



## DEVELOPMENT AND PERFORMANCE ANALYSIS OF ALCOHOL AND HELMET-USE DETECTOR FOR BIKE RIDERS

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### Abstract

The growing prevalence of road accidents, particularly those involving bike riders, has become a major public safety concern, with alcohol consumption often serving as a significant contributor to fatalities and injuries. This research developed a system that prevents motorcycle ignition under unsafe conditions. The system incorporates helmet detection and alcohol sensing to prevent impaired riding. The helmet integrates sensors, including an MQ-3 alcohol sensor, Electroencephalogram (EEG) detectors, and accelerometers, enabling it to monitor alcohol levels while the microcontroller Arduino Uno processes the data received and enforces control. In the event of high blood alcohol concentration or where the helmet is not worn, the system disables the motorcycle's engine and sends real-time emergency alerts via GSM modules. Tests were conducted using various alcohols such as Origin Bitter (30%), Smirnoff (40%), Blackwood (40%), Action Bitter (50%), Whiskey (50%) and palm wine (4%). The performance of the system was evaluated by the measurement of the variation of alcohol detection in breathe of riders with different types of alcoholic beverages ingested. The system consistently detected alcohol within 8–15 seconds, although visual signs of impairment were absent in the riders. One-way ANOVA analysis was conducted to examine the variations in alcohol detection among different types of alcoholic beverages. The results indicate that the difference in alcohol content across the tested drinks is not statistically significant at a 95% confidence level, as evidenced by a p-value of 0.217. Moreover, a significant difference was observed in the detection results of the beverages. The p-value for character observation was 0.000, which is highly significant, meaning that the detection process varies considerably among the different beverages with results obtained showing reduced alcohol detection time with increase in alcohol percentage by volume in beverages. This study underscores the critical role of sensor-based alcohol detection systems in reducing impaired riding, preventing accidents, and promoting road safety. It emphasizes the need for continued optimization of smart helmet technology to enforce helmet use and ensure accurate and timely alcohol detection, particularly under diverse riding conditions and varying ethanol concentrations.

**Key words:** Alcohol detection, Bike riders, MQ-3 alcohol sensor, Electroencephalogram detectors, Road safety, Smart helmet

## 1.0 Introduction

Vehicular accidents occur within and outside Nigeria. Its increase has made government at various levels to seek for and take steps to tackle the issue. Driving under the influence of alcohol or other drugs constitutes a significant cause of accidents both worldwide and right here in Nigeria (Akande, et al, 2023). Alcohol is known to impair vision and the reasoning of the consumer. Governments in the US and other countries conduct regular checks on roadside for sobriety tests (Osarenmwinda and Moses, 2024). Accidents are steadily on the rise and this has prompted officials to establish various protective measures (Rahman et al. 2020). Accidents are unexpected occurrences or errors leading to injury or even fatalities. Notably, motorcycles and bicycles are involved in these incidents more frequently, when compared to other kinds of vehicles (Tapadar et al. 2018). According to the World Health Organization (WHO), 70% of severe injuries and 40% of deaths can be prevented if riders consistently wear helmets. Studies also show that nearly 90% of bike rider fatalities occur when helmets are not worn (Guspa et al. 2017). Alcohol consumption increases the risk of fatal accidents; as impaired riders have a higher tendency to be involved in crashes (Jesusdoss et al. 2019). Nataraja and Mamatha (2018) submitted based on investigations, that places with official records of people drinking and driving set a clear allowed amount of alcohol in a person's blood known as Blood Alcohol Concentration (BAC) legal limit. Nigeria based on available record doesn't have this, or if they do, our findings suggest it's not being put into practice. While Blood Alcohol Concentration (BAC) limit varies from one region or nation to another, the difference is always tiny, well under 1.00 BAC. Drinking

alcohol is a major concern that afflicts people worldwide regardless of socioeconomic class. The submission of Salve (2019) highlighted that despite existing laws prohibiting drunk driving, enforcement remains a significant challenge due to limited resources and the vastness of the country. The report underscores the necessity for improved enforcement measures and the implementation of alcohol detection systems that can operate effectively across diverse regions and times to mitigate alcohol-related road incidents (Press Information Bureau, 2019).

Quite a number of research have gone into the development of systems that ensures a good state of mind of the rider or driver. The use of Arduino for seat belt management and alcohol detection was suggested by (Malathi et al. 2017). This method prohibits drivers from operating a vehicle while intoxicated and/or without a seat belt. The output from the infrared and alcohol sensors is compared by the comparator and then sent to the microprocessor. If the result is valid, the relay is activated, allowing the vehicle to start. If the comparator output is false, the GSM modem connected to GPS sends information about the location and a message stating that the driver has not fastened their seat belt or has consumed alcohol. Plans for this system include sending notifications to nearby police stations.

Alcohol detection for vehicle locking devices was created by (Al-Youif et al. 2018). The device has demonstrated its capability to detect and measure the concentration of a gas. In case it detects that the concentration of a gas exceeds a specific threshold that is not allowed, it can control the ignition of the car. While this is only a prototype, it can be utilized as a basis for other innovative systems. The relay can be

used to regulate the ignition of the car, and an alarm system can be installed on the device. The device, which has features for speed tracking, alcohol detection, over speeding, reckless driving, driving without a license, and seat belt checking, was created by (Jacob et al. 2020). If any of these conditions are violated, the controller sends emergency data to the cloud, where the Road Transport Officer (RTO) receives updates about vehicles that are not complying with the regulations. The next step is to establish a coordinate and mapping system for the driver’s location, which will enable GPS to determine the type of road the vehicle is traveling on.

A typical smart helmet incorporates a microcontroller to process sensor data, a liquid-crystal display (LCD) or organic light-emitting diode (OLED) panel for notifications, light-emitting diodes (LEDs) for warning signals, and a wireless communication module such as Wi-Fi, RF, Bluetooth, or cellular networking to transmit data. Various sensors are integrated to achieve specific functions such as air quality

monitoring or SOS message transmission. Common sensors include:

- IR Sensors and Force-Sensitive Resistors (FSR): Used to confirm helmet wear status (Altamura et al. 2019)
- Physiological Sensors: These include body temperature, photoplethysmogram (PPG), and EEG sensors to monitor the rider’s health (Eldemerdash et al. 2020)
- Alcohol Sensors: Prevent excessive alcohol use while riding by detecting alcohol in the rider’s breath (Magno et al. 2017)
- Environmental Sensors: Gas, temperature, and humidity sensors are employed to assess external factors that might pose a risk (Vishnukumar et al. 2018)
- IR Cameras: Used for temperature scanning of the rider’s body (Mohammed et al. 2020)

This combination of sensors as seen in Fig 1 enhances the smart helmet’s capability to monitor the rider’s safety, providing real-time data to prevent accidents and ensure safety.

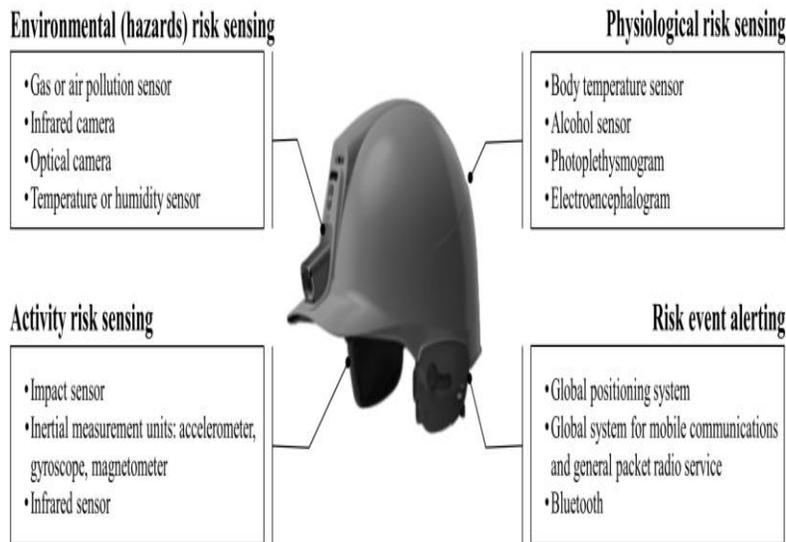


Fig 1. Major risk sensing and adopted sensors (Paulchamy et al. 2018)

According to Basumallick et al. (2024), the integration of these technologies into motorcycle safety equipment will enhance rider safety through real-time monitoring and preventive measures. Alcohol by Volume (ABV) serves as a critical parameter in determining the ethanol concentration in beverages, directly influencing cognitive and motor functions. ABV was typically labeled on alcoholic products and plays a significant role in assessing the degree of impairment in motorcyclists. The higher the ABV percentage, the stronger and more immediate the physiological and neurological effects on the rider.

The Alcohol by Volume (ABV) of some commonly ingested liquid substances widely consumed vary (Jones, 2019). The ABV classification is as follows:

- 0% ABV: No alcohol content (e.g., water, juice).
- 5% ABV: Light beers, containing 5 milliliters of ethanol per 100 milliliters of liquid.

## 2.0 Methods and materials

### 2.1 Methods

In the development of the alcohol detection and engine locking system, several major materials played key roles in the assembly and functionality of the research. The Arduino Uno served as the central microcontroller, responsible for processing the sensor data and controlling the system's operations. It read inputs from the alcohol sensor and sent signals to the relay to lock or start the engine, acting as the brain of the system. The MQ-3 alcohol sensor was crucial for detecting alcohol vapors in the rider's breath. This sensor's resistance changes in response to the concentration of

- 12% ABV: Standard wines, with 12 milliliters of ethanol per 100 milliliters.
- 40% ABV: Distilled liquors such as whiskey and vodka, comprising 40 milliliters of ethanol per 100 milliliters.
- 100% ABV: Pure ethanol, not intended for direct consumption.

The distribution of alcohol content across different beverage categories is as follows (Spedding, 2016):

- Liquors: 35-50% ABV (e.g., vodka, gin, whiskey, tequila).
- Wines: 12-15% ABV (e.g., red wine, white wine).
- Beers: 4-6% ABV (e.g., lagers, ales).
- Ciders: 4-8% ABV.

This study focuses on developing a smart motorcycle safety system that incorporates helmet detection and alcohol sensing to prevent impaired riding. In a situation alcohol is detected or the rider isn't wearing a helmet, unsafe riding is prevented by disabling of the engine ignition. The system performance is evaluated based on its response time in detecting alcohol in a rider for various alcohol percentage volume beverages ingested.

alcohol in the environment, providing the necessary data for the Arduino to assess whether the rider is under the influence (Aribisala et al., 2024).

A DC motor was used to simulate the engine's operation. The motor was controlled by the relay, which responded to the alcohol sensor's output. When alcohol was detected, the relay would prevent the motor from starting, thus locking the engine. Relay modules were essential for controlling the flow of current to the DC motor. The relay acted as a switch that would interrupt the engine's ignition when alcohol was detected, preventing the rider from starting the motorcycle. The RF transmitter and receiver modules allowed for wireless

communication between the helmet and the motorcycle. This was important for detecting whether the rider was wearing the helmet. If the helmet was removed, the system would prevent the bike from starting. Additionally, components like LED indicators and buzzer were used to provide visual and auditory feedback to the rider. The LED would display the system's status, while the buzzer would alert the rider when alcohol was detected. Other materials such as transistors, diodes, resistors, capacitors, and jumpers were used for circuit connections and signal processing, ensuring the system operated smoothly and reliably.

The MQ-3 sensor was calibrated to accurately detect alcohol concentrations within permissible limits. Components were

assembled on a perf board, ensuring proper connections and power supply. Arduino code was developed and uploaded to process sensor inputs, compare them against predefined thresholds, and control the relay for engine locking.

The system's performance was evaluated in a controlled setting to ensure accurate alcohol detection and engine locking response. Real-world testing was conducted to assess system reliability and responsiveness under various conditions. Test data were analyzed to identify discrepancies and refine the system for optimal performance.

**2.2 Materials**

A number of components and materials were used to build the smart helmet as shown in Table 1.

Table 1. Components and their specifications

S/N	COMPONENT	QUANTITY	VALUE
1	Arduino UNO R3	1	5v
2	Alcohol Sensor MQ3	1	5v, 200 kΩ – 470 kΩ
3	Motor Driver IC L293D	1	4.5-5v
4	DC Motor	1	12v
5	Piezo Buzzer	1	5v
6	Battery	1	9v
7	Breadboard	1	-
8	Perforated board	1	-
9	Buzzer	1	5v
10	Relay	4-6	5v
11	Switch	1	-

12	LED RED	1	-
13	Capacitor	1	-
14	Diode	4	5v
15	Transmitter modules	1	12v
16	Receiver module	1	12v
17	Resistor 220 ohms	2	220Ω
18	Transistor	1	5v
19	Few jumpers	20	-
20	Rechargeable batteries for helmet	4	9v
21	Battery cap	4	-
22	Regulator	2	-

### 2.3 The Working Principle

Figure 2 shows the flowchart for the system to be fully operational, the following conditions must be satisfied:

- If neither the helmet is worn nor alcohol is detected, the system should not start.
- If the helmet is worn but alcohol is detected, the system should not start.
- If the helmet is worn and no alcohol is detected, the system should start.

Figure 3 shows the block diagram of the helmet module. The helmet module plays a crucial role in this system by detecting the rider's head presence, functioning as a safety measure. If the helmet is not detected, the system will emit an alert sound, and the LED display will prompt the rider to wear the helmet. Additionally, if alcohol content

is detected in the rider's breath, the system will trigger an alert sound, preventing the bike from starting.

The system uses a combination of sensors, including belt-tie conductance sensors and an MQ5 alcohol sensor, integrated within the helmet module. These sensors are powered by a 9V battery, regulated by a 7805 IC to convert 9V to 12V. The data from each sensor is fed into an encoder, which continuously encodes the sensor values. These encoded signals are then transmitted via an RF transmitter to the Engine Control Unit (ECU) for further processing.

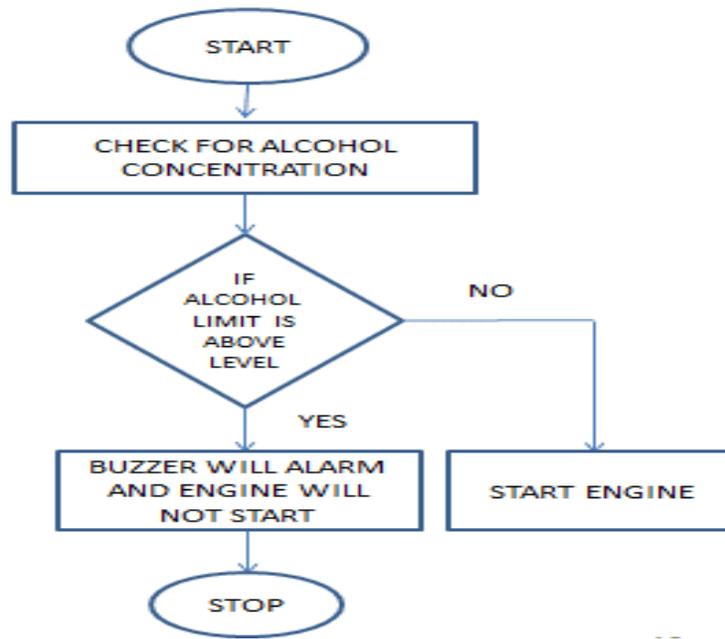


Figure 2. Flow chart of alcohol detection system

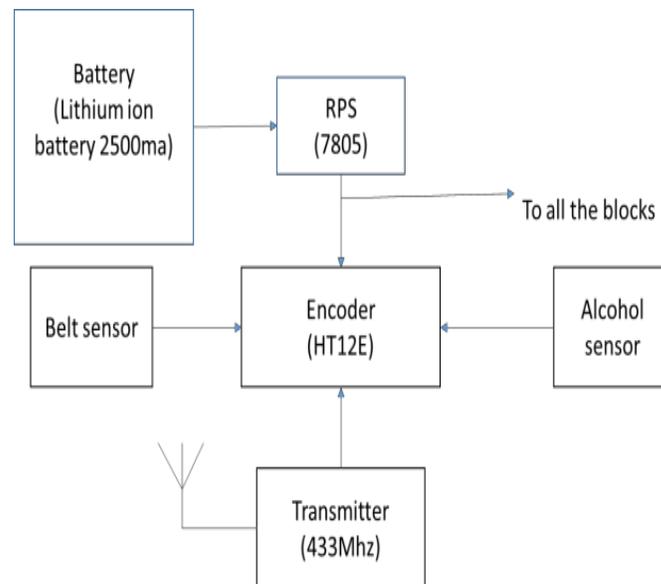


Figure 3. Block diagram of helmet module

### 2.4 Engine Control Unit

The ECU consists of a GPS module GSM module, PIC microcontroller, RF receiver, and decoder as shown in Figure 4. The RF receiver receives signals from the helmet module, which are decoded by the HT12D decoder IC. The Arduino microcontroller constantly scans the decoded data to determine whether the bike should start or

not. A relay mechanism controls the engine’s spark plug connection to the ground; it is only connected to ground when the helmet is worn, and no alcohol is detected.

In addition, a vibration sensor is fixed to the vehicle. In the event of an accident, this sensor detects any impact and sends a signal through the RF system, triggering the GSM

module to send an SMS to the specified contact number, including the accident's location. The system's status and alcohol

detection are displayed on an LCD screen, providing real-time feedback on the system's operation.

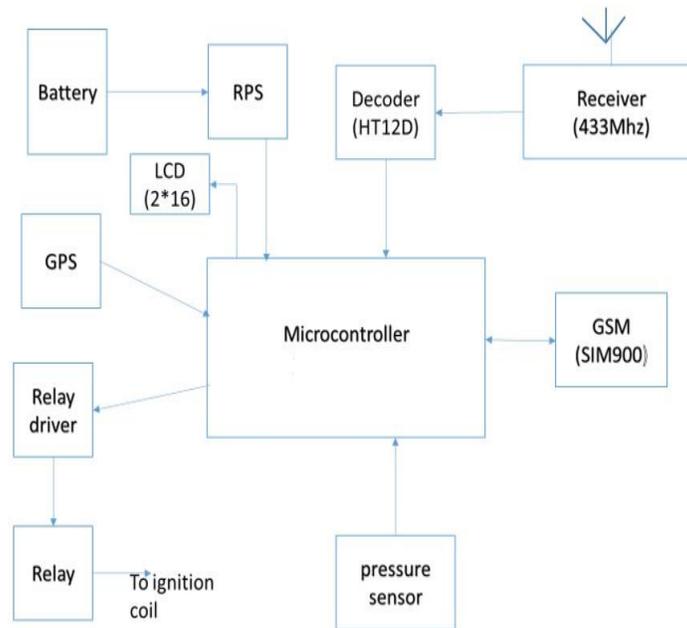


Figure 4. Engine control unit

### 2.5 Helmet Unit

This system integrates infrared sensor switches, MCU encoder and Rf transmitter as shown in Figure 5. The switch and an alcohol sensor are built right in the helmet, as shown in Figure 6. Data are read by the sensors and relayed to the MCU for processing. If the driver's breath is alcohol-free and the helmet switch is fastened, the MCU sends a signal to the RF encoder. The encoder block checks if both conditions are met. If they are, it turns those signals into coded binary output. The RF transmitter then sends out this coded message. The system uses the amplitude shift keying (ASK) Modulation technique.

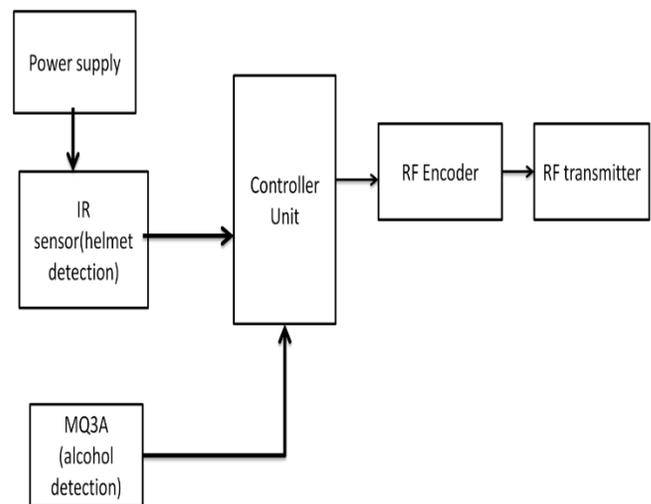


Figure 5. Helmet unit

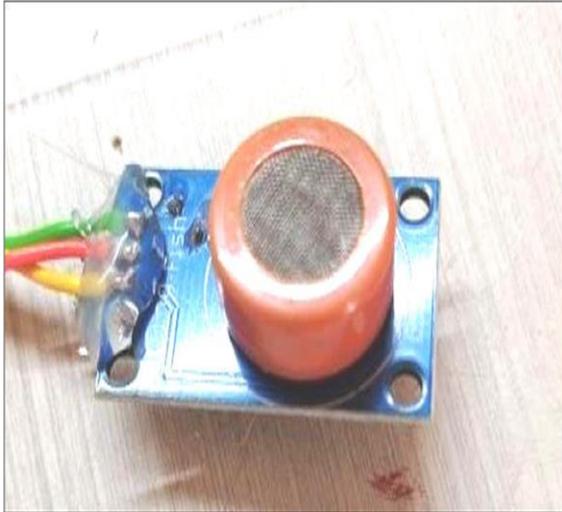


Figure 6. Alcohol sensor.

### 2.6 Alcohol Detection Analysis

Comparative analysis was conducted using One-way ANOVA to measure the fidelity of the mechatronics-based system against alcohol percentage. Following the comprehensive testing and data acquisition, key statistical methodologies including percentage analysis, sensing response time, one-way XY regression, ANOVA testing, and predictive modeling, were employed to evaluate the efficiency of the alcohol

detection system. These analytical techniques provided insights into sensor accuracy, reaction time, and the correlation between alcohol intake and impaired motor control.

The smart helmet, shown in Figures 7 and 8, uses an alcohol sensor to accurately detect ethanol levels in a rider's breath, correlating each level with a specific alcohol percentage. It then processes this data with embedded control algorithms, activating safety features like cutting off the engine

when necessary. This automation enhances road safety by preventing intoxicated individuals from operating motorcycles, thereby reducing accident risks and promoting intelligent vehicular safety solutions.



Figure 7. Developed smart helmet .

## 3.0 Results and discussions

### 3.1 Results of Research

This sub-section presents the results of the analysis on Alcohol by Volume (ABV) levels in various alcoholic beverages, used for the tests on motorcycle riders in Offa, Kwara State, Nigeria. The study evaluates alcohol detection efficiency using the developed smart helmet, providing insights into its real-world application and effectiveness in preventing impaired riding.

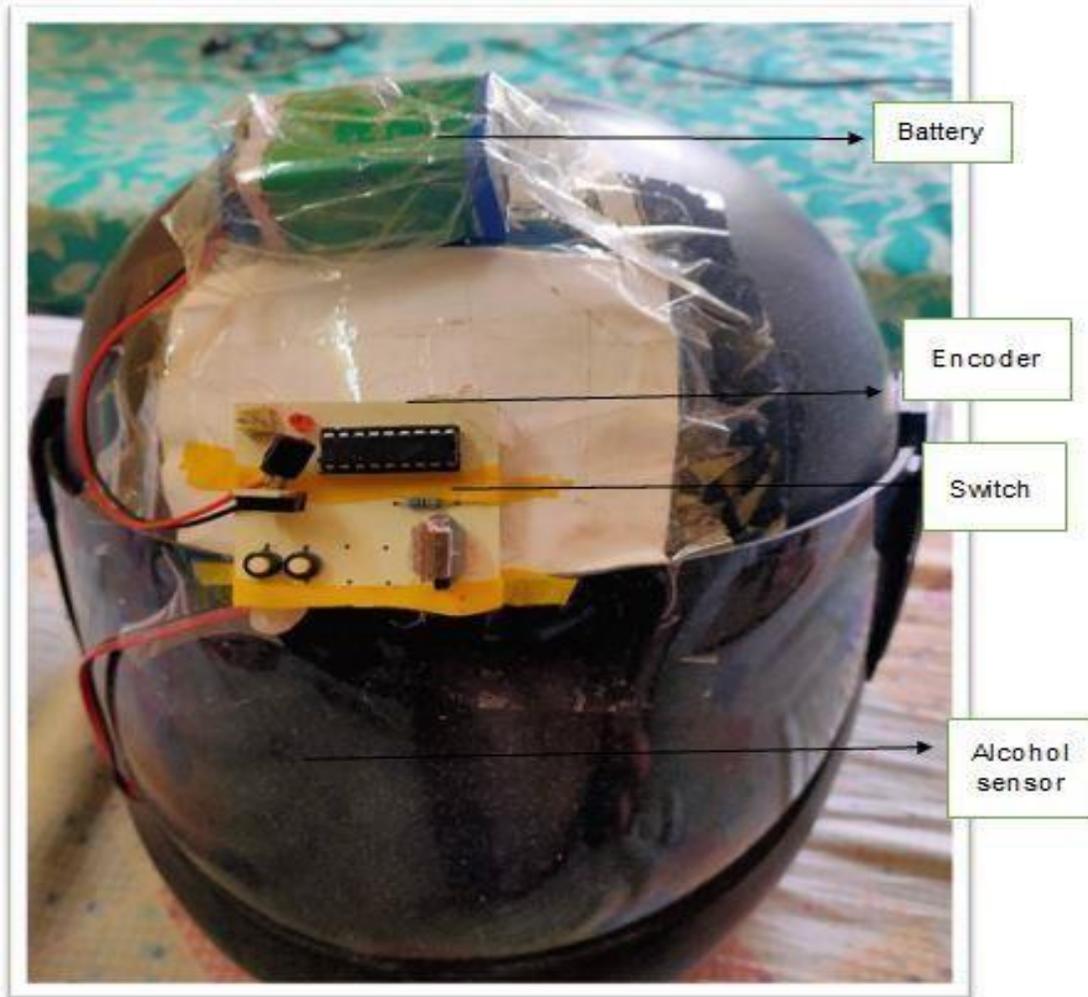


Fig 8. Helmet section

- Origin Bitter with Alcohol by Volume (ABV) of 30% was used and the results obtained from the smart helmet-based alcohol detection system from a rider's breath, is as contained in Table 2. The system consistently detected alcohol in all five trials, confirming the reliability

of the sensor. The detection time remained stable at 15 seconds. Interestingly, despite measurable alcohol presence in their breath, none of the tested subjects exhibited visible signs of intoxication.

Table 2. Test carried out at Idi-Agbon Area Offa on origin bitter alcohol.

S/N	ORIGIN BITTER ABV (%)	SENSING TIME (s)	RESULT	LOOK DRUNK
1	30	15	Positive	NO
2	30	15	Positive	NO
3	30	15	Positive	NO
4	30	15	Positive	NO
5	30	15	Positive	NO

**Alcohol by Volume (ABV) on Smirnoff Alcohol:**

Test was conducted with Smirnoff liqueur, with 40% alcohol by volume, in the Railway station region of Offa as shown in Table 3. The system was able to detect alcohol in all five tests and produced a positive result within 10 seconds of the measurement time. The shorter detection time compared to the original High (15 seconds) indicates that the ethanol concentration in Smirnoff (ABV 40%) is higher and more easily detected by the sensor. Despite the confirmation of the presence of alcohol in the breath, none of the tests performed showed any signs of impairment.

Table 3. Test carried out at Railway Station Area Offa on Smirnoff.

S/N	SMIRNOFF ABV (%)	SENSING TIME (s)	RESULT	LOOK DRUNK
1	40	10	Positive	NO
2	40	10	Positive	NO

			e	
3	40	10	Positive	NO
4	40	10	Positive	NO
5	40	10	Positive	NO

**Alcohol by Volume (ABV) on Blackwood Alcohol:**

With Blackwood (40% alcohol concentration), test were carried out using riders in Omo-Owo Area in Offa. The detection of alcohol in the riders breathe is shown in Table 4. In all five tests, the system recorded good results within the 10-second test period, demonstrating its high sensitivity and consistent performance. Despite the presence of alcohol, none of the tests showed clear evidence of intoxication.

Table 4. Test carried out at Omo-Owo Area Offa on Blackwood

S/N	BLACKWOOD ABV (%)	SENSING TIME (s)	RESULT	LOOK DRUNK
1	40	10	Positive	NO
2	40	10	Positive	NO
3	40	10	Positive	NO
4	40	10	Positive	NO

5	40	10	Positive	NO
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- Tests were carried out using Action Bitter (50% ABV) at the Offa, General hospital Area. The time for detection of alcohol levels in subject is as shown in Table 5. In all five tests, the system detected alcohol within 8 seconds. Despite high alcohol consumption, none of the subjects showed obvious impairment.

Table 5. Test carried out at General Hospital Area Offa on Action Bitter

S/N	ACTION BITTER ABV (%)	SENSING TIME (s)	RESULT	LOOK DRUNK
1	50	8	Positive	NO
2	50	8	Positive	NO
3	50	8	Positive	NO
4	50	8	Positive	NO
5	50	8	Positive	NO

The use of Whiskey (50% alcohol) tests was conducted in the Offa at Tipper Garage region. Alcohol detection in drivers' alcohol is as shown in Table 6. Whiskey with a 50% alcohol content by volume is considered a high-alcohol beverage. The system detected alcohol in the five tests conducted in 8 seconds each.

Table 6. Test carried out at Tipper Garage Area Offa on Whisky

S/N	WHISKY ABV (%)	SENSING TIME (s)	RESULT	LOOK DRUNK
1	50	8	Positive	NO
2	50	8	Positive	NO
3	50	8	Positive	NO
4	50	8	Positive	NO
5	50	8	Positive	NO

Tests on palm wine (4% alcohol) in the Afelele Junction region in Offa was conducted. In all five tests, the sensor failed to detect alcohol, leading to false readings. Additionally, none of the subjects showed clear evidence of impairment. The results showed that the system is optimized to detect moderate to high alcohol levels.

Table 7. Test carried out at Afelele Junction Area Offa on palm wine

S/N	PALM WINE ABV (%)	SENSING TIME (s)	RESULT	LOOK DRUNK
1	4	Didn't sense	Negative	NO
2	4	Didn't sense	Negative	NO
3	4	Didn't sense	Negative	NO
4	4	Didn't sense	Negative	NO
5	4	Didn't sense	Negative	NO

### 3.2 Statistical Analysis of XY by R: Anova and Regression Approach

As illustrated in Figure 9, Action Bitters and Whiskey have the highest alcohol content, both 50% ABV, followed by Smirnoff and Black Wood, both 40% ABV. Original Bitter is slightly lower at 30%, while Palm Wine has the lowest alcohol content at 4%. The higher the alcohol content, the higher

the potential for intoxication. The Sensing Time for the various alcohols tested are shown. Origin Bitters has the longest sensing time 15 seconds, while the least sensing time of 8 seconds were obtained for Bitter and whisky. The low alcohol content of palm wine could be the reason why the system couldn't sense it alcohol content.

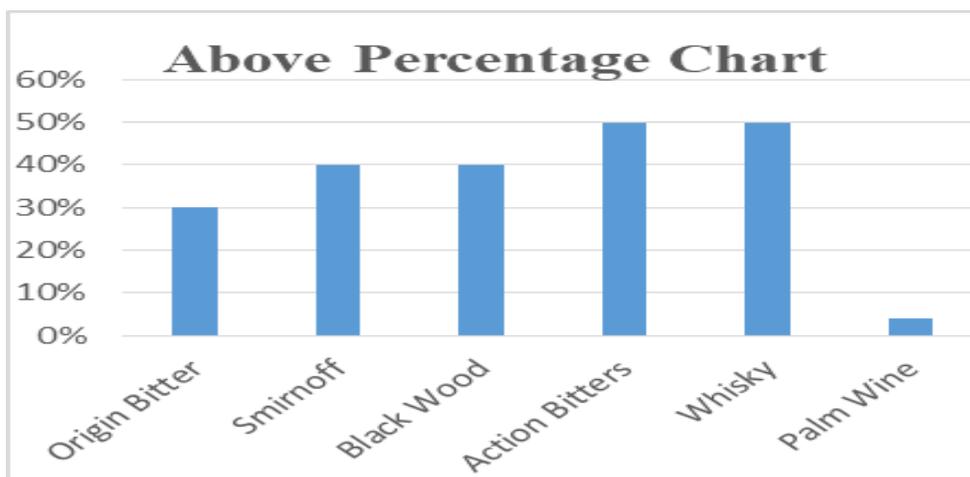


Figure 9. Above percentage chart

### One-way ANOVA Test Analysis

The one-way ANOVA analysis was conducted to examine the variations in alcohol detection among different types of alcoholic beverages as shown in Tables 8-10. The results indicate that the difference in alcohol content across the tested drinks is not statistically significant at a 95% confidence level, as evidenced by a p-value of 0.217. This suggests that while the alcohol content varies among the beverages, the differences are not substantial enough to confirm a meaningful distinction between them. The F-value of 1.568 further supports this conclusion, indicating that the variations observed in alcohol content are not strong enough to reject the null hypothesis. Moreover, a significant difference was observed in the detection results of the beverages. The p-value for character observation was 0.000, which is highly significant, meaning that the detection process varies considerably among the different beverages. The F-value for character observation was 52.889, much

higher than that for alcohol content, indicating that the detection mechanism successfully differentiates between some beverages while failing to detect others with the same level of accuracy. This disparity suggests that factors beyond just alcohol concentration, such as sensing time and detection sensitivity, may influence the results.

Palm wine was the only beverage that yielded a negative detection result, supporting the hypothesis that lower alcohol content may impact detectability. Since palm wine typically has a lower alcohol percentage compared to other beverages tested, its negative detection result aligns with the assumption that the detection method may have a threshold below which alcohol is not identified. In contrast, other beverages, including Origin Bitters, Smirnoff, Black Wood, Action Bitter, and Whisky, all had positive detection results, signifying that their alcohol content was sufficient for identification.

Table 8. Coefficient level

<b>COEFFICIENT LEVEL</b>		
Output Created		15-DEC-2023 07:48:54
Comments		
Input	Active Dataset	DataSet0
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	24
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics for each analysis are based on cases with no missing data for any variable in the analysis.
Syntax		/criteria=cilevel (0.95).

Table 9. F-value and p-value

<b>ANOVA</b>					
		Sum Squares	of df	Mean Square	F
Treatment (Different Types of Alcohol)	Between Groups	35.143	9	3.905	1.568
	Within Groups	34.857	14	2.490	
	Total	70.000	23		
Character Observations	Between Groups	29.143	9	3.238	52.889
	Within Groups	.857	14	.061	
	Total	30.000	23		

**Table 10.** Character Observation level

ANOVA		
		Sig.
Treatment (Different Types of Alcohol)	Between Groups	.217
	Within Groups	
	Total	
Character Observations	Between Groups	.000
	Within Groups	
	Total	

**4.0 Conclusion**

The development of a smart helmet with alcohol detection features has yielded valuable insights into its operational effectiveness, as well as the performance of the alcohol sensor. Tests were conducted using various beverages, including Origin Bitter (30%), Smirnoff (40%), Blackwood (40%), Action Bitter (50%), Whiskey (50%) and palm wine (4%). The performance of the system was evaluated by the measurement of the variation sensing time or alcohol detection among different types of alcoholic beverages ingested by riders. The system consistently detected alcohol within 8–15 seconds, although visual signs of impairment were absent in the riders. One-way ANOVA analysis was conducted to examine the variations in alcohol detection among different types of alcoholic beverages. The results indicate that the difference in alcohol content across the tested drinks is not statistically significant at a 95% confidence level, as evidenced by a p-value of 0.217. Moreover, a significant difference was observed in the detection results of the beverages. The p-value for character observation was 0.000, which is

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