iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 13 Issue: V Month of publication: May 2025

DOI: https://doi.org/10.22214/ijraset.2025.71456

An IOT-Based Smart Helmet for Riding Security and Emergency Notification

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Abstract: This project is designed to enhance rider safety by implementing a smart helmet system equipped with real-time monitoring and accident detection capabilities. The smart helmet integrates a range of sensors and modules that collectively work to ensure the rider's well-being while on the road.

At the core of the system is the ESP32 microcontroller, which serves as the brain of the helmet. It handles the data collected from various sensors, processes it, and manages communication with external devices via built-in Wi-Fi and Bluetooth modules. The ESP32 ensures fast and efficient data handling, which is crucial in emergency situations where every second counts.

A piezoelectric sensor and a vibration sensor are used to detect any sudden impact or crash. These sensors are sensitive to pressure and motion, respectively, and can determine whether the rider has experienced an accident. Once an abnormal impact is detected, the system automatically initiates a safety protocol.

To further ensure road safety, the helmet is equipped with a gas sensor, specifically designed to detect the presence of alcohol. This feature helps in preventing intoxicated driving by alerting the system or even restricting the functionality of the vehicle if alcohol levels are above permissible limits.

A MEMS (Micro-Electro-Mechanical Systems) sensor is included to monitor the rider's posture and body orientation. This allows the system to detect falls or unnatural body positions that might indicate a crash or loss of balance. When such a condition is detected, the system acts immediately to alert emergency contacts.

Once any accident or abnormal condition is identified, the helmet uses a GPS module to determine the precise location of the rider. The real-time location data is then transmitted via the ESP32 to a connected mobile device, which can alert family members, emergency responders, or nearby authorities.

This smart helmet not only provides accident detection but also offers live tracking of the rider, ensuring they are never out of reach. In addition, the integration of wireless communication enables remote monitoring and timely alerts, which is essential for quick medical or rescue responses.

Overall, this intelligent helmet system represents a significant step forward in motorbike safety technology. By combining sensor technology with real-time communication, the project ensures immediate attention in the case of accidents, reducing the response time and potentially saving lives.

Keywords: Iothelmet ,Crash Detection , GPS Tracking , Bluetooth Connectivity

I. INTRODUCTION

In recent times, road safety has become a serious concern, especially for two-wheeler riders.

Motorcyclists are more vulnerable to accidents and injuries compared to car drivers. To address this issue, a smart helmet has been designed to ensure rider safety using modern technology.

This smart helmet integrates various sensors to detect and respond to emergencies. It helps monitor the rider's condition and surroundings in real time. The helmet uses a piezoelectric sensor and vibration sensor to detect accidents or sudden impacts. In the case of a collision, these sensors immediately trigger alerts to notify emergency contacts. A gas sensor is also included to check for alcohol in the rider's breath. If alcohol is detected, the helmet can alert the user or stop ignition.

To monitor posture, a MEMS sensor is added to detect if the rider has fallen. Fall detection is crucial for triggering fast emergency help when the rider is unconscious or unable to respond. The GPS module in the helmet tracks the exact location of the rider. This information is vital during emergencies, as it helps guide help to the correct spot. The ESP32 microcontroller is the core of the system and handles all communication and data processing. It sends alerts and the live location to a connected mobile phone. This ensures that the rider is never alone during an accident. Help can reach them quickly, reducing response time.

This smart helmet system is an innovative way to improve road safety. It not only detects accidents but also prevents riding under the influence. It ensures that a rider's safety is always monitored, even during solo rides.

The system is affordable and can be implemented in real-world applications. It is especially useful in areas where medical help may take time to arrive. Overall, the smart helmet provides a reliable and smart solution to reduce road accident impacts. It is a step toward smarter and safer commuting for two-wheeler users.

II. EXISTING IMPLEMENTATION

A. Existing System

The IoT-based Smart Helmet Monitoring System is designed to improve worker safety in hazardous environments by using advanced sensor technologies integrated into a safety helmet.The system first ensures that the helmet is worn correctly by the user. This is crucial because a helmet that is not properly worn cannot provide adequate protection.To detect unsafe conditions related to alcohol consumption, the helmet includes a gas sensor that monitors the presence of alcohol vapor near the wearer. This helps in preventing accidents caused by impaired judgment.A Micro-Electro-Mechanical Systems (MEMS) sensor is also embedded in the helmet to detect falls. The MEMS sensor can identify sudden movements or impacts that indicate the wearer has fallen, which is critical for prompt emergency response.For real-time location tracking, a GPS module is integrated. This allows supervisors or emergency teams to know the exact position of the worker, especially in large or remote work sites.All sensor data collected from the gas sensor, MEMS sensor, and GPS module are processed by the ESP32 microcontroller embedded in the helmet. The ESP32 serves as the central processing unit, coordinating data collection and communication.

The ESP32 transmits the processed data wirelessly, enabling continuous monitoring of the worker's safety status. This real-time data transmission allows for immediate alerts to be sent if any unsafe condition is detected.For instance, if the gas sensor detects alcohol, or if the MEMS sensor detects a fall, the system will trigger an alert that can be sent to supervisors via a connected app or control center.This rapid alert system ensures quick intervention, potentially saving lives by providing immediate assistance to the affected worker.The system's IoT capability also allows for remote monitoring, meaning safety managers can oversee multiple workers' conditions simultaneously from a centralized location.Data collected over time can be stored and analyzed to identify patterns or frequent safety issues, helping improve workplace safety protocols.Overall, this Smart Helmet system combines safety monitoring with IoT technology to create a proactive safety solution that enhances worker protection.The modular design of the system allows for easy upgrades or addition of new sensors as needed.It is lightweight and does not interfere with the user's comfort, making it practical for daily use in demanding work environments.The use of an ESP32 microcontroller ensures low power consumption and reliable wireless connectivity through Wi-Fi or Bluetooth.In conclusion, this IoT-based Smart Helmet Monitoring System integrates multiple sensors and communication technologies to provide comprehensive safety monitoring, immediate alerts, and real-time location tracking, thereby significantly improving workplace safety.

III. SYSTEM IMPLEMENTATION

A. Proposed System

This rider safety monitoring system is designed to ensure comprehensive protection by providing realtime monitoring and immediate alerts in case of accidents.At its core, the system uses an ESP32 microcontroller which acts as the central controller, gathering data from multiple sensors installed on the rider's helmet.The system enables remote monitoring by sending alerts and live location details directly to the rider's mobile device through IoT connectivity, allowing for instant communication with emergency contacts.A Piezoelectric sensor and vibration sensor are integrated to detect sudden impacts or vibrations, which often indicate collisions or accidents. These sensors help in quick accident detection.When a sudden vibration or impact is sensed, the system can immediately trigger an emergency alert, notifying the rider or emergency services for timely assistance.A gas sensor continuously monitors the presence of alcohol vapors around the rider to ensure that they are not intoxicated before or during riding.If the gas sensor detects alcohol levels above a safe limit, it triggers an alert, helping prevent accidents caused by impaired riding.

The system also includes a MEMS (Micro-Electro-Mechanical Systems) sensor that detects falls or abnormal helmet movements, which are potential indicators of an accident.The MEMS sensor enhances safety by identifying unexpected helmet displacements, enabling the system to react quickly to dangerous situations.All sensor data is processed by the ESP32 microcontroller, which makes decisions on when to send alerts based on predefined safety thresholds.The system's real-time GPS tracking allows for continuous monitoring of the rider's exact location, essential for quick emergency response.Through IoT connectivity, the system communicates vital information such as accident alerts and location details to a mobile app or cloud platform.Remote monitoring enables family members, friends, or emergency services to track the rider's safety status and respond promptly if needed.The helmet design ensures that the sensors do not interfere with rider comfort or mobility, promoting consistent use.

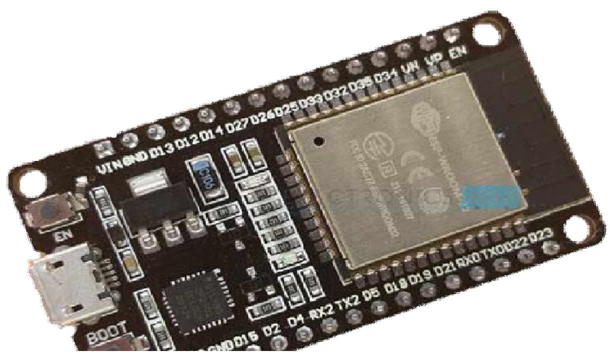
International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 13 Issue V May 2025- Available at www.ijraset.com

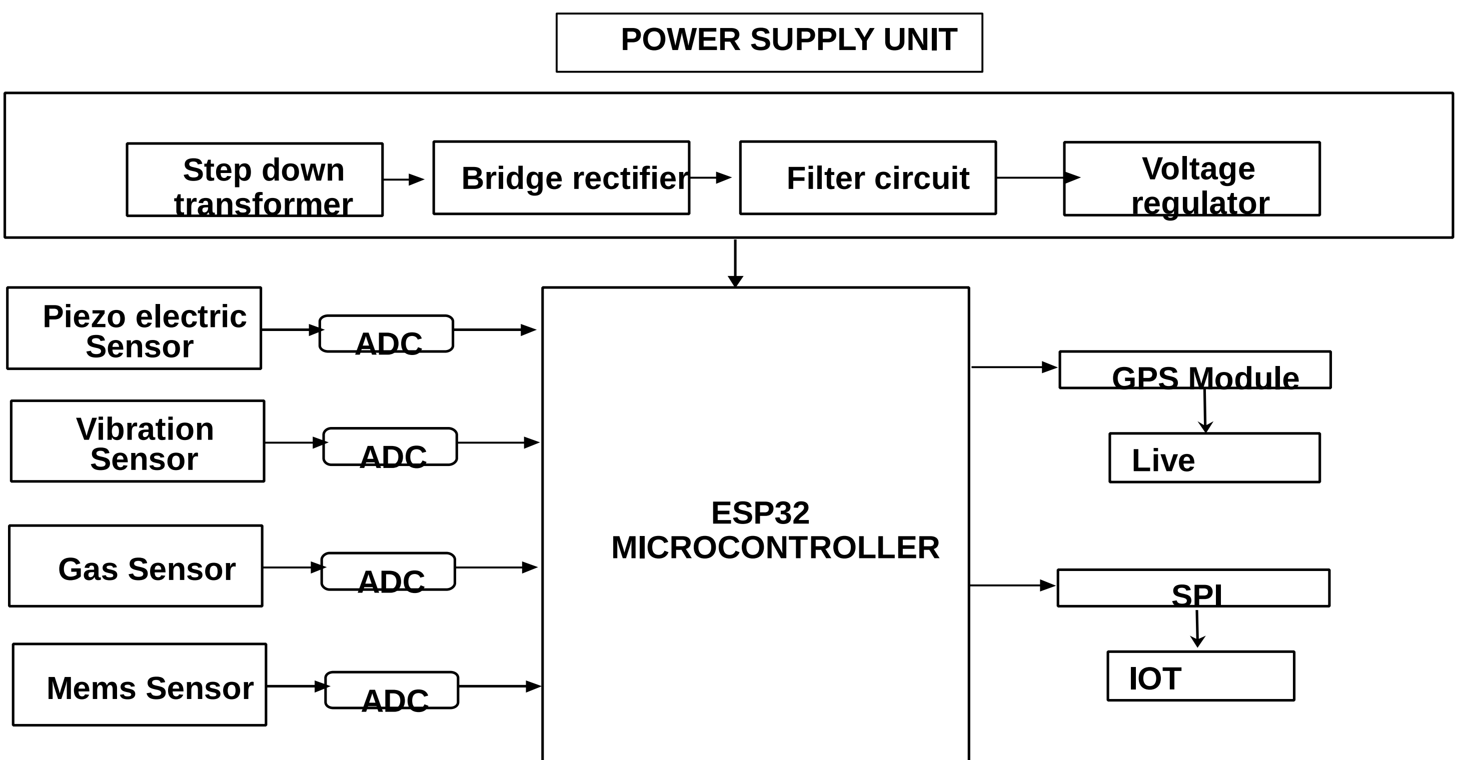
Low power consumption of the ESP32 and sensors helps maintain longer battery life for continuous operation during rides.The system's modularity allows for easy upgrades or addition of new sensors in the future for enhanced safety features.By combining impact detection, alcohol sensing, fall detection, and GPS tracking, the system creates a robust safety network for riders.Overall, this IoT-enabled rider safety system provides peace of mind by enhancing accident detection, preventing drunk riding, and enabling swift emergency response.

B. Advantages

1) The system provides real-time accident detection, allowing for immediate emergency alerts and faster help.
2) It monitors alcohol presence to prevent intoxicated riding, enhancing rider and public safety.
3) Continuous GPS tracking offers accurate live location data for quick response in case of emergencies.
4) Remote monitoring through IoT enables alerts and safety updates to be sent directly to the rider's mobile device or caregivers.
5) The integration of multiple sensors ensures comprehensive safety by detecting falls, collisions, and unsafe conditions.
6) The ESP32 microcontroller provides efficient processing with low power consumption, extending battery life.
7) The compact and lightweight design of the helmet system ensures rider comfort and encourages consistent use.

C. Block Diagram





SYSTEM SPECIFICATION

IV. HARDWARE REQUIREMENTS

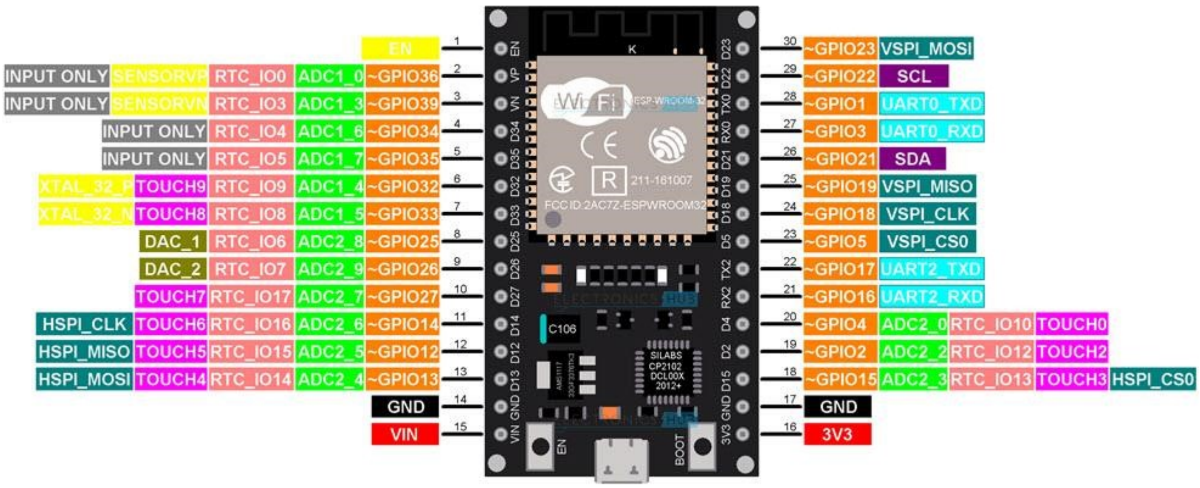
A. ESP32 Microcontroller

In this tutorial, we will learn about ESP32, a dual core MCU from Espressif Systems with integrated Wi-Fi and Bluetooth. If you worked with ESP8266, then ESP32 is a significant upgrade with a lot more features. This Getting Started with ESP32 guide is for complete beginners, with or without prior experience in IoT or ESP8266.

ESP32

B. Pinout of ESP32 Board

I will make a separate dedicated tutorial on ESP32 Pinout. But for the time being, take a look the pinout diagram of the ESP32 Development Board.



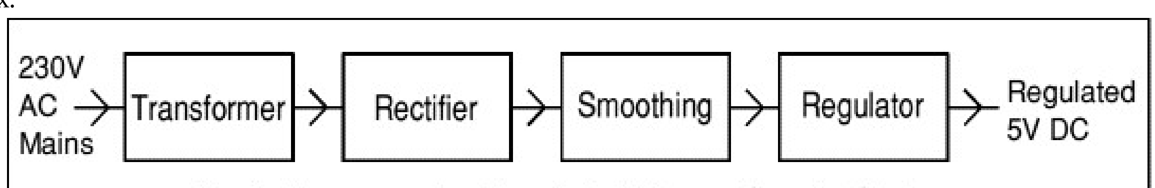
PINOUT

This pinout is for the 30 – pin version of the ESP Board. In the pinout tutorial, I will explain the pin out of both the 30 – pin as well as the 36 – pin version of the ESP Boards.

C. Power Supply

Power supply is a reference to a source of electrical power. A device or system that supplies electricalor other types of energyto an output loador group of loads is called a power supply unit or PSU. The term is most commonly applied to electrical energy supplies, less often to mechanical ones, and rarely to others.

Power supplies for electronic devices can be broadly divided into linear and switching power supplies. The linear supply is a relatively simple design that becomes increasingly bulky and heavy for high current devices; voltage regulation in a linear supply can result in low efficiency. A switched-mode supply of the same rating as a linear supply will be smaller, is usually more efficient, but will be more complex.



Block Diagram of a Regulated Power Supply System

D. Piezo Electric Sensor

Force-sensing resistors consist of aconductive polymer, which changes resistance in a predictable manner following application of force to its surface. They are normally supplied as a polymer sheet orinkthat can be applied byscreen printing. The sensing film consists of both electrically conducting and non-conducting particles suspended in matrix. The particles are sub-micrometre sizes, and are formulated to reduce the temperature dependence, improve mechanical properties and increase surface durability.

Applying a force to the surface of the sensing film causes particles to touch the conducting electrodes, changing the resistance of the film. As with all resistive based sensors, force-sensing resistors require a relatively simple interface and can operate satisfactorily in moderately hostile environments. Compared to other force sensors, the advantages of FSRs are their size (thickness typically less than 0.5 mm), low cost and goodshockresistance. A disadvantage is their low precision: measurement results may differ 10% and more.

USES:
Force-sensing resistors are commonly used to create pressure-sensing "buttons" and have applications in many fields, includingmusical instruments, car occupancy sensors,Foot pronationsystems andportableelectronics.

E. Custom Force Sensors

The unique construction and ink characteristics of FlexiForce sensors enable Tekscan to create customdesigned force sensing resistor sensors to meet your specific OEM needs.
FlexiForce sensors are ideal for OEM products due to our ability to customize:

- Geometry - sensors can be designed in a variety of shapes and sizes to meet your application and product needs.
- Ink technology - we offer three pressure-sensitive ink variations to meet your application and product needs: standard, enhanced, and high temperature.
- Integration support - our team of mechanical, electrical, and application engineers are here to ensure a successful product integration.

F. Vibration Sensor

Vibration sensors are used in a number of different projects, machines and applications. Whether you're attempting to gauge the speed of a vehicle, or to gauge the power of an impending earthquake, the device you're likely using is considered to be a "vibration sensor." Some of them operate on their own, and others require their own power source.
Various machine operating conditions concerning temperature extremes, magnetic fields, vibration range, frequency range, electromagnetic compatibility (EMC) and electrostatic discharge (ESD) conditions and the required signal quality necessitate the need for a variety of sensors.

VIBRATION SENSOR

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 13 Issue V May 2025- Available at www.ijraset.com

WORKINGS

It works on electromechanical principle vibration velocity sensors operate in accordance with the electrodynamics principle and are used for measuring the bearing absolute vibration based on the piezoelectric effect. Change in resistance due to the force acting on it and convert it into 4 - 20 mA. they're measuring differences in oscillation, so they probably want a -12 and +12swing with 0 as the base lineal we have piezoelectric sensor which detects the vibration created on the surface. We can also use shock sensor to detect vibrations

ADC

The ADC0808, ADC0809 data acquisition component is a monolithic CMOS device with an 8-bit analog-to-digital converter, 8-channel multiplexer and microprocessor compatible control logic. The 8-bit A/D converter uses successive approximation as the conversion technique. The converter features a high impedance chopper stabilized comparator, a 256R voltage divider with analog switch tree and a successive approximation register. The 8-channel multiplexer can directly access any of 8-single-ended analog signals. The device eliminates the need for external zero and full-scale adjustments. Easy interfacing to microprocessors is provided by the latched and decoded multiplexer address inputs and latched TTL TRI-STATE outputs.

The design of the ADC0808, ADC0809 has been optimized by incorporating the most desirable aspects of several A/D conversion techniques. The ADC0808, ADC0809 offers high speed, high accuracy, minimal temperature dependence, excellent long-term accuracy and repeatability, and consumes minimal power. These features make this device ideally suited to applications from process and machine control to consumer and automotive applications. For 16-channel multiplexer with common output (sample/hold port) see ADC0816 data sheet. (See AN-247 for more information.)

V. ADC CIRCUIT

A. Gas Sensor

A gas detector is a device that detects the presence ofgasesin an area, often as part of a safety system. A gas detector can sound an alarm to operators in the area where the leak is occurring, giving them the opportunity to leave. This type of device is important because there are many gases that can be harmful to organic life, such as humans or animals.

Gas detectors can be used to detectcombustible,flammableandtoxicgases, andoxygendepletion. This type of device is used widely in industry and can be found in locations, such as on oil rigs, to monitor manufacturing processes and emerging technologies such asphotovoltaic. They may be used infirefighting.

Gas leak detection is the process of identifying potentially hazardousgas leaksbysensors. Additionally a visual identification can be done using a thermal camera These sensors usually employ an audible alarm to alert people when a dangerous gas has been detected. Exposure to toxic gases can also occur in operations such as painting, fumigation, fuel filling, construction, excavation of contaminated soils, landfill operations, entering confined spaces, etc. Common sensors include combustible gas sensors, photoionization detectors,infrared point sensors,ultrasonic sensors,electrochemical gas sensors, andmetal–oxide–semiconductor(MOS) sensors. More recently, infrared imaging sensors have come into use. All of these sensors are used for a wide range of applications and can be found in industrial plants, refineries, pharmaceutical manufacturing, fumigation facilities, paper pulp mills, aircraft and shipbuilding facilities, hazmat operations, wastewater treatment facilities, vehicles, indoor air quality testing and homes.

Gas leak detection methods became a concern after the effects of harmful gases on human health were discovered.

Before modern electronicsensors, early detection methods relied on less precise detectors. Through the 19th and early 20th centuries, coal miners would bringcanariesdown to the tunnels with them as an early detection system against life-threatening gases such ascarbondioxide,carbon monoxideandmethane. The canary, normally a very songful bird, would stop singing and eventually die if not removed from these gases, signaling the miners to exit the mine quickly.

The first gas detector in the industrial age was the *flame safety lamp* (orDavy lamp) was invented by SirHumphry Davy(of England) in 1815 to detect the presence of methane (firedamp) in underground coal mines. The flame safety lamp consisted of an oil flame adjusted to specific height in fresh air. To prevent ignition with these lamps the flame was contained within a glass sleeve with a mesh flame arrestor. The flames height varied depending on the presence of methane (higher) or the lack of oxygen (lower). To this day, in certain parts of the world flame safety lamps are still in service.

The modern era of gas detection started in 1926–1927 with the development of the catalytic combustion (LEL) sensor by Dr.Oliver Johnson. Dr Johnson was an employee of Standard Oil Company in California (now Chevron), he began research and development on a method to detect combustible mixtures in air to help prevent explosions in fuel storage tanks.

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A demonstration model was developed in 1926 and denoted as the Model A. The first practical "electric vapor indicator" meter begun production in 1927 with the release of the Model B.

GAS SENSOR

B. Mems Sensor

General Description:

MEMS SENSOR

The A3G4250D is a low-power 3-axis angular rate sensor able to provide unprecedented stability at zero rate level and sensitivity over temperature and time. It includes a sensing element and an IC interface capable of providing the measured angular rate to the external world through a standard SPI digital interface. An I 2 C-compatible interface is also available. The sensing element is manufactured using a dedicated micro-machining process developed by STMicroelectronics to produce inertial sensors and actuators on silicon wafers.

The IC interface is manufactured using a CMOS process that allows a high level of integration to design a dedicated circuit which is trimmed to better match the sensing element characteristics.

The A3G4250D has a full scale of ±245 dps and is capable of measuring rates with a user- selectable bandwidth. The A3G4250D is available in a plastic land grid array (LGA) package and can operate within a temperature range of -40 °C to +85 °C.

C. GPS

The Global Positioning System (GPS) is a U.S. space-basedglobal navigation satellite system. It provides reliable positioning, navigation, and timing services to worldwide users on a continuous basis in all weather, day and night, anywhere on or near the Earth.

GPS MODULE

VI. CONCLUSION

The development and implementation of the IoT-based Smart Helmet Monitoring System raise several important ethical aspects that must be acknowledged and addressed to ensure responsible use and deployment.Firstly, the primary ethical objective of the project is to enhance human safety. By integrating real-time monitoring and intelligent accident detection systems, the project is committed to reducing the risk of injury or fatality for riders. This aligns with the fundamental ethical principle of preserving life and promoting well-being through technology.The system uses sensors such as gas, vibration, MEMS, and piezoelectric to detect potentially dangerous situations like alcohol impairment, falls, or collisions. These features help ensure that riders are in a fit condition to operate their vehicles and that they receive immediate assistance in case of an emergency. Ethically, this proactive approach promotes accountability and encourages safer driving behavior.Another critical ethical aspect is data privacy and security. The system involves real-time GPS tracking and continuous sensor monitoring, which results in the collection of sensitive personal data such as the rider's location and behavior. It is essential that this data is securely stored and transmitted, with encryption and strict access controls, to prevent misuse or unauthorized access. Users must be informed about what data is being collected and how it will be used, ensuring transparency and informed consent.The system also supports equity and accessibility by being designed in a compact, affordable, and user-friendly way. This ensures that the safety benefits it offers can be made available to a broader segment of the population, including those in resource-limited settings.From a socio-technical perspective, the system fosters a culture of safety and responsibility. By enabling remote monitoring through mobile alerts and IoT connectivity, it strengthens the support network around a rider — involving family members, emergency responders, or supervisors, especially in high-risk professions like delivery or construction.

Furthermore, there must be a balance between autonomy and surveillance. While it is ethically justified to use monitoring systems for safety purposes, users should retain control over their personal data and be able to disable monitoring features when not needed, as long as it does not compromise safety regulations.In conclusion, this project upholds ethical standards by prioritizing safety, ensuring data protection, encouraging responsible behavior, and promoting equitable access. It demonstrates how technology can be ethically integrated into daily life to address real-world challenges without infringing on individual rights and freedoms.

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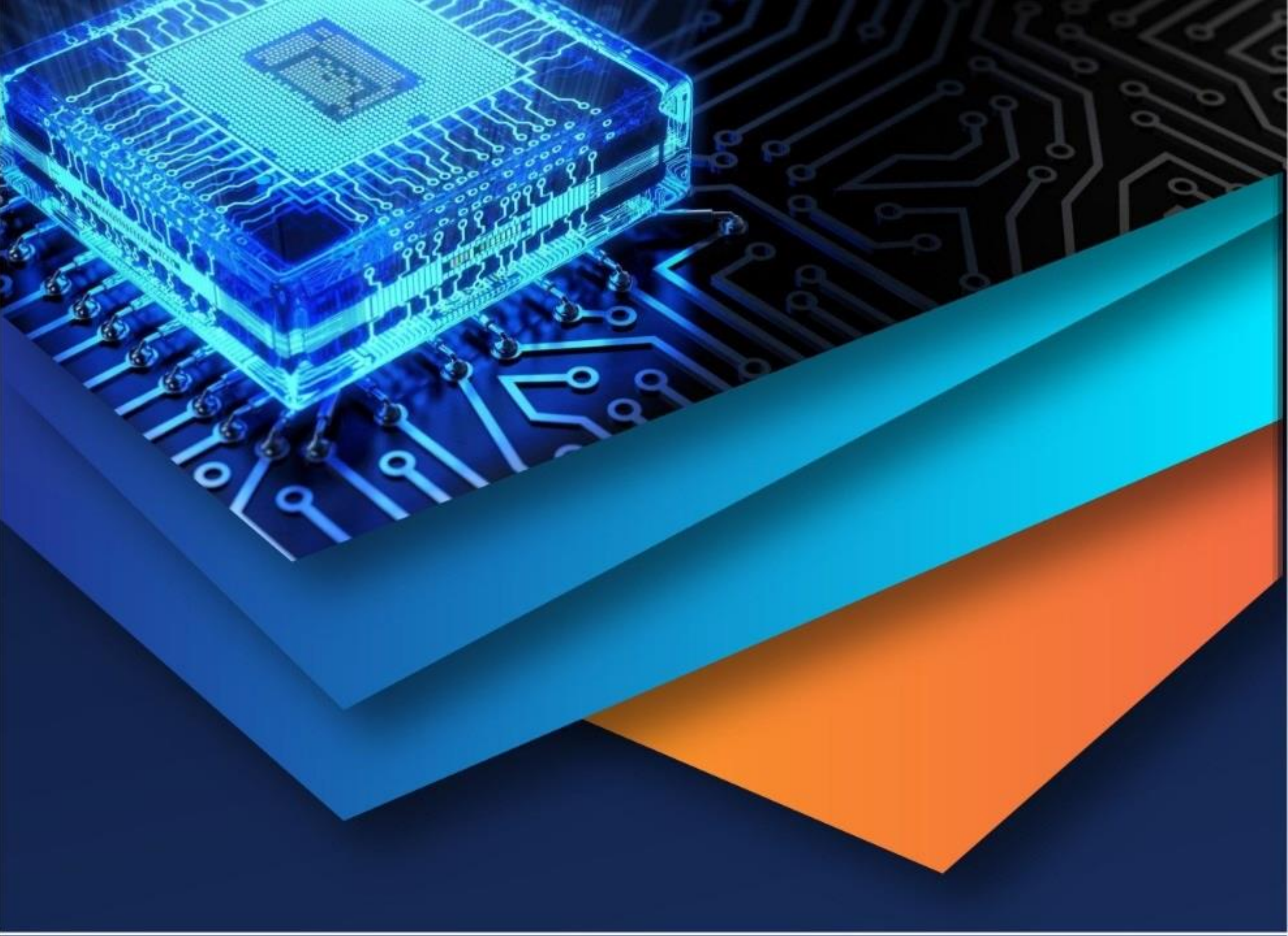

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