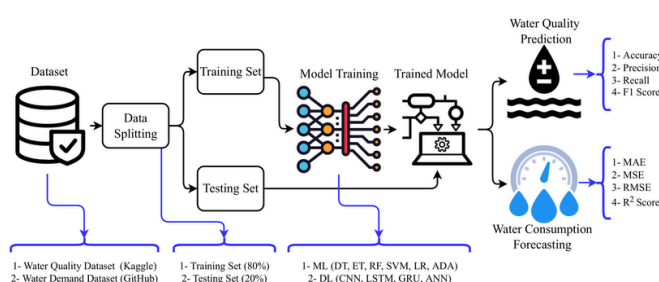
Dr.Nitha C Velayudhan



Water quality is crucial for health, agriculture, and the environment, but increasing pollution from industries, urbanization, and climate change has made monitoring more important than ever. Traditional laboratory testing methods, while accurate, are slow and costly, limiting their effectiveness in real-time scenarios. This project introduces a machine learning-based system that predicts water quality using parameters such as pH, turbidity, dissolved oxygen, temperature, nitrates, and conductivity. Models like Random Forest and LSTM are applied to classify water into categories ranging from Excellent to Very Poor, with results showing high accuracy. A visualization dashboard further supports real-time monitoring, enabling quick responses to pollution events.

The system reduces manual effort, improves efficiency, and supports sustainable water management by providing automated predictions and visual insights.

It benefits environmental agencies, municipalities, and industries by ensuring timely interventions and compliance with regulations. Future improvements include integrating IoT sensors for real-time data collection, deploying the system on cloud platforms for scalability, and using advanced deep learning models to cover more pollutants. Overall, the project demonstrates how machine learning can provide a reliable, scalable, and eco-friendly solution for water quality monitoring and management.



SHORT AND MINIMIZED VERSION

By

Jomel J Jacob

Guide/Mentor

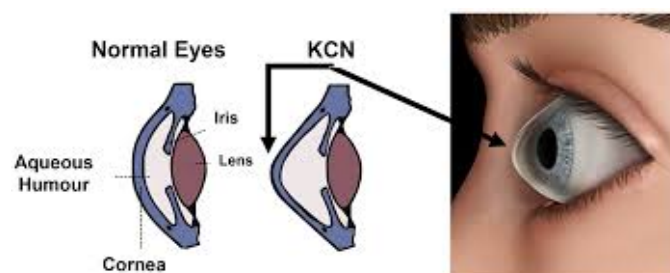
Dr.Nitha C Velayudhan



Keratoconus is a progressive eye disease where the cornea thins and bulges, while glaucoma damages the optic nerve due to high intraocular pressure. Both can cause irreversible blindness if not detected early. Traditional diagnostic methods are costly, time-consuming, and require expert interpretation, making them less accessible in rural or under-resourced areas.

This project develops an automated detection system using machine learning and deep learning to identify keratoconus from corneal data and glaucoma from retinal images. Models such as Random Forest and CNNs are applied, integrated into a web-based platform built with Flask, allowing users to upload medical data for instant analysis. The system achieved over 90% accuracy, reducing manual effort, cost, and diagnostic delays.

The solution provides fast, reliable, and scalable screening, improving accessibility and supporting early intervention. Future enhancements include larger datasets, mobile applications, and explainable AI for better trust and transparency. In conclusion, the project demonstrates how AI can revolutionize ophthalmic diagnostics by offering affordable and accurate detection of keratoconus and glaucoma.



Job Application Tracker

By

Akshaya Jayan

Guide/Mentor

Dr.Nitha C Velayudhan



The Job Application Tracker is a centralized system designed to simplify the job search process by allowing users to record, track, and manage applications efficiently. It stores essential details such as company information, job roles, application dates, statuses, and interview schedules, ensuring that no deadlines or opportunities are overlooked. With features like reminders, document storage, and analytics, the tracker improves organization, time management, and clarity during the recruitment journey. Its architecture combines a React-based frontend, Node.js/Django backend, and secure cloud storage, supported by JWT authentication for user safety.

Beyond its current capabilities, the project envisions several enhancements to make the tool more powerful and accessible.

Future scope includes mobile applications for cross-platform use, browser extensions for auto-capturing job details, advanced analytics dashboards, AI-powered job recommendations, and calendar integration for smart reminders. Additional features like document versioning, collaboration with mentors, gamification, and multi-language support further expand its usability. In conclusion, the Job Application Tracker provides a practical, user-friendly solution for job seekers, empowering them to stay organized and proactive in their career growth while offering strong potential for future innovation.

Job / Role	City / Country	Resume / Co...	Location	Salary	Interview Stage
Designer	Sydney, AUS	Resume 1	Hybrid	80,000 USD	Applied
Designer	Perth, AUS	Resume 2	Remote	85,000 USD	HR screening
Designer	Wellington, NZ	Resume 3	On-site	72,000 USD	1st interview
Designer	Auckland, NZ	Resume 4	Hybrid	90,000 USD	Final interview
Designer	Sydney, AUS	Resume 5	On-site	82,000 USD	2nd interview

PREDICTIVE MAINTENANCE SYSTEM

By

Steev Sebastian

Guide/Mentor

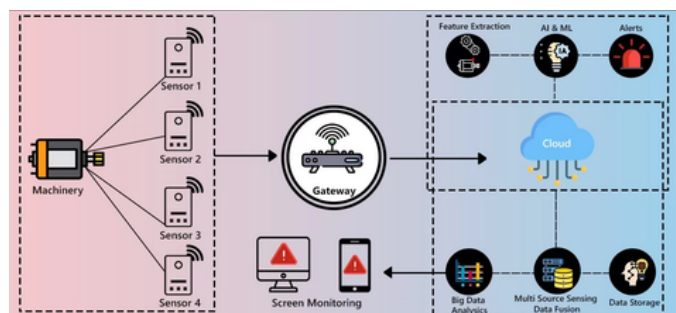
Dr.Nitha C Velayudhan



This project focuses on developing a predictive maintenance simulation entirely in MATLAB using machine learning. By generating synthetic sensor data and applying a Random Forest model, the system predicts equipment failures with remarkable accuracy (99.1%) and precision (91.2%). The simulation includes modules for data preprocessing, feature engineering, real-time prediction, and performance evaluation, all without requiring physical hardware. Key findings highlight power consumption and thermal stress as the most critical indicators of failure, while the cost-benefit analysis shows significant savings and a short ROI period of 3–4 months.

The project demonstrates how predictive maintenance can reduce downtime and improve industrial reliability.

With its modular design and real-time capability, it provides a strong foundation for future enhancements such as deep learning integration, multi-machine simulations, and real-world hardware deployment.



Fake News Detection System

By

Aldo Paul K P

Guide/Mentor

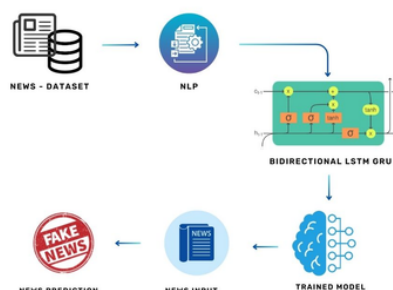
Dr.Nitha C Velayudhan



This project addresses the growing challenge of misinformation in digital media by building a machine learning-based fake news detection system. Using Natural Language Processing techniques like tokenization, stop-word removal, and TF-IDF vectorization, the system trains models such as Logistic Regression, Naïve Bayes, and Random Forest to classify news articles as real or fake. Among these, Logistic Regression achieved the best performance with 94% accuracy, stable precision, and recall.

The project highlights the effectiveness of text analytics in combating misinformation and promoting digital literacy. Future scope includes integrating deep learning models like LSTM or BERT, extending detection to regional languages, adding credibility analysis of sources, and enabling real-time classification through browser extensions or APIs.

In conclusion, the Fake News Detection project demonstrates how machine learning and NLP can be effectively applied to address one of the most pressing issues in the digital era. By achieving high accuracy with relatively simple models and preprocessing techniques, it proves that automated systems can play a vital role in identifying misinformation and supporting media integrity. With further advancements such as deep learning integration, multilingual capabilities, and real-time deployment, this system has the potential to evolve into a powerful tool for journalists, social platforms, and the public, ultimately contributing to a more informed and trustworthy digital environment.



FACE RECOGNITION-BASED CHEATING DETECTION SYSTEM FOR ONLINE EXAMS

By

Harikrishnan Sasikumar

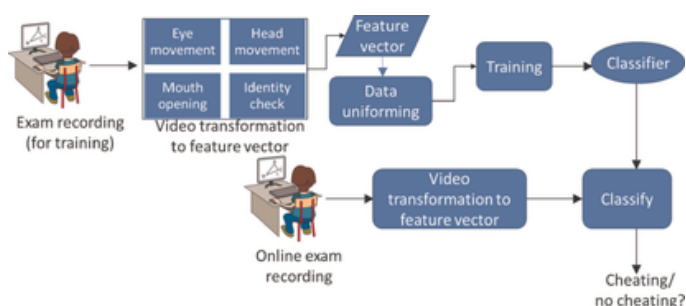
Guide/Mentor

Dr.Nitha C Velayudhan



The project introduces a face recognition-based cheating detection system designed to uphold academic integrity in online examinations. Using a simple front-facing webcam, the system continuously monitors facial orientation and presence to detect suspicious behaviors such as turning away from the screen or disappearing from view. Core techniques include real-time face detection, head pose estimation with OpenCV's SolvePnP, and continuous presence monitoring. When thresholds are violated, the system triggers automated alerts containing candidate identification details and timestamps, sent via secure channels like email, SMS, or dashboards. Implemented in Python with libraries such as OpenCV, Dlib, and MediaPipe, the system is lightweight, scalable, and easy to deploy on standard devices without specialized hardware.

The project is strong because it offers real-time monitoring, fast processing, and easy setup, making it practical for institutions. Its main limitations are that it cannot detect cheating through speech or external devices, may give false alerts in poor lighting, and depends on a stable internet and camera feed. Future improvements could add gaze tracking, emotion detection, secure browsers, and smarter classifiers to reduce errors. Overall, the system is a simple and effective way to ensure fairness in online exams, with potential to grow into more advanced proctoring solutions.



SIGN LANGUAGE DETECTION

By

Nivedya T S

Guide/Mentor

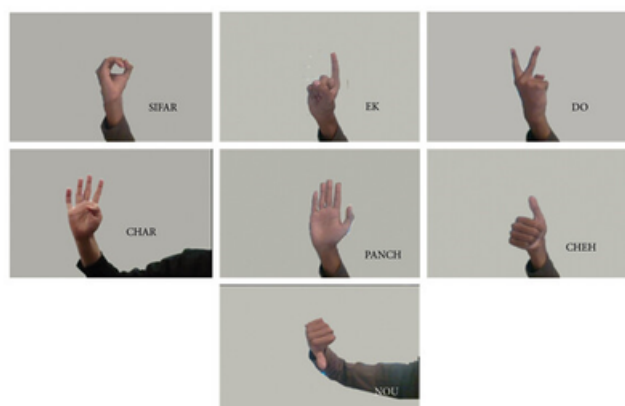
Dr.Nitha C Velayudhan



The Sign Language Recognition System is designed to bridge communication barriers between hearing- and speech-impaired individuals and the general population. Using computer vision and deep learning models such as CNNs and LSTMs, the system can recognize both static and dynamic hand gestures in real time and translate them into text or speech. Its modular architecture—covering gesture acquisition, preprocessing, feature extraction, classification, and output generation—ensures efficient and accurate performance. With training accuracy of about 95% and validation accuracy near 92%, the project demonstrates strong results in recognizing commonly used gestures while providing a non-intrusive, camera-based solution that avoids the limitations of sensor-based systems.

Beyond its technical achievements, the project carries significant social value by promoting inclusivity, independence, and accessibility for differently-abled individuals.

While current limitations include restricted vocabulary, sensitivity to lighting and background variations, and dependency on camera quality, the system provides a solid foundation for future enhancements. Expanding the gesture set, supporting multiple sign languages, and improving robustness in diverse environments can make it a comprehensive communication tool. Overall, the project highlights how technology can empower the hearing- and speech-impaired community by enabling smoother, real-time communication and advancing assistive technologies.



DEEPPFAKE DETECTION SYSTEM

By

Rochelle Saji Achandil

Guide/Mentor

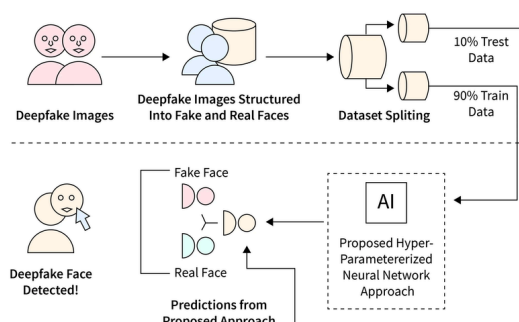
Dr.Nitha C Velayudhan



The project focuses on developing a Deepfake Detection System that leverages advanced deep learning models such as CNN, LSTM, and Vision Transformers to identify manipulated images and videos. By extracting spatial features like texture inconsistencies and temporal cues such as unnatural motion patterns, the system can differentiate between authentic and synthetic media. Benchmark datasets like FaceForensics++ and DFDC are used to train and evaluate the model, ensuring robustness and accuracy across diverse manipulation techniques.

To enhance usability, the system is deployed as a Chrome plugin, allowing real-time verification of online media.

This integration makes the technology accessible to everyday users, journalists, and investigators, thereby promoting digital trust and combating misinformation. The project not only contributes to media forensics and cybersecurity but also emphasizes ethical AI usage, offering a scalable solution to safeguard authenticity in the digital ecosystem.



AirSense AI

By

Lakshmi A

Guide/Mentor

Dr.Nitha C Velayudhan



The AirSense AI project is designed to provide real-time monitoring and classification of airborne synthetic drugs using advanced sensor fusion and machine learning techniques. By integrating the PM5003 particulate matter sensor with the BME688 gas sensor on a Raspberry Pi 4 platform, the system collects data such as PM levels, VOC index, temperature, humidity, pressure, and gas resistance. These inputs are processed through a trained Random Forest Classifier, enabling accurate identification of substances like synthetic drugs, talcum powder, and baking soda. The compact prototype, supported by Python scripts, delivers instant classifications and alerts, making it a practical solution for forensic labs, airports, and smart homes.

The project highlights the potential of combining edge computing with AI-driven sensor systems to enhance safety and environmental monitoring.

Its advantages include real-time detection, portability, cost-effectiveness, and scalability, while limitations such as sensor range, environmental sensitivity, and dependency on pre-trained models suggest areas for improvement. Future developments could involve integrating more advanced sensors, adopting deep learning models, and enabling cloud-based analytics for broader applications. Overall, AirSense AI demonstrates how accessible hardware and open-source tools can be leveraged to build impactful solutions for security and air quality management.





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