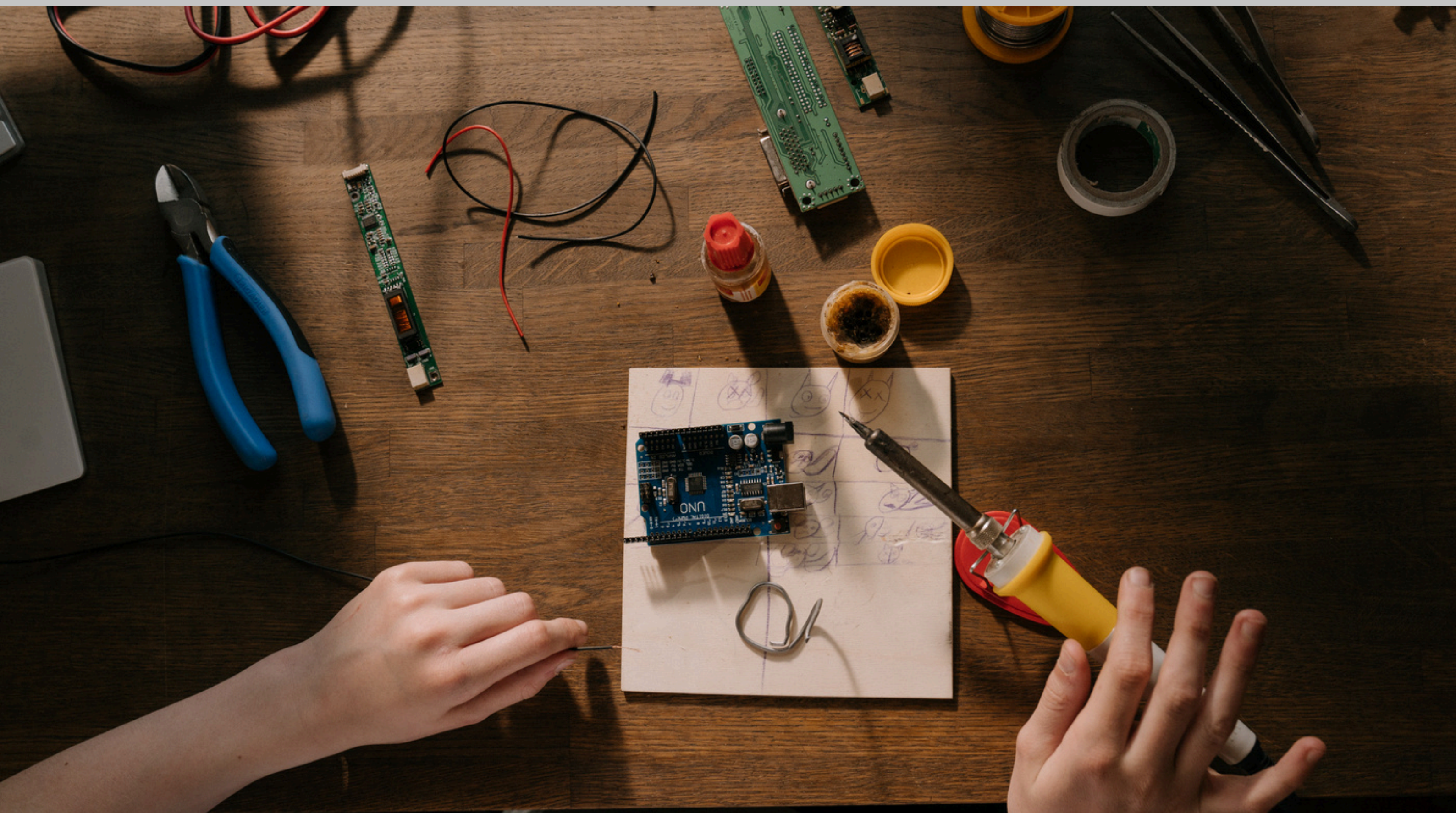
ISBN: 978-93-24272-36-8

Design and development of a non-invasive breathing monitoring system for asthma patients



Authors:

1 Saja Sameer Abbas Radhi
2 Kawthar Ali Abed Alkhuder Siraj
3 Maryam Hassan Salim Hassan
4 Fatima Emaad Hama Raouf Kareem

Published by
Novateur Publication
466, Sadashiv Peth, M.S.India-411030
novateurpublication.org

Design and development of a non-invasive breathing monitoring system for asthma patients

By

[1]Saja Sameer Abbas Radhi [3]Kawthar Ali Abed Alkhuder Siraj

[3]Maryam Hassan Salim Hassan [4]Fatima Emaad Hama Raouf Kareem

[1]Department Of Medical Device Technology Engineering, Middle Technical University, Engineering Technical College.

[2,3,4]Department Of Biomedical Engineering, Al_Mustaqbal University College.

Iraq

1-ex.sagasameer1@gmail.com

2-kawthersurag11@gmail.com

3-maryam8560893@gmail.com

4-Fatimaemaad97@gmail.com

ACKNOWOLEDGMET

In the name of Allah, the Most Gracious, the Most Merciful

Praise be to Allah, who taught by the pen, taught man what he did not know,

I am pleased to extend my sincere thanks and appreciation to [Book Shore International] for accepting and publishing my scientific book [Design and development of a non-invasive breathing monitoring system for asthma patients]

which is the result of continuous effort and work in order to provide knowledge and contribute to enriching scientific research.

In this regard, I can only express my deep gratitude to everyone who contributed to achieving this accomplishment, from supervisors, colleagues and readers, and to everyone who supported and helped bring this scientific work to light.

I also extend my special thanks to the editorial team at [Book Shore international] for their distinguished efforts in reviewing and publishing the book according to the highest standards of academic quality, which enabled it to spread and reach a wider base of researchers and specialists.

I ask Allah to make this work sincere for His sake, and to be beneficial to science and its people, and to contribute to the development of human knowledge.

Please accept my sincere thanks and appreciation.

Abstract:

Asthma is a long-term respiratory disorder that impacts millions of individuals globally, marked by inflammation of the airways, bronchial constriction, and fluctuating airflow limitations. It is essential to monitor respiratory patterns in individuals with asthma for effective disease management, treatment enhancement, and timely intervention to avert exacerbations. Traditional methods such as spirometry and peak flow meters can be cumbersome, necessitating active participation from patients, and often fail to provide real-time data outside of clinical environments. To overcome these limitations, we introduce an innovative non-invasive breathing monitoring system specifically designed for asthma patients. This system incorporates a wearable sensor device that utilizes sophisticated signal processing algorithms to continuously track respiratory parameters in real-time. The device features non-contact sensing technology, which removes the necessity for direct skin contact or additional respiratory equipment, thus promoting patient comfort and adherence. The fundamental elements of the system consist of a respiratory sensor, a microcontroller unit, a wireless communication module, and an intuitive interface for data visualization and analysis. The respiratory sensor utilizes radar-based technology to identify subtle movements of the chest linked to breathing, facilitating precise and dependable monitoring of respiratory rate, tidal volume, and breathing patterns. The microcontroller unit processes the raw data from the sensor in real-time, employing sophisticated signal processing methods to derive pertinent respiratory parameters. The wireless communication module allows for effortless data transmission to a smartphone application or a cloud-based platform, enabling remote monitoring by healthcare professionals and tailored asthma management. Initial assessments of the system indicate encouraging outcomes regarding accuracy, reliability, and user-friendliness.

Keywords (Asthma management. Asthma Patient care. Respiratory rate tracking. Respiratory monitoring system).

Contents

Chapter one

Chapter one

Introduction

1.1 Introduction:

Asthma is a common chronic respiratory condition that affects individuals across all age groups globally. It is marked by recurring episodes of wheezing, difficulty in breathing, a sensation of tightness in the chest, and persistent coughing. The World Health Organization (WHO) estimates that approximately 235 million people are affected by asthma worldwide, resulting in around 383,000 fatalities each year due to the disease. Despite significant advancements in treatment and management approaches, asthma continues to pose a major public health issue, placing a considerable strain on healthcare systems and negatively influencing the quality of life for those impacted.

A primary challenge in managing asthma is the need for timely and precise monitoring of respiratory function. While traditional assessment methods, such as spirometry and peak flow meters, are commonly utilized in clinical environments, they have limitations regarding continuous monitoring outside of these settings. Patients often perceive these devices as cumbersome, necessitating active engagement and adherence to specific protocols, which can hinder long-term compliance and the accuracy of data collected. Additionally, asthma is a variable condition, with symptoms fluctuating due to various triggers, including allergens, air pollution, respiratory infections, and physical exertion. These temporary changes in lung function may go undetected with infrequent measurements, resulting in inadequate disease management and a heightened risk of exacerbations.

To overcome these obstacles, there is an increasing demand for innovative solutions that facilitate non-invasive, real-time monitoring of respiratory parameters in individuals with asthma. Leveraging advances in sensor technology, signal processing algorithms, and wireless communication, our system aims to provide continuous, unobtrusive monitoring of respiratory parameters in a home or community setting.

1.2 literature review :

Asthma is a complex respiratory condition characterized by chronic inflammation of the airways, resulting in recurrent episodes of wheezing, breathlessness, chest tightness, and coughing. While the exact etiology of asthma remains incompletely understood, it is widely recognized as a multifactorial disease influenced by genetic predisposition, environmental exposures, and immune dysregulation. Effective management of asthma requires comprehensive assessment of respiratory function, identification of exacerbating factors, and tailored treatment interventions to achieve symptom control and prevent disease progression. Traditional methods of assessing lung function, such as spirometry and peak flow measurement, play a central role in the diagnosis and management of asthma. Spirometry measures lung volumes and airflow rates, providing valuable information about airway obstruction, bronchial hyper responsiveness, and reversibility of airflow limitation. Peak flow meters, on the other hand, measure the peak expiratory flow rate, which serves as a surrogate marker of airway narrowing and is often used for monitoring asthma control and predicting exacerbations.While spirometry and peak flow measurement are valuable tools in clinical practice, they have limitations when it comes to continuous monitoring of respiratory function outside the clinic. Patients may find these devices cumbersome, requiring active participation and adherence to specific protocols, which can impede longterm compliance and data accuracy. Moreover, periodic measurements may fail to capture transient changes in respiratory function associated with asthma exacerbations, leading to underestimation of disease severity and inadequate treatment adjustments. To address these limitations, researchers have increasingly focused on developing innovative solutions for non-invasive, real-time monitoring of respiratory parameters in asthma patients. These technologies leverage advances in sensor technology, signal processing algorithms, and wireless communication to provide continuous, unobtrusive monitoring of respiratory function in home or community settings.One promising approach involves the use of wearable sensors capable of detecting subtle chest movements associated with breathing. These sensors employ a variety of technologies, including accelerometers, strain gauges, and impedance pneumography, to capture respiratory signals without the need for direct skin contact or respiratory accessories. By analyzing these signals using advanced signal processing techniques, researchers can extract relevant respiratory parameters such as respiratory rate, tidal volume, and breathing patterns in realtime.Several studies have demonstrated the feasibility and utility of wearable respiratory monitoring systems in asthma management. For example, Sankaran et al. (2019) developed a wearable device capable of monitoring respiratory rate and tidal volume using an accelerometerbased sensor placed on the chest. They found that the device accurately detected changes in respiratory parameters during asthma exacerbations, enabling timely intervention and improved symptom control.

Similarly, Smith et al. (2020) conducted a pilot study evaluating the performance of a non-invasive breathing monitoring system in children with asthma. The system, which utilized impedance pneumography to measure respiratory impedance, demonstrated good agreement with conventional spirometry in assessing lung function and detecting asthma exacerbations.In addition to wearable sensors, researchers have explored other non-invasive modalities for respiratory monitoring, including acoustic-based techniques, optical imaging, and radar-based sensing. These modalities offer unique advantages in terms of sensitivity, portability, and ease of use, making them promising candidates for future asthma monitoring applications.

Overall, the literature suggests that non-invasive breathing monitoring systems hold great promise for improving asthma management by providing continuous, objective assessment of respiratory function in real-time. By enabling early detection of exacerbations, personalized treatment interventions, and remote monitoring by healthcare providers, these technologies have the potential to enhance patient outcomes, reduce healthcare costs, and empower individuals with asthma to better manage their condition. However, further research is needed to validate the accuracy, reliability, and clinical utility of these systems in larger patient populations and real-world settings.

1.3 Related problems :

- Lack of access to affordable and reliable health monitoring devices restricts individuals from effectively managing their health.
- Inaccurate or unreliable health monitoring systems may lead to incorrect readings and misinterpretations, potentially impacting medical decisions.
- Limited integration of multiple health parameters in existing monitoring devices hinders comprehensive health assessment and diagnosis.
- Environmental factors such as air quality often go unnoticed, yet they can significantly impact overall health and well-being.

- Monitoring systems that require complex setups or specialized expertise may not be accessible or practical for everyone, especially in remote or underserved areas.
- Privacy and data security concerns arise with the use of health monitoring devices, necessitating robust measures to protect sensitive personal information

1.4 aim of project:

The objective of this project is to create, develop, and validate a non-invasive respiratory monitoring system specifically designed for individuals with asthma. This system is intended to facilitate continuous, real-time observation of respiratory metrics, including respiratory rate, tidal volume, and breathing patterns, within a home or community environment. The main goals of the project encompass: Technology Development: The design and prototyping of a wearable sensor device that can capture respiratory signals without requiring direct contact with the skin or the use of respiratory accessories. This device will employ cutting-edge sensor technologies and signal processing algorithms to effectively detect and analyze chest movements related to breathing.

System Integration: Integrating the sensor device with a microcontroller unit, wireless communication module, and user-friendly interface for data visualization and analysis. The system will be designed to be compact, lightweight, and easy to use, ensuring patient comfort and compliance.

Algorithm Development: The process involves the creation and refinement of signal processing algorithms aimed at extracting pertinent respiratory parameters from raw sensor data in real-time. These algorithms will be meticulously crafted to accurately measure respiratory rate, tidal volume, and breathing patterns, even amidst noise or motion disturbances.

Validation Studies: Comprehensive validation studies will be undertaken to evaluate the accuracy, reliability, and clinical applicability of the non-invasive breathing monitoring system. These studies will include comparisons with established methods such as spirometry and peak flow measurement, as well as assessments conducted in real-world environments involving asthma patients.

Usability Testing: Usability testing and user feedback sessions will be performed to assess the acceptability, comfort, and user-friendliness of the monitoring system among asthma patients. Feedback from users will be integrated into iterative design enhancements to better align the system with patient needs and preferences.

Clinical Evaluation: The clinical impact of the non-invasive breathing monitoring system on asthma management outcomes will be assessed, focusing on aspects such as symptom control, medication adherence, and healthcare utilization. This may include pilot studies or clinical trials aimed at determining the system's effectiveness in enhancing patient outcomes and minimizing the risk of asthma exacerbations.

Chapter two

Chapter two

2.1 introduction

In this chapter, we will talk about the materials that we used in our proposed project "Design and development of a non-invasive breathing monitoring system for asthma patients"

2.2 ARDUINO:

Arduino is an open-source electronics platform that utilizes user-friendly hardware and software. Arduino boards can interpret various inputs, such as light detected by a sensor, a finger pressing a button, or a message from Twitter, and convert these inputs into outputs, which may include activating a motor, illuminating an LED, or publishing content online[4] You can direct your board's actions by transmitting a series of commands to the microcontroller installed on it. Throughout the years, Arduino has served as the central processing unit for countless projects, ranging from simple everyday items to intricate scientific devices[5]. A global community of creators, including students, hobbyists, artists, programmers, and professionals, has come together on this open-source platform. Their collective contributions have resulted in a vast repository of accessible knowledge, which can significantly benefit both beginners and seasoned experts[6].Arduino originated at the Ivrea Interaction Design Institute as a user-friendly tool designed for rapid prototyping, specifically targeting students lacking expertise in electronics and programming. Once it gained traction within a broader community, the Arduino board began to evolve, responding to emerging needs and challenges. This evolution expanded its offerings from basic 8-bit boards to a diverse range of products suitable for IoT applications, wearables, 3D printing, and embedded systems. All Arduino boards are entirely open-source, enabling users to construct them independently and customize them to meet their specific requirements[7].

The software, too, is open-source, and it is growing through the contributions of users worldwide.

2.2.1 Important of the Arduino:

Arduino's straightforward and user-friendly interface has facilitated its application in numerous projects and initiatives. The Arduino software is designed to be intuitive for novices while also offering the versatility required by experienced users. It is compatible with Mac, Windows, and Linux operating systems. Educators and learners utilize it to create affordable scientific instruments, demonstrate principles of chemistry and physics, or to embark on their journey into programming and robotics[8]. Designers and architects create interactive prototypes, while musicians and artists utilize it for installations and to explore innovative musical instruments. Additionally, makers employ it to construct numerous projects showcased at the Maker Faire, among other applications[8]. Arduino serves as an essential resource for acquiring new skills and knowledge. Individuals, including children, enthusiasts, artists, and programmers, can begin experimenting by adhering to the detailed instructions provided in a kit or by exchanging ideas with fellow members of the Arduino community online. Numerous other microcontrollers and platforms for physical computing exist, such as the Parallax Basic Stamp, Netmedia's BX-24, Phidgets, MIT's Handyboard, among others, which provide comparable capabilities[9]. All of these tools take the messy details of microcontroller programming and wrap it up in an easy-to-use package[10]. Arduino also simplifies the process of working with microcontrollers, but it offers some advantage for teachers, students, and interested amateurs over other systems:

1.Inexpensive - Arduino boards are relatively inexpensive compared to other microcontroller platforms. The least expensive version of the Arduino module can be assembled by hand, and even the pre-assembled Arduino modules cost less than $50

2.Cross-platform - The Arduino Software (IDE) runs on Windows, Macintosh OSX, and Linux operating systems. Most microcontroller systems are limited to Windows.

3.Simple, clear programming environment - The Arduino Software (IDE) is easy-to-use for beginners, yet flexible enough for advanced users to take advantage of as well. For teachers, it's conveniently based on the Processing programming environment, so students learning to program in that environment will be familiar with how the Arduino IDE works.

4.Open source and extensible software - The Arduino software is published as open source tools, available for extension by experienced programmers[11]. The language can be expanded through C++ libraries, and people wanting to understand the technical details can make the leap from Arduino to the AVR C programming language on which it's based. Similarly, you can add AVR-C code directly into your Arduino programs if you want to.

5.Open source and extensible hardware - The plans of the Arduino boards are published under a Creative Commons license, so experienced circuit designers can make their own version of the module, extending it and improving it. Even relatively inexperienced users can build the breadboard version of the module in order to understand how it works and save money[12].In this project we used Arduino UNO which is shown in Figure(2.1) 1-Arduino Uno is a microcontroller board based on the

ATmega328P (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator (CSTCE16M0V53-R0), 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[13]."Uno" means one in Italian and was chosen to mark the release of Arduino Software (IDE) 1.0. The Uno board and version 1.0 of Arduino Software (IDE) were the reference versions of Arduino, now evolved to newer releases. The Uno board is the first in a series of USB Arduino boards, and the reference model for the Arduino platform; for an extensive list of current, past or outdated boards see the Arduino index of boards[14].

In figure (2.1) show the shape of board and pins description .

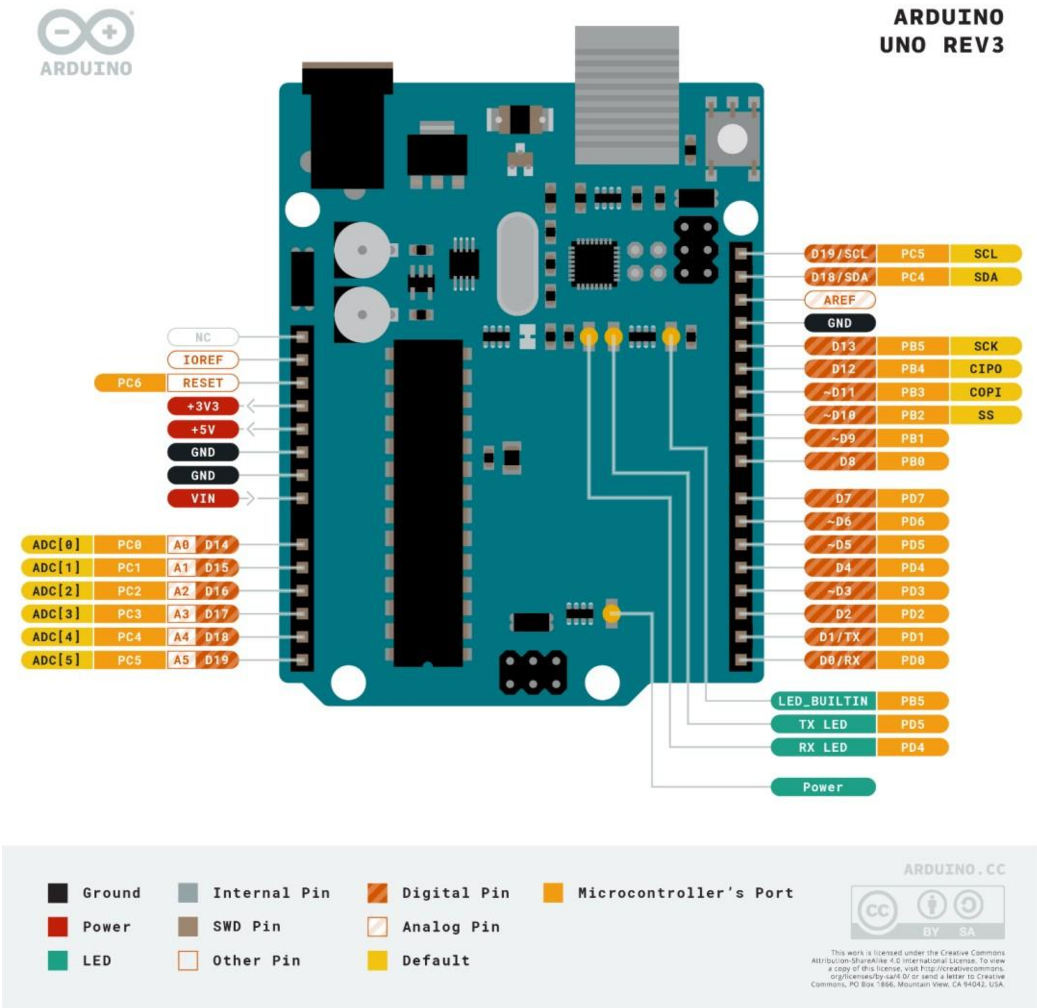


figure (2.1) Arduino uno

table (2.1)

Tech specs

MICROCONTROLLER	ATmega328P
OPERATING VOLTAGE	5V
INPUT VOLTAGE (RECOMMENDED)	7-12V

INPUT VOLTAGE (LIMIT)	6-20V
DIGITAL I/O PINS	14 (of which 6 provide PWM output)
PWM DIGITAL I/O PINS	6
ANALOG INPUT PINS	6
DC CURRENT PER I/O PIN	20 mA
DC CURRENT FOR 3.3V PIN	50 mA
FLASH MEMORY	32 KB (ATmega328P) of which 0.5 KB used by bootloader
SRAM	2 KB (ATmega328P)
EEPROM	1 KB (ATmega328P)
CLOCK SPEED	16 MHz
LED_BUILTIN	13
LENGTH	68.6 mm
WIDTH	53.4 mm
WEIGHT	25

2.2 Max30102 H /spo2 sensor :

The MAX30102 is an advanced optical sensor module that incorporates two light-emitting diodes (one red and one infrared) along with a photodetector, specifically designed for monitoring heart rate and blood oxygen saturation (SpO2). This module offers a comprehensive solution for pulse oximetry and heart rate measurement, characterized by its compact size and minimal power requirements. The operation of the

MAX30102 involves emitting red and infrared light through the skin and measuring the light absorbed by the blood. By analyzing the variations in light absorption at these two wavelengths, the sensor can determine both the oxygen saturation in the blood and the heart rate. It is equipped with a high-resolution, 19-bit analog-to-digital converter (ADC) to ensure precise signal processing and features integrated algorithms for ambient light rejection, which reduce the impact of external light interference. Additionally, the sensor supports an I2C interface, facilitating straightforward integration with microcontrollers and various digital devices. The MAX30102 is widely utilized in wearable fitness trackers, medical equipment, and other applications where monitoring heart rate and SpO2 is crucial. It is recognized for its reliability, accuracy, low power consumption, and compact design20]. max30102 pins diagram shown in figure (2.2).

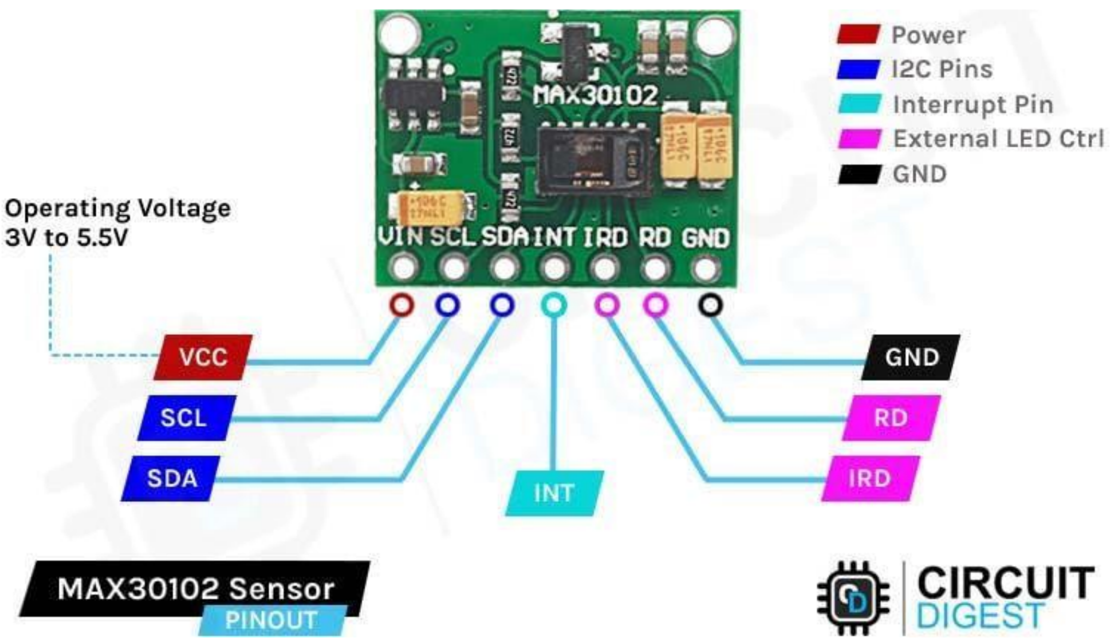


Figure (2.2) max30102 pin diagram

Pins description:

Here is a description of the pins on the MAX30102 sensor module:

VIN: This pin is used to supply power to the sensor module. The recommended operating voltage range is 3.3V to 5V.

GND: This pin is connected to ground.

SDA: This pin is used for I2C serial communication. It is connected to the data line of the I2C bus.

SCL: This pin is used for I2C serial communication. It is connected to the clock line of the I2C bus.

INT: This pin is used to indicate when new data is available. When the interrupt is triggered, the microcontroller can read the data from the sensor.

LED1: This pin is connected to the red LED. It is used to emit light through the skin and detect the amount of light absorbed by the blood.

LED2: This pin is connected to the infrared LED. It is used to emit light through the skin and detect the amount of light absorbed by the blood.

PD: This pin is connected to the photodetector. It is used to detect the amount of light that is transmitted through the skin.

The VIN, GND, SDA, and SCL pins are required for power and communication with the sensor, while the LED and PD pins are used for sensing. The INT pin is optional, but can be useful for interruptdriven data acquisition [21].

2.3 temperature and humidity sensor dht11:

The DHT11 is a popular digital temperature and humidity sensor used in various applications due to its simplicity, low cost, and ease of use. Here's an overview of the DHT11 sensor:

1. Principle of Operation:

The DHT11 sensor consists of a humidity sensing component and a thermistor (temperature sensor) connected to a simple capacitive humidity sensing element and an NTC temperature sensor.The sensor converts the temperature and humidity measurements into a digital signal that can be read by a microcontroller.

2. Key Specifications:

Temperature Range: Typically, the DHT11 can measure temperatures ranging from 0°C to 50°C with an accuracy of ±2°C.Humidity Range: It can measure relative humidity (RH) from 20% to 90% with an accuracy of ±5%.

3. Features:

Digital Output: The DHT11 provides digital output, making it easy to interface with microcontrollers without the need for analog-to-digital conversion.Low Power Consumption: It operates at low power, making it suitable for battery-powered applications.Single-Wire Communication: The sensor communicates with the microcontroller using a single-wire serial interface, simplifying wiring and reducing pin count.

4. Wiring and Interface:

The DHT11 sensor has four pins: VCC (3.3V to 5V), Data (digital signal output), NC (no connection), and GND (ground).

The data pin is connected to a digital input/output pin of the microcontroller for data transmission.Communication with the sensor involves sending a start signal, receiving the sensor data, and decoding the digital signal to obtain temperature and humidity readings.

5. Library Support:

Various libraries are available for popular microcontroller platforms such as Arduino, Raspberry Pi, and ESP8266, simplifying the integration of the DHT11 sensor into projects.These libraries provide functions for initializing the sensor, reading temperature and humidity values, and handling communication errors.

6. Limitations:

Accuracy: While the DHT11 sensor provides basic temperature and humidity measurements, its accuracy may not be sufficient for applications requiring precise measurements.

Response Time: The sensor has a relatively slow response time, which may not be suitable for applications requiring rapid changes in temperature or humidity monitoring.

7. Applications:

Home Automation: Monitoring indoor temperature and humidity for HVAC control and environmental monitoring. Weather Stations: Integrating into weather stations for local climate monitoring. Greenhouses: Monitoring temperature and humidity levels in agricultural settings. Industrial Monitoring: Monitoring environmental conditions in industrial environments.

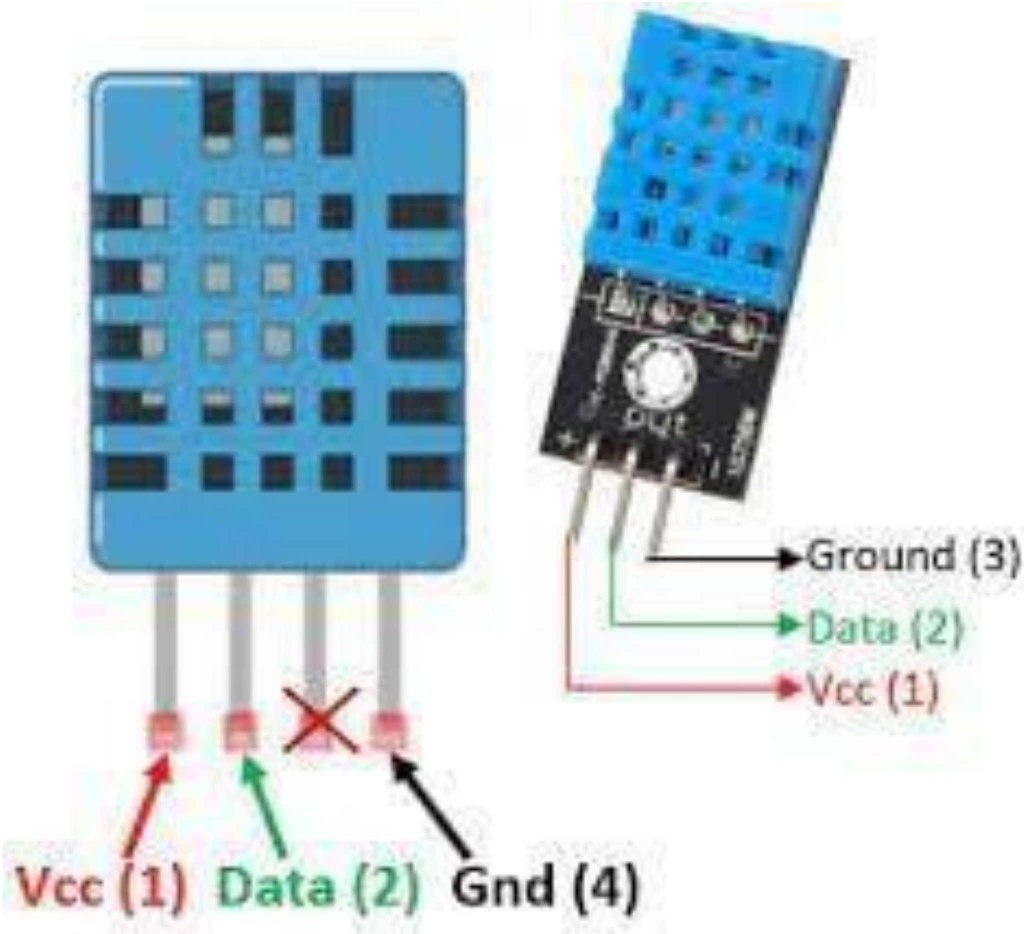


Figure (2.3) dht11pin diagram

2.4 lcd 16 x 2:

A 16x2 LCD featuring an I2C interface is a widely utilized display module that can be conveniently connected to microcontrollers like Arduino, Raspberry Pi, and similar devices. The I2C interface minimizes the number of wires needed for communication, thereby streamlining the wiring process and conserving the number of pins utilized on the microcontroller. Below is a concise overview of the pins found on a standard 16x2 LCD with an I2C interface:

VCC: This pin is used to supply power to the module. Typically, it is connected to +5V or +3.3V.

GND: This pin is connected to ground.

SDA: This pin is used for I2C serial communication. It is connected to the data line of the I2C bus.

SCL: This pin is used for I2C serial communication. It is connected to the clock line of the I2C bus.

In addition to the aforementioned pins, there may be additional pins designated for managing the backlight of the display, including a positive and negative pin for an LED backlight. The I2C address of the module might also be adjustable through the use of jumpers or solder bridges present on the module. When interfacing an I2C LCD with a microcontroller, it is essential to utilize a suitable library to enable effective communication with the module. Numerous libraries are available for widely used microcontrollers, such as the LiquidCrystal_I2C library designed for Arduino. These libraries offer a streamlined interface for displaying text and controlling the LCD [24][25].

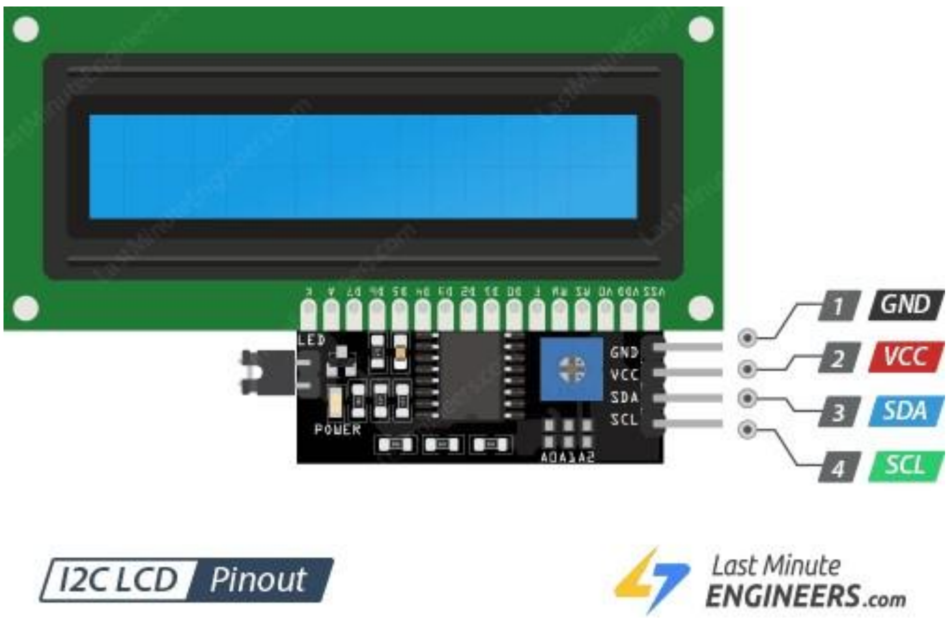


Figure (2.4) lcd 16 x 2 i2c pin diagram

2.5 MQ135

The MQ135 is a gas sensor widely used for detecting various air pollutants and gases in the environment. Here's an overview of the MQ135 air quality sensor:

1. Principle of Operation:

The MQ135 sensor operates on the principle of chemiresistive sensing, where changes in gas concentration alter the sensor's resistance.It contains a tin dioxide (SnO_2) semiconductor sensing element that reacts with specific gases, causing a change in its resistance.By measuring the resistance changes, the sensor can detect the presence and concentration of various gases in the air.

2. Target Gases:

The MQ135 sensor is sensitive to a range of gases, including:

Benzene

Alcohol

Smoke

Carbon Dioxide (CO_2)

Ammonia (NH_3)

Nitrogen Oxides (NO_x)

Volatile Organic Compounds (VOCs)

It can detect these gases at concentrations typically found in indoor and outdoor environments.

3. Features:

Analog Output: The MQ135 generates an analog voltage output that corresponds to the concentration of the gases it detects. High Sensitivity: This sensor exhibits a high level of sensitivity to multiple gases, rendering it ideal for applications related to air quality monitoring. Compact Size: The sensor Is designed in a compact form, facilitating its integration into a wide range of electronic devices and projects. Low Cost: It is affordably priced in comparison to other air quality sensors, making it a viable option for hobbyists and DIY enthusiasts.

4. Calibration:

Calibration is essential to guarantee precise measurements when utilizing the MQ135 sensor. This process entails subjecting the sensor to known concentrations of the target gases and making the necessary adjustments to the calibration factors. Certain calibration techniques may include the use of reference gas concentrations or calibration gases within controlled settings.

5. Applications:

Indoor Air Quality Monitoring: Identifying and tracking contaminants within indoor spaces, including residences, workplaces, educational institutions, and industrial environments. Outdoor Air Quality Monitoring: Utilizing sensors in urban locations, adjacent to industrial sites, and at traffic junctions to evaluate outdoor air quality and pollution metrics. Safety Systems: Incorporating into safety frameworks to identify gas leaks, smoke, and other dangerous situations in both residential and commercial properties. Environmental Monitoring: Aiding environmental assessment efforts to evaluate air quality, pollution levels, and their effects on public health.

6. Limitations:

Cross-Sensitivity: The MQ135 sensor may demonstrate cross-sensitivity to various gases, potentially impacting the precision of its measurements. Response Time: It may exhibit a comparatively slow response time, especially when identifying swift fluctuations in gas concentrations. Calibration Drift: Over time, the calibration of the sensor may deviate, necessitating regular recalibration to ensure continued accuracy.

Figure (2.5) mq135 pin diagram

Chapter three

Chapter Three

Design and implementation

3.1 introduction

In this chapter we will talk about how to link the electronic materials to our proposed project that we talked about in the previous chapter

3.2 Electronic circuit design

3.2.1 Flow Charts:

The Flow Charts in **Figure (3.1)** below show that the connection between electronics components

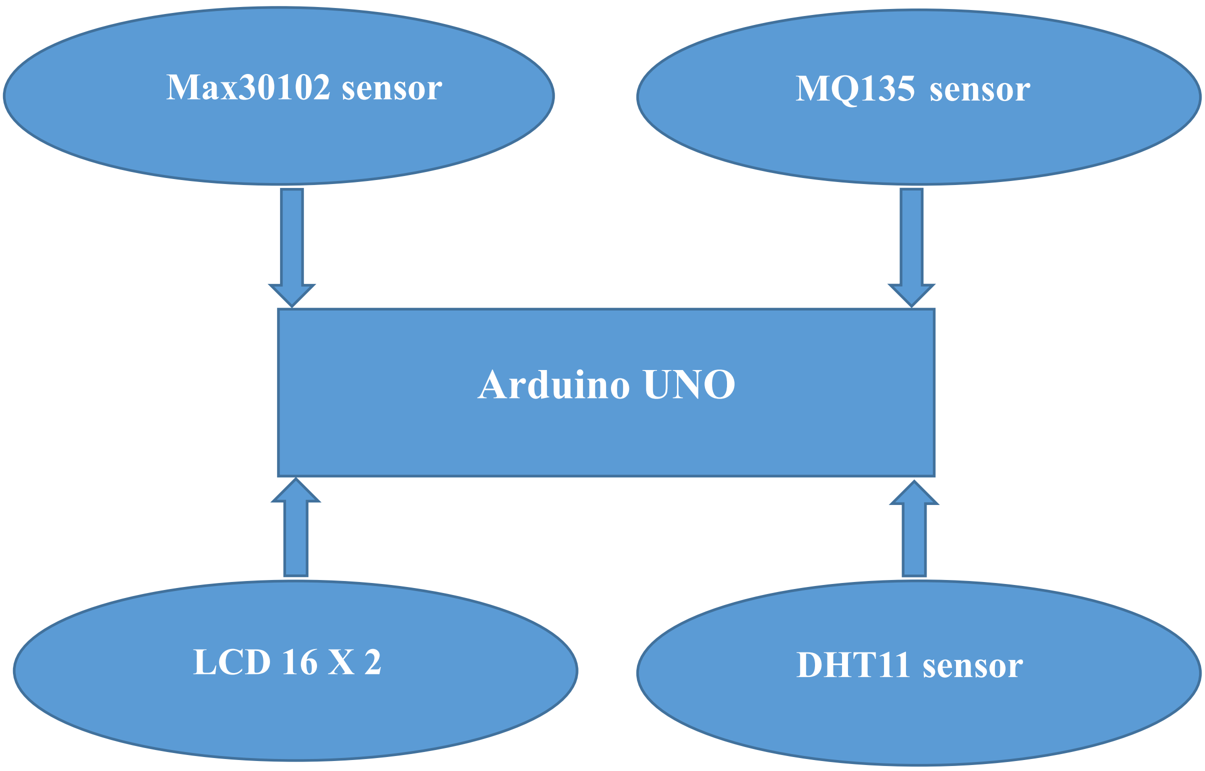


Figure (3.1) Flow Chart

3.2.2 Connection the circuit diagram:

Procedure

1- Connected the max30102 sensor to Arduino uno as shown in figure (3.2) below

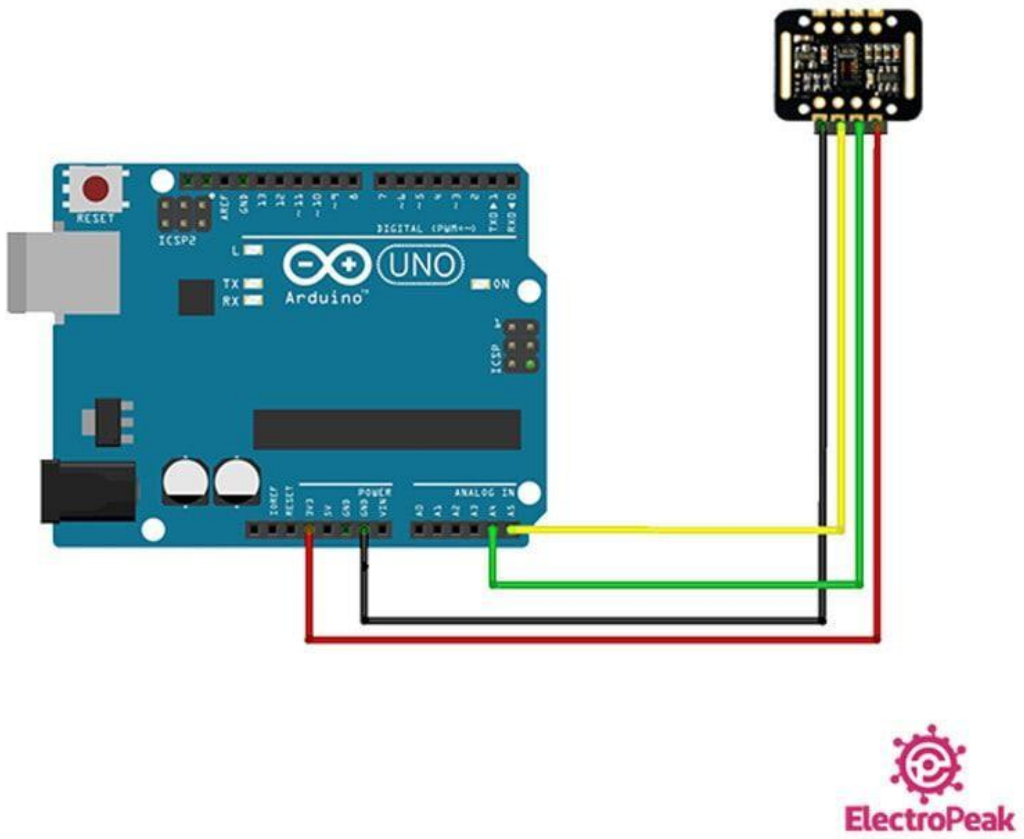


Figure (3.2) Arduino Uno with max30102 connection

2-Connected the mq135 sensor to Arduino uno as shown in figure (3.3) below

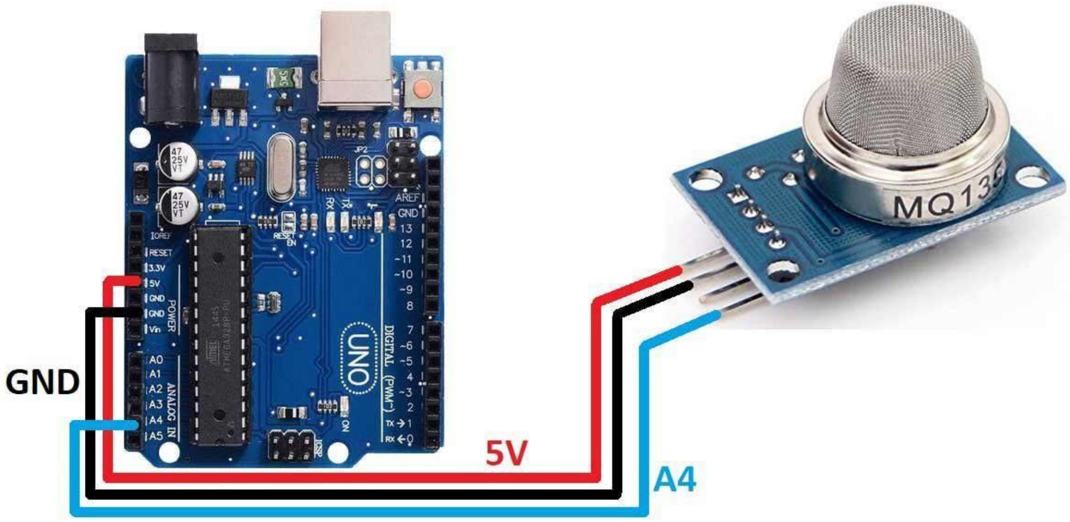


Figure (3.3) Arduino Uno with mq135 connection

3-Connected the dht11 to Arduino uno as shown in figure (3.4) below

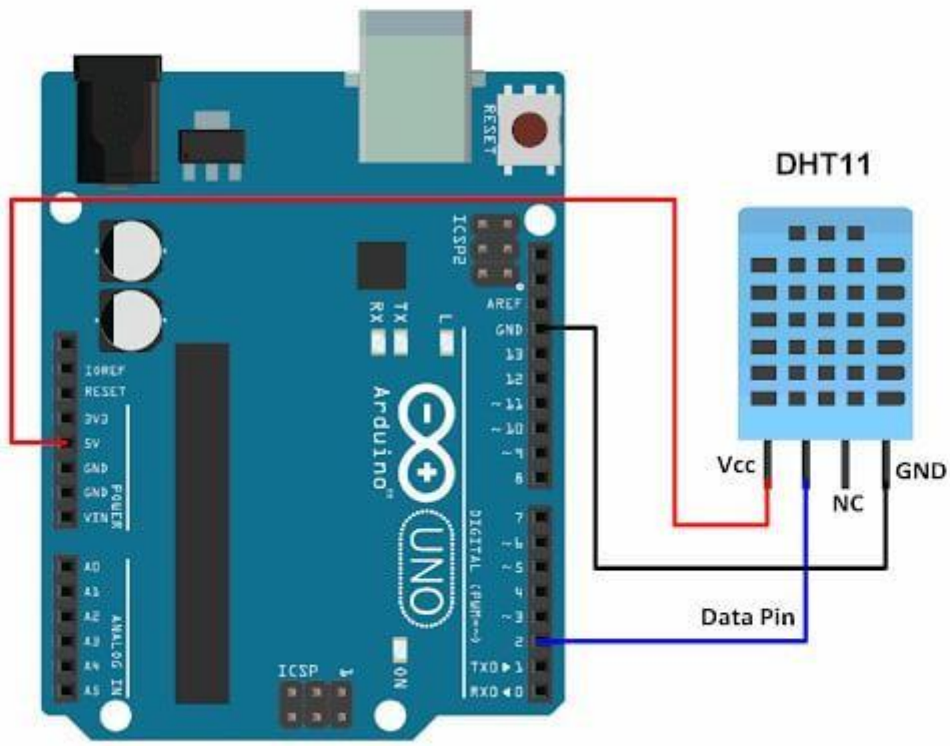


figure (3.4) Arduino Uno with dht11 connection

4-Connected the lcd 16 xi2c to Arduino uno as shown in figure (3.5) below

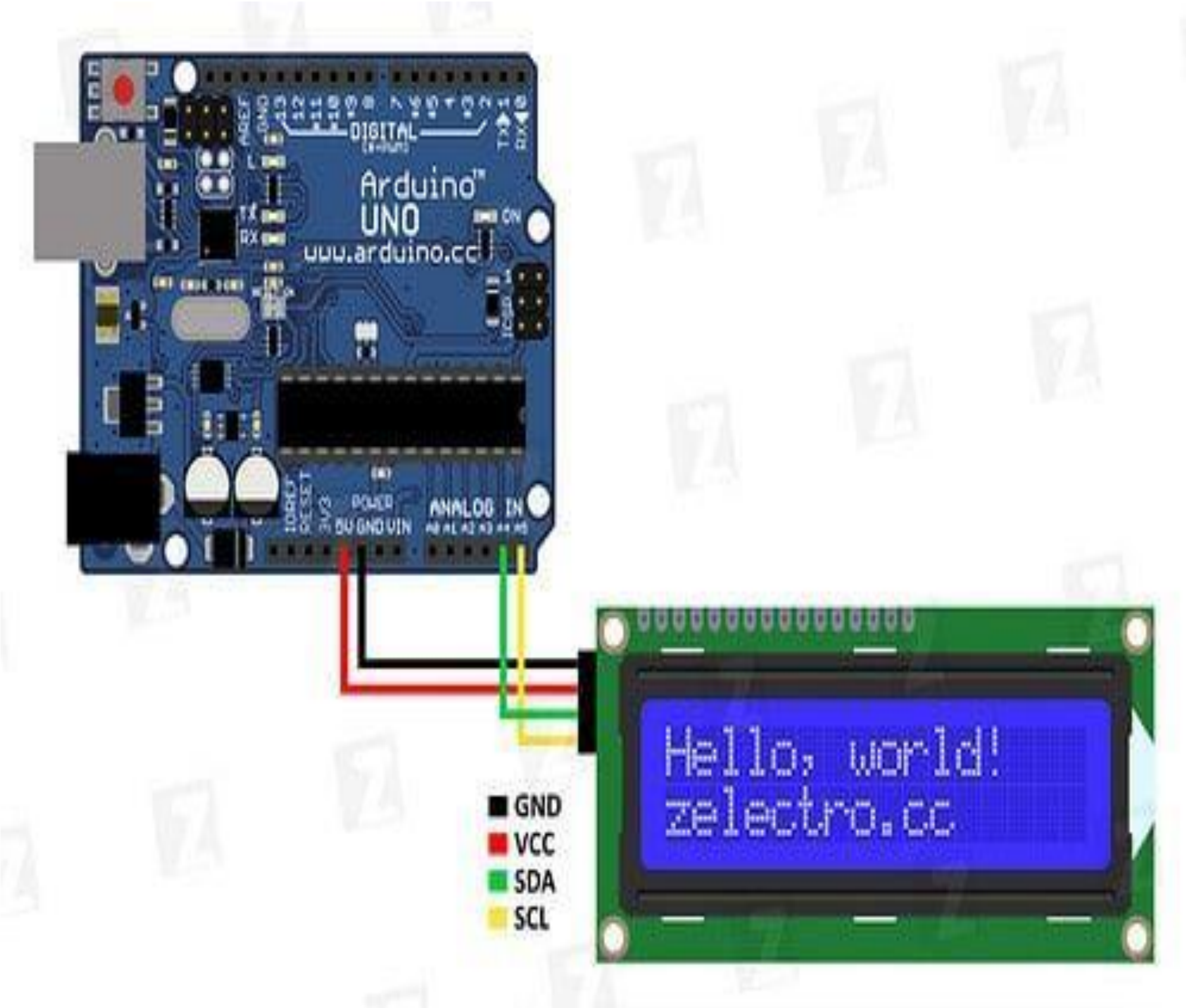


figure (3.5) Arduino Uno with lcd 16 x2 i2c connection

5- After completing the connection for all components upload the code to the Arduino, the shape of project shown in the images below fig(3.6)

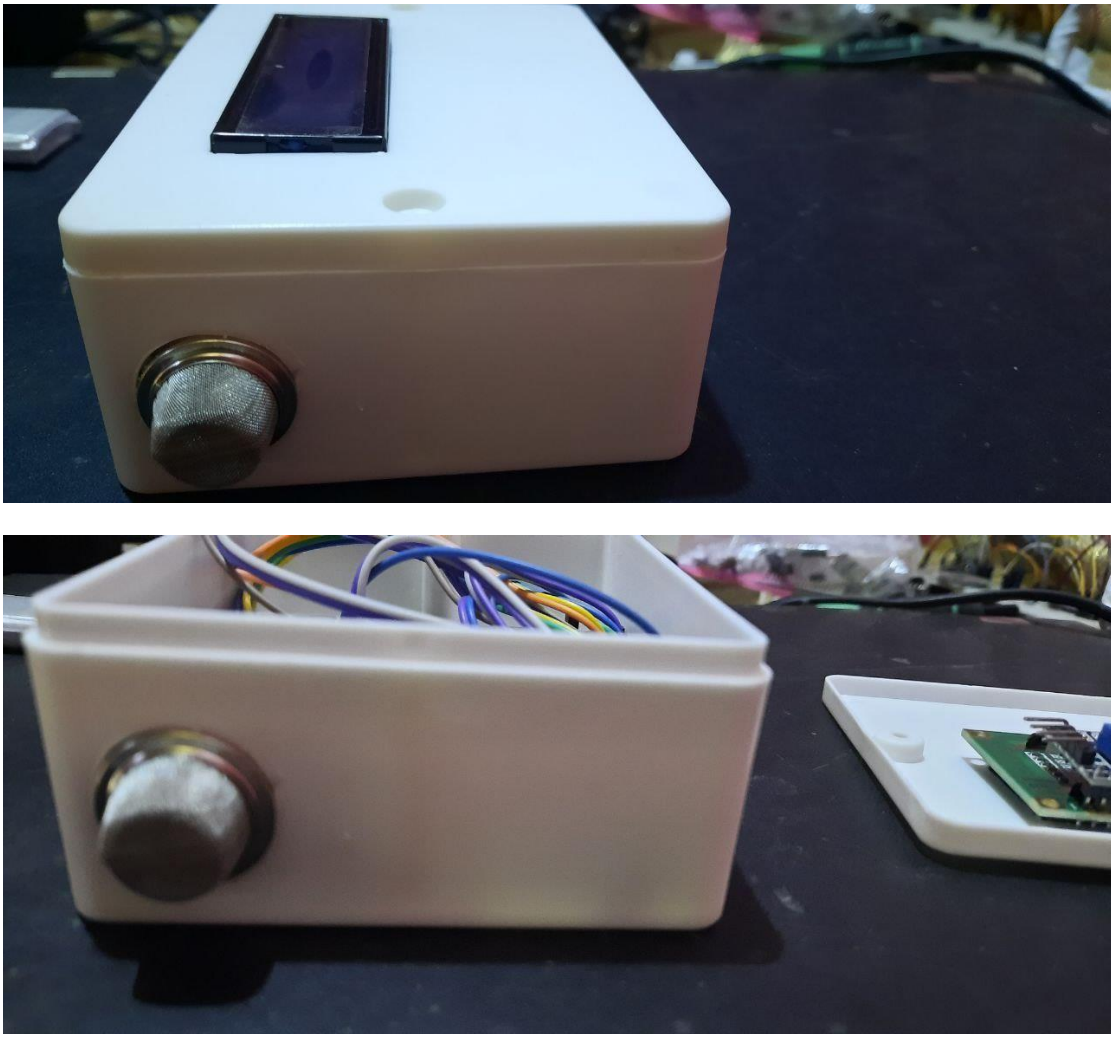


Figure (3.6) shape of project

Chapter four

Chapter four

4.1 Results:

Results have been obtained for a project entitled "Design and Development of a Non-Invasive Breathing Monitoring System for Asthma Patients," utilizing the specified sensors.

1. Results of Using the MAX30102 Sensor:

Non-invasive assessment of pulse rate and blood oxygen saturation levels (SpO_2). Observation of respiratory rate and identification of alterations in breathing patterns. Combining pulse oximetry information with respiratory metrics for thorough monitoring of asthma patients.

2. Results of Using the MQ135 Sensor:

The identification of air pollutants and allergens present in the patient's surroundings, including smoke, volatile organic compounds (VOCs), and ammonia. The analysis of air quality data in relation to asthma symptoms and exacerbations to facilitate personalized asthma management. The determination of triggers and environmental elements that contribute to asthma attacks.

3. Results of Using the DHT11 Sensor:

Assessment of ambient temperature and humidity levels. Examination of environmental factors influencing asthma symptoms, including extreme temperatures and variations in humidity. Incorporation of temperature and humidity data alongside respiratory metrics for a comprehensive evaluation of the health of asthma patients.

4. Results of Using the LCD 16x2 Display:

The immediate visualization of respiratory metrics, including pulse rate, SpO2 levels, temperature, and humidity measurements. An Intuitive interface designed for asthma patients to oversee their respiratory well-being and observe variations over time. Enhancement of interaction between patients and healthcare professionals through the graphical representation of data during medical appointments.

4.2 conclusion:

The establishment of a non-invasive breathing monitoring system for individuals with asthma marks a notable progress in the management of asthma and the overall care of patients. By incorporating sensors such as the MAX30102, MQ135, DHT11, and an LCD 16x2 display, this system delivers thorough monitoring of respiratory metrics, environmental factors, and physiological signs in a manner that is both user-friendly and accessible. The data gathered from these sensors yield critical insights into the respiratory well-being of asthma patients, thereby supporting tailored and proactive management approaches. Through the continuous assessment of respiratory rate, pulse rate, blood oxygen saturation, air quality, temperature, and humidity, the system facilitates the early identification of variations in asthma symptoms and potential exacerbations, thereby enabling prompt interventions and the prevention of negative health consequences.

4.3 future work:

For future work on the project "Design and Development of a NonInvasive Breathing Monitoring System for Asthma Patients," several areas can be explored to enhance the system's functionality, performance, and usability:

1. Sensor Fusion and Data Integration:

Explore sensor fusion techniques to combine data from multiple sensors (e.g., MAX30102, MQ135, DHT11) for more comprehensive monitoring of asthma patients.Develop algorithms for integrating respiratory parameters, pulse oximetry readings, environmental data, and patient metadata to provide personalized insights into asthma management.

2. Machine Learning and Predictive Analytics:

Investigate the use of machine learning algorithms to analyze sensor data patterns and predict asthma exacerbations or symptom onset in advance.Train predictive models using historical data to identify early warning signs of asthma attacks and trigger timely interventions or alerts for patients and caregivers.

3. Mobile Application Development:

Develop a mobile application companion for the non-invasive breathing monitoring system, allowing patients to monitor their respiratory health remotely.Incorporate features such as real-time data visualization, symptom tracking, medication reminders, and teleconsultation with healthcare providers for improved asthma selfmanagement.

4. Wearable Device Enhancement:

Enhance the design and ergonomics of the wearable sensor device to improve comfort, portability, and user experience for asthma patients.

Explore the integration of additional sensors or functionalities, such as motion sensors for activity monitoring or GPS for location-based asthma triggers detection.

5. Clinical Validation and User Studies:

Conduct clinical validation studies to evaluate the accuracy, reliability, and clinical utility of the non-invasive breathing monitoring system in real-world asthma patient populations.Perform usability studies and user feedback sessions to gather insights on the system's acceptance, usability, and impact on asthma management from patients, caregivers, and healthcare providers.

6. Regulatory Compliance and Commercialization:

Ensure compliance with regulatory standards and requirements for medical devices and data privacy (e.g., FDA regulations, HIPAA compliance) for potential commercialization and deployment in clinical settings.Explore partnerships with healthcare institutions, medical device manufacturers, and digital health platforms for the commercialization and distribution of the non-invasive breathing monitoring system.

7. Longitudinal Monitoring and Long-Term Outcomes:

Implement longitudinal monitoring capabilities to track asthma patients' respiratory health over extended periods and assess long-term outcomes of the monitoring system.Evaluate the system's impact on asthma control, medication adherence, healthcare utilization, and quality of life through longitudinal studies and follow-up assessments.

Reference:

1. Bates, A. J., & Loke, T. K. (2017). Respiratory monitoring in asthma: current and emerging technologies. Clinical Medicine Insights: Circulatory, Respiratory and Pulmonary Medicine, 11, 1-8.
2. Shoaib, M., & Balagani, K. S. (2019). A Review on Noninvasive Respiratory Monitoring Technologies. International Journal of Engineering Research in Electronics and Communication Engineering, 6(5), 44-48.
3. Schiffman, S. S. (2005). Exploiting the Chemical Senses in Developing Non-Invasive Monitoring Systems for Asthma and Diabetes. Journal of Chemical Information and Modeling, 45(6), 1605-1611.
4. Jartti, T., & Korppi, M. (2015). Devices for Asthma Control Monitoring in Children. International Journal of Pediatrics, 2015, 1-10.
5. Heimann, M., Röttger, S., & Metz, J. (2017). Non-invasive respiratory monitoring in pediatric emergency care. Notfall + Rettungsmedizin, 20(3), 237-247.
6. Naeini, P. S., & Soltanian-Zadeh, H. (2014). Non-invasive Measurement of Respiratory Parameters in Diagnosing and Monitoring Asthma. Iranian Journal of Allergy, Asthma, and Immunology, 13(2), 89-98.
7. Baratloo, A., Mirbaha, S., & Delavar Kasmaei, H. (2014). Invasive and Non-invasive Methods for Diagnosis of Asthma and COPD. Emergency, 2(1), 1-5.
8. Monárrez, R., & Luna, A. (2018). Wearable Non-Invasive Sensors for Asthma Diagnosis. In Proceedings of the

International Conference on Smart Portable, Wearable, Implantable and Disability-oriented Devices and Systems (pp. 31-35). Springer, Cham.

9. Kim, J., & Kim, E. (2017). A Comprehensive Review of NonInvasive Respiratory Monitoring Techniques in the Neonatal Intensive Care Unit. Journal of Neonatal-Perinatal Medicine, 10(3), 233-241.

10. Alrifai, I., Ramzan, N., & Latif, A. (2020). A Novel NonInvasive Respiratory Monitoring System for Asthma and COPD Patients. Journal of Physics: Conference Series, 1551(1), 012021.

11. Felder, E., & Aggarwal, B. (2018). Invasive and NonInvasive Monitoring of Asthma: Current Practice and Future Trends. Current Allergy and Asthma Reports, 18(6), 33.

12. Paz, R., & Lynch, T. (2019). Non-invasive Monitoring of Asthma Control: Breathomics as a Promising Approach. Frontiers in Pediatrics, 7, 1-8.

13. Al-Tabatabaie, F., Nguyen, T., & Lee, S. (2018). Wearable Non-Invasive Respiratory Monitoring Devices for Asthma. In Proceedings of the International Conference on Smart Portable, Wearable, Implantable and Disability-oriented Devices and Systems (pp. 37-40). Springer, Cham.

14. Dwivedi, S., & Pandey, D. K. (2019). Non-invasive Respiratory Monitoring System. International Journal of Computer Sciences and Engineering, 7(8), 476-481.

15. Birnbaum, H. G., & Berthiaume, J. T. (2015). Invasive and Non-invasive Methods for Diagnosis of Asthma and COPD. Expert Review of Pharmacoeconomics & Outcomes Research, 15(6), 951-965.

16. Baruah, B. P., & Das, S. (2021). A Non-invasive

Respiratory Monitoring System Using Micro-Controller and Sensors for Asthma Patients. Journal of Mechanical Engineering Research & Developments, 44(1), 51-57.

17. Jouybari, L. M., & Khodadadi, H. (2018). Non-Invasive Monitoring of Respiratory Signals in Asthma Patients. Journal of Medical Signals & Sensors, 8(2), 65-70.