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SMART HELMET:-ACCIDENT PREVENTION AND EMERGENCY RESPONSE

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ABSTRACT

Too many lives are lost on our roads due to preventable accidents—specifically, drunk driving and riders choosing to go without a helmet. We designed and built an intelligent guardian system, the Smart Helmet, to put an end to these risks before a dangerous journey can even begin. This powerful but affordable solution is driven by an Arduino micro-controller and divided into two core parts. The Helmet Unit contains the safety checks: a small, sensitive MQ-3 sensor instantly checks the rider's breath for alcohol, and a tiny IR (Infrared)proximity sensor ensures the helmet is correctly buckled and worn. This pass/fail safety status is then beamed wirelessly and instantly to the motorcycle using a dedicated RF signal. The Bike Unit receives this signal, displays a clear, simple message (like" READY TO START" or "ALCOHOL DETECTED") on an LCD screen, and uses a heavy-duty Relay switch to control the ignition. It operates on one simple, nonnegotiably principle: If the rider has consumed alcohol, or if the helmet is not properly worn, the bike's engine will not turn on.

Keywords: Smart Helmet, Drunk Driving Prevention, Helmet Detection, Arduino Microcontroller, MQ-3 Alcohol Sensor, IR Proximity Sensor, RF Wireless Communication, Motorcycle Ignition Control, Accident Prevention.

I. INTRODUCTION

The introduction of a research paper serves accidents continue to claim lives due to alcohol-impaired riding and neglect of helmet use. Existing systems often respond only after a crash occurs. To address this gap, we developed an Arduino-based Smart Helmet System that actively prevents accidents before they happen. The helmet integrates an MQ-3 alcohol sensor and an IR proximity sensor to verify rider sobriety and proper helmet usage. Sensor data is wirelessly transmitted to the motorcycle via an RF module. A relay-controlled ignition system allows the engine to start only when all safety conditions are satisfied, ensuring proactive, affordable, and effective rider safety enforcement.

II. METHODOLOGY

The development of the Smart Helmet System was executed through a systematic, four-phase approach: Component Interfacing and Calibration, Wireless Communication Setup, Software Development and Control Logic, and System Integration and Testing.

Component Interfacing and Calibration

The first phase involved establishing reliable communication between the Arduino microcontrollers and the selected sensors and actuators input.

Helmet Unit Sensor Interface

- MQ-3 Alcohol Sensor: The sensor was wired in a standard voltage divider configuration, and its analog output ($\mathbf{V_{out}}$) was connected to the Arduino's Analog Pin A0. Calibration was performed by exposing the sensor to known alcohol concentrations to establish a clear threshold value (analog reading) corresponding to the legal Blood Alcohol Content (BAC). This threshold determines the digital "Pass" or "Fail" state.
- IR Proximity Sensor: The sensor was mounted inside the helmet lining near the head's expected resting position. It was configured as a digital input connected to the Arduino's Digital Pin D2. The sensor's sensitivity was adjusted so that a clear HIGH signal was generated only when a surface (the rider's head) was detected within a distance of 1-3 cm, ensuring the helmet was worn, not merely closed.

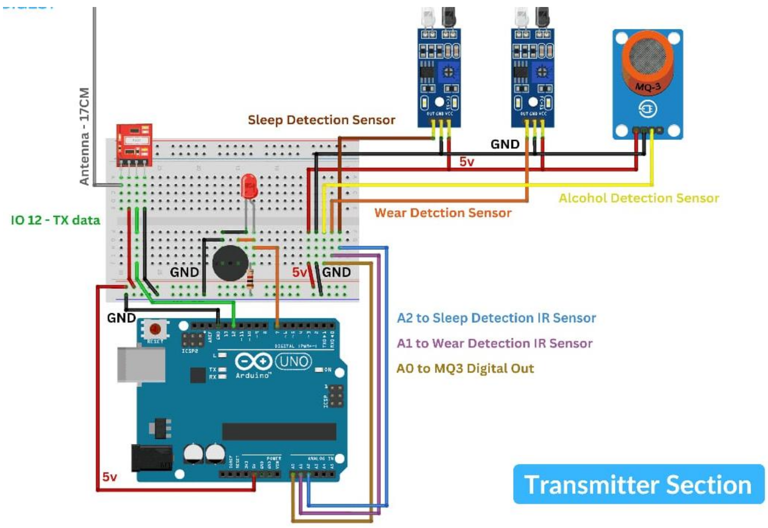

Fig.1 Transmitter unit

Bike Unit Actuator Interface

- 16x2 LCD Display: The display was interfaced with the Arduino using the module to conserve digital I/O pins. The Arduino was programmed to display initial boot-up messages and the real-time status as determined by the received wireless data.
- Relay Module: The single-channel relay's control pin was connected to the Arduino's Digital Pin D7. The relay's normally open (NO) terminals were wired in series with the motorcycle's ignition system wire. A HIGH signal from Pin D7 activates the relay (closing the circuit, enabling ignition), and a LOW signal deactivates it (opening the circuit, disabling ignition).

Wireless Communication Setup (RF Module)

- A robust, low-cost wireless data link was essential for safety. The 433 MHz RF modules were paired with HT12E Encoder and HT12D Decoder ICs.
- Data Encoding (Helmet Unit): The Arduino outputted a 4-bit parallel data signal to the HT12E Encoder. This data represented the system state: for example, '1000' for SAFE (Unlock), '0100' for Alcohol Detected, and '0010' for Helmet Not Worn. The HT12E converted this parallel data into a

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serial stream for transmission by the RF Transmitter. The Address Pins on the HT12E were hardwired to match the HT12D Decoder to prevent interference from other devices.

- Data Decoding (Bike Unit): The RF Receiver outputted the serial data to the HT12D Decoder. Upon receiving a valid, matching address code, the HT12D converted the serial stream back into the 4-bit parallel data, which was then read by the Bike Unit Arduino's digital input pins.

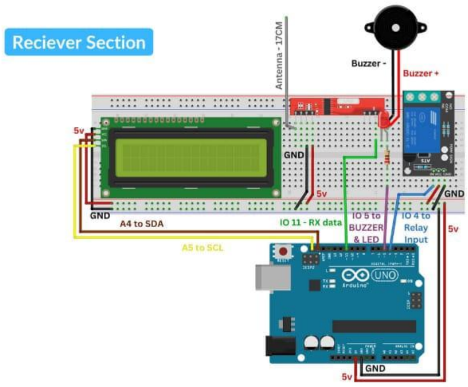

Fig.2 Receiver unit

III. MODELLING AND ANALYSIS

The Smart Helmet System is modelled as a dual-unit embedded safety enforcement architecture consisting of a Helmet Unit and a Bike Unit, interconnected through a wireless communication link. The system is designed to function as a preventive safety mechanism by continuously monitoring rider compliance before engine ignition.

The Helmet Unit integrates an Arduino microcontroller, an MQ-3 alcohol sensor, and an IR proximity sensor. The MQ-3 sensor models rider sobriety by measuring alcohol concentration in exhaled breath and comparing it against a predefined threshold. The IR sensor models helmet-wearing compliance by detecting proper positioning and fastening of the helmet. Sensor outputs are processed using logical decision rules to generate a binary safety status.

The Bike Unit receives this status via an RF communication module and validates it in real time. A relay-controlled ignition model enforces an electronic interlock mechanism, permitting engine startup only when all safety conditions are satisfied. System analysis confirms low-latency response, high reliability, and cost efficiency, demonstrating the feasibility of real-time accident prevention through embedded safety modelling.

IV. RESULTS AND DISCUSSION

The Smart Helmet System was successfully implemented and tested under various operating conditions. Experimental results show that the MQ-3 alcohol sensor accurately detected alcohol presence in the rider's breath, while the IR proximity sensor reliably confirmed proper helmet usage. The RF communication link provided fast and stable data transmission between the Helmet Unit and the Bike Unit.

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When alcohol was detected or the helmet was not worn correctly, the relay-based ignition control prevented the engine from starting. Only when both safety conditions were satisfied did the system allow engine ignition. The LCD display clearly indicated the system status, improving user awareness.

These results demonstrate that the proposed system effectively enforces safety rules before riding begins. Compared to conventional safety measures, the system offers a proactive, low-cost, and reliable solution to reduce motorcycle accidents caused by alcohol consumption and improper helmet usage.

S N.	Condition	Output
1	Helmet properly worn	Vehicle ignition enabled
2	Helmet not worn	Vehicle ignition disabled
3	Alcohol not detected	Engine allowed to start
4	Alcohol detected	Engine locked automatically
5	Normal eye blinking detected	No warning generated
6	Prolonged eye closure detected	Warning buzzer activated
7	System status monitoring	Data displayed on LCD

Table 1. Performance Result

V. CONCLUSION

This research successfully developed an Arduino-based Smart Helmet System to proactively prevent two primary causes of motorcycle accidents: alcohol-impaired driving and non-compliance with helmet laws. The system integrates an MQ-3 alcohol sensor and an IR proximity sensor within the Helmet Unit. This safety status is wirelessly transmitted via a 433MHz RF link to the Bike Unit, which utilizes a Relay Module to enforce a mandatory electronic interlock. Engine ignition is strictly denied unless both the rider is sober and the helmet is properly worn. This prototype validates a cost effective, low-latency preventative safety mechanism, proving that accessible technology can actively enforce safety compliance and significantly contribute to reducing road fatalities. Future work will focus on integrating GPS/GSM for emergency response and optimizing power consumption.

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