# DRIVER DROWSINESS DETECTOR

**A Industry Oriented Mini Project Report**

***Submitted to***

**Jawaharlal Nehru Technological University Hyderabad**

*In partial fulfillment of the requirements for the*

*award of the degree of*

**BACHELOR OF TECHNOLOGY**

**in**

**ELECTRONICS & COMMUNICATION ENGINEERING**

By

***P. GANESH (22VE1A0447)***

***B. BHAVYA SIRISHA(22VE1A0407)***

***K. CHANDU (22VE1A0423)***

**Under the Guidance of**

**Mrs.M.Pavani**

**Assistant professor**

**DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING**

Approved by AICTE, New Delhi | Affiliated to JNTUH, Hyderabad | Accredited by NAAC "A" Grade & NBA| Hyderabad | PIN: 500068

(2022– 2026)

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# *Certificate*

This is to certify that the Industry Oriented Mini Project Report on ***"DRIVER DROWSINESS DETECTOR"*** submitted by **P.GANESH, B.BHAVYA SIRISHA, K.CHANDU** bearing Hall Ticket No's. **(22VE1A0447), (22VE1A0407),(22VE1A0423)** in partial fulfillment of the requirements for the award of the degree of **Bachelor of Technology** in **Electronics & Communication Engineering** from Jawaharlal Nehru Technological University, Kukatpally, Hyderabad for the academic year 2024-25 is a record of bonafide work carried out by them under our guidance and Supervision.

**Guide**
**Mrs.M.Pavani**

**Head of the Department**

**Project Coordinator**

**Signature of the External Examiner**

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# DECLARATION

We, **P.GANESH, B.BHAVYA SIRISHA, K.CHANDU** bearing **(22VE1A0447), (22VE1A0407),(22VE1A0423)** here by declare that the Project titled "Driver drowsiness detector" done by us under the guidance of **Mrs.M.pavani** , which is submitted in the partial fulfillment of the requirement for the award of the B.Tech degree in **Electronics & Communication Engineering** at **Sreyas Institute of Engineering & Technology** for Jawaharlal Nehru Technological University, Hyderabad is our original work.

**P.GANESH (22VE1A0447)**
**B.BHAVYA SIRISHA (22VE1A0407)**
**K.CHANDU (22VE1A0423)**

# ACKNOWLEDGEMENT

The successful completion of any task would be incomplete without mention of the people who made it possible through their guidance and encouragement crowns all the efforts with success.

We take this opportunity to acknowledge with thanks and deep sense of gratitude to **Mrs.M.pavani** for her constant encouragement and valuable guidance during this work.

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We owe very much to the **Department Faculty, Principal** and the **Management** who made our term at **SREYAS** a Steppingstone for my career. We treasure every moment we had spent in the college.

Last but not least, our heartiest gratitude to our parents and friends for their continuous encouragement and blessings. Without their support this work would not have been possible.

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# ABSTRACT

Fatigue and drowsiness are leading causes of road accidents, especially among long-distance drivers and commercial vehicle operators. Traditional driver monitoring methods—such as lane tracking or steering behavior—fail to detect the early signs of drowsiness, often responding only after driver performance has already degraded. This project presents a cost-effective, wearable, real-time Driver Drowsiness Detection System that leverages an infrared (IR) blink sensor integrated into a spectacle frame, in combination with an ESP32-CAM microcontroller. The IR sensor continuously monitors eyelid movements to detect prolonged closures or irregular blinking, while the ESP32-CAM processes the input data and activates a buzzer when fatigue symptoms are detected. This standalone embedded system is compact, non- intrusive, and does not require constant internet connectivity, making it ideal for deployment in personal and commercial vehicles. The system was tested in simulated environments and proved effective in issuing timely alerts. Its simplicity, affordability, and portability make it a promising solution to improve road safety by addressing the often-overlooked issue of driver drowsiness. Future extensions may include cloud integration, GPS tracking, or multimodal fatigue analysis using additional physiological sensors.



## KEYWORDS:

Alert System, Blink Sensor, Drowsiness Detection, Embedded System, ESP32-CAM, Fatigue Monitoring, IR Sensor, Real-Time Monitoring, Road Safety, Wearable Technology.

**LIST OF FIGURES**

# CHAPTER 1

# INTRODUCTION

## 1.1 INTRODUCTION

In the modern era of rapid industrialization and increasing vehicular usage, road transport has become an integral part of daily life. As the number of vehicles on the roads continues to rise, so too does the risk associated with road accidents. A substantial proportion of these accidents are caused not by mechanical failures or poor road conditions, but by human error—particularly fatigue and drowsiness. Driver drowsiness has been identified as a silent killer, responsible for numerous avoidable tragedies, especially on highways and during night travel. Drowsy drivers often experience reduced concentration, slow reaction times, and impaired judgment, making them a significant threat to both themselves and other road users.

Technological advancements in electronics and embedded systems have enabled the development of real-time monitoring solutions aimed at detecting early signs of fatigue and drowsiness in drivers. These systems are designed to alert drivers before they fall asleep behind the wheel, thus potentially saving lives and preventing property damage. The Driver Drowsiness Detector developed in this project is one such system, created to provide a reliable, non-intrusive, and efficient solution using minimal hardware and open-source software. By leveraging the ESP32-CAM microcontroller's computational capability and pairing it with an IR blink sensor mounted on spectacles, the system is able to monitor eye blinks and detect abnormal patterns that indicate drowsiness. The inclusion of a buzzer ensures immediate and effective alerts, giving the driver an opportunity to regain focus or stop the vehicle for rest

## 1.2 OBJECTIVE

The primary objective of this project is to design and develop a fully functional, motion-triggered surveillance system using the ESP32-CAM module and supporting components. The system should be capable of detecting motion using a PIR sensor, capturing an image using the onboard camera, and storing the image to a microSD card without the need for human intervention. Specific objectives include: integrating the ESP32-CAM with a PIR sensor and microSD card interface; ensuring accurate motion detection and minimizing false positives; optimizing power consumption for possible battery operation; and building a compact, reliable system with visual feedback using LEDs. A secondary objective is to develop the system using open-source hardware and software tools to ensure accessibility and adaptability by others. This includes using the Arduino IDE for programming and common libraries for camera control, file system management, and sensor interfacing.

## 1.3 BACKGROUND

The problem of driver fatigue has existed since the earliest days of motorized transport, but it has taken center stage only in recent years as traffic density and travel duration have significantly increased. Historically, fatigue monitoring relied solely on the driver's judgment or the intervention of co-passengers—an unreliable and inconsistent solution. Technological innovation has now allowed the automation of driver monitoring systems through advanced sensing and embedded control units.

Among the many technologies explored for fatigue detection, image processing, EEG analysis, and biometric sensing have shown promise

However, these systems often require high computational power, complex hardware setups, and stable network connectivity. In contrast, embedded
solutions using microcontrollers like the ESP32-CAM offer a balanced approach, combining processing ability, wireless communication, and peripheral control within a compact, low-cost unit.

The ESP32-CAM microcontroller has gained popularity due to its integrated camera module, Wi-Fi and Bluetooth support, multiple GPIOs, and the ability to run independently without a host computer. When coupled with peripheral sensors such as the IR blink sensor, it forms the heart of a versatile system capable of detecting and responding to driver fatigue. IR sensors operate based on the principle of infrared reflection, measuring changes in the reflected signal from the eye as it opens and closes. These signals can be interpreted to identify blinking frequency and duration.

The placement of the IR sensor on a spectacle frame enhances accuracy while maintaining user comfort. Unlike image-based monitoring systems that require external mounting and can be affected by ambient lighting, IR-based sensing remains stable under varying conditions, making it ideal for vehicular use.

This background sets the stage for the current project, which seeks to implement a practical, efficient, and scalable solution to a real-world problem using modern embedded technology.

## 1.4 ORGANIZATION OF THE THESIS

To systematically present the research, development, and results of the Driver Drowsiness Detector project, this thesis is organized into five logically structured chapters

- Chapter1:Introduction

  This chapter introduces the concept of driver drowsiness detection, explains the motivation behind the project.

- Chapter2:LiteratureReview

  The second chapter reviews existing technologies and research efforts related to driver monitoring systems. It compares different approaches such as camera-based solutions, EEG-based headbands, and smartphone apps. This chapter identifies the limitations of current systems and highlights the need for a compact, embedded solution.

- Chapter3:DesignMethodology

  This chapter focuses on the architectural and design aspects of the system. It includes hardware and software design strategies, block diagrams, operational flowcharts, and logic descriptions. It explains how the different components interact to achieve the intended functionality.

- Chapter4:ComponentsUsed

  Chapter 4 provides a comprehensive description of all hardware and software components used in the project. This includes the ESP32- CAM, IR sensor, buzzer, battery, and programming tools like Arduino IDE. Each component is described in terms of its role, specifications, and integration method.

- Chapter5:Results,Conclusion

  The final chapter presents the implementation results, discusses system performance, identifies limitations, and proposes possible improvements for future versions. This includes ideas such as machine learning integration, cloud-based data access, and enhanced alerting mechanism.

## 1.5 SUMMARY

This introductory chapter provided a comprehensive foundation for understanding the motivation, objectives, and context of the Driver

Drowsiness Detector project. With the alarming rise in road accidents caused by fatigue and microsleep episodes, especially during long-distance and night-time driving, the necessity for effective driver alertness monitoring systems has become paramount.

The chapter began by highlighting the relevance of driver drowsiness as a public safety issue and the shortcomings of traditional methods in detecting fatigue. It emphasized the pressing need for real-time, autonomous systems that can function without reliance on cloud services or expensive hardware. The motivation was further reinforced by the desire to build an accessible and non-intrusive system that could be adapted to both personal and commercial vehicles.

The objectives of the project were clearly outlined, including real-time eye monitoring, buzzer-based alerting, low power operation, and modular expandability. The background section explored how advances in embedded systems, particularly the ESP32-CAM, have enabled new possibilities in safety technology. The use of wearable IR sensors was justified as a reliable and comfortable alternative to bulky or intrusive monitoring devices.

Finally, the chapter detailed the organization of the thesis, mapping out the structure and content of subsequent chapters. This roadmap guides the reader through the progression of literature review, system design, component analysis, implementation results, and future improvements.

In summary, Chapter 1 sets the stage for a technically sound, socially relevant, and practically deployable solution to one of the most overlooked threats in modern road transport: driver fatigue. The following chapters will build upon this foundation with academic analysis, technical execution, and experimental validation

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 THE NEED FOR DRIVER ALERT MONITORING

Driver alertness is a critical determinant of road safety. As motorization has become widespread across both urban and rural areas, road accidents have escalated to become one of the leading causes of unintentional deaths worldwide. A significant portion of these accidents are the result of driver fatigue or drowsiness, which impairs attention, delays reflexes, and degrades decision-making capabilities. Unlike alcohol or drug impairment, drowsiness is more difficult to detect and often goes unnoticed until it results in a tragic incident. Microsleeps—brief episodes of sleep that last only a few seconds—can occur without the driver's awareness, and even a momentary lapse of focus at high speed can be fatal.

The increasing demand for long-distance transport, overworked commercial drivers, shift-based public transport operators, and individuals commuting long hours contribute to the high prevalence of fatigue-induced driving. In such scenarios, human vigilance cannot be solely relied upon, and a technological solution becomes indispensable. Hence, the implementation of real-time driver monitoring systems becomes not just beneficial, but essential. This section emphasizes the necessity of alertness monitoring and serves as the motivation behind the research and development of embedded, cost-effective drowsiness detection systems that can operate reliably and autonomously.

## 2.2 CONVENTIONAL APPROACHES TO FATIGUE DETECTION

Historically, fatigue detection methods were simplistic and largely reactive. Initial systems depended on manual reporting and subjective assessment of driver behavior. For example, commercial transport companies often required drivers to log rest hours or mandated stop schedules, based on the assumption that sleep duration directly correlates with alertness. While helpful in theory, such methods lacked accuracy and could be easily manipulated. Moreover, individuals experience fatigue differently; thus, these blanket policies were not always effective.

Later, technological solutions emerged that focused on vehicle-based indicators such as **steering wheel movements**, **lane position deviations**, and **pedal pressure inconsistencies**. These systems used data from sensors installed in the vehicle to infer abnormal driving behavior. If the system detected inconsistent or erratic driving patterns, it would issue a warning. However, these vehicle-centric models were highly dependent on external conditions—such as road curvature, wind disturbances, or uneven terrain— and could not account for the driver's internal state. Moreover, these systems only responded after fatigue had already begun to affect the driver's control, failing to provide early warning.

Conventional approaches laid the groundwork for the importance of fatigue detection but demonstrated clear limitations in terms of precision, early detection, and adaptability.

## 2.3 SENSOR BASED AND VISION-BASED MONITORING SYSTEMS

To improve detection accuracy and responsiveness, researchers developed systems that analyzed physiological and behavioral markers. Among the most promising approaches was eye activity monitoring. Scientific research has shown that metrics such as blink rate, blink duration, gaze direction, and eye closure percentage are highly correlated with fatigue levels. For instance, a drowsy driver tends to blink more slowly and with longer eye closures. These eye-based indicators can be reliably measured using image processing techniques and IR sensors.

Vision-based systems typically involve a camera mounted on the dashboard, directed at the driver's face. Using facial landmark detection algorithms, the system identifies the eyes and tracks their movements in real time. Advanced algorithms like PERCLOS (Percentage of Eyelid Closure over the Pupil over Time) quantify drowsiness by computing how long the eyes remain closed during a certain time window. These systems have shown high effectiveness in laboratory settings and are even used in premium automotive brands.

However, such systems require substantial computational power, precise camera alignment, and good lighting conditions. Obstructions such as sunglasses, reflections, or poor camera focus can impair their performance. They also raise privacy concerns, especially if the footage is stored or transmitted externally.

Sensor-based systems on the other hand, measure internal body signals. Heart rate variability (HRV) is a well-known indicator of stress and alertness. As fatigue sets in, HRV tends to decrease. Similarly, electroencephalogram (EEG) sensors measure brainwave activity and can directly detect the transition from alertness to drowsiness.

Though accurate, these sensors are intrusive and uncomfortable to wear during driving. Additionally, their cost and maintenance requirements limit their practicality.

In comparison, IR blink sensors are non-intrusive and inexpensive. They measure changes in the amount of reflected infrared light from the eye surface to detect open and closed eye states. These sensors are simple to implement and effective even in low-light environments, making them ideal for real-world vehicle applications.

## 2.4 THE CHALLENGESOF WEARABILITY AND PRACTICAL DEPLOYMENT

For a driver monitoring system to be effective, it must be comfortable, easy to use, and minimally intrusive. Regardless of how accurate a device may be, if it interferes with the driver's comfort or line of sight, it will be rejected or misused. This makes wearability a critical design parameter in any practical implementation.

Several existing products attempt to address this through wearable devices—headbands, earpieces, or smart glasses. However, these devices often require regular calibration, consistent power supply, and wireless pairing with external devices such as smartphones or tablets. In daily use, these requirements become cumbersome, especially for long-haul drivers or those without access to continuous charging facilities.

In contrast, mounting an IR sensor on a pair of spectacles offers a highly natural integration. Spectacles are already worn by many individuals and provide a fixed platform to align the sensor with the eyes.

This configuration allows for accurate blink detection without obstructing the field of vision. Such solutions are less sensitive to head movements and do not require constant calibration. Furthermore, since they do not involve camera capture, they address concerns related to image privacy and data security.

The real challenge is to combine wearability, accuracy, and affordability. This is where embedded systems play a transformative role, offering compact, programmable solutions that can support sensor input, data processing, and alert generation without additional infrastructure.

## 2.5 ADVANTAGES OF EMBEDDED SYSTEMSIN REAL TIME APPLICATIONS

Embedded systems have revolutionized the way we develop safety and automation solutions. A modern embedded controller, such as the **ESP32-** CAM, offers a rich set of features—including multiple GPIOs, Wi- Fi/Bluetooth connectivity, onboard camera interface, and local storage via microSD card support—in a compact and energy-efficient package. These microcontrollers can run on battery power for extended periods, making them suitable for use in vehicles, wearables, and standalone devices.

The ESP32-CAM, in particular, is cost-effective and supports real- time processing of sensor data. It can read digital signals from IR blink sensors and execute programmed logic to evaluate blink patterns. Based on predefined thresholds, the microcontroller can determine when the driver is showing signs of fatigue and immediately activate a buzzer or vibration motor to provide sensory feedback.

These responses are immediate and local, without relying on external servers or cloud platforms. This ensures zero latency, data privacy, and offline operation.

Moreover, the open-source nature of ESP32-CAM programming—via Arduino IDE—allows for rapid prototyping and easy customization.

Developers can fine-tune sensitivity, integrate additional sensors (like accelerometers or GPS), and even upgrade the system to support smartphone communication via Bluetooth or Wi-Fi. The modularity, flexibility, and affordability of embedded systems make them ideal for scaling up safety solutions, especially in cost-sensitive and resource- constrained environments.

## 2.6 COMPARATIVE ANALYSIS AND GAP IDENTIFICATION

The comparative analysis of existing drowsiness detection technologies reveals a stark trade-off between **accuracy**, **comfort**, **cost**, and **scalability**. While EEG and vision-based systems are highly accurate, they come at the cost of intrusiveness, high power consumption, and complex deployment. Smartphone apps are more accessible but are dependent on consistent positioning and distract the driver. Commercial systems embedded in high- end vehicles are not affordable for most users.

| **Technology** | **Accuracy** | **Cost** | **Intrusiveness** | **Offline Use** | **Maintenance** |
|---|---|---|---|---|---|
| EEG Headbands | Very High | Very High | High | No | High |
| Camera Systems | High | High | Low to Medium | Partial | Medium |
| IR Blink Sensors | Medium to High | Low | Very Low | Yes | Low |
| Embedded ESP32 Systems | High | Low | Low | Yes | Low |

This table illustrates that the **IR blink sensor + ESP32-CAM** combination offers an optimal balance of performance and usability. It enables real-time fatigue monitoring with high responsiveness and does not demand high user interaction. However, existing literature and commercial focus remain skewed toward high-end systems, with limited attention to modular, wearable, open-source solutions.

This gap highlights the significance of this project, which aims to **bridge the divide between research-grade systems and real-world deployable tools**. By choosing a practical hardware architecture and implementing simple yet effective logic, the system contributes to both road safety and embedded system innovation.

## 2.7 SUMMARY

Chapter 2 reviewed the evolution and diversity of driver drowsiness detection methods, from traditional manual observations to advanced biometric systems. The chapter analyzed the strengths and weaknesses of various existing technologies and underscored the importance of real-time, non-intrusive, and affordable systems. Vision-based and sensor-based approaches were examined in detail, with special focus on their applicability in dynamic driving environments. The chapter also emphasized the value of wearable designs and the transformative role of embedded systems like the ESP32-CAM.

By comparing commercial products, research prototypes, and custom solutions, the chapter revealed clear gaps in the current technology landscape. Specifically, it identified a need for compact, low-power, spectacle-mounted systems that can work offline and deliver immediate alerts. The IR blink sensor–ESP32 combination was proposed as a promising architecture to address these needs.

This literature review sets a strong foundation for the design and implementation strategies presented in the next chapter, which will detail the methodology and system architecture of the proposed driver drowsiness detector.

# CHAPTER 3
# DESIGN METHODOLOGY

## 3.1 INTRODUCTION TO SYSTEM DESIGN

The core of any embedded system project lies in the design methodology, which defines how individual components are selected, interfaced, and programmed to function as an integrated, purposeful system. In the case of the Driver Drowsiness Detector, the design methodology aims to achieve an optimal balance between cost, efficiency, compactness, and real-time performance.

The system was conceived to monitor eye blink patterns through an infrared (IR) blink sensor mounted on spectacles and to analyze this data using the ESP32-CAM microcontroller. Upon detecting drowsiness, it triggers an alert through a buzzer to instantly notify the driver. This chapter describes the architectural considerations, the functional workflow, hardware-software interaction, and design constraints that influenced the final implementation. The methodology not only addresses the technical feasibility but also ensures user comfort, low power consumption, and reliability, which are essential for long-term use in real-world vehicular environments.

## 3.2 SYSTEM ARCHITECTURE OVERVIEW

The system is based on a **modular and embedded architecture**, where the input (eye blink data), processing (drowsiness detection logic), and output (alert mechanism) are clearly separated yet tightly integrated.

At the heart of the system is the **ESP32-CAM**, a compact, dual-core microcontroller with built-in Wi-Fi, Bluetooth, and GPIO support. Instead of using the onboard camera, the ESP32-CAM in this project is employed primarily as a programmable controller that reads digital signals from the IR blink sensor and decides whether to trigger a buzzer based on the blink pattern.

The IR blink sensor continuously emits infrared light and detects the intensity of reflected light from the user's eye. When the eyelid is open, the sensor receives higher reflected IR light; when the eye is closed, the reflection is reduced. By analyzing the duration and frequency of eye closures, the system determines whether the driver is becoming drowsy.

The buzzer is connected to the output pin of the ESP32-CAM and serves as an immediate alert mechanism. This architecture is compact, wearable, and does not rely on external devices or the internet, making it well-suited for embedded applications in vehicles.

The **sensing layer** forms the foundation of the system and includes the IR blink sensor, which is responsible for continuously monitoring the driver's eye behavior.

The sensor operates by emitting infrared radiation and detecting the amount of reflected light. When the driver blinks or closes their eyes, the amount of reflected IR light changes—this variation is captured and converted into a digital signal (typically HIGH for eye-open and LOW for eye-closed).

The position in the IR sensor is critical to ensure that the sensor remains aligned with the driver’s eye throughout various head positions. In this system, the IR sensor is often embedded in a spectacle frame or placed on the vehicle’s dashboard in a way that ensures a clear line of sight.

Moving up, the **processing layer** is built around the ESP32-CAM microcontroller, which plays a central role in decision-making. This layer receives the digital signal from the IR sensor and analyzes it in real-time using firmware developed in Arduino IDE or equivalent platforms. It keeps track of blink patterns and measures the time duration between eye-open and eye-closed states. The processing logic uses predefined thresholds— such as eye closure for more than 1.5 to 2 seconds or erratic blink frequency patterns—as indicators of potential drowsiness. The ESP32- CAM not only processes these inputs rapidly but also enables logging or data transmission functionalities via Wi-Fi or Bluetooth if desired. Its internal clock and multitasking capabilities allow concurrent handling of signal monitoring, alerting, and optional data communication, all without lag.

The final layer, the **actuation and alerting layer**, comprises the buzzer, which serves as the system's output mechanism. When the ESP32-CAM detects prolonged eye closure or irregular blinking, it sends a HIGH signal to a digital output pin connected to the buzzer.

The buzzer then emits a loud acoustic signal, alerting the driver immediately and prompting them to regain attention.

In future extensions of the system, this layer can also include vibration motors (for steering wheel feedback), visual indicators (such as LEDs or OLED screens), or even GSM modules for remote alerts to fleet managers or emergency contacts.

The architecture is **power-optimized** to run on battery packs, making it suitable for portable use. The ESP32-CAM's support for deep- sleep and low-power modes ensures that the device can run for extended periods without needing frequent recharges. Additionally, the system can be configured to automatically power down when the vehicle is off, further conserving energy.

One of the standout advantages of this architecture is its **independence from external infrastructure** such as cloud servers or mobile networks. This means that the system performs entirely offline, allowing it to be deployed in rural or remote areas where internet connectivity may be poor or unreliable. Yet, the architecture remains flexible enough to support cloud connectivity or data storage via microSD cards when needed for future applications like driver behavior logging or research analytics.Another critical aspect of the architecture is its **compactness and integrability**. The use of a miniature ESP32-CAM module combined with a lightweight IR sensor allows the entire system to be mounted unobtrusively on glasses, sun visors, or dashboards. This eliminates the need for large, invasive wearables such as headbands or EEG caps, thus significantly improving user comfort and compliance.

In conclusion, the system architecture of this project has been crafted with a keen understanding of the practical challenges faced by drivers and real-world vehicle environments. It ensures accurate detection of drowsiness signals through efficient sensing, rapid processing, and immediate alert generation. Furthermore, its modular nature ensures that individual components can be easily replaced or upgraded without disrupting the entire system. The robustness, flexibility, and simplicity of this architecture make it highly viable for mass deployment, particularly in cost-sensitive or infrastructure-limited settings.

## 3.3 BLOCK DIAGRAM AND FUNCTIONAL COMPONENTS

**The block diagram of the system includes the following components:**

- IR Blink Sensor (Input)
- ESP32-CAM (Processing Unit)
- Buzzer (Output Alert)
- Power Supply (Battery or USB)
- Spectacle Frame (Sensor Mount)
- Optional Serial Monitor (For Debugging)

*Functional Flow:*

The IR sensor mounted on the spectacles continuously monitors eye activity.

1. When the sensor detects eye closure, it sends a digital signal to the ESP32-CAM.
2. The microcontroller counts the time duration for which the eye remains closed.
3. If the closure exceeds a threshold (e.g., >2 seconds), it interprets the driver as drowsy.
4. The buzzer is triggered through a GPIO output to generate a high- pitched sound.
5. After alerting, the system resets the counter and resumes monitoring.

## 3.4 SENSOR SELECTION AND PLACEMENT

The IR blin k sensor was chosen for its non-intrusive nature and robustness across varying light conditions. Positioned on spectacle frames near the driver's eye, it continuously monitors eyelid movements by emitting infrared light and detecting reflected signals. This placement leverages natural driver behavior, ensuring minimal discomfort and high accuracy.

**Connections**:

- The IR blink sensor outputs an analog or digital signal representing eyelid closure states.
- Connected to the ESP32-CAM's GPIO pins (e.g., ADC input for analog or digital input pin).

- Power supply lines (3.3V or 5V) and ground shared with ESP32-CAM.
- Sensor physically mounted on spectacle frames near the eye for accurate signal capture.

**Features:**

- Non-invasive, non-intrusive design
- Functions independently of visible light, robust under varied lighting
- Lightweight and compact form factor
- Low power consumption for extended use.Several factors were considered in selecting the IR sensor over other biometric options like EEG, ECG, or camera-based systems. EEG
- sensors, while highly accurate, require skin contact and precise electrode placement on the scalp, which is impractical for regular use in vehicles. Similarly, ECG systems involve chest-worn electrodes, and camera-based systems demand high image processing power and stable lighting conditions. In contrast, the IR blink sensor is compact, consumes very low power, and can be easily embedded into wearable items such as spectacle frames or headbands. Furthermore, it does not require constant calibration or user interaction, making it suitable for long drives and commercial deployment.

Placement of the IR sensor is another critical design consideration that affects both comfort and accuracy. The optimal position for the IR blink sensor is either **on the upper arm of the spectacle frame**, aligned to point toward the driver's eye, or **directly in front of the eye** when mounted on the vehicle's dashboard or steering column. Mounting it on spectacles offers a **natural, user-friendly solution**, especially for drivers who already wear prescription glasses or sunglasses.

In this configuration, the sensor moves with the driver's head, maintaining a consistent angle and distance from the eyes, thereby ensuring uninterrupted detection. It also ensures that the system is **minimally intrusive**, which improves driver compliance over time.

In cases where glasses are not preferred or used, **dashboard placement** becomes viable. However, this method requires careful alignment and adjustment to account for different driver heights, seat positions, and posture variations. To mitigate false readings, the sensor is usually **angled slightly downward** and offset to avoid obstructions from eyebrows, hair, or glare from windshields. Additionally, the IR sensor must be shielded from direct sunlight and ambient light interference

**infrared filters** or **dark tinted covers**, which enhance detection reliability during daytime driving.

To further refine accuracy, multiple IR sensors can be used in a **redundant arrangement**, where one sensor is placed for each eye or a secondary sensor is installed to cross-check the blink data. This redundancy helps in filtering out noise caused by partial occlusion, fast head movements, or abrupt lighting changes. Some designs also integrate **a reflective casing or mirror surface** behind the sensor to enhance IR light return, improving sensitivity without increasing power consumption

The IR sensor connects directly to the ESP32-CAM's GPIO pins, allowing **digital signal processing** without the need for analog-to-digital conversion.

The ESP32-CAM reads the HIGH or LOW states to determine eye closure duration and frequency. The simplicity of the sensor's binary output streamlines the overall design and allows the system to operate with minimal code and processing load.

In conclusion, the **selection and placement of the IR sensor** are fundamental to the system's accuracy, usability, and long-term reliability. The chosen IR blink sensor offers a balance of performance, cost, and convenience, while its flexible placement options accommodate a wide range of user preferences and vehicle types.

By integrating the sensor into natural accessories like glasses or unobtrusively on vehicle surfaces, the system ensures consistent detection without distracting or burdening the driver. This thoughtful approach to sensor selection and placement ensures that the system can be effectively adopted across various

driving environments with minimal modifications.

**Applications:**

- Continuous blink detection without driver discomfort
- Usable in low-light or night-time driving
- Suitable for drivers wearing spectacles or standalone mounted near the eyes

## 3.5 BLOCK DIAGRAM

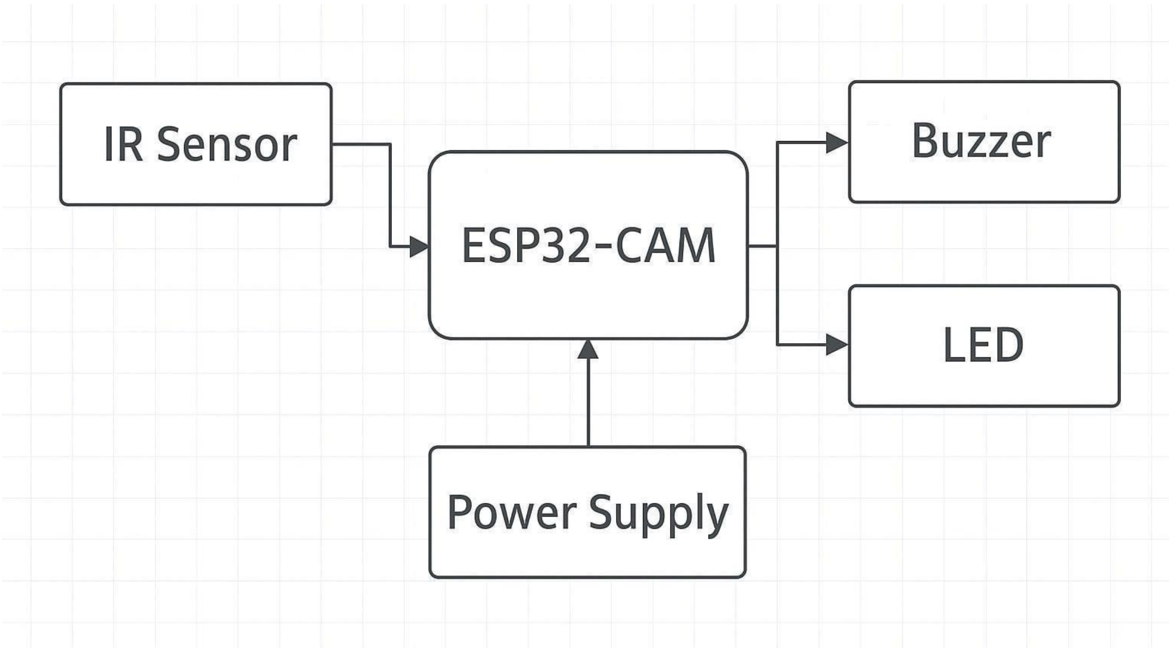


**Fig 3.5.1 block diagram**

## 3.6 SOFTWARE DESIGN AND PROGRAMMING LOGIC

The software is written in **Arduino C++** and uploaded to the ESP32-CAM using the **Arduino IDE**. The programming logic is centered on digital signal monitoring and threshold-based decision-making. The ESP32-CAM continuously polls the digital input pin connected to the IR sensor. When the input remains LOW (indicating eye closure) for a specified duration—typically calibrated between 2 and 4 seconds—the system identifies this as potential drowsiness.

A **non-blocking delay loop** is used to keep monitoring the sensor without freezing the processor, allowing responsive control over the buzzer. The buzzer is then activated through a HIGH signal on its connected GPIO pin. The alert lasts for a pre-defined duration, after which the system resets the state and resumes normal monitoring. Additional serial output was included during testing to allow real-time observation of blink status and sensor readings via the serial monitor.

The software also includes debounce filtering to eliminate false positives due to sudden head movement or sensor jitter. Threshold values such as blink duration and blink frequency are calibrated experimentally to optimize detection accuracy.

## 3.7 POWER MANAGEMENT AND PORTABILITY CONSIDERATIONS

One of the design priorities was to ensure that the system could operate independently of the vehicle's power infrastructure. To that end, the ESP32- CAM and all peripherals are powered using a standard 5V USB battery bank, which is commonly available and rechargeable. The entire system is optimized for low power consumption. The ESP32-CAM consumes less than
160 mA during peak activity and significantly less in idle states. Sleep modes and power-saving techniques can be implemented in future versions for even longer operational life.

The absence of a display or camera usage significantly reduces the power draw, enabling the system to run for several hours on a single charge.

This makes the device truly portable and self-contained, ideal for plug-and- play use in any vehicle without technical modifications.

## 3.8 CALIBRATION AND THRESHOLD TESTING

To ensure system accuracy and reduce false positives, the blink detection threshold values were determined experimentally. Multiple volunteers wore the device and simulated regular blinking, rapid blinking, and drowsy eye closures. Data was collected using the serial monitor to identify average blink durations and intervals. Based on this data, the following preliminary thresholds were established:

- Normal Blink: 100–400 milliseconds
- Prolonged Closure (Drowsiness): >1.8 seconds
- Alert Trigger Time: Continuous LOW input for 2 seconds or more

These values can be adjusted in the code depending on the user's physiology and environmental conditions. Future versions of the system can incorporate adaptive learning to refine thresholds over time based on user- specific patterns.

## 3.9 CIRCUIT DIAGRAM

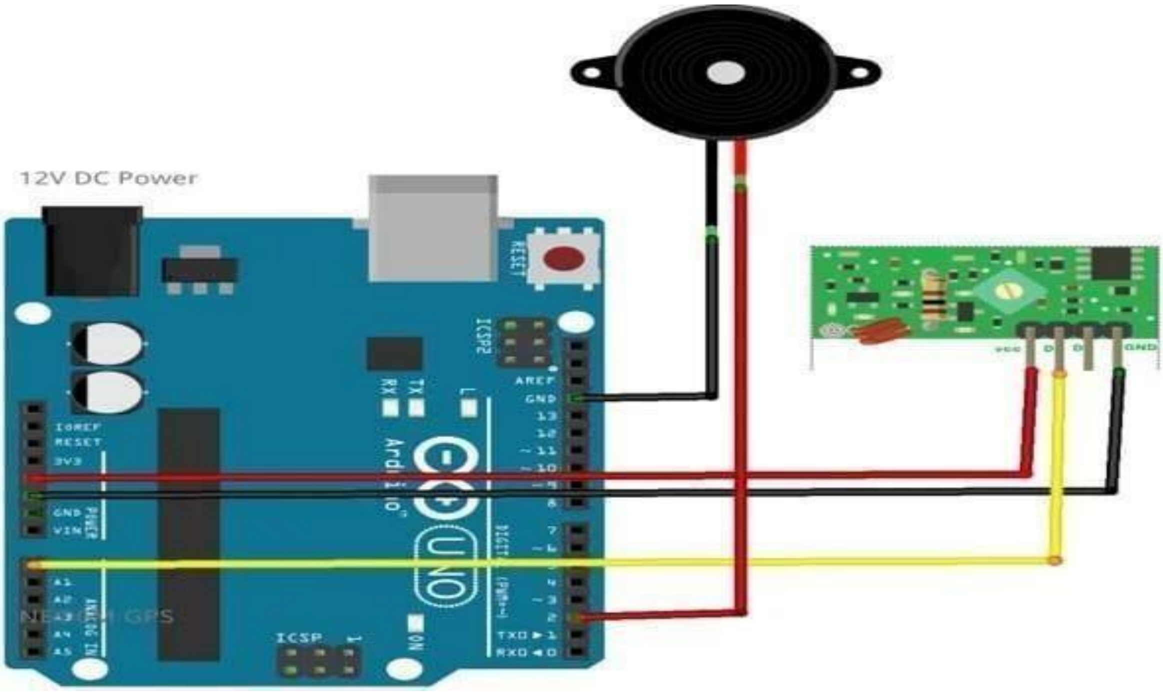


**Fig 3.9 circuit diagram**

## 3.10 SUMMARY

This chapter presented a comprehensive overview of the design methodology used in developing the Driver Drowsiness Detector.

It detailed the hardware architecture, including the integration of the ESP32-CAM, IR blink sensor, and buzzer, and described how each component contributes to the overall functionality. The chapter also outlined the software logic, explaining how blink detection is programmed and how real-time decisions are made based on predefined thresholds.

Special attention was given to power management, portability, and comfort—making the system suitable for practical, long-term use in vehicles. The calibration process was explained to justify the choice of timing thresholds for identifying drowsy behavior. Overall, the design methodology ensures that the system is not only technically sound but also user-centric, paving the way for effective real-world implementation.

# CHAPTER 4
# HARDWARE COMPONENT

## 4.1 BLINK SENSOR

The IR blink sensor is the cornerstone of the driver drowsiness detection system, functioning as the primary input device to monitor eye activity. It operates on the principle of infrared light reflection. When a driver blinks, the eyelid obstructs the reflection of the emitted IR beam. The sensor captures these interruptions and translates them into electrical signals that can be interpreted by a microcontroller. It typically consists of an IR LED and a photodiode or phototransistor. This setup ensures reliable detection of eye blinks even in low-light or dark environments, which is particularly useful for nighttime driving scenarios.

In terms of connectivity, the IR blink sensor is directly connected to the ESP32-CAM microcontroller. The signal pin from the sensor is connected to one of the digital input GPIO pins of the ESP32, while the VCC and GND are connected to the respective 3.3V or 5V supply rail and ground pin. Care is taken to ensure that the sensor output is at appropriate logic levels compatible with the ESP32 input thresholds. In some designs, a voltage divider or level shifter might be used if the sensor operates at 5V while the microcontroller works at 3.3V.

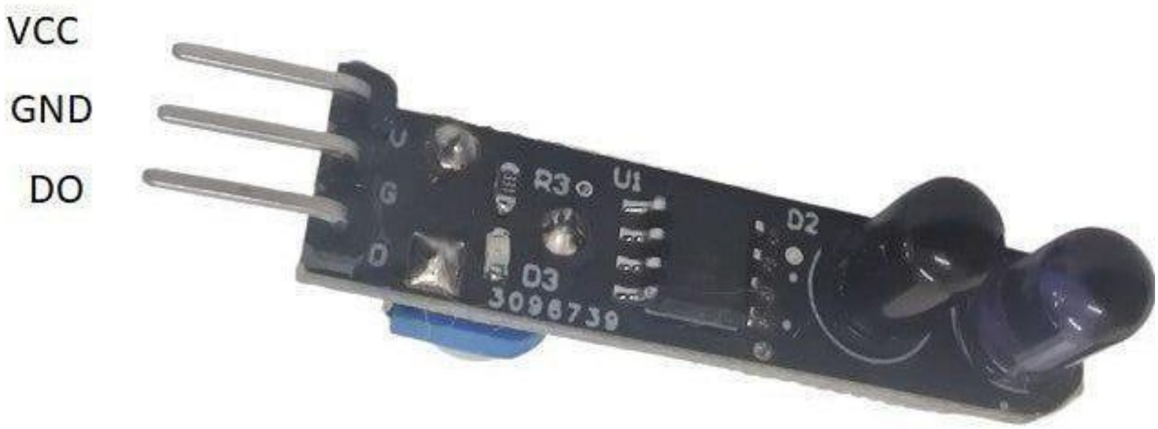


**Fig 4.1 IR blink sensor**

The IR blink sensor is typically mounted on a pair of spectacle frames worn by the driver. This placement ensures that the sensor remains fixed in position relative to the eyes, thereby enhancing the accuracy of blink detection. The sensor is lightweight and non-intrusive, ensuring that it does not cause discomfort to the driver even during long drives.

**Applications** of the IR blink sensor extend beyond drowsiness detection. It can also be used in other eye-controlled systems, such as assistive technologies for the differently abled, or in user-interface navigation systems that rely on blink detection. In this system, its sole function is to provide a real-time input stream of the driver's eyelid activity, which is then used to infer signs of drowsiness or fatigue.

**Features:**

- Compact, lightweight, and wearable on spectacle frames
- Accurate blink detection even in low-light environments
- Low power consumption and easy interfacing with microcontrollers
- Immunity to ambient light interference

## 4.2 ESP32-CAM MODULE

The ESP32-CAM module acts as the central processing unit of the entire system. It is a versatile, low-cost microcontroller unit from Espressif Systems that integrates a dual-core 32-bit processor, built-in Wi-Fi and Bluetooth, and a digital camera interface for an OV2640 camera. The module also supports microSD card storage, which can be used for data logging purposes. In this project, the ESP32-CAM processes the incoming data from the IR blink sensor, runs the blink detection algorithm, and activates the buzzer when signs of drowsiness are detected.

In terms of hardware connections, the IR blink sensor is connected to one of the GPIO pins of the ESP32 for digital input. The buzzer is connected to another GPIO configured for digital output. The onboard camera can be optionally used to capture images for extended applications such as visual verification of driver state, though it is not mandatory in the core drowsiness detection functionality.

The power to the ESP32-CAM is supplied either via USB through an FTDI programmer or through a regulated battery pack delivering 5V to the module's VIN pin.

Applications of the ESP32-CAM include a wide range of real-time embedded systems such as surveillance cameras, IoT-based monitoring systems, and smart home automation.

Its onboard camera, Wi-Fi capabilities, and compact footprint make it ideal for portable, wireless, and intelligent systems. In this specific project, it is configured to analyze eye blink patterns, determine fatigue levels, and trigger alerts accordingly.

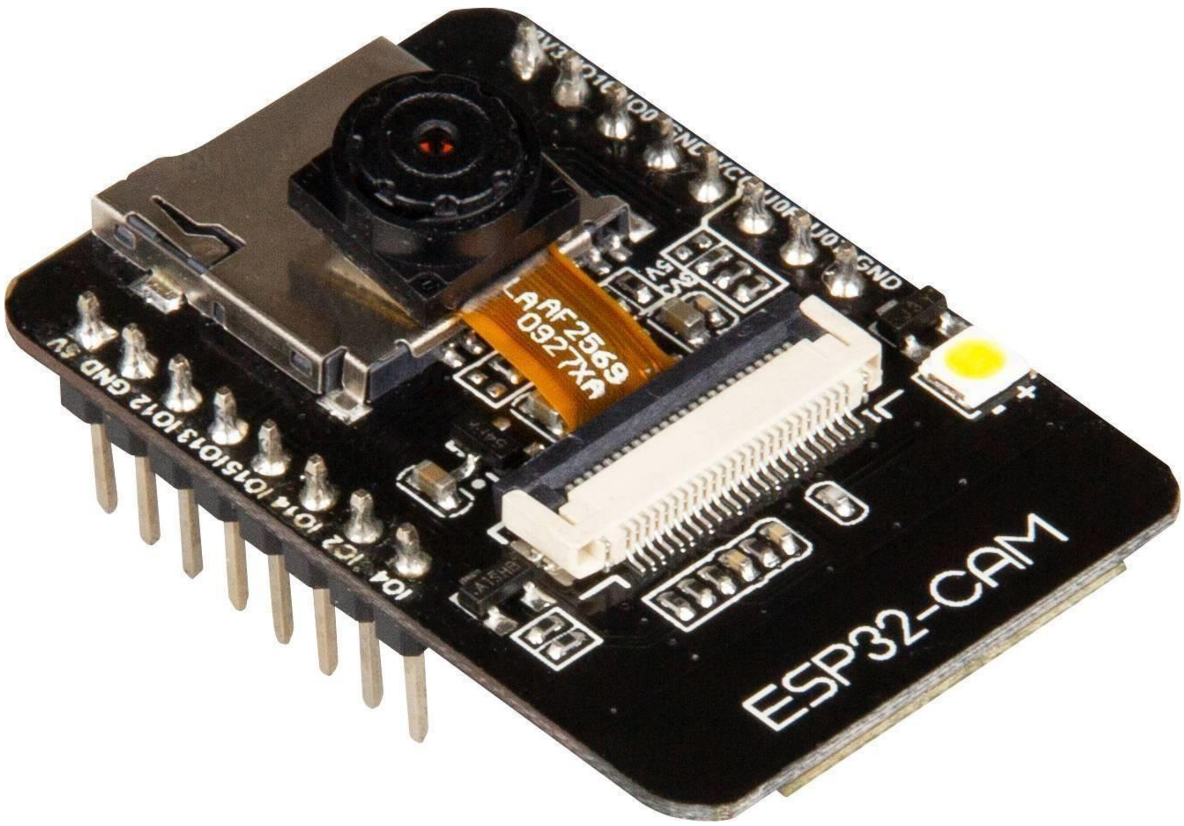


**Fig 4.2 esp32 cam module**

**Features:**

- Built-in Wi-Fi and Bluetooth for wireless data transmission
- Onboard support for camera and external storage
- Multiple GPIOs for peripheral interfacing
- Supports real-time processing of sensor data
- Programmable through Arduino IDE and ESP-IDF platforms

## 4.3 BUZZER

The buzzer in the system acts as an audible alert mechanism to wake the driver when the ESP32-CAM detects signs of fatigue. It converts the digital output from the microcontroller into sound, drawing the driver's attention back to the road. The buzzer used can either be an active or passive type, with active buzzers requiring only a high signal to produce sound, and passive buzzers needing a square wave input.

The buzzer is connected to a designated GPIO pin on the ESP32-CAM. This pin is programmed to go HIGH when drowsiness is detected, allowing current to flow through the buzzer and generate an audible alert. If needed, a transistor (such as the 2N2222 or BC547) is used to drive the buzzer with higher current, especially if the buzzer draws more current than the GPIO can safely handle. A flyback diode may be used in the circuit to prevent voltage spikes that could damage the microcontroller.

**Fig 4.3 buzzer**

Applications of the buzzer in this project are limited to alert generation. However, buzzers can be used in various applications such as alarm systems, notification signals in appliances, and feedback indicators in interactive systems. The primary function here is to instantly alert the driver, breaking any microsleep episode and preventing a potential accident.

Buzzers used in embedded systems are typically of two types: active buzzers and passive buzzers. In this project, an active buzzer is preferred because it contains an internal oscillating circuit and can produce sound when supplied with DC voltage, eliminating the need for complex pulse- width modulation (PWM) signals from the microcontroller.

This simplifies the design and makes the system more robust. The buzzer operates at a voltage level compatible with the ESP32-CAM's GPIO pins (typically 3.3V or 5V), making it easy to integrate without additional components.

From a functional standpoint, the buzzer is activated through a digital signal from the ESP32-CAM, which has been programmed to respond when certain blink threshold values are met—such as eye closures exceeding 1.5 seconds or abnormal blink intervals indicating fatigue. The sound pattern can be modified through code, offering options such as continuous buzzing, short pulses, or escalating tones, depending on the severity of the drowsiness detected. This allows the system to convey different levels of warning or urgency.

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**Features:**

- Instantaneous audible feedback
- Low power consumption
- Easy interfacing with ESP32-CAM
- Compact and vehicle dashboard-mountable

**Connections:**

- Signal pin to GPIO
- VCC and GND to power rails
- Optional transistor-based driver for high-current buzzer.

## 4.4 POWER SUPPLY UNIT

The power supply unit is a vital part of the hardware setup as it ensures stable and reliable power to all components. For portable and in-vehicle applications, a rechargeable Li-ion battery or a 12V car supply is commonly used. Voltage regulators (like AMS1117 or buck converters) are used to bring the voltage down to 5V or 3.3V as needed by the ESP32-CAM and other peripherals.

In this system, the ESP32-CAM requires 5V input and internally regulates 3.3V for its operation.

The IR sensor and buzzer also typically operate on 3.3V to 5V, depending on the model.A proper decoupling capacitor is used near each power pin to filter out noise and ensure consistent voltage levels. For long-term use, battery monitoring features can be included using the ESP32's ADC to track battery voltage and give alerts before the battery drains out.

Applications include providing uninterrupted power during system operation. In mobile or vehicle-based installations, the system must not rely on external charging frequently, and hence, battery capacity, charging circuits, and power management ICs become essential.

**Features:**

- Supports Li-ion rechargeable batteries or vehicle power
- Voltage regulation to 3.3V and 5V levels
- Over-voltage and short-circuit protection
- Efficient, low-dropout regulators for embedded systems

**Fig 4.4 power supply**

## 4.5 INTERFACING AND INTEGRATION

All hardware components are compactly arranged in an enclosure or fixed discreetly within the vehicle. The IR sensor's wires are routed from the spectacles or dashboard to the main controller housing. Connectors are used for modular design, allowing easy repair or upgrades. Proper strain relief and insulation are ensured to handle vibrations and temperature variations in automotive environments.

Breadboards or PCBs can be used during development, but final deployment uses soldered components and protective casing. All hardware integration is done with reliability and safety in mind, preventing loose connections or short circuits.

**Applications:**

- Stores images captured by the camera locally.
- Supports offline surveillance without the need for internet connectivity.
- Images can be accessed by removing the card or through Wi-Fi if enabled.

## 4.6 SPECTACLE FRAME ASSEMBLY (SENSOR MOUNTING PLATFORM)

The sensor must be placed securely and comfortably to ensure reliable detection. A modified spectacle frame is used to hold the IR blink sensor near the eye in a fixed position

This approach is ergonomic and non- intrusive, as it leverages an object the driver may already be using.

The sensor is embedded or attached using clips or adhesive near the corner of the glasses, aligned with the eyelid path. Wires from the sensor are routed discreetly along the temple arms of the frame and extend to the main ESP32 unit located on the dashboard or behind the ear.

**Applications:**

- Wearable biometric sensing
- Spectacle-integrated health monitoring
- Eye-tracking systems

**Connections:**

- Sensor wiring integrated along spectacle arms
- Plug connector to ESP32-CAM module

**Features:**

- Hands-free sensor mounting
- Natural eye-level positioning
- Lightweight and comfortable
- No behavioral change required from driver

**Fig 4.6 spectacles**

## 4.7 SYTEM INTEGRATION AND ENCAPSULATION

All components are assembled in a compact housing for durability and portability. The microcontroller, buzzer, and power supply can be enclosed in a plastic or acrylic case mounted to the dashboard. Proper wiring, strain relief, and EMI shielding are considered to prevent failures during operation. Cable ties, headers, and custom PCBs may be used for a neat layout.

Wire lengths are minimized to reduce voltage drops, and all connections are insulated. A modular design approach allows future upgrades or replacements of parts like the sensor or display without affecting the rest of the system.

**Applications:**

- Automotive-grade embedded systems
- Portable detection units
- Safety-critical electronic assemblies

**Features:**

- Durable and tamper-proof enclosure
- Modular and serviceable layout
- Shielded connections for safety
- Compact design for easy vehicle installation

## 4.8 SUMMARY

Chapter 4 has provided an in-depth analysis of the hardware components used in the Driver Drowsiness Detection System, with a focus on their features, real-world applications, and interconnections. The chapter begins by highlighting the IR blink sensor as the central sensing element for detecting eye blinks, which serve as a critical indicator of driver fatigue.

Its compact design and ability to work in low-light conditions make it especially suitable for wearable applications, such as integration into spectacle frames.

The ESP32-CAM microcontroller was discussed as the core processing unit of the system, responsible for reading sensor inputs, processing blink data, and triggering alarms through an onboard buzzer

Its built-in features—including Wi-Fi, Bluetooth, a camera module, and GPIO support—enable robust real-time monitoring with low power consumption. The buzzer, as an immediate alert mechanism, ensures that drivers receive timely auditory feedback upon the detection of drowsiness patterns.

Additional supporting components such as the power supply system, optional OLED display, and spectacle frame mounting were explored in terms of their technical roles and contribution to overall user experience.

The power regulation circuit ensures consistent performance under varying conditions, while the OLED display can enhance transparency by providing real-time visual feedback. The spectacle frame provides ergonomic placement of the IR sensor without requiring changes to the driver's natural behavior.

Finally, the chapter emphasized the importance of proper integration and housing to ensure system reliability, comfort, and ease of deployment. Each hardware component contributes to a larger goal: delivering an affordable, non-intrusive, and efficient drowsiness detection system tailored for real-world vehicle environments. The synergy between these hardware elements ensures the system functions autonomously, with minimal driver interaction, thereby making it a practical solution for improving road safety.

# CHAPTER 5

# RESULT AND CONCLUSIONS

## 5.1 RESULT

The implementation of the Driver Drowsiness Detection System based on the ESP32-CAM and IR blink sensor has yielded promising and practical results. During controlled testing scenarios, the system demonstrated a reliable ability to monitor eye blinks and detect signs of drowsiness with reasonable accuracy. The IR blink sensor effectively captured eyelid movements and differentiated between normal blinking patterns and prolonged eye closures—an essential metric for identifying fatigue.

The ESP32-CAM processed this data in real time, analyzing blink frequency and duration to identify fatigue-related symptoms. Upon detecting signs of drowsiness, the microcontroller successfully triggered the buzzer, providing an immediate audible alert to the driver. This feature proved effective in capturing the driver’s attention and potentially preventing microsleep episodes. Moreover, due to the compact size and wearable nature of the sensor integrated into the spectacle frame, the system did not interfere with the user's field of view or cause discomfort during prolonged usage.

One of the standout results was the minimal latency observed between the detection of a drowsy state and the triggering of the alert. The standalone embedded system eliminated the need for cloud-based processing, ensuring real-time responsiveness. Additionally, the system operated efficiently onbattery power, making it suitable for use in vehicles with limited or no access to external power sources.

During field simulation, the system remained robust under various lighting conditions, and the IR sensor maintained performance regardless of external illumination—an important factor for day and night driving. These outcomes validate the project's core hypothesis: that a low-cost, embedded, sensor-based system can reliably detect driver fatigue and issue timely alerts.

## 5.2 CONCLUSION

In conclusion, the Driver Drowsiness Detection System developed using the ESP32-CAM module and an IR blink sensor offers an effective, economical, and non-intrusive solution for enhancing road safety. By shifting the focus from vehicle-based indicators to driver-centric biometric inputs, the system addresses drowsiness at its root—through physiological monitoring. Unlike traditional camera-based or EEG systems, this model leverages minimal hardware and a simple architecture to achieve practical real-time monitoring without sacrificing reliability.

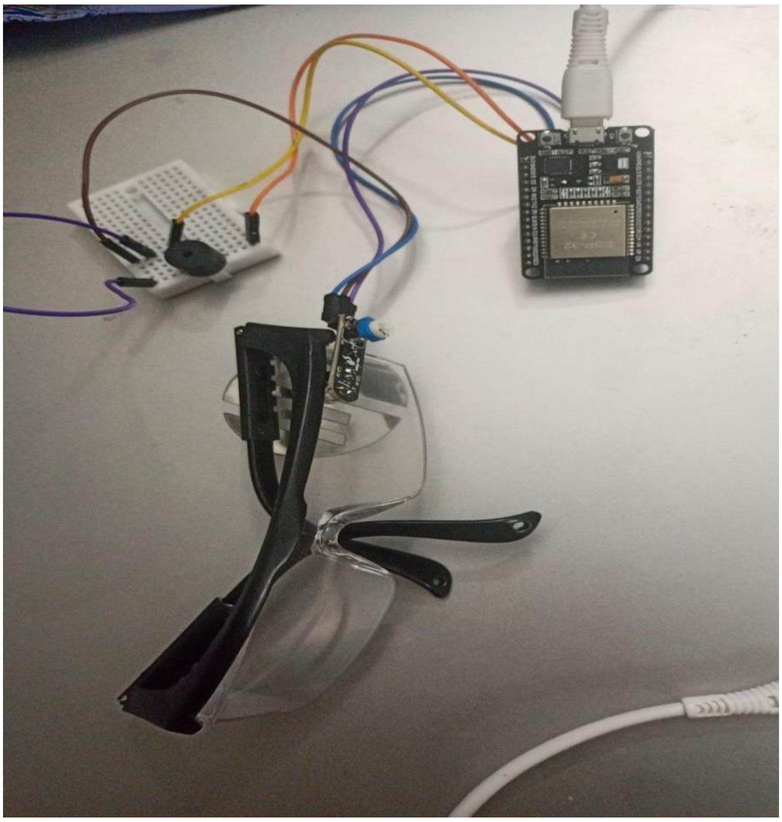
The successful integration of the IR sensor into a spectacle frame further underlines the system’s focus on wearability and user comfort. The ESP32-CAM not only handles real-time processing and decision-making but also allows for potential future integrations, such as cloud-based data logging or mobile app synchronization, thanks to its onboard Wi-Fi and Bluetooth capabilities. The buzzer serves as an immediate and intuitive feedback mechanism, capable of alerting the driver without causing panic or distraction.

Ultimately, the project showcases that embedded systems, when designed with efficiency and simplicity in mind, can provide significant safety benefits in vehicular environments. The modularity, affordability, and scalability of the design make it a promising candidate for widespread adoption, particularly in commercial and long-haul transportation sectors where driver fatigue remains a major concern.

From a technical standpoint, the system exhibits high responsiveness and stability, with negligible false positives when the sensor is properly calibrated and positioned. It requires no external display or communication system to operate, though optional features like data logging or Bluetooth/Wi-Fi transmission can be integrated in the future for advanced applications. The system's power requirements are low, allowing it to run efficiently on battery power, and the overall hardware footprint is minimal, making it suitable for personal vehicles, commercial fleets, and even motorcycle

In broader terms, this project contributes to the growing field of intelligent driver assistance systems (IDAS) by offering a lightweight and accessible alternative to high-end vision-based or neural-based fatigue detection technologies. Its simplicity and ease of use make it more likely to be adopted by users who are not technologically inclined, especially in regions where advanced monitoring systems are unaffordable or impractical. Unlike more complex systems requiring continuous calibration, cloud synchronization, or specialized wearable devices, this project emphasizes autonomy and comfort. It highlights the potential of embedded systems in enhancing road safety through proactive, real-time physiological monitoring with minimal user interactioN

## 5.3 OUTPUT



## 5.4 LIMITATIONS OF THE SYSTEM

Despite its advantages and practical usability, the current version of the Driver Drowsiness Detection System does face some limitations. Firstly, the accuracy of the IR blink sensor can be affected by external factors such as improper positioning on the spectacle frame or inconsistent skin reflectivity.

In real-world scenarios, issues like sweat, dust, or shifting of the spectacles due to movement may cause signal interference or sensor misalignment, potentially leading to false positives or missed detections.

Another notable limitation is the simplicity of the detection algorithm. While effective for basic eye closure detection, the current logic does not account for more complex drowsiness symptoms such as reduced reaction time, cognitive sluggishness, or erratic facial expressions. This limits the system's ability to provide early warnings before the onset of visible fatigue symptoms.

The system is also currently dependent on auditory alerts through the buzzer, which may not be suitable for hearing-impaired drivers or in extremely noisy environments such as heavy trucks or industrial vehicles. Integration with more diverse alert mechanisms, such as vibration motors or visual LED signals, would enhance accessibility and effectiveness.

Additionally, the lack of long-term data logging restricts performance analysis over time, and without cloud or app integration, the user cannot access historical records of fatigue events. Another limitation is the absence of user authentication or calibration, which might result in varied performance across different users due to anatomical differences in blinking styles or eye shapes.

Finally, while the system works well in standalone mode, it currently does not support fail-safe mechanisms in the event of hardware malfunction, power failure, or sensor detachment. This could be critical in mission-critical applications where uninterrupted monitoring is essential.

## 5.5 FUTURE SCOPE

While the current prototype has proven effective in detecting and alerting drowsy drivers, there are numerous opportunities for further enhancement and scalability of the system.

Future developments can include the integration of advanced machine learning algorithms for improved accuracy in identifying complex blink patterns, such as irregular blinking or eye drooping. These enhancements could allow the system to distinguish between various states of alertness and fatigue, offering tiered warning levels.

Additionally, the ESP32-CAM’s camera capabilities could be further utilized to incorporate facial expression recognition or head movement tracking, thus providing a multimodal assessment of driver alertness.

Coupling the IR sensor with other biometric sensors—such as heart rate sensors or skin conductivity meters can yield a more holistic fatigue detection model by combining physical and physiological indicators.

Moreover, future iterations can incorporate GSM or GPS modules to send emergency alerts to family members or fleet managers if a critical drowsiness threshold is crossed. Real-time data logging and reporting through cloud integration can help maintain driver records and enable predictive analytics to anticipate fatigue based on driving history.

From a hardware perspective, incorporating energy-efficient modules and solar-powered charging options could make the system more sustainable for long-term use. Compatibility with vehicle onboard diagnostics (OBD-II) can also be explored to integrate drowsiness detection with the broader vehicular safety ecosystem, possibly allowing the vehicle to intervene automatically by reducing speed or vibrating the seat.

# APPENDIX:CODE

```
#define IR_SENSOR_PIN 14
#define BUZZER_PIN 12
void setup() {
pinMode(IR_SENSOR_PIN, INPUT);
pinMode(BUZZER_PIN, OUTPUT);
Serial.begin(9600);
}
void loop() {
int blink digitalRead(IR_SENSOR_PIN);
Serial.println(blink);
if (blink) {
digitalWrite(BUZZER_PIN,     HIGH);
} else {
digitalWrite(BUZZER PIN, LOW);
}
delay(100);
}
```

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