CHAPTER 1

INTRODUCTION

Acetone ((CH3)2CO) is one of the simplest and most widely used ketones in industry. It is a mobile liquid that has no colour, and it is completely miscible with water and most organic solvents and oils. It is a common building block in organic chemistry, and a precursor to polymers so it is widely used in industries and Labs such as: cleaning, methacrylate's synthesizing, dissolving plastic, purifying paraffin, tissues dehydrating, in various pharmaceutical and cosmetic products, and it is one of the biomarkers that are used for indicating fruits and vegetable freshness.Acetone is a volatile organic compound that is produced as a byproduct of the metabolism of fats in the liver. When the body is in a state of ketosis, such as during fasting, low-carbohydrate diets, or certain medical conditions like diabetes, the production of acetone increases, and it can be detected in the breath.

Measuring acetone in breath can provide a non-invasive way to monitor the levels of ketones in the body. This can be useful for people with diabetes who are following a low-carbohydrate or ketogenic diet, as well as for athletes who are trying to optimize their performance by improving their metabolic efficiency. In addition, monitoring acetone in breath can also be used to track weight loss progress, as higher levels of acetone may indicate that the body is burning more fat for energy. However, it's important to note that while acetone in breath can be a useful biomarker, it should always be interpreted in the context of other health markers and symptoms and should not be used as a standalone diagnostic tool. Here, just to test a basic prototype we are using gas sensor MQ-135 and temperature & humidity sensor DHT-22 which has been interfaced with Arduino Uno R3.

Measurements of endogenous acetone in breath have been made for over 50 years. Early studies examined the effect of caloric intake (fasting and calorie restriction diets), dietary macronutrient composition, and exercise on breath acetone. While people with and without obesity participated in these investigations, the focus was on the effects of fasting and diabetes. The breath acetone concentration (BrAce) was understood to be a non-invasive measure of ketosis. As a by-product of fat metabolism, acetone in blood and breath is known to increase with fasting and caloric restriction as stored fat is mobilized to meet energy demands (1,4,8,24,25). This relationship has been known for more than 50 years. In the last 25 years, studies that better quantified the relationship between BrAce and the rate of fat loss have been performed. The review below focuses on studies correlating and quantifying the relationship between BrAce and fat loss. An initial report mentioned that maintaining an average BrAce of 500 nM (2.6 ppm) should result in a weight loss of 227 g (0.5 lbs) per week. This report appeared to be the first to attempt to quantify the relationship between BrAce and fat loss. However, it was difficult to discern how the authors arrived at this conclusion because the methodological details and resultant data supporting this statement were not provided

In recent years, breath analysis has been attracted tremendous attention as a potentially powerful tool for studying the medical diagnosis diseases because of its non-invasive nature and capability of real-time monitoring. Human breath is a complicated mixture of different gases including nitrogen, oxygen, carbon dioxide, water vapor and trace levels of more than 1000 compounds which are either generated in the body (endogenous) or absorbed as contaminants from the environment (exogenous). Certain breath constituents such as volatile organic compounds (VOCs) (isoprene, ammonia, and acetone) and a restricted number of inorganic gases (NO, CO) have been identified as putative biomarkers of specific diseases. For metabolic monitoring, several candidates are attractive. As an example, acetone has been considered as a main breath biomarker for diabetes. It should be noted that, endogenous acetone is produced primarily through ketogenesis.

CHAPTER 2

LITERATURE SURVEY

1. **B. Dontha, M. Faltas, P. -I. Gouma and A. Kiourti, "Electromagnetic-Based Deformation Monitoring for Breath Acetone Sensors," in *IEEE Journal of Electromagnetics, RF and Microwaves in Medicine and Biology*, vol. 6, no. 4, pp. 524-531, Dec. 2022.**

   This paper proposes the novel electromagnetic (EM) based mechanism for quantifying bending in chemo-actuators that detect breath acetone and validate feasibility in a proof-of-concept in vitro setup. Breath acetone serves as a biomarker of human metabolism, yet previously reported techniques are invasive, non-continuous, and/or operate at high temperatures.

2. **Y. Obeidat. "The Most Common Methods for Breath Acetone Concentration Detection: A Review," in *IEEE Sensors Journal*, vol. 21, no. 13, pp. 14540-14558, 1 July1, 2021.**

   This paper proposes the review of the most common techniques that are used for breath acetone detection. A comparison between these techniques and the possibility of using them for the diagnosis of diabetes mellitus are presented and discussed in detail. Finally, this review emphasizes the need for cheap, highly sensitive, easy to use and portable devices to help individuals living with diabetes mellitus to monitor their disease.

3. **F. Usman, J. O. Dennis, A. Y. Ahmed, F. Meriaudeau, O. B. Ayodele and A. A. S. Rabih, "A Review of Biosensors for Non-Invasive Diabetes Monitoring and Screening in Human Exhaled Breath," in IEEE Access, vol. 7, pp. 5963-5974, 2019.**
   This paper reviews the recent literature on the detection of exhaled breath acetone and acetone vapor of diabetic interest. The biosensors have been classified based on their transduction methods. The performance characteristics of the biosensors have been explored for comparison.

3. **L. Tshotetsi, B. W. Mwakikunga and P. Rheeder. "Monitoring of glucose in people living with diabetes mellitus: A study comparing nano-based acetone/glucose breath analyzer, two commercial glucometers and laboratory-based glucose analysis," 2021 , pp. 1-4, doi: 10.1109/NanofIM54124.2021.9737347.**

Non-invasive glucose testing is one of the novel methods for monitoring glucose in people living with diabetes mellitus. We researched how breathe acetone derived glucose levels compare to serum glucose and capillary glucose measure on two commercial glucose meters in diabetes mellitus patients at Steve Biko Academic Hospital. Breath acetone samples were collected in 127 patients from a diabetes clinic which was compared to lab analysed glucose and other 2 commercial glucose meters in a cross-sectional study.

4. **G. Neri, A. Bonavita, G. Micali and N. Donato. "Design and Development of a Breath Acetone MOS Sensor for Ketogenic Diets Control," in *IEEE Sensors Journal*, vol. 10, no. 1, pp. 131-136 , Jan. 2010.**

This paper proposes the design of a handy and noninvasive measurement of acetone in the human breath, which is useful for ketosis monitoring and control, by means of MOS sensors is reported. The results obtained indicate that MOS sensors based on Pt-In2O 3 nano powders are promising as fast and quantifiable means of determining acetone in the breath, posing the advantages of real time measurements and low costs devices for the control of ketogenic diet.

CHAPTER 3

OBJECTIVE

1. To study and analyze various parameters and existing methods that are used as a Breathalyzer

2. To develop a simple non-invasive device to monitor ketone levels as it is a key indicator for abnormal glucose level.

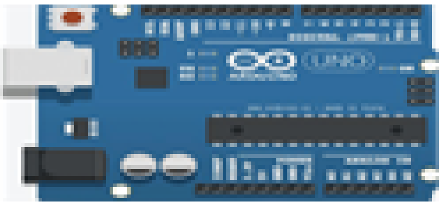
3. To measure the concentration of acetone particles in the user's breath in order to give a ketone value as ketones in the body break down into volatile acetone.

CHAPTER 4

COMPONENTS

AURDUINO UNO

Arduino UNO is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. You can tinker with your UNO without worrying too much about doing something wrong, worst case scenario you can replace the chip for a few dollars and start over again



DHT 22 TEMPERATURE AND HUMIDITY SENSOR

The DHT22 is a basic, low-cost digital temperature and humidity sensor. It uses a capacitive humidity sensor and a thermistor to measure the surrounding air and spits out a digital signal on the data pin (no analog input pins needed). It's fairly simple to use but requires careful timing to grab data.

10K RESISTORS

A 10k ohm resistor has 4 color bands: brown, black, orange, and gold for 5% tolerance, respectively. The first two bands signify the digits while the third one is the multiplier while fourth are tolerance.

MQ 135 GAS SENSOR

A device that is used to detect or measure or monitor the gases like ammonia, benzene, sulfur, carbon dioxide, smoke, and other harmful gases are called as an air quality gas sensor. The MQ135 air quality sensor, which belongs to the series of MQ gas sensors, is widely used to detect harmful gases, and smoke in the fresh air. This article gives a brief description of how to measure and detect gases by using an MQ135 air quality sensor.

OLED

OLED is Organic Light Emitting Diode that emits light in response to an electric current. OLED display works with no backlight so it can display deep black levels. It is small in size and light in weight than Liquid Crystal Displays

SDA (Serial Data):

SDA is used to transmit data between master and slave. The data and acknowledgment are sent through SDA.

SCL (Serial Clock):

It is a clock signal. This pin transmits clocks to slave, SCL. Data will be sent to other devices on clock tick event. Only master device has control over this SCL line

VCC:

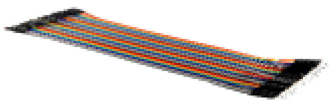
This is power supply pin. +3.3V supply is required. More than 3.3 V supply can damage the display.

GND:

This is Ground pin. Connect ground of supply to this pin

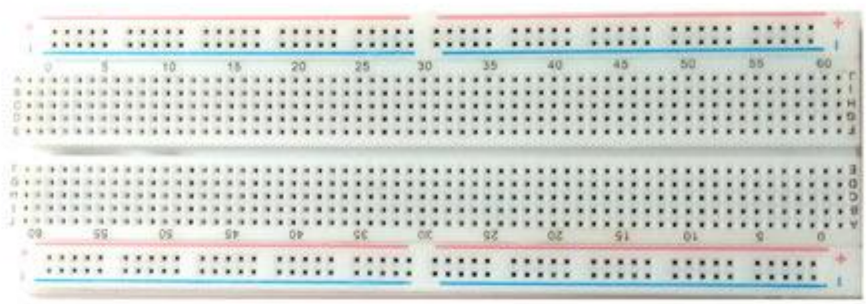
JUMPER WIRES

A jump wire (also known as jumper, jumper wire, DuPont wire) is an electrical wire, or group of them in a cable, with a connector or pin at each end (or sometimes without them – simply "tinned"), which is normally used to interconnect the components of a breadboard or other prototype or test circuit, internally or with other equipment or components, without soldering. Individual jump wires are fitted by inserting their "end connectors" into the slots provided in a breadboard, the header connector of a circuit board, or a piece of test equipment.



BREADBOARD

The arrangement of different components on a breadboard can be done by inserting their terminals into the breadboard, so it is frequently known as a plugboard. Breadboard definition is a plastic board in rectangular shape that includes a lot of small holes in it to allow you to place different components to build an electronic circuit is known as a breadboard. The connection on the breadboard is not permanent but they can be connected without soldering the components



CHAPTER 5

METHODOLOGY

The keto genic diet, while originally thought to treat epilepsy in children, is now used for weight loss due to increasing evidence indicating that fat is burned more rapidly when there is a low carbohydrate intake. This low carbohydrate intake can lead to elevated ketone levels in the blood and breath. Breath and blood ketones can be measured to gauge the level of ketosis and allow for adjustment of the diet to meet the user's needs. Blood ketone levels have been historically used, but now breath acetone sensors are becoming more common due to less invasiveness and convenience .New technologies are being researched in the area of acetone sensors to capitalize on the rising popularity of the diet. Current breath acetone sensors come in the form of handheld breathalyser devices. Technologies in development mostly consist of semiconductor metal oxides in different physio-chemical formations. These current devices and future technologies are investigated here with regard to utility and efficacy. Technologies currently in development do not have extensive testing of the selectivity of the sensors including the many compounds present in human breath.While some sensors have undergone human testing, the sample sizes are very small, and the testing was not extensive. Data regarding current devices is lacking and more research needs to be done to effectively evaluate current devices if they are to have a place as medical devices. Future technologies are very promising but are still in early development stages.

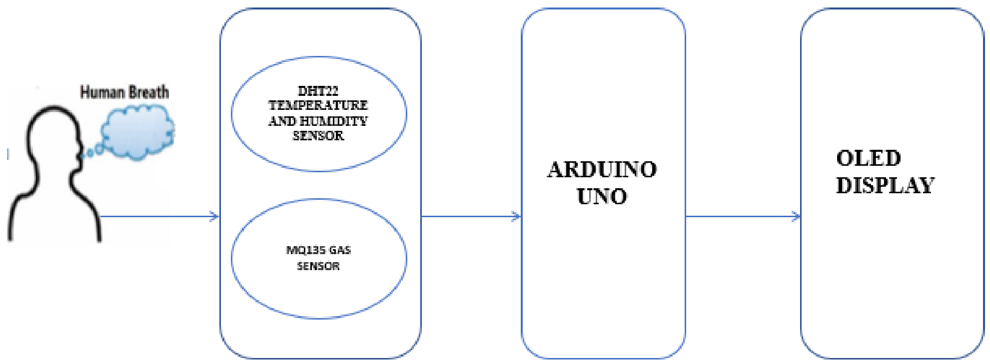
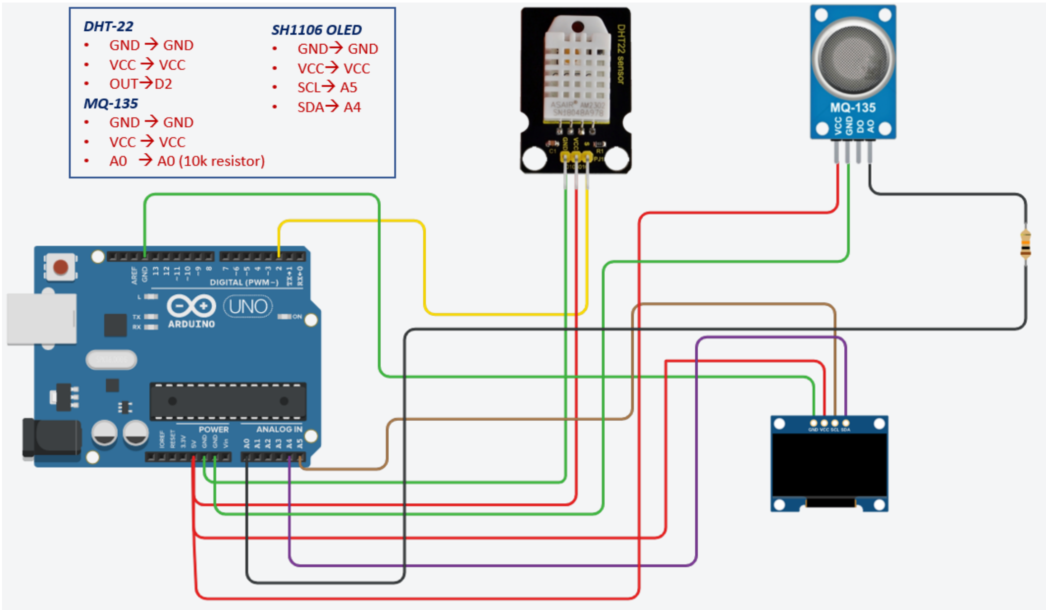


Fig 5.1 Block diagram

To create a human breath analyzer to measure ketosis using an Arduino Uno, gas sensor, and temperature and humidity sensor, the following methodology can be used:

- Gather the required materials: Arduino Uno board, gas sensor (such as MQ-135 Gas Sensor Module), temperature and humidity sensor (such as the DHT22 sensor), breadboard, jumper wires, and a power supply.
- Connect the temperature and humidity sensor to the Arduino Uno board using jumper wires. to a power supply, such as a USB cable.
- Write and upload the code to the Arduino Uno board using the Arduino IDE. The code should read the analog signal from the gas sensor and convert it to a digital value. The digital values can be displayed on an LCD display or sent to a computer via serial communication.
- Calibrate the gas sensor by exposing it to a known concentration of ketones. This can be done by using a ketone breath analyzer device to determine the corresponding concentration in the breath. Note the corresponding digital value in the Arduino IDE.
- Use the calibrated sensor to measure the ketone concentration in a person's breath. This can be done by having the person exhale into the sensor for a few seconds. The digital value from the sensor can be converted to a corresponding ketone concentration using a calibration curve.
- Take into account the temperature and humidity readings from the DHT22 sensor to adjust the ketone concentration calculation, as these factors can affect the accuracy of the gas sensor.

5.2 HARDWARE INTERFACE



Gas sensor MQ-135 has four pins VCC, GND, D0 & A0. VCC is connected to the 5v pin of Arduino uno, GND is interfaced with GND pin and similarly A0 of sensor is attached to the analog pin A0 of Arduino with a load resistor of 10kohm. Here pin D0 is unused.

For DHT-22, the data pin of sensor has been connected to digital pin 2 of Arduino Uno whereas Positive pin has been interfaced to 5v and negative to GND.

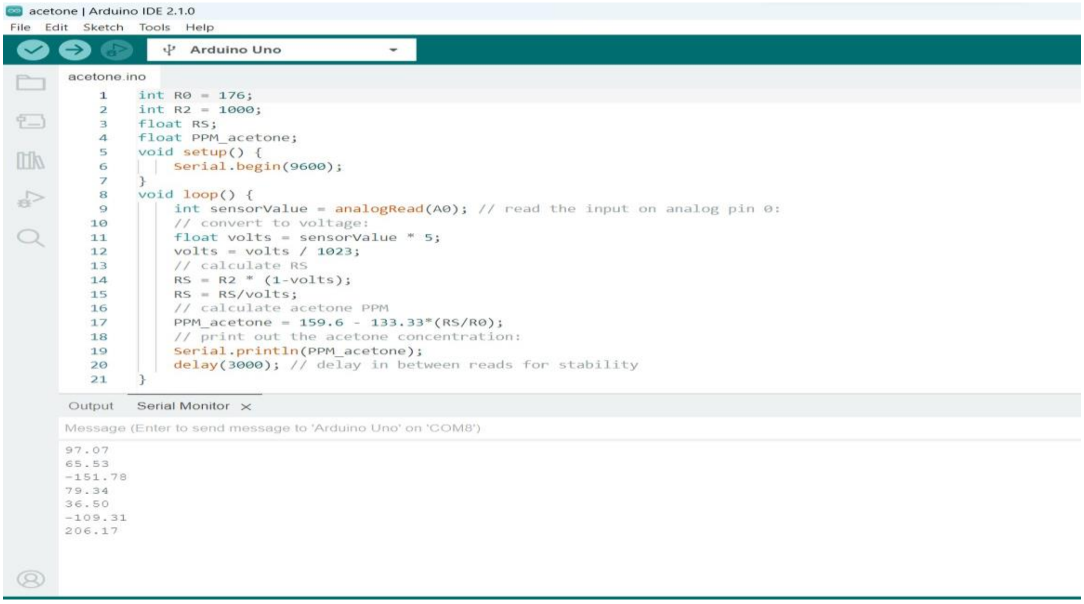
To display the result SH1106 1.3-inch monochrome i2c screen is being used and has four pins VCC, GND, SCL &SDA. VCC is connected to 5v and GND to ground pin in Arduino Uno. SCL is connected to analog pin A5 of Arduino Uno and SDA to A4 respectively.

CHAPTER 6

RESULTS AND DISCUSSION

The result of this method would be a measurement of the ketone concentration in a person's breath, taking into account temperature and humidity.

When the hardware connections and software are ready, just run the aurdino code (given below) on the computer .


acetone | Arduino IDE 2.1.0

File Edit Sketch Tools Help

Arduino Uno

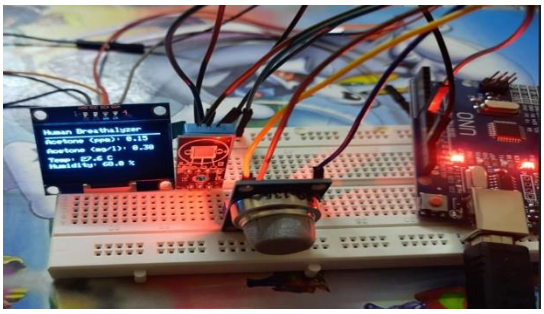
acetone.ino

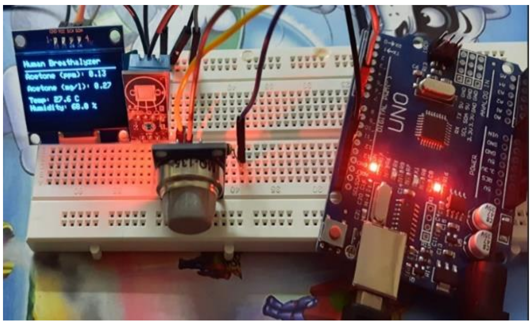
```
int R0 = 176;
int R2 = 1000;
float RS;
float PPM_acetone;
void setup() {
    Serial.begin(9600);
}
void loop() {
    int sensorValue = analogRead(A0); // read the input on analog pin 0:
    // convert to voltage:
    float volts = sensorValue * 5;
    volts = volts / 1023;
    // calculate RS
    RS = R2 * (1-volts);
    RS = RS/volts;
    // calculate acetone PPM
    PPM_acetone = 159.6 - 133.33*(RS/R0);
    // print out the acetone concentration:
    Serial.println(PPM_acetone);
    delay(3000); // delay in between reads for stability
}
```

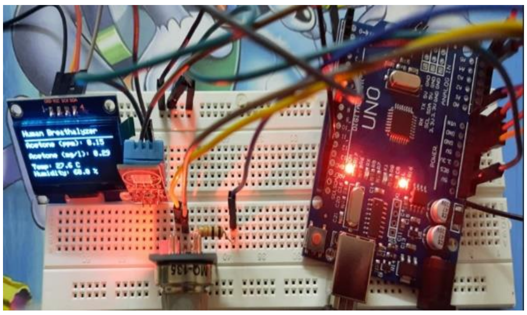
Output Serial Monitor

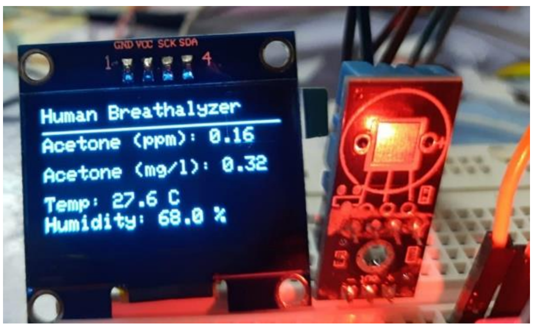
Message (Enter to send message to 'Arduino Uno' on 'COM8')

```
97.07
65.53
-151.78
79.34
36.50
-109.31
206.17
```









CHAPTER 7

CONCLUSION AND FUTURE SCOPE

Endogenous breath acetone is correlated with and can be used to understand the rate of fat loss in healthy subjects. Maintaining a 2 ppm BrAce while on a calorie restriction diet should cause a fat loss rate of 227 g week21 . Acetone is correlated with fat loss because it and two other ketone bodies are the by-products of fat metabolism. Breath acetone is strongly correlated with the blood ketone body BOHB. Breath acetone can range in concentration from 1 ppm in healthy non-dieting subjects to 1,250 ppm in diabetic ketoacidosis. In healthy individuals, breath acetone is affected by multiple factors. Dietary macronutrient composition has the greatest impact followed, in rank order, by caloric restriction, exercise, pulmonary factors, and other factors. Because of its relationship to fat metabolism , a high-fat, low-carbohydrate diet will generate more breath acetone than a standard mixed diet. A reduction in consumed calories relative to that needed for weight maintenance can increase breath acetone and fat loss. Exercise can promote caloric restriction. Additionally, exercise can cause breath acetone elevation during a workout. Human respiratory factors can affect the acetone concentration in the breath sample. Other foods (e.g., garlic), drugs (e.g., disulfiram), and environmental conditions can increase breath acetone due to their ability to increase fat metabolism or block acetone metabolism. While the relationship between breath acetone and fat loss is well established, additional research is needed to better understand these factors and advance this area of integrative physiology.

❖ FUTURE SCOPE:

1. To make the device as a wearable product.
2. To make the device more efficient to find the accurate acetone value of a persons .
3. To study and develop a device to analyze the diabetic level in person using breath aceto

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APPENDIX

Specification of Arduino uno microcontroller:

- Microcontroller: Microchip ATmega328P[7]
- Operating Voltage: 5 Volts
- Input Voltage: 7 to 20 Volts
- Digital I/O Pins: 14
- PWM Pins: 6 (Pin # 3, 5, 6, 9, 10 and 11)[9]
- UART: 1
- I2C: 1
- SPI: 1
- Analog Input Pins: 6
- DC Current per I/O Pin: 20 mA
- DC Current for 3.3V Pin: 50 mA
- Flash Memory: 32 KB of which 0.5 KB used by bootloader
- SRAM: 2 KB
- EEPROM: 1 KB
- Clock Speed: 16 MHz
- Length: 68.6 mm
- Width: 53.4 mm
- Weight: 25 g
- ICSP Header: Yes
- Power Sources: DC Power Jack & USB Port

Specification of DHT11Temperature and Humidity sensor:

- PCB size-22.0mm X 20.5mm X 1.6mm
- Working voltage- 3.3 or 5V DC
- Operating voltage -3.3 or 5V DC
- Measurement range- 20-95%RH；0-50℃
- Resolution- 8bit（temperature），8bit（humidity）
- Compatible interfaces- 2.54 3-pin interface and 4-pin Grove interface

Specifications of MQ135 Gas Sensor

- Operating Voltage: 2.5V to 5.0V
- Power consumption: 150mA
- Detect/Measure: NH_3, Nox, CO_2, Alcohol, Benzene, Smoke
- Typical operating Voltage: 5V
- Digital Output: 0V to 5V (TTL Logic) @ 5V Vcc
- Analog Output: 0-5V @ 5V Vcc