IARE
INSTITUTE OF
AERONAUTICAL ENGINEERING
EDUCATION FOR LIBERATION

HIGH IMPACT PRACTICES (HIPS)

CORNERSTONE PROJECTS (CoPs)

INFORMATION PACKET

2025 - 2026

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EDUCATION FOR LIBERATION
INSTITUTE OF AERONAUTICAL ENGINEERING

25 YEARS 2000 2025

I appreciate your interest in the Cornerstone Project (CoP), Department of Electronics and Communication Engineering at the Institute of Aeronautical Engineering!

A **cornerstone project (CoP)** is typically introduced during the early or middle stages of an academic program at the Institute of Aeronautical Engineering. It focuses on helping students build foundational skills and understand how to apply basic concepts to real-world scenarios. These projects are usually smaller in scope, moderately complex, and designed to strengthen practical understanding of core subjects.

These projects encourage students to connect theoretical learning to data-centric applications, such as developing the data learning model, performing simple data analysis, or creating prototype engineering solutions. Emphasis is placed on learning by doing, helping students build confidence in applying methods like data preprocessing, statistical analysis, basic modeling, and reporting results. By working on these projects, students begin to understand how engineering and data science principles apply in real-world scenarios. Ultimately, cornerstone projects act as the foundation of experiential learning at IARE, transitioning students from passive learners to active problem-solvers, equipped with both technical skills and professional behaviors necessary for the challenges of advanced engineering education.

Cornerstone Project (CoP) teams are:

- Collaborative Project – This is an excellent opportunity for students who are committed to working towards social developments and emerging needs.
- Project Activity – The project coordinator listed current working areas for offering cornerstone projects with a team size of at least two students. The coordinator allotted mentors based on the work area and facilitated exclusive project laboratories for selected cornerstone project (CoP)students. This cornerstone project (CoP)bridges the gap between academic learning and real-world social applications. It helps enhance the professional development
- Short-term - Each undergraduate student may participate in a project for an assigned period.

The primary goal of cornerstone projects in Electronics and Communication Engineering is to provide a balanced platform of technical complexity, innovation, and interdisciplinary learning that allows students to gain hands-on experience across core ECE domains.

- **Simulate real-world engineering environments** – Familiarize students with the lifecycle of electronics and communication systems design, testing, and deployment, aligned with industry practices and standards.
- **Encourage cross-domain application of ECE concepts** – Promote the integration of electronics, signal processing, embedded systems, and communication principles into sectors like healthcare, transportation, automation, energy, and defense.
- **Promote responsible engineering and sustainability** – Instil a strong foundation in ethical engineering, safety standards, and environmentally conscious design throughout project execution.
- **Support data-driven and intelligent systems** – Encourage the use of AI, IoT, and real-time data processing techniques to design smart systems that enhance automation, monitoring, and decision-making.
- **Foster hands-on system-level project experience** – Engage students in projects involving the complete design flow: from circuit design, simulation, prototyping, to final validation using tools like MATLAB, LabVIEW, HDL, or Arduino/Raspberry Pi.
- **Build strong engineering portfolios** – Help students develop industry-ready portfolios showcasing innovation, practical skills in hardware/software co-design, and impactful solutions to engineering challenges.
- **Bridge theoretical learning with practical hardware/software integration** – Translate academic concepts into real-world applications through design, implementation, and testing of communication protocols, embedded systems, and VLSI circuits.
- **Incorporate emerging ECE technologies** – Encourage exploration of advanced topics such as 5G/6G, edge computing, software-defined radio, wearable electronics, and autonomous systems to remain aligned with future industry trends.

Cornerstone Projects (CoPs) focuses on the challenges presented by the Sustainable Development Goals (SDGs)

Sustainability Development Goals (SDGs) for the Dept. of ECE, IARE	
SDG 4	Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all
SDG 8	Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all
SDG 9	Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation
SDG 12	Ensure sustainable consumption and production patterns

Themes of Cornerstone Projects (CoPs) for the Electronics and Communication Engineering:

The following project domains are recommended for cornerstone projects (CoPs), and the students should frame the problem statements from any one of the following themes:

1. Design and Fabrication of a Multi-Output Regulated DC Power Supply System with Integrated over voltage, over current, and Short Circuit Protection for Laboratory and Embedded Applications **(SDG #9, SDG #12)**

2. Development of a Low-Cost, Energy-Efficient Automatic Street Lighting System Based on Light Dependent Resistors (LDR) and Transistor-Based Switching Circuits **(SDG #9, SDG #12)**

3. Design, Simulation, and Analysis of a Low-Distortion Audio Frequency Amplifier Using a Combination of BJT and MOSFET Stages for Enhanced Gain and Frequency Response **(SDG #9)**

4. Development of a Low-Power Infrared Sensor-Based Burglar Alarm Circuit Using Op-Amps and Relays for Real-Time Intrusion Detection in Security Applications **(SDG #8, SDG #9)**

5. Design and Construction of a Handheld Metal Detector System Using Inductive Coil Sensing and Signal Amplification Techniques for Security and Industrial Applications **(SDG #8, SDG #9)**

6. Design and Testing of an AC Light Dimmer Circuit Using TRIAC-DIAC Triggering and Phase Control Technique for Domestic and Industrial Lighting Systems **(SDG #9, SDG #12)**

7. Development of a Touch-Activated Buzzer System Using Capacitive Sensing and 555 Timer IC for Human Interface and Alerting Applications **(SDG #9)**

In order to participate in cornerstone projects, you must formally apply and be accepted by the project coordinator. To proceed, please mail to the project coordinator, Dr. P Munaswamy (p.munaswamy@iare.ac.in), Head of Electronics and Communication Engineering (ECE). This will bring up all available open positions tagged as cornerstone projects.

Please note that participation by the cornerstone project (CoP)team requires registration for the accompanying project work from any of the specified domains. More information will be provided to all selected cornerstone project (CoP)applicants who have been offered a position.

If you have any questions about a particular team, please contact the faculty mentor.
We encourage you to contemplate this fascinating new opportunity. We look forward to receiving your application submission!

Design and Fabrication of a Multi-Output Regulated DC Power Supply System with Integrated over voltage, over current, and Short Circuit Protection for Laboratory and Embedded Applications.

Dr.P. Munaswamy, Professor & Head, ECE (Electronics & Communication Engineering) – Faculty Mentor

GOALS

To design a stable, multi-output DC power supply system that can provide different regulated voltage levels (e.g., +5V, +12V, -12V, 3.3V) required for diverse embedded and laboratory applications. To integrate robust protection features such as overvoltage, overcurrent, and short-circuit protection using hardware fault detection circuits and sensor feedback loops to ensure device and user safety. Enabling real-time monitoring and logging of voltage and current across all output channels using microcontrollers and embedded sensors for diagnostics and fault analysis.To enhance energy efficiency and load handling through proper thermal management, optimized layout, and selection of high-efficiency regulators (linear or switching). Implementing a user-friendly interface (LED indicators or LCD display) to show real-time voltage, current levels, and fault warnings for each output channel. Providing a modular and scalable system design that can be customized for academic laboratories, embedded hardware development, and testing environments.

To validate the system performance through simulation and practical testing across various load conditions and compare it with industry standards (e.g., ripple, regulation, response time). Promote safe, sustainable, and low-cost hardware design practices aligned with SDG 9 (Industry, Innovation and Infrastructure).

METHODS & TECHNOLOGIES

This project involves designing and simulating a multi-output DC power supply using linear and switching regulators, integrating protection circuits for overvoltage, overcurrent, and short circuits, and incorporating microcontroller-based monitoring with sensor feedback and user-friendly display interfaces.

- Design and implement multi-output regulated power circuits using linear and switching regulators for +5V, +12V, -12V, and 3.3V outputs.
- Develop integrated protection mechanisms for overvoltage, overcurrent, and short circuit conditions using Zener diodes, fuses, and current-limiting circuits.
- Utilize current and voltage sensors such as ACS712 or INA219 for accurate measurement and feedback control.
- Provide visual output indicators and user interface, including LED signals or LCD display for live system status and fault notifications.
- Simulate, test, and fabricate the circuit using tools like Proteus, LTspice, and KiCad for reliable performance and PCB integration.

DESIGN, & TECHNICAL ISSUES

The main design and technical challenges involve maintaining voltage stability across multiple outputs, ensuring accurate and fast fault detection, managing heat dissipation, and designing a compact yet safe circuit layout suitable for embedded and laboratory applications.

- Ensuring consistent and ripple-free output across multiple voltage levels under varying load conditions.Designing fast-acting circuits for overvoltage, overcurrent, and short-circuit conditions without false triggering.

- Managing heat dissipation in linear regulators and power components to avoid overheating or damage.Achieving precise readings from voltage and current sensors despite electrical noise or component tolerances.

- Routing high-current paths safely and minimizing interference with analog signal lines in a space-constrained layout.Ensuring microcontroller-based systems can process and respond to faults without delay or software lag.

- Choosing suitable components that balance cost, efficiency, availability, and performance for student lab use.

- Providing proper insulation, grounding, and fuses to ensure safe handling during testing and use.

MAJORS & AREAS OF INTEREST

This project primarily lies at the intersection of power electronics, embedded systems, and electronic circuit design, with strong relevance to instrumentation, control, and safety engineering, making it ideal for applications in educational labs and embedded hardware development environments.

- Core focus on designing voltage regulation circuits and power conversion systems.
- Use of microcontrollers for real-time monitoring, protection control, and data processing.
- Development of analog and digital circuits including regulators, sensors, and protection modules.
- Real-time measurement and control of electrical parameters like voltage and current.
- Application of current and voltage sensors for feedback and system automation.
- Writing embedded code for sensing, display, decision-making, and fault handling.
- Managing heat dissipation and ensuring long-term reliability of power components.
- Layout and prototyping of safe, compact, and efficient printed circuit boards.
- Implementation of overcurrent, overvoltage, and short-circuit protection aligned with safety norms.
- Creation of multi-use, protected power supplies ideal for student projects and testing environments

MENTOR CONTACT INFORMATION

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Development of a Low-Cost, Energy-Efficient Automatic Street Lighting System Based on Light Dependent Resistors (LDR) and Transistor-Based Switching Circuits.

Dr.P. Munaswamy, Professor & Head, ECE (Electronics & Communication Engineering) – Faculty Mentor

GOALS

To design an automatic lighting system that turns street lights ON during darkness and OFF during daylight using ambient light sensing. Reduce energy consumption by eliminating unnecessary operation of street lights during daytime. Build a cost-effective and efficient solution using minimal components like LDRs, transistors, and relays without the need for microcontrollers.

Eliminate manual switching and promote automation in public lighting infrastructure. Provide a reliable system that functions accurately in varying environmental light conditions. Use solid-state switching techniques to improve response time and reduce mechanical wear and tear.

To improve road safety and visibility by ensuring timely activation of lighting based on real-world lighting conditions. Enable easy deployment in rural and urban areas with minimal maintenance requirements. Explore integration possibilities with solar panels or battery backups for off-grid energy solutions. To support sustainable urban development goals by promoting smart and energy-aware public infrastructure.

METHODS & TECHNOLOGIES

The project uses LDR-based light sensing combined with transistor switching circuits to automate street lighting, ensuring low-cost implementation, energy efficiency, and reliable performance without the need for complex microcontroller systems.

- Light Dependent Resistor (LDR) is used as a light sensor to detect ambient light levels and act as the system's input.
- Voltage divider circuits convert the light-dependent resistance of the LDR into a measurable voltage that changes with light intensity.
- NPN or PNP bipolar junction transistors (BJTs) function as electronic switches, turning the lighting circuit ON or OFF based on LDR input.
- Relay modules or power transistors are used to handle higher loads such as street lamps or LED arrays.
- Zener diodes provide voltage regulation or protection in the control circuit if needed.
- LEDs or compact fluorescent lights (CFLs) serve as the street lighting output, chosen for energy efficiency and long life.
- Power supply units deliver regulated DC voltage to the control circuit, typically via an adapter or battery bank.
- Hysteresis control can be added to prevent flickering of lights around threshold light levels using resistive feedback.
- Simulation software like Proteus or Multisim is used to model and verify circuit performance before physical implementation.
- Breadboard prototyping and soldered PCB assembly allow for rapid testing and reliable final deployment.

RESEARCH, DESIGN, & TECHNICAL ISSUES

The design of the system faces challenges such as environmental sensitivity of the LDR, power losses in switching components, and long-term stability issues, requiring careful calibration, proper component selection, and reliable circuit layout to ensure consistent and efficient operation in outdoor lighting conditions.

- Inconsistent LDR sensitivity under varying weather conditions such as fog, rain, or dust may affect switching accuracy.
- Ambient light fluctuation near threshold levels can cause flickering or unstable switching of lights if hysteresis is not implemented.
- Temperature effects on component behavior, especially for resistors and transistors, can shift operating points and reduce system reliability.
- Proper calibration of the voltage divider involving the LDR is essential to determine the exact light intensity for switching.
- Power losses in transistor switches must be minimized to maintain overall system energy efficiency.
- Designing for high-load compatibility, such as controlling multiple street lamps, requires correct selection of relays or power transistors.
- Ensuring electrical isolation and safety between the low-voltage control circuit and high-power lighting outputs is crucial.
- PCB layout and component placement can affect circuit stability, especially in outdoor conditions with potential interference.
- Component aging and drift in LDRs and transistors can lead to long-term instability in the system's switching threshold.
- Scalability and adaptability of the system for different geographic regions or lighting intensities requires careful design planning.

MAJORS & AREAS OF INTEREST

This project falls under the domain of electronics and communication engineering, focusing on practical circuit-based automation.

- It emphasizes analog and digital circuit design principles, particularly using discrete components.
- The system showcases sensor-based automation through the use of LDRs for real-time light detection.
- Power electronics is a key area, involving switching mechanisms using transistors and relays.
- The design promotes the development of energy-efficient systems suitable for public lighting.
- It supports sustainable and renewable energy technologies by enabling compatibility with solar power.
- The project contributes to smart infrastructure by automating street lighting in urban and rural areas.
- It applies control system concepts using simple hardware logic without microcontrollers.
- Embedded system principles are explored through hardware prototyping and system integration.
- The overall approach encourages low-cost engineering solutions for large-scale public utility automation.

MENTOR CONTACT INFORMATION

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Design, Simulation, and Analysis of a Low-Distortion Audio Frequency Amplifier Using a Combination of BJT and MOSFET Stages for Enhanced Gain and Frequency esponse

Dr.P. Munaswamy, Professor & Head, ECE (Electronics & Communication Engineering) – Faculty Mentor

GOALS

The primary goal of this project is to design an audio amplifier circuit capable of delivering high gain while maintaining low distortion across the entire audible frequency range (20 Hz to 20 kHz). By combining Bipolar Junction Transistors (BJTs) and Metal-Oxide-Semiconductor Field-Effect Transistors (MOSFETs), the amplifier leverages the high gain of BJTs and the high input impedance and fast switching of MOSFETs to achieve an optimized performance for audio signals. The amplifier is intended to produce a clear, accurate, and faithful reproduction of input sound signals with minimal harmonic distortion.

Simulation and analysis form an essential part of this project to verify the theoretical design. Simulation tools such as LTspice, Multisim, or Proteus will be used to model the amplifier's behavior under various signal and load conditions. Key performance parameters such as voltage gain, frequency response, input/output impedance, and Total Harmonic Distortion (THD) will be evaluated. Special attention will be given to linearity and stability to ensure smooth amplification and consistent signal quality across the audio spectrum.

Another important goal is to build a robust and reliable amplifier that is thermally stable and capable of driving standard speaker loads like 4Ω or 8Ω without degradation in signal quality. Careful biasing, proper coupling and decoupling, and thermal considerations will be addressed in the design. This project also aims to create an educational prototype that demonstrates fundamental analog electronics principles in real-world audio applications, making it valuable for learning, experimentation, and potential integration into embedded sound systems.

METHODS & TECHNOLOGIES

This project uses a combination of BJT and MOSFET stages to design a high-performance audio amplifier, employing techniques like RC coupling, bias stabilization, and simulation-based analysis to achieve enhanced gain, wide frequency response, and low distortion suitable for clear and efficient audio signal amplification.

- BJTs (Bipolar Junction Transistors) in the input stage for better transconductance and low noise characteristics in signal amplification.
- Implement MOSFETs (Metal-Oxide-Semiconductor Field-Effect Transistors) in the output stage to achieve high input impedance and efficient power handling.
- Design the circuit in common-emitter (BJT) and common-source (MOSFET) configurations to maximize gain and response.
- Incorporate RC coupling between stages to block DC components while maintaining AC signal integrity.
- Apply biasing techniques such as voltage divider bias and source resistor feedback to stabilize the operating point and improve thermal stability.
- Perform circuit simulation using tools like LTspice, Multisim, or Proteus to verify voltage gain, bandwidth, and distortion levels before physical implementation.
- Use frequency response analysis (Bode plots) to evaluate amplifier performance over the 20 Hz–20 kHz range.
- Implement bypass capacitors and emitter/source degeneration techniques to reduce distortion and improve linearity.

- Design for low Total Harmonic Distortion (THD) by optimizing the load line and operating region of the transistors.
- Fabricate the circuit on a breadboard for initial testing, followed by PCB design using EasyEDA or KiCad for compact and stable implementation.

RESEARCH, DESIGN, & TECHNICAL ISSUES

The design and development of the amplifier involve challenges such as ensuring linearity, minimizing distortion, stabilizing biasing networks, and accurately matching BJT and MOSFET stages, all while maintaining consistent performance across the entire audio frequency range under real-world operating conditions.

- Matching the gain characteristics of BJT and MOSFET stages can be challenging and requires precise selection of operating points.
- Maintaining linearity across the entire audible frequency range (20 Hz to 20 kHz) without significant distortion is a critical design concern.
- Designing stable biasing networks to ensure thermal and voltage stability under varying input conditions is essential.
- Simultaneous optimization of gain, bandwidth, and distortion requires trade-offs that must be carefully balanced during simulation and testing.
- Coupling and bypass capacitor values significantly affect the amplifier’s low-frequency response and must be chosen carefully.
- The amplifier may experience phase shifts or frequency roll-off at high frequencies if layout or stage design is not optimized.
- Load matching between stages, especially between the MOSFET output and the speaker, is necessary to avoid power loss or signal degradation.

MAJORS & AREAS OF INTEREST

This project is closely related to areas such as analog electronics, amplifier and circuit design, audio signal processing, and semiconductor device applications, making it highly relevant to fields like audio engineering, communication systems, and consumer electronic device development.

- Analog electronics and amplifier design
- Electronic circuit simulation and analysis
- Semiconductor device modeling (BJT and MOSFET)
- Signal processing and distortion reduction
- Audio engineering and acoustic systems
- Power electronics and load matching techniques
- Embedded hardware prototyping and PCB design
- Control systems and feedback networks
- Communication systems and audio transmission
- Consumer electronics and audio device development

MENTOR CONTACT INFORMATION

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Development of a Low-Power Infrared Sensor-Based Burglar Alarm Circuit Using Op-Amps and Relays for Real-Time Intrusion Detection in Security Applications

Dr.V.Siva Nagaraju, Professor, ECE (Electronics & Communication Engineering) – Faculty Mentor

GOALS

The primary goal of this project is to develop a reliable and low-power burglar alarm system that uses infrared (IR) sensors to detect motion or presence of intruders in a designated area. The system aims to sense thermal radiation changes caused by human movement using passive infrared (PIR) sensors and then trigger an alert mechanism. This helps in creating a real-time intrusion detection solution suitable for homes, offices, or small-scale security setups.

To process the signal from the IR sensor, the project incorporates operational amplifiers (op-amps) for signal conditioning, amplification, and threshold detection. The system uses a comparator configuration to activate a relay when motion is detected, which in turn triggers an alarm such as a buzzer or light. By avoiding the use of microcontrollers, the project focuses on analog simplicity, low cost, and reduced power consumption, which are ideal for battery-operated or standby-mode devices.

Another goal is to ensure the system is sensitive enough to detect unauthorized movement while avoiding false alarms due to small disturbances or environmental noise. The design will focus on optimizing the range, angle of detection, and system responsiveness. Practical considerations such as compact PCB layout, efficient power usage, and reliable relay control will also be addressed to ensure smooth deployment in real-world security applications.

METHODS & TECHNOLOGIES

Cornerstone Project (CoP) team will focus on Interdisciplinary Tools for Social Good and Sustainable Analytics

- Use of Passive Infrared (PIR) sensors to detect motion based on changes in ambient infrared radiation.
- Conversion of PIR sensor's analog signal into a voltage waveform representing motion activity.
- Application of operational amplifiers (op-amps) in comparator mode to process the PIR sensor output.
- Setting of a reference voltage using a voltage divider to define the motion detection threshold.
- Activation of a relay driver circuit based on op-amp output to switch an alarm device.
- Integration of a relay to interface low-power control with high-power alert systems like buzzers or lights.
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RESEARCH, DESIGN, & TECHNICAL ISSUES

The project presents challenges such as accurately calibrating the PIR sensor and op-amp circuit, minimizing false triggers from environmental factors, managing low power consumption, and ensuring reliable relay operation, all while maintaining real-time response and stability for effective intrusion detection.

- Selecting a PIR sensor with appropriate sensitivity and range for accurate indoor motion detection.
- Minimizing false triggers caused by environmental factors such as sunlight, reflections, or sudden temperature changes.
- Calibrating the PIR sensor and op-amp threshold voltage to distinguish between actual motion and background noise.
- Designing a stable comparator circuit using operational amplifiers to ensure consistent switching behavior.
- Preventing rapid relay activation or chattering by implementing hysteresis or timing delay circuits.
- Managing power consumption to support long-term, low-power operation in battery-powered setups.
- Ensuring reliable relay performance and compatibility with alarm output devices like buzzers or lights.

MAJORS & AREAS OF INTEREST

This project aligns with key areas such as analog electronics, sensor interfacing, and control systems, making it relevant to fields like embedded systems, smart security, and low-power consumer electronics, while providing practical experience in real-time intrusion detection and hardware prototyping.

- This project is rooted in electronics and communication engineering, focusing on real-world circuit design.
- It explores analog electronics by utilizing operational amplifiers for signal processing and control.
- The use of infrared sensors highlights the importance of sensor interfacing in motion detection systems.
- Low-power design techniques are emphasized to support energy-efficient and battery-operated applications.
- Relay-based switching introduces control system fundamentals in practical hardware setups.
- It contributes to the development of real-time intrusion detection systems for security applications.
- The project offers insight into embedded system concepts using discrete components.
- It supports smart home automation by enabling compact and responsive security circuits.
- Hands-on experience with PCB design and prototyping is gained through circuit implementation.
- The system aligns with the growing demand for affordable, user-friendly consumer electronics in security.

MENTOR CONTACT INFORMATION

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Design and Construction of a Handheld Metal Detector System Using Inductive Coil Sensing and Signal Amplification Techniques for Security and Industrial Applications

Dr.V.Siva Nagaraju, Professor, ECE (Electronics & Communication Engineering) – Faculty Mentor

GOALS

The primary goal of this project is to design a functional and portable handheld metal detector capable of identifying the presence of metallic objects using inductive coil sensing. The system should effectively detect ferrous and non-ferrous metals by recognizing changes in magnetic fields when metal disrupts the electromagnetic pattern generated by the sensing coil. The emphasis is on making the system compact, affordable, and user-friendly for security personnel and industrial workers.

Another key objective is to develop an amplification and filtering circuit that can pick up the weak signal generated by the inductive coil when it interacts with metal. Operational amplifiers and signal conditioning components will be used to increase the sensitivity and accuracy of the system. By properly amplifying and shaping the signal, the detector can ensure reliable metal detection even for small objects or at varying depths, depending on the strength and tuning of the coil.

The system also aims to provide real-time indication of metal detection using audiovisual alerts such as LEDs or buzzers. This alert mechanism must be fast and responsive to support real-time scanning in security scenarios like airport checks, warehouse inspections, or construction zones. A low-power design is preferred to enable extended use with battery operation, making it suitable for handheld applications in both indoor and outdoor environments.

Lastly, the project seeks to create a robust prototype that demonstrates practical use of electromagnetic principles in sensing technology. Through careful coil design, circuit simulation, hardware integration, and enclosure development, the detector should function reliably in various real-world environments. The goal is not only to meet technical performance requirements but also to provide an educational platform for learning about inductive sensing, analog electronics, and signal processing in embedded hardware design.

METHODS & TECHNOLOGIES

This project utilizes an inductive coil to detect metal presence through electromagnetic field disturbances, with amplified and filtered signals processed by op-amps to activate real-time visual or audio alerts, forming a compact, low-power handheld metal detector suitable for security and industrial applications.

- Use of an inductive coil to generate an electromagnetic field for detecting metallic objects based on field disturbances.
- Design of the sensing coil with specific diameter, wire gauge, and number of turns to maximize sensitivity and detection range.
- Application of AC signals through the coil to create a varying magnetic field for metal interaction detection.
- Detection of changes in inductance or induced eddy currents when a metal object comes near the sensing area.
- Use of operational amplifiers for signal amplification to enhance weak signals generated from the coil.
- Implementation of bandpass or low-pass filters to remove unwanted noise and improve signal clarity.
- Inclusion of comparators or threshold detection circuits to activate an alert when metal is detected.
- Use of audio-visual indicators such as buzzers and LEDs to provide real-time feedback to the

user.

- Design of the circuit to operate on low-power battery supply for portable, handheld use.
- Testing and validation of the detector in different environmental conditions to ensure consistent performance.

RESEARCH, DESIGN, & TECHNICAL ISSUES

The project involves challenges such as optimizing the coil design for sensitivity, accurately amplifying and filtering weak signals, minimizing noise and false triggers, and ensuring reliable, low-power operation, all while maintaining portability and consistent performance across various metal types and environments.

- Selecting the optimal coil size, shape, and number of turns to balance detection range, sensitivity, and portability.
- Designing a reliable AC signal source to drive the coil with consistent frequency and amplitude.
- Accurately detecting small changes in inductance or eddy currents caused by nearby metallic objects.
- Amplifying very weak signals from the coil without introducing significant noise or distortion.
- Filtering the signal to eliminate environmental noise and electromagnetic interference.
- Preventing false triggering due to movement, vibration, or proximity to non-metallic materials.

MAJORS & AREAS OF INTEREST

This project relates to key areas such as analog electronics, inductive sensing, and signal amplification, making it relevant to fields like security systems, industrial inspection, and embedded hardware design, with a strong focus on developing low-power, portable, and practical electronic detection solutions.

- Electronics and Communication Engineering
- Electromagnetic field theory and inductive sensing
- Analog circuit design and signal amplification
- Sensor technology and embedded hardware integration
- Operational amplifier applications in detection systems
- Security and surveillance system design
- Industrial inspection and non-destructive testing
- Low-power portable electronic device development
- PCB design and electronic product prototyping
- Applied physics and instrumentation engineering
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MENTOR CONTACT INFORMATION

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Design and Testing of an AC Light Dimmer Circuit Using TRIAC-DIAC Triggering and Phase Control Technique for Domestic and Industrial Lighting Systems

Dr.V.Siva Nagaraju, Professor, ECE (Electronics & Communication Engineering) – Faculty Mentor

To design and test an AC light dimmer circuit that allows smooth and adjustable control of light intensity for both domestic and industrial applications. The system aims to use a TRIAC-DIAC pair in a phase control configuration to modulate the amount of power delivered to an incandescent or resistive lighting load by delaying the conduction angle within each AC cycle. This provides efficient dimming while minimizing energy loss and heat generation compared to traditional resistive methods.

Another objective is to implement a variable resistance or capacitor-based triggering circuit to control the firing angle of the TRIAC, thus varying the brightness level. The project also aims to provide a compact and cost-effective solution that avoids flickering and maintains consistent light output. Proper testing and calibration of the dimming range are essential to ensure the circuit performs reliably across different voltage and load conditions.

Finally, the project seeks to develop a practical understanding of AC power control techniques, semiconductor switching devices, and safe handling of mains power. It encourages hands-on learning of TRIAC-DIAC behavior, zero-crossing detection, and triggering methods, ultimately contributing to more efficient and user-friendly lighting control systems that can be scaled for automation or smart lighting integration.

METHODS & TECHNOLOGIES

This project uses TRIAC-DIAC triggering and phase-angle control techniques to adjust the conduction period of AC power, enabling smooth light dimming by varying the firing angle with a simple RC network, resulting in an efficient, safe, and user-controlled lighting solution for domestic and industrial use.

- Use of a TRIAC as the main AC switching device to control power delivered to the light load.
- Integration of a DIAC in series with the TRIAC gate to enable precise triggering once the breakover voltage is reached.
- Application of phase-angle control by adjusting the point in the AC cycle at which the TRIAC is triggered.
- Implementation of a variable resistor-capacitor (RC) network to control the charging time and thus the firing angle.
- Use of a potentiometer to allow manual adjustment of brightness by varying the delay in TRIAC triggering.
- Design of the circuit to operate on standard AC mains voltage with appropriate safety considerations.
- Simulation of the dimmer circuit using tools like LTspice or Proteus to analyze waveform behavior and dimming response.
- Use of snubber circuits (if necessary) to protect the TRIAC from voltage spikes and ensure reliable operation.
- Testing of the dimmer across various load types (e.g., incandescent lamps, resistive heaters) to confirm versatility.
- Implementation of isolation techniques and proper enclosure design to ensure safe handling and user operation.

RESEARCH, DESIGN, & TECHNICAL ISSUES

This project involves addressing challenges such as precise control of the TRIAC firing angle, minimizing flicker and noise, managing heat and electrical safety, and ensuring compatibility with various AC loads, all while maintaining reliable, efficient, and user-safe light dimming performance.

- Determining the correct values for the RC timing circuit to ensure accurate and adjustable firing angle control.
- Ensuring stable and noise-free triggering of the TRIAC to avoid flickering or inconsistent light output.
- Managing electromagnetic interference (EMI) generated due to rapid switching in AC lines.
- Addressing the heating effects on the TRIAC under continuous load operation and ensuring proper heat dissipation.
- Ensuring compatibility of the dimmer with different types of loads such as incandescent bulbs or resistive heaters.
- Protecting the circuit from voltage spikes and surges using snubber circuits or appropriate filtering techniques.
- Maintaining electrical safety during circuit design and testing, especially while handling high-voltage AC mains.
- Selecting a suitable DIAC that can reliably trigger the TRIAC at the desired voltage threshold.
- Avoiding false triggering due to sudden line voltage changes or load disturbances.
- Designing an enclosure and layout that ensures thermal safety, compactness, and user-friendly operation.

MAJORS & AREAS OF INTEREST

- The work highlights analog circuit design techniques used in phase-angle control applications.
- It contributes to the field of power electronics by implementing efficient light dimming strategies.
- The project supports advancements in energy-efficient lighting systems for residential and industrial use.
- It encourages hands-on learning in embedded hardware interfacing and real-time load control.
- Circuit simulation and waveform analysis are core areas of interest throughout the design process.
- Safety considerations in high-voltage circuit handling form a critical aspect of the design.
- It connects with industrial automation by offering scalable lighting control solutions.
- The project also aligns with product design and development in smart consumer electronics.

MENTOR CONTACT INFORMATION

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Development of a Touch-Activated Buzzer System Using Capacitive Sensing and 555 Timer IC for Human Interface and Alerting Applications

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GOALS

The primary goal of this project is to develop a reliable and cost-effective touch-activated buzzer system using capacitive sensing and a 555 timer IC, tailored for human interface and alerting applications. This system aims to enhance the way users interact with electronic devices by replacing traditional mechanical switches with a more modern, contactless touch interface. By doing so, the design ensures improved user convenience, hygiene, and system durability, making it especially useful in environments where physical contact should be minimized.

A key objective is to create an intuitive and accessible interface that responds effectively to human touch. This system can serve as an alert mechanism in various scenarios, such as notifying the presence of individuals, triggering alarms in emergencies, or confirming user inputs. The use of a simple 555 timer circuit to generate audio alerts through a buzzer not only simplifies the design but also ensures low power consumption and affordability—making it suitable for applications in homes, schools, hospitals, and public systems.

Additionally, the project targets the development of a robust and maintenance-free system by eliminating the mechanical wear and tear associated with conventional switches. The design will emphasize energy efficiency, ensuring it can function effectively in battery-powered devices or low-power embedded systems. Ultimately, this system is intended to be scalable, with potential for future enhancements such as adding multiple touch sensors, adjustable alert patterns, or integration into smart home or IoT platforms.

METHODS & TECHNOLOGIES

Cornerstone Project (CoP) team will focus on core methods and technologies on Touch-Activated Buzzer System Using Capacitive Sensing and 555 Timer IC for Human Interface and Alerting Applications

Capacitive Touch Sensing: Detects the presence of a human finger by measuring changes in capacitance. Uses a conductive surface (metal plate or PCB pad) as the sensing element. Enables contactless and hygienic user interaction.

555 Timer IC Configuration: Operated in **monostable** mode for single alert pulse or **astable** mode for continuous sound. Generates precise timing signals to control the buzzer. Timing is set using external resistors and capacitors.

Buzzer Activation: Uses a piezoelectric or magnetic buzzer to produce an audible alert. Activated by the output pulse from the 555 timer.

Signal Conditioning: May include transistors or MOSFETs to amplify the signal or switch the buzzer if higher current is required.

Power Supply: Operates on a low-voltage DC source (e.g., 5V or 9V battery).Ensures portability and energy efficiency.

Component Integration: Basic passive components: resistors, capacitors, and optionally diodes for protection. Breadboard or PCB-based implementation for stable circuit layout.

Simulation and Design Tools: Circuit simulation using tools like Proteus, LTspice, or Multisim layout design using software such as KiCad, Eagle, or Fritzing.

Technology Domains: Analog Electronics – for timer and buzzer circuitry, Human-Machine Interface (HMI) – for touch-based input design, Embedded Hardware Design – for real-time control and alert triggering.

DESIGN & TECHNICAL ISSUES

Cornerstone Project (CoP) team interested in the following majors or areas of interest should consider these challenges and design aspects while building Touch-Activated Buzzer System Using Capacitive Sensing and 555 Timer IC for Human Interface and Alerting Applications

Touch Sensor Sensitivity: Environmental factors (humidity, temperature, nearby conductive objects) may cause false triggering or reduced responsiveness. Requires careful calibration and possible shielding to ensure consistent operation.

Signal Integrity and Noise: Long or unshielded wires between the touch sensor and circuit may introduce electrical noise. Sensor layout must minimize interference and ensure clean signal delivery.

Trigger Signal Compatibility: The capacitive sensor’s output may not produce sharp logic levels suitable for the 555 timers. May need additional signal conditioning components like transistors or Schmitt triggers.

RC Timing Accuracy: Incorrect resistor-capacitor values in the 555-timer circuit can lead to wrong pulse duration or erratic buzzer activation. Requires precise calculation and component selection.

Power Supply Fluctuations: Unstable or noisy power supply can affect both the sensor's performance and the timer’s accuracy. A regulated DC supply or battery stabilization circuit is recommended.

Electromagnetic Interference (EMI): The buzzer may introduce EMI, which could interfere with touch detection. Proper circuit layout and separation of high-frequency paths are needed.

MAJORS & AREAS OF INTEREST

Cornerstone Project (CoP) team interested in the following majors or areas of interest will develop relevant skills and interdisciplinary expertise through the execution of onTouch-Activated Buzzer System Using Capacitive Sensing and 555 Timer IC for Human Interface and Alerting Applications**.**

- **Electronics and Communication Engineering (ECE)**
- **Electrical Engineering**
- **Embedded Systems and Control**
- **Instrumentation and Measurement**

MENTOR CONTACT INFORMATION

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