Driver Drowsiness Detection System

Snehasree Senthilkumar (22BEE0163)

Vellore Institute of Technology

Industrial Applications of Microcontrollers - A Practice Based Approach

Introduction:

Driver fatigue and drowsiness are among the leading causes of road accidents globally, accounting for a significant proportion of fatalities and injuries. Extended driving hours, monotonous routes, and insufficient rest contribute to a decline in driver alertness, compromising reaction times and decision-making abilities. This problem is not confined to personal vehicles but is of particular concern in industrial contexts, such as transportation fleets, logistics operations, and heavy machinery operations, where safety and operational efficiency are paramount.

There is a pressing need for an embedded system that can proactively monitor signs of driver drowsiness and provide immediate alerts, thereby mitigating potential hazards and enhancing overall road and workplace safety. Such a system will help prevent accidents and support compliance with occupational safety regulations, as well as better monitoring.

Scope of Solution:

The proposed system is designed to implement a microcontroller-based drowsiness detection and alert mechanism, specifically tailored for industrial and commercial vehicular applications.

Key features of the solution include:

- An ESP8266 microcontroller integrated with an infrared sensor module that continuously monitors the driver's eye activity, enabling the detection of abnormal or prolonged eye closures that are indicative of drowsiness or fatigue.
- An immediate audible alert mechanism, facilitated by a buzzer, which is activated upon detection of such events to promptly notify the driver and encourage the restoration of attention.
- Simultaneous real-time and wireless data transmission to the ThingSpeak IoT platform, where instances of driver inactivity are systematically logged in a time-stamped CSV format. This enables efficient and comprehensive remote monitoring of individual drivers or entire fleets.

This solution is versatile, supporting deployment in both standalone vehicles and large-scale fleet operations. It enhances operational safety by enabling proactive intervention and facilitates compliance with safety protocols in industrial environments where continuous monitoring of driver alertness and cargo security is critical.

This solution provides a foundational platform that can be further extended with additional sensors (e.g., heart rate, steering behaviour) and additional alerting features (e.g., triggered call to emergency contacts when the driver's drowsiness is detected) to build comprehensive driver monitoring systems in industrial environments.

Components Required:

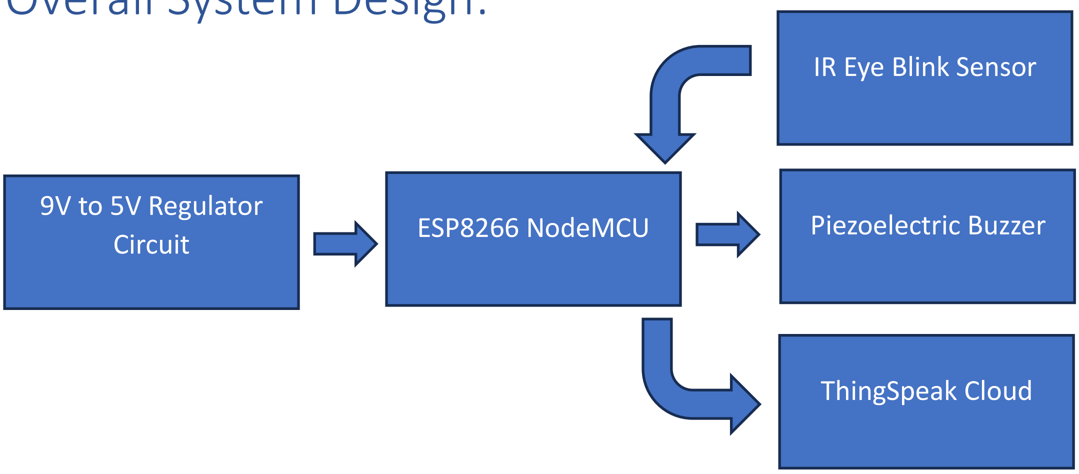
Hardware Components:

S.No	***Component Name***	***Quantity***
1	ESP8266 NodeMCU Module	1
2	Infrared Eye Blink Sensor Module	1
3	Piezoelectric Buzzer	1
4	LM7805 Voltage Regulator IC	1
5	9V Battery	1
6	10 uF Capacitor	2
7	Transparent Goggles	1
8	Breadboard	1
9	Connecting Wires	As Required

Software Requirements:

S.No	Software Name	Libraries Included
1	Arduino IDE	ESP8266WiFi.h WiFiClient.h
2	KiCAD (PCB Design)	-
3	Fritzing (Simulation)	-
4	ThingSpeak (by MathWorks)	-
5	Excel/Google Sheets	-

Overall System Design:



The proposed system is designed around the ESP8266 microcontroller, serving as the central processing and communication unit. It was chosen due to it's in-built wi-fi module which enables development of IoT applications. A high-level block diagram of the system is shown above.

Functional Overview:

Power Supply:

A 9V battery is regulated down to a stable 5V using an LM7805 voltage regulator circuit, ensuring safe and reliable operation of the ESP8266 module.

Sensing:
An infrared eye-blink sensor is interfaced with the ESP8266 to continuously monitor the driver's eye activity. Prolonged eye closures indicative of drowsiness are detected through digital signals from this sensor.

Alert Mechanism:
Upon detection of abnormal eye closure duration, the ESP8266 activates a buzzer to generate an immediate audible alert, prompting the driver to regain attention.

IoT Data Logging:
Simultaneously, the ESP8266 establishes a Wi-Fi connection and publishes event data to the ThingSpeak cloud platform. Each instance is time-stamped and stored, enabling remote monitoring and historical analysis of driver alertness.

Primary Sensor System:

Below is the Fritzing circuit diagram of the primary sensor system, comprising of ESP8266 NodeMCU, infrared eye blink sensor, piezoelectric buzzer, all powered through a regulated 5V supply given to the Vin pin of the ESP8266 (given by yellow wire).

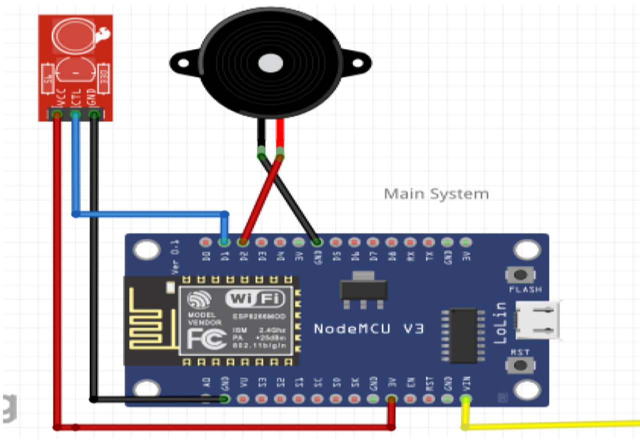


Figure 1: Fritzing Circuit Diagram of the Primary System

Microcontroller Unit (ESP8266 NodeMCU)

The **ESP8266 NodeMCU** serves as the central controller, handling input from the eye-blink sensor, executing the detection logic, and triggering the buzzer when drowsiness is detected. It also manages Wi-Fi connectivity to upload event data to the ThingSpeak cloud for remote monitoring.

Infrared Eye-Blink Sensor

The system employs an infrared (IR) eye-blink sensor module to monitor the driver's eye activity in real time. This sensor operates on the principle of detecting variations in reflected infrared light from the eye surface. When the eyelids close, the characteristics of the reflected IR signal change significantly, producing a high digital output. This output is directly interfaced with the ESP8266, enabling the system to effectively determine the duration of eye closures.

Audible Alert Mechanism (Buzzer)

A **piezoelectric buzzer** provides an immediate audible alert when prolonged eye closure is detected, prompting the driver to regain focus. This real-time warning helps reduce the risk of accidents caused by drowsiness.

Below is the KiCAD schematic of the main system:

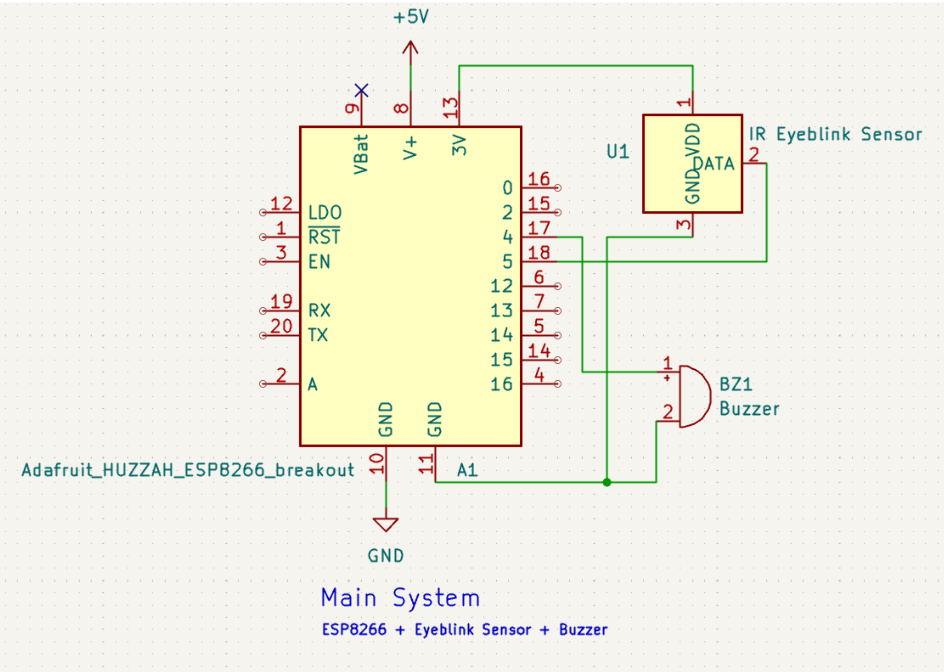


Figure 2: KiCAD Schematic of the Primary Sensor System

ThingSpeak IoT Cloud Platform

To enable comprehensive remote monitoring and data analysis, the system integrates with the ThingSpeak IoT cloud platform. Whenever a drowsiness event is detected, the ESP8266 transmits relevant data—including event occurrence and timestamp—over Wi-Fi to a dedicated ThingSpeak channel. This data is systematically logged and can be exported in CSV format for further review. Such cloud-based data management facilitates real-time fleet or driver oversight and provides valuable historical records that can support safety audits and operational decision-making within industrial or commercial transportation contexts.

Below is the way in which data regarding drowsiness activity is logged and exported as a CSV file, opened in Microsoft Excel. The time-stamp is in UTC (Coordinated Universal Time), which is the international standard. This makes monitoring driver activity more accessible and effective.

created_at	entry_id	field1
2025-07-04 06:55:10 UTC	1	Drowsiness Detected
2025-07-04 06:55:36 UTC	2	Drowsiness Detected
2025-07-04 06:58:24 UTC	3	Drowsiness Detected
2025-07-04 06:59:44 UTC	4	Drowsiness Detected
2025-07-04 07:00:14 UTC	5	Drowsiness Detected
2025-07-04 07:01:16 UTC	6	Drowsiness Detected
2025-07-04 07:01:52 UTC	7	Drowsiness Detected

Figure 3: Screenshot of the exported CSV file from ThingSpeak

Power Supply System:

The system is powered by a 9V battery, which is regulated down to a stable 5V using an LM7805 voltage regulator circuit. To enhance voltage stability and filter out transients, two 10 µF electrolytic capacitors are placed at the input and output ends of the regulator. Additionally, a heat sink is mounted on the LM7805 to dissipate excess heat, ensuring reliable performance under continuous operation. This design provides consistent power to the ESP8266, sufficient to support the Wi-Fi spikes, and connected peripherals, making it suitable for integration into vehicular environments.

Below is the KiCAD Schematic for the power supply system, followed by the Fritzing simulator connections:

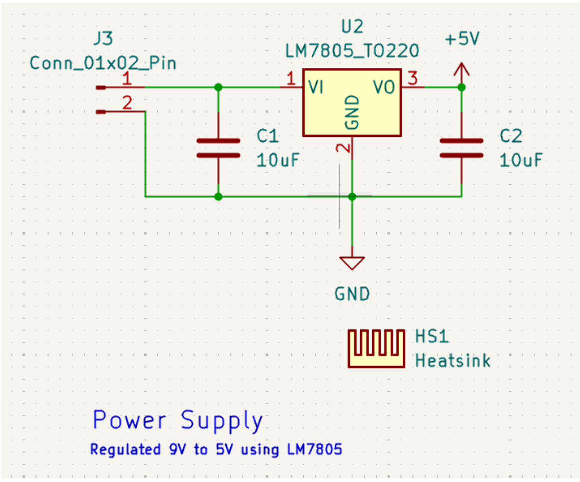


Figure 4: KiCAD Schematic of the Power Supply

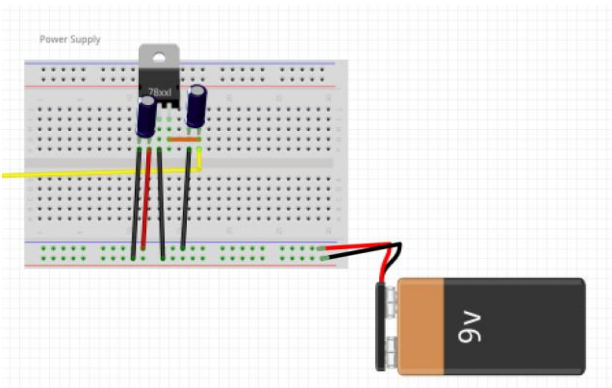


Figure 5: Fritzing Circuit Diagram of Power Supply

The final prototype developed and tested in hardware is as shown below:

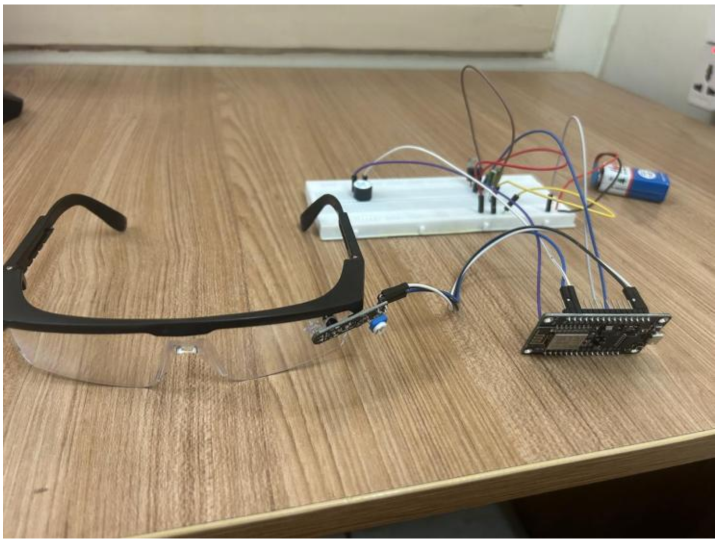


Figure 6: Hardware Prototype Successfully Tested

PCB Design:

After finalizing the circuit design, detailed schematics were created. To simplify assembly and improve mechanical durability, all components were chosen as through-hole devices. Power distribution traces were designed with increased width to minimize voltage drop and resistive losses, while signal traces were kept narrow and as short as possible to reduce parasitic capacitance and maintain signal integrity. Careful consideration of trace geometry and strategic component placement ensured reliable operation without compromising the compact footprint of the board.

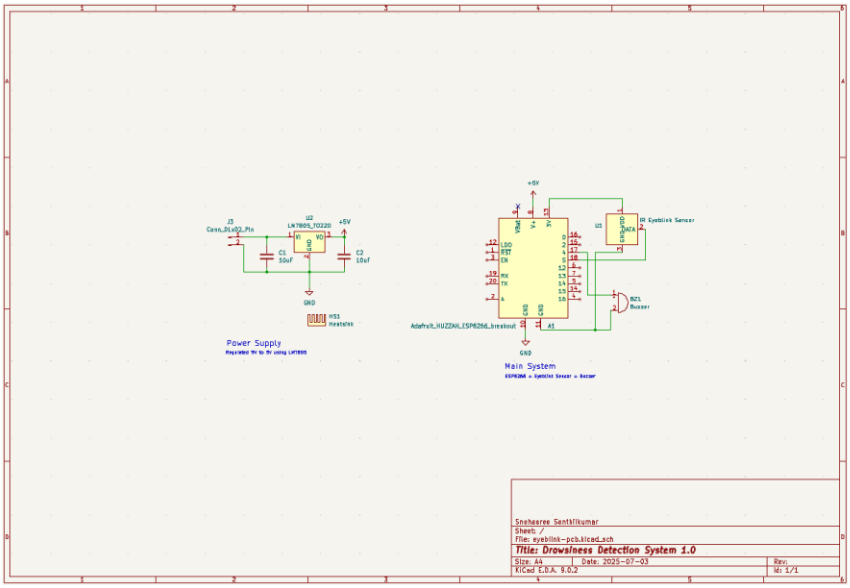


Figure 7: Complete Schematic Diagram of the Driver Drowsiness Detection and Alert System PCB

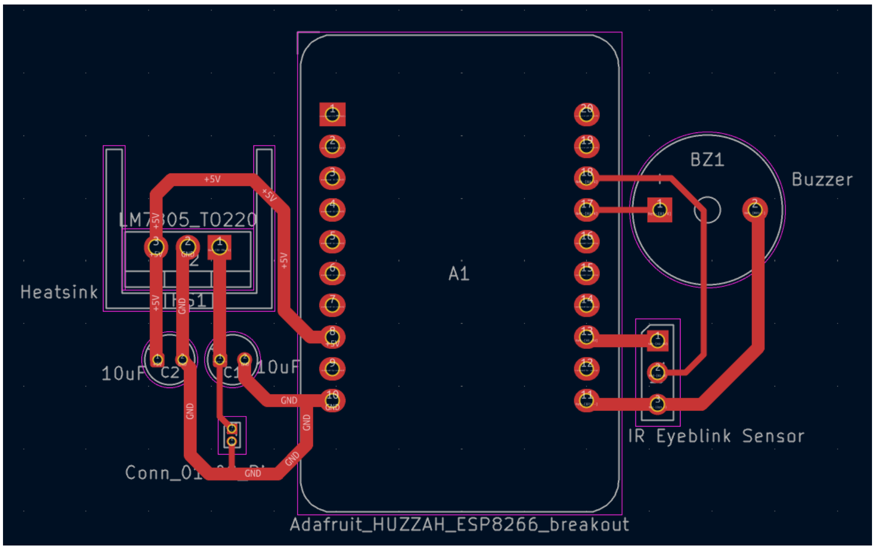


Figure 8: PCB Design

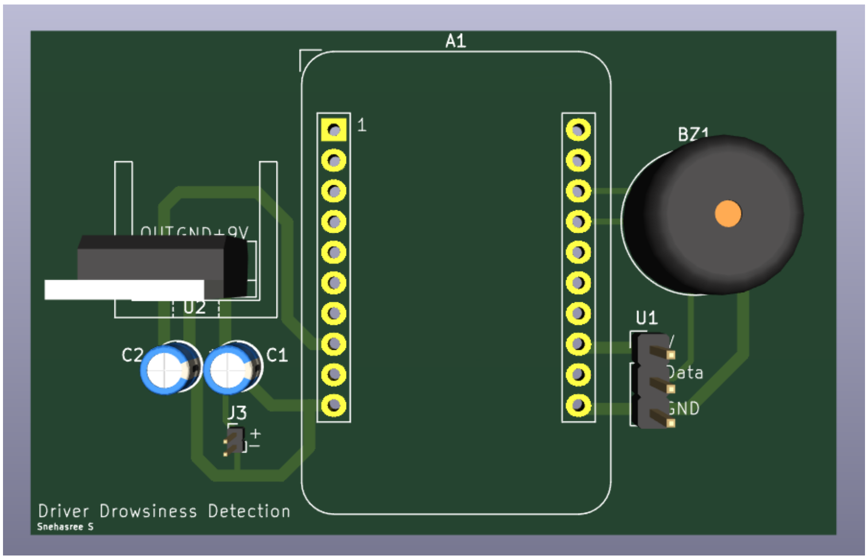


Figure 9: Top View of the 3D PCB

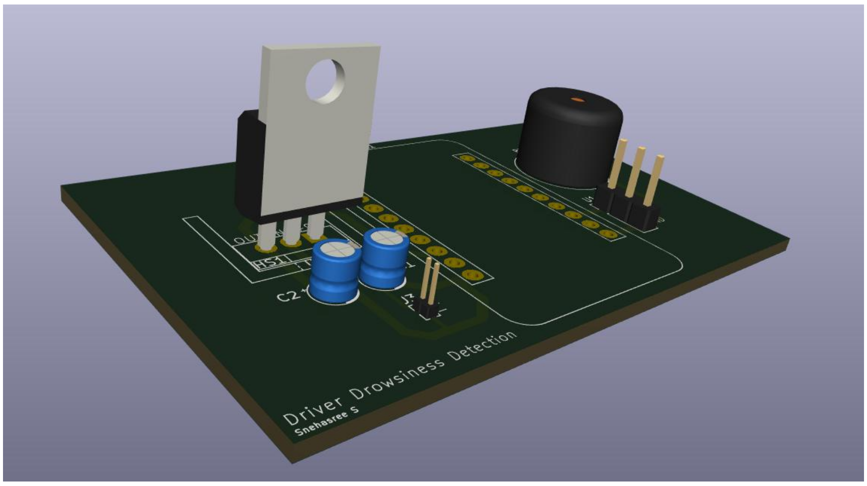


Figure 10: Side View of the 3D PCB

Conclusion

This project successfully demonstrates a cost-effective embedded solution for detecting driver drowsiness using an infrared eye-blink sensor integrated with an ESP8266 microcontroller. The system reliably triggers an audible alert through a buzzer upon identifying prolonged eye closure, thereby enhancing driver safety. Additionally, by leveraging the ThingSpeak IoT platform, it enables real-time remote monitoring and systematic data logging of drowsiness events. The design's low power requirements, ease of integration, and cloud connectivity make it well-suited for both individual and industrial fleet applications. This work lays a strong foundation for future enhancements, such as incorporating additional physiological sensors and automated emergency response mechanisms.