Breathalyzer Design

**Van Do**

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Excelsior College

ELEC495

Integrated Technology Assessment

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**Team Report**

Conner Brentzel will use a light sensor module in order to determine if a vehicle is approaching a traffic light that is transitioning from green to yellow and finally to red. The thought is to include an ultrasonic sensor in order to determine if the vehicle is close to the traffic light and will emit an alert audibly via a speaker and visually via a LCD.

Joshua Danyeur will build a simple switch mode power supply to take the 120V AC from a home outlet and turning it into a 24V DC signal; utilizing a transformer and a few circuit parts.

Scott Adamson will create a sensor system that will detect and alert an object’s whereabouts in regards to the device.

**Introduction**

This project will aim to build a breathalyzer used to detect the level of alcohol in the body system. It is not enough to face the consequences of inhibition when it is too late, and a driver is pulled over. Instead, responsible drinkers can use this device to judge a tolerable level of sobriety before leaving. This can be used wherever there is nightlife, or a gathering of friends in which alcohol is served. Measuring blood alcohol content is all but reliable in terms of weight,

What encapsulates this project is the materials needed to accomplish functional breathalyzers that police often use. Additionally, the project will aim to serve as a learning challenge as PCB design will be implemented into the overall product. This endeavor focuses on aiming to learn PCB design that was not available as a course at Excelsior University. This will result in well-rounded knowledge of electronics as a focus in the major.

**Background**

An Arduino Uno R3 will be used to develop the device using an FDA approved commercial breathalyzer, called BACtrack, as reference (BACtrack GO, N.D.). To justify the feasibility of this project, the components are easily exchangeable if any were to fail, while regular periods of calibration are required for the commercial alternative. The components include a piezo buzzer, an LCD module, and an MQ3 Gas Sensor. This will be fitted onto a custom designed PCB for ease of use. According to the datasheet on the MQ-3, it is a SnO2 semiconductor which features lower conductivity in clean air. In the presence of gasses, the conductivity rises and can be programmed to measure BAC (Alcohol Gas Sensor, 2014). A study was conducted to determine the overall perception of a personal breathalyzer. Min, A., et al, showed that young adults below the age of 34 that are at risk of the consequences of binge drinking are highly receptive towards a personal device that helps aid in decision making (Min, A, et al, 2020).

**Project**

Diagram

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Figure 1 - Logical flowchart of Breathalyzer

Figure 1 shows an illustration of the approach of the program that will later be developed. The PCB will need an overall review of what components will be implemented and how to fit the components into the design. This will be learned and demonstrated by the end of the project to include design engineering and soldering. The overall concept is to take the voltage of the sensor during clean air and develop a comparator circuit in the presence of alcohol. Then, the input should be programmed to convert into the equivalent result in alcohol per mg/l. The formula for conversion will later be developed as the design is further researched.

**PERT & Gantt Chart**

**Gantt:**

Chart, timeline

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Figure 2 - Gantt Chart for M2Project Report

Following this timeline, I expect the earliest to be done with my design is in early November. I do expect timeline changes as this may not be realistic.

**PERT:**

Diagram

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Figure 3 - Pert Chart for M2Project Report

**Summary (9/25)**

Parts have been ordered from online. I am awaiting its arrival for initial circuit setup. During component research I have found that the MQ-3 sensor returns a constant value during clean air. I plan on building the code first to test and debug while figuring out a formula to convert the value to a BAC.

Chart

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Figure 4 - MQ-3 Sensor Rs/R0 per mg/L of alcohol

(Technical Data MQ-3 Gas Sensor, N.D.)

From the above chart the sensor resistance of various concentrations of gases versus clean air is lowered when in the presence of higher concentrations. From this I can conclude that if I can determine the value of Rs in clean air, I can also determine R0 and in turn Rs/R0.

**Summary 10/8/22**

A simulated circuit has been drawn via LTspice and is ready for connection. The components will be connected via breadboard first to confirm correct operating procedures. Coding will then commence to follow the flowchart detailed in an earlier report. The code will define each input/output port and will output the results of the converted detected alcohol signal from the MQ3 gas sensor. This will be converted by the microcontroller into an appropriate BAC in order to help determine sobriety. Although the sensor returns a signal in a range of 25 – 500 ppm, an equivalent value in the form of BAC will help achieve project goals.

Diagram, schematic

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Figure 5 - Block Diagram of Breathalyzer via EasyEDA

BAC formula:

According to the previous reference of Rs/R0, the sensitivity of the sensor is dependent on the measured BAC in grams per deciliter (g/dL), also whereas the R0 is the resistance of the sensor when only 0.4 mg/L of alcohol is present in the air.

So far, an equation to determine the relationship between the Rs/R0 and BAC is inspired by the data chart for the MQ-3 sensor. For now, it is only an assumption that the relationship is logarithmic in nature, and as such should be solved from the various plots in the graph.

Chart

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Where F0=1, X0= 0.5

F1 = .2, X1 = 4

Since this is the first result for BAC conversion, multiple rounds of testing must be done to ensure that the BAC falls in line with an accurate measure of alcohol consumed. According to Carey, K. & Hustad, J., (2005), BAC is calculated using grams or milligrams of alcohol in a given volume of blood (usually 100 ml or its equivalent, 1 dl). Then, this value can be expressed as grams percent. As such, the following mg/L to g/dL conversion is attained:

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Figure 6 - Device powered on and sample code loaded.

**Summary 10/23/22**

I have found to be getting nowhere with testing the previous developed equation. I have decided to research more on the schematics and found a promising step in the right direction. According to Ighalo, J. et al., their analysis of the MQ-3 module details the operation of the output signal:

“Instead of measuring the resistance directly, we measure the voltage level at the point between the sensor and a load resistor R2. The sensor and load resistor R2 form a voltage divider, and the lower the sensor resistance, the higher the voltage reading which was then fed directly into the input of the LM393 comparator.” (P. 73)

A picture containing text, sky

Description automatically generated

Figure 7 - MQ-3 Schematic Diagram (Ighalo et al., 2019)

By using LM393 comparator present on the board the voltage determines whether the comparator outputs HIGH or LOW with a corresponding value sent to the microcontroller. The compared voltage from the sensor is determined by an on-board potentiometer that sets the threshold for comparison. The potentiometer will be set to a low resistance such that the voltage across the potentiometer is as high as it can be for the purposes of this project which aims to detect any levels of alcohol.

Pin A0 has a value range of 0-1024 as an analog voltage to the MC Port 0. This signal is divided by 1024 resulting in the percentage of alcohol present in a breath. BAC is calculated by a factor of 2100 per liter of blood. The newly developed formula for BAC is as follows:

Throughout the week of troubleshooting code and device setup, each I/O peripheral has been coded for final product functionality. The MQ3 Alcohol Sensor has been developed to convert the input signal into the appropriate BAC. The piezo buzzer has been configured for activation upon readings of .08% BAC or higher. Lastly, he LCD module correctly displays the percentage of alcohol to the 3rd significant figure. As such, the project may confidently move on to PCB design and soldering.

**C Code:**

#include <LiquidCrystal.h>

#include <Wire.h>

#define piezo 9

const int rs = 12, en = 11, d4 = 5, d5 = 4, d6 = 3, d7 = 2; // declaring LCD pins

LiquidCrystal lcd(rs, en, d4, d5, d6, d7);

void setup() {

pinMode (piezo, OUTPUT); // declaring peripheral I/O ports

pinMode (0, INPUT);

Serial.begin(9600);

lcd.begin(16, 2); // initiallizing 16x2 LCD module

lcd.print("Sensor warming.."); // Allowing heating current to warm the sensor

delay(2000);

lcd.clear(); // Clear LCD screen for test results

}

void loop() {

float SensorValue = analogRead(0);

float Breath = SensorValue / 1024;

float BAC = Breath \* .21;

Serial.println(SensorValue); // monitoring values for testing & debugging

Serial.println(Breath,3); // precision decimal points

lcd.setCursor(0,0); // first line measurements

lcd.print("BAC = ");

lcd.print(BAC, 3); //convert to %

lcd.print("%");

if (BAC < .08) // if else statements to determine sobriety

{

lcd.setCursor(0,1);

lcd.println("Normal "); // extra spaces are intentional for clearing row of unnecessary characters

}

else

{

lcd.setCursor(0,1);

lcd.println("DRUNK ");

digitalWrite(9, HIGH);

delay(250);

digitalWrite(9, HIGH);

delay(250);

digitalWrite(9, HIGH);

delay(250);

}

delay(200); // Looping the breathalyzer test every .2 seconds.

}

A picture containing text, person, electronics

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Figure 8 - Working device under presence of alcohol

**Summary (11/6):**

A screenshot of a video game

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Figure 9 - Custom PCB design for breathalyzer device

My circuit board has been designed using EasyEDA and is ready for review. This circuit board will fit on top the Arduino microcontroller and will house all the components necessary for a functioning breathalyzer. This portion of the project took the most time due to self-learning PCB design. I have checked and passed design rules so I am confident this board will meet manufacturing requirements and prevent chip failures. This board features a piezo buzzer to alarm the tester as intoxicated. It also has space for a switch to reset the device after a test. In the middle of the board, I plan on mounting an LCD module that is supported by a potentiometer and 1k Ohm resistor to adjust the brightness of the screen. Lastly, the sensor module pictured on the right will be soldered to the pads on the right of the board using Dupont wires as a means of ease of use while using the breathalyzer.

Additionally, I have also revised my code so that it will respond to varying degrees of alcohol sensed through the device. Using if, else if, and else statements, I programmed three categories to inform the tester of their level of intoxication.

**C Code:**

#include <LiquidCrystal.h>

#include <Wire.h>

#define piezo 9

const int rs = 12, en = 11, d4 = 2, d5 = 3, d6 = 4, d7 = 5; // declaring LCD pins

LiquidCrystal lcd(rs, en, d4, d5, d6, d7);

void setup() {

pinMode (piezo, OUTPUT); // declaring peripheral I/O ports

pinMode (0, INPUT);

Serial.begin(9600);

lcd.begin(16, 2); // initiallizing 16x2 LCD module

lcd.print("Sensor warming.."); // Allowing heating current to warm the sensor

delay(20000);

lcd.clear(); // Clear LCD screen for test results

}

void loop() {

float SensorValue = analogRead(0);

float Breath = SensorValue / 1024;

float ratio = .21; // conversion of presence of alcohol per liter in blood

float BAC = Breath \* ratio;

Serial.println(SensorValue); // monitoring values for testing & debugging

Serial.println(Breath,3); // precision decimal points

Serial.println(BAC,3); // precision decimal points

if (BAC >.079) // Drunken limit

{

lcd.clear();

lcd.setCursor(0,0);

lcd.print("BAC = ");

lcd.print(BAC);

lcd.print("% "); // extra spaces are intentional for clearing row of unnecessary characters

lcd.setCursor(0,1);

lcd.print("DRUNK ");

digitalWrite(piezo, HIGH);

delay(250);

digitalWrite(piezo, HIGH);

delay(250);

digitalWrite(piezo, HIGH);

}

else if ((BAC > .04) && (BAC < .079)) // threshold for detected drunkeness

{

lcd.clear();

lcd.setCursor(0,0); // first line measurements

lcd.print("BAC = ");

lcd.print(BAC); // extra spaces are intentional for clearing row of unnecessary characters

lcd.print("% ");

lcd.setCursor(0,1);

lcd.print("DRINK WATER ");

}

else { // Below the limit

lcd.clear();

lcd.setCursor(0,0); // first line measurements

lcd.print("BAC = 0.00% ");

lcd.setCursor(0,1);

lcd.print("Not Detected "); // extra spaces are intentional for clearing row of unnecessary characters

}

}

Ending comments:

I will ask my teammates what they of my work so far and if there could be any improvements. I would like to solicit critique right away so that I have time to change my design before I start ordering my first PCBs and begin soldering. For the purposes of having my work reviewed, I will also attach to the assignment my EasyEDA project file if Dr. Tang is willing to take a quick look.

I am glad I had the opportunity to begin learning a new skill in PCB design, and I believe it will help me provide a strong argument to the extent of my education and experience. I am also thankful that besides the challenging task of coming up with a customer PCB with no experience, the project continues to be on track for completion.

**Milestones**:

Module 1: Submit Project Proposal

Module 2: Develop Gantt and PERT chart along with costs.

Module 3: Design the PCB along with necessary components using JLC PCB software and printing. Document the process so far whether it is successful or not.

Module 4: Identity and reflect on areas of improvement. Prepare material for presentation at Team Webinar.

Module 5: ~~Begin soldering components to PCB and testing connections.~~

Begin PCB design, submit to classmates/lecturer for critique and advice. (Video document)

Module 6: ~~Build the product and video document accordingly.~~

Finish soldering and verification of device functionality (Video document)

Module 7: ~~Test the product and video document accordingly.~~

Finalize project report and video for submission.

Module 8: Presentation development and Final Webinar.

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