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An Alcohol Driver Detection System Examination Using Virtual Instruments

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Abstract: This study explores an alcohol driver detection system employing virtual instruments. This research focuses on the design, development, and evaluation of a system aimed at detecting and preventing alcohol-induced driving incidents. Using virtual instruments, the system integrates sensors and technologies to accurately and efficiently identify alcohol levels in drivers. The MQ-3 alcohol sensor element's analog output voltage is detected by the system, which then converts it to measurements for the alcohol concentration and blood alcohol concentration (BAC). After the readings are presented on the LCD screen, a DC Piezo Buzzer alert is set off when the alcohol level reaches a predetermined threshold. When a DC Piezo Buzzer goes off, it produces a loud sound that can be heard from a distance for the driver to pull off the road. The pitch of the tone can be changed by varying the voltage applied to the piezoelectric disk. The device can accurately identify the presence of alcohol and provide matching measurements, according to experimental results, with the lowest alcohol percentage of 37.5% having a lower BAC value of 0.021 with an analog value of 100 (threshold). This technology can be an effective tool for lowering the incidence of drunk-driving collisions and enhancing traffic safety. Furthermore, the research delves into the potential real-world application and impact of such a system in enhancing road safety measures and reducing alcohol-related induced accidents. The findings will contribute to the advancement of technology-driven solutions for mitigating risks associated with drunk driving.

Keywords: virtual instrumentation, MQ-3 alcohol sensor element, DC Piezo buzzer, blood alcohol concentration, Arduino Uno R3 microcontroller, traffic safety.

使用虚拟仪器的酒精驾驶员检测系统检查

摘要：本研究探讨了采用虚拟仪器的酒精驾驶员检测系统。这项研究的重点是设计、开发和评估旨在检测和预防酒后驾驶事故的系统。该系统使用虚拟仪器，集成传感器和技术，准确有效地识别驾驶员的酒精含量。系统检测 MQ-3 酒精传感器元件的模拟输出电压，然后

将其转换为酒精浓度和血液酒精浓度(巴克)的测量值。读数显示在液晶显示屏屏幕上后，当酒精含量达到预定阈值时，就会发出直流压电蜂鸣器警报。当直流压电蜂鸣器响起时，它会产生很大的声音，从远处就可以听到，以便驾驶员将车驶离道路。通过改变施加到压电盘上的电压可以改变音调。根据实验结果，该设备可以准确识别酒精的存在并提供匹配测量，最低酒精含量为 37.5%，巴克值较低为 0.021，模拟值为 100（阈值）。该技术可以成为降低酒后驾驶碰撞事故发生率、提高交通安全的有效工具。此外，该研究还深入探讨了该系统在加强道路安全措施和减少酒精相关事故方面的潜在现实应用和影响。这些发现将有助于推进技术驱动的解决方案的发展，以减轻与酒后驾驶相关的风险。

关键词：虚拟仪器、MQ-3 酒精传感器元件、直流压电蜂鸣器、血液酒精浓度、Arduino Uno 右 3 微控制器、交通安全。

1. Introduction

Driver detection systems are designed to stop drivers from operating a vehicle while under the influence of drugs, alcohol, or weariness. To identify impairment and sound alerts or prohibit the car from starting, these systems employ several technologies, such as breathalyzers, sensors, and cameras. Numerous reports claim that driver distraction has been a factor in many road accidents over time. One of the major factors contributing to most collisions is an inattentive driver. According to annual data, these incidents result in close to 500,000 injuries and thousands of fatalities each year [1], [2]. Numerous accidents have been caused by driver drowsiness because of exhaustion, tiresome road conditions, and adverse weather conditions [3-5]. In general, poor driving practices are the main cause of traffic accidents [6]. These scenarios occur when a driver is intoxicated or sleepy [7]. Most fatal accidents have driver fatigue as a major contributing factor. Drivers lose control of their vehicles when they nod off [8]. Accordingly, smart or intelligent vehicle systems must be designed [9] using cutting-edge technology.

In many cultures, drinking alcohol is a prevalent practice connected to celebration-related occasions. However, even a modest amount of alcohol will impact how people behave because it slows their reaction and impairs perception. To reduce drunk driving and increase road safety, alcohol driver detection devices are a crucial tool. They can add an extra layer of safety for drivers and passengers and help discourage people from driving after drinking.

The relationship between the amount of alcohol consumed, the resulting blood alcohol content (BAC), and the factors that affect BAC has been researched for over a century. The relationship between breath and blood alcohol concentrations was noted during this research. Today, traffic law enforcement routinely uses blood and breath tests to determine a driver's BAC. However, the first approach has the drawback of requiring blood samples for testing, whereas the second method is non-invasive. Therefore, breath testing has replaced blood testing as the most widely used method, and the availability of portable breath analyzers is now widespread [2], [11].

The ignition interlock device (IID) is one of the most commonly used varieties of driver detection systems. These devices are built into cars and prevent the engine from starting until the driver blows into a breathalyzer. The gadget will prevent the car from starting if the driver's BAC is higher than a certain threshold. The tiredness detection system is another form of driver detection system that uses sensors to track the driver's actions and degree of awareness. To avoid accidents, these devices can recognize when a motorist is getting tired or preoccupied and sound an alarm or advise a driver to take a break. In both private cars and commercial vehicles such as trucks and buses, driver detection devices are becoming more prevalent.

Voas et al. [12] present a review of the literature on drunk driver detection. In this study, the usefulness of IIDs in reducing recidivism for drunk driving is reviewed. The researchers discovered a correlation between interlock devices and decreased rates of repeated drunk driving [13]. The development of a Breath Alcohol Detection System for Vehicle Interlock and the creation of a breath alcohol detection system for a car interlock device are discussed in this study. According to the authors, their technology successfully identified alcohol in a driver's breath. Wallin et al. [14] tested the effectiveness of an alcohol ignition interlock scheme for first-time intoxicated drivers in Sweden. The program was linked to a significant decrease in drunk-driving recidivism, according to the authors. Chevalier et al. [15] evaluated the French alcohol ignition interlock program for DUI offenders. In this study, the effectiveness of an alcohol ignition interlock scheme for drunk drivers in France was tested. The program was linked to a significant decrease in drunk-driving recidivism, according to the authors. Marques et al. [16] evaluated the accuracy and dependability of a remote alcohol monitoring system. The researchers discovered that the technology was reliable over time and could detect alcohol in a person's breath with accuracy. In [17], the history, utility, and present application of alcohol ignition interlocks are discussed. The authors contend that ignition interlocks should be used more frequently because they are an effective instrument in the fight against drunk-driving [18]. The article on BAC used numerous techniques to detect BAC, such as breathalyzers, blood tests, and urine tests, which are thoroughly discussed. The authors outline the benefits and drawbacks of each technique and offer suggestions for enhancing BAC measurement [19]. Advanced Driver Assistance Systems for Alcohol-Impaired Driving were studied. The authors discuss the potential for adopting advanced driver assistance systems (ADAS) to prevent drunk driving and examine how ADAS technology, including automated emergency braking and lane departure warning systems, can be employed to reduce drunk-driving [10, 20-22]. Amedeo et al. [20] also presented a general overview of smartphone-based and handheld mobile breath alcohol testing technology. The authors discuss the benefits and drawbacks of these systems and offer prospective directions for further study and development.

Drivers can become distracted for a variety of reasons, including using electronics, interacting with fellow passengers, driving while intoxicated, and being exhausted. Because drunk driving is a major contributor to traffic fatalities worldwide, there must be a means to lessen its prevalence. However, concerns exist regarding the efficiency and dependability of driver detection systems. It has been discovered that some systems occasionally generate false warnings or fail to recognize impairments. Concerns have also been raised concerning the expense and privacy effects of installing these systems in cars. A trustworthy technique is required to ensure traffic safety. To address this issue, the main objective of this research is to provide a workable way to reduce such incidents and promote road safety. Driver detection technologies can increase traffic safety and lower the number of accidents caused by drunk driving. To create trustworthy and efficient systems that can be widely used without incurring excessive costs or privacy problems, more research is necessary. Finally, this work is summarized in the conclusion section, along with a brief discussion of potential future improvements.

2. Methodology

2.1. System Design and Implementation

The design and execution of an alcohol driver detection system include various components and stages, including hardware selection, circuit design, programing, and testing. A general overview of the system design and implementation process is provided below:

2.1.1. Hardware Choice

The right hardware components must be chosen as the initial step in the construction of an alcohol-driving detection system. This includes the buzzer, LCD screen, microcontroller, and alcohol sensor. These systems frequently include a 16x2 LCD display, a DC piezo buzzer, and an MQ-3 alcohol sensor element. The Arduino Uno R3 microcontroller is typically used because of its versatility and ease of programming.

2.1.2. Designing the Circuit that Connects the Hardware Components

This entails generating a schematic diagram that displays the connections between the alcohol sensor, buzzer, LCD display, and microcontroller. The circuit must be built to ensure that the components are powered correctly and that signals are transferred accurately.

2.1.3. Programing

Following the creation of the circuit, the system's control code must be written. As a result, the buzzer and display are activated on the basis of the alcohol concentration levels once the microcontroller has been programmed to read the data from the sensor about alcohol concentration, process them, and do so. The code must also include error handling and other features to ensure that the system operates reliably.

2.1.4. Testing

To ensure that the system performs as planned, testing is the last phase. Connecting the parts, loading the program code into the microcontroller, and testing the system in various scenarios are all part of this process. To guarantee that the system operates consistently and accurately, the system should be tested under various conditions, including those with varying levels of alcohol. The proposed system block diagram is shown in Fig. 1. It is intended to be inexpensive, straightforward, and sufficiently accurate to yield useful BAC measurements. The Arduino Uno board, power supply, buzzer, LCD display, temperature sensor, alcohol sensor, and relay are the seven components that make up the system hardware. An individual computer is coupled with the Arduino Uno board.

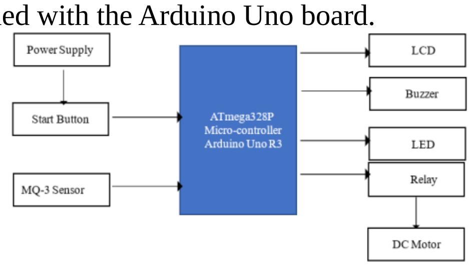

Fig. 1 Block diagram of the system (The authors)

2.2. Hardware Components

Fig. 2 displays the hardware of the system. The MQ-3 alcohol sensor is used to gauge the amount of alcohol in a breath sample. The outcome is influenced by humidity and temperature. The user can view several forms of information (messages and measures) on the LCD. The relay is actuated, the engine ignition system is switched off, and the buzzer is turned on when the blood alcohol level rises above a predetermined threshold. The Arduino board, which was used to power the breadboard, was powered by a computer system's 5V power source when the prototype of the system was designed. Prior to use, the MQ-3 alcohol module was preheated with an Arduino board for 24 h. Its pins were then connected to the positive and negative sides of a breadboard, and the analog pin of the MQ-3 was connected to the analog A0 pin of the Arduino board, sending an input signal to the Arduino board for processing. The VCC pin of the LCD was attached to the positive of the breadboard, the VEE pin to the center pin of the variable resistor, and the VSS pin to the ground leg of a 10K ohms variable resistor (potentiometer) that was connected to the breadboard.

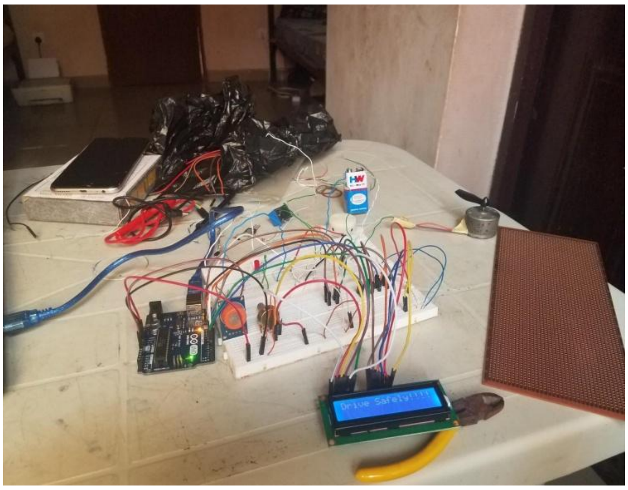

Fig. 2 Hardware components (The authors)

Only the D0–D3 pins from the LCD were not linked, and the other pins were connected to the digital pins on the Arduino board. The LED positive pin of the LCD was connected to a 320-ohm resistor. The buzzer's positive wire was attached to a digital pin on the Arduino board, and its negative wire was attached to the breadboard's ground. The cathode leg of the LED was linked to the breadboard's ground, while the anode leg was connected to a 320-ohm resistor that was attached to a digital pin on the Arduino board. A 9V battery power supply was used to power the DC motor separately, and a 5V relay was used to regulate the 12V DC motor. The COM pin was connected to the positive wire of the 9V battery, the NO pin of the relay was connected to the positive wire of the DC motor, and the negative wire of the power supply and the negative wire of the 12V DC motor were connected together. The connection was made so that Pin 1 (VCC) of the relay was connected to a digital pin of the Arduino board, and Pin 2 (GRD) was connected to the ground of the breadboard.

2.2.1. Arduino Uno R3 Pin Diagram

Based on the ATmega328P microcontroller chip, the Arduino Uno R3 is a microcontroller board. It is the most preferred board in the Arduino family and frequently used in robotics, electronic prototyping, and do-it-yourself projects. The Uno R3 board includes a 16 MHz quartz crystal, 14 digital input/output pins, 6 analog input pins, a USB port, a power jack, an ICSP header, and a reset button. In addition, digital pin 13 is coupled to a built-in LED. As shown in Fig. 3, the digital input and output pins can be set up as input or output and used to read digital signals or operate extraneous devices such as LEDs, motors, and sensors. Analog signals may be read from sensors such as temperature sensors and light sensors using the analog input ports. The board can be linked to a computer via a USB port for serial communication and programming. The board can be powered by an external power source through the power jack, and the microcontroller may be programmed using an external programmer with the ICSP header. The Uno R3 can be easily attached to the board using common headers and pins, which makes it compatible with a variety of sensors, modules, and shields. The Arduino IDE, a free software development environment with a code editor, compiler, and serial monitor, can be used to program it.

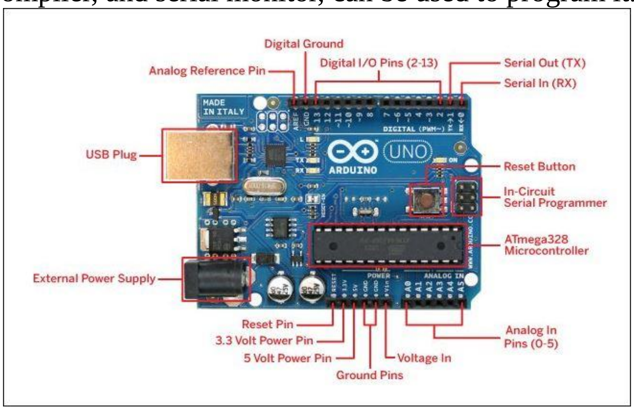

Fig. 3 Arduino Uno R3 [17]

2.2.2. MQ-3 Sensor

A typical gas sensor used to identify the presence of alcohol vapor in the air is the MQ-3 alcohol sensor element. A tiny ceramic sensing element with a metal oxide semiconductor substance is the sensor element. The detecting element of the MQ-3 sensor absorbs alcohol molecules when exposed to alcohol vapor, changing the electrical conductivity of the metal oxide semiconductor material. The amount of alcohol present in the air has a direct correlation with this decrease in conductivity, which is the input element that detects the presence of alcohol in a machine operator's breath. Fig. 4 depicts the MQ-3 gas sensor's structure and configuration. On a crust formed of plastic and stainless steel net, the sensitive layer of tin dioxide (SnO_2), measuring electrode, and heater are fixed. For sensitive components, the heater provides an optimal working environment. The wrapped MQ-3 has six pins, four of which are used for signal retrieval and the other two for heating current supply.

Fig. 4 MQ-3 sensor module [19]

2.2.3. LCD

The amount of alcohol found in the body of a vehicle's driver is displayed on a 16x2 LCD liquid crystal display (LCD), together with information on the driver's drunkenness, for the benefit of other passengers. As shown in Fig. 5, LCD screens are electrical display modules that have several uses. This project employed a 16x2 LCD display, a relatively basic module that is frequently used in different devices and circuits to display both warning and regular messages. A 16x2 LCD has two lines, each of which can display 16 characters. On this LCD, each character is displayed using a 5x7 pixel matrix.

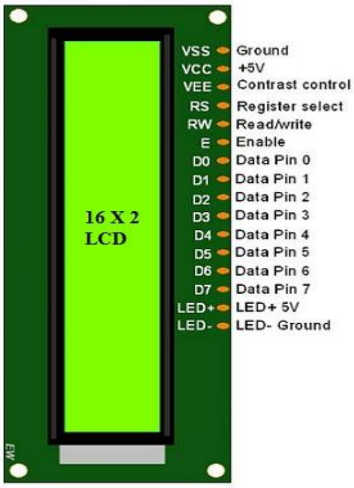

Fig. 5 LCD 16×2 pin diagram [14]

2.3. DC Piezo Buzzer

A piezoelectric crystal is vibrated and used in a DC Piezo Buzzer, an electronic device, to produce sound. Piezo buzzers, in contrast to electromagnetic buzzers, do not require an outside power source to make noise. Instead, they generate a sound wave using electricity from a DC power source. A substance that can change electrical energy into mechanical energy and vice versa is a piezoelectric crystal. The crystal experiences rapid expansion and contraction when an electrical voltage is applied, which results in high-frequency vibration. The mechanical vibration is subsequently transferred to a diaphragm or other sound-producing component, which transforms it into audible sound waves. A typical DC piezo buzzer with a voltage range of 3–24 V is shown in Fig. 6. When alcohol is detected, this output device alerts the driver and passengers in the car.

Fig. 6 Buzzer [19]

3. Experimental Results and Discussion

3.1. Blood Alcohol Concentration (BAC)

The amount of alcohol in someone's system is determined by their BAC. Usually, it is represented as a percentage of the total volume of blood. The level of alcohol impairment is measured by BAC, which is frequently used by law enforcement to evaluate if a person is driving while intoxicated (DUI). Blood or breath can be used to determine BAC. Law enforcement organizations most frequently use breathalyzer tests because they are quick, simple, and non-invasive. Breathalyzer instruments calculate a person's BAC using a formula after measuring the amount of alcohol in the breath. Numerous variables, including the test type employed, the equipment's calibration, and the presence of interfering substances, might have an impact on the accuracy of BAC results. For instance, the presence of mouthwash or other alcohol-containing compounds can interfere with breathalyzer results. It is crucial to remember that BAC readings do not always accurately reflect how impaired a person is. While some people may show signs of impairment even at lower blood alcohol concentrations, others might not do so. Additional elements such as sleep deprivation or drug use can impair the capacity to drive safely. BAC analysis is a crucial method for determining the degree of alcohol-related impairment. However, to evaluate if a person is fit to drive, it should be performed in conjunction with other methods, including behavior observation and results from field sobriety testing.

Equation (1) was used to sense the level of alcohol in the BAC of machine operators/drivers and inhibit the machine from working or running.

$$BAC = (A\times 5.14/W\times r) - 0.015\times H \quad (1)$$

where:
A - total amount of alcohol consumed, in ounces (oz);
W - person's body weight, in pounds (lbs);
r - alcohol distribution ratio, which is typically 0.73 for men and 0.66 for women;
H - number of hours since the person started drinking.

For example, suppose a person weighs 150 lbs and has consumed four 12-oz beer bottles over the course of three hours. The alcohol content of each beer is 5% (0.6 oz of alcohol per beer). Therefore, the total amount of alcohol consumed is 4 x 0.6 oz = 2.4 oz.

Using the BAC formula, we can calculate a person's BAC as follows:

$$BAC = (2.4\times 5.14/150\times 0.73) - 0.015\times 3$$

$$BAC = 0.049$$

Therefore, the person's BAC is 0.049, which is below the legal limit (which is 0.08) for driving in most states.

3.2. Experimental Results

The sensor would need to be calibrated and tested to establish the correlation between the sensor output and BAC to calculate the BAC of an alcoholic drink with a different percentage of alcohol content using an alcohol driver detection system, as shown in Table 2. The sensor would be subjected to various alcohol concentrations, the analog output voltage would be measured, and the readings would be compared to known BAC, as shown in Table 1. Fig. 7 shows the distance between the BACs. The BAC and analog value decrease as each distance increases. Fig. 8 shows BACs with different percentages of alcohol. The sensor output voltage must be compared against the calibration curves for each type of alcoholic drinks to determine the corresponding alcohol percentage and BAC. It is important to remember that many variables, including weight, gender, food intake, and the amount of time since drinking, have an impact on BAC. The dependability and accuracy of the sensor and the calibration and testing procedures utilized will affect how accurately BAC readings are obtained using an alcohol driver detection system.

Table 1 Distance (cm), analog value (threshold), and BAC (%) of an alcoholic drink with 37.5% alcohol (The authors)

Distance (cm)	Analog Value (Threshold)	BAC %
0	500	0.10
5	350	0.072
10	260	0.053
20	210	0.043
30	150	0.031
40	100	0.021
50	80	0.016

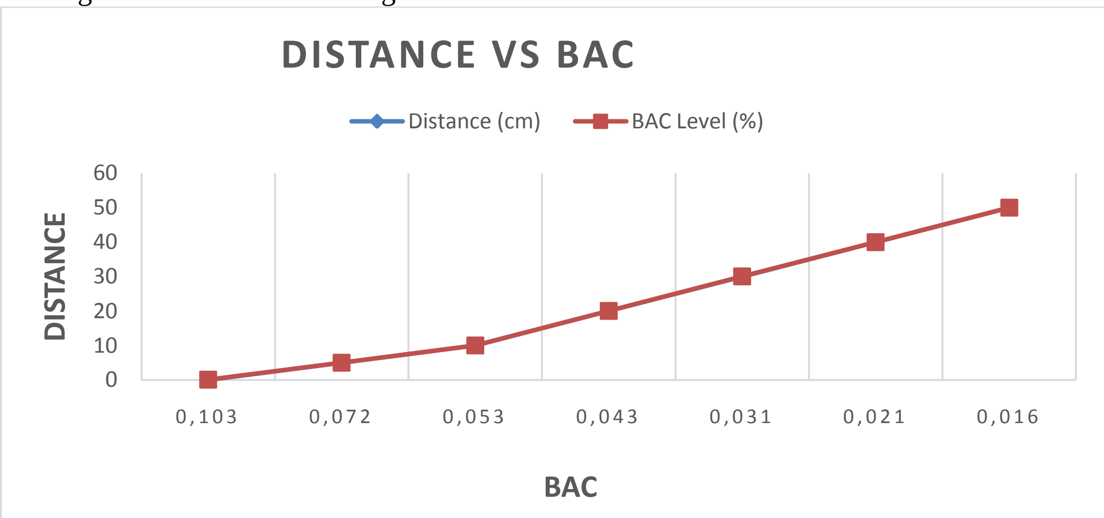

Fig. 7 Distance (cm) vs. BAC (%) (The authors)

Table 2 Alcohol percentage, analog value, and BAC reading for three different alcoholic drinks (The authors)

Alcohol %	Analog Value (Threshold)	BAC %
43	135	0.028
40	122	0.025
37.5	100	0.021

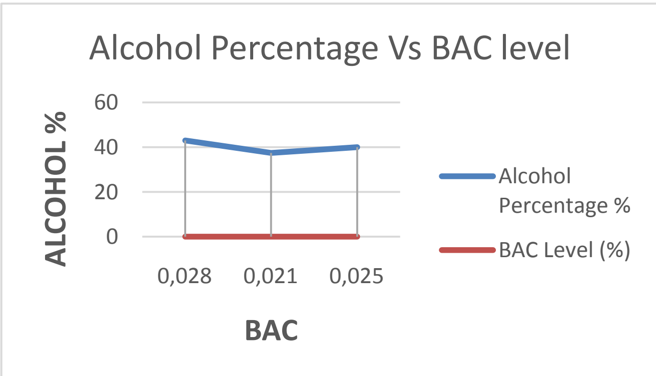

Fig. 8 Alcohol percentage vs. BAC (The authors)

4. Conclusion

In conclusion, the investigation of a virtual instrumentation-based system for alcohol driver identification offers a potentially effective way to reduce drunk-driving accidents. An Arduino Uno R3 microcontroller and some sensors and parts, including an MQ-3 alcohol sensor element, a DC Piezo Buzzer, and an LCD, were used to build and implement the system. The MQ-3 alcohol sensor element is used by the system to detect the presence of alcohol in the air, and the analog output voltage is then converted to the relevant alcohol percentage and BAC measurements. Once the readings reach a particular threshold, which indicates the presence of alcohol, they are displayed on the LCD display, and a DC Piezo Buzzer alert is activated. Moreover, the implications of this research extend beyond academia, as the proposed system holds substantial potential in real-world applications. The development of an accurate and swift alcohol detection system using virtual instruments could reduce alcohol-related accidents and enhance public safety on roads. The findings of the investigation showed that the system could provide readings for the alcohol percentage and BAC and accurately detect alcohol. The system's accuracy is based on the calibration and testing procedures employed and the precision and dependability of the sensors and other components. Additionally, by warning drivers when alcohol is present in their breath, the alcohol driver detection system, based on virtual instrumentation, offers a potentially efficient method for preventing drunk-driving incidents. This technology can be a useful tool for reducing the frequency of drunk-driving accidents and enhancing road safety. The findings of this research offer several academic contributions. First, it showcases the potential of virtual instruments in the domain of road safety, illustrating their adaptability in creating innovative solutions for addressing critical issues such as drunk driving. Second, the comprehensive evaluation of the system's accuracy, response time, and usability provides valuable insights into the practicality and reliability of such technological implementations. This not only contributes to the scientific understanding of alcohol detection mechanisms but also offers a practical framework for further advancements in this field. The exploration of an alcohol driver detection system using virtual instruments not only adds to the body of knowledge within the realm of technological solutions for safety but also offers a tangible contribution to mitigating the risks associated with alcohol-impaired driving, thereby potentially saving lives and minimizing road accidents. The findings of this research pave the way for further advancements and practical implementations in the domain of driver safety and alcohol detection systems.

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