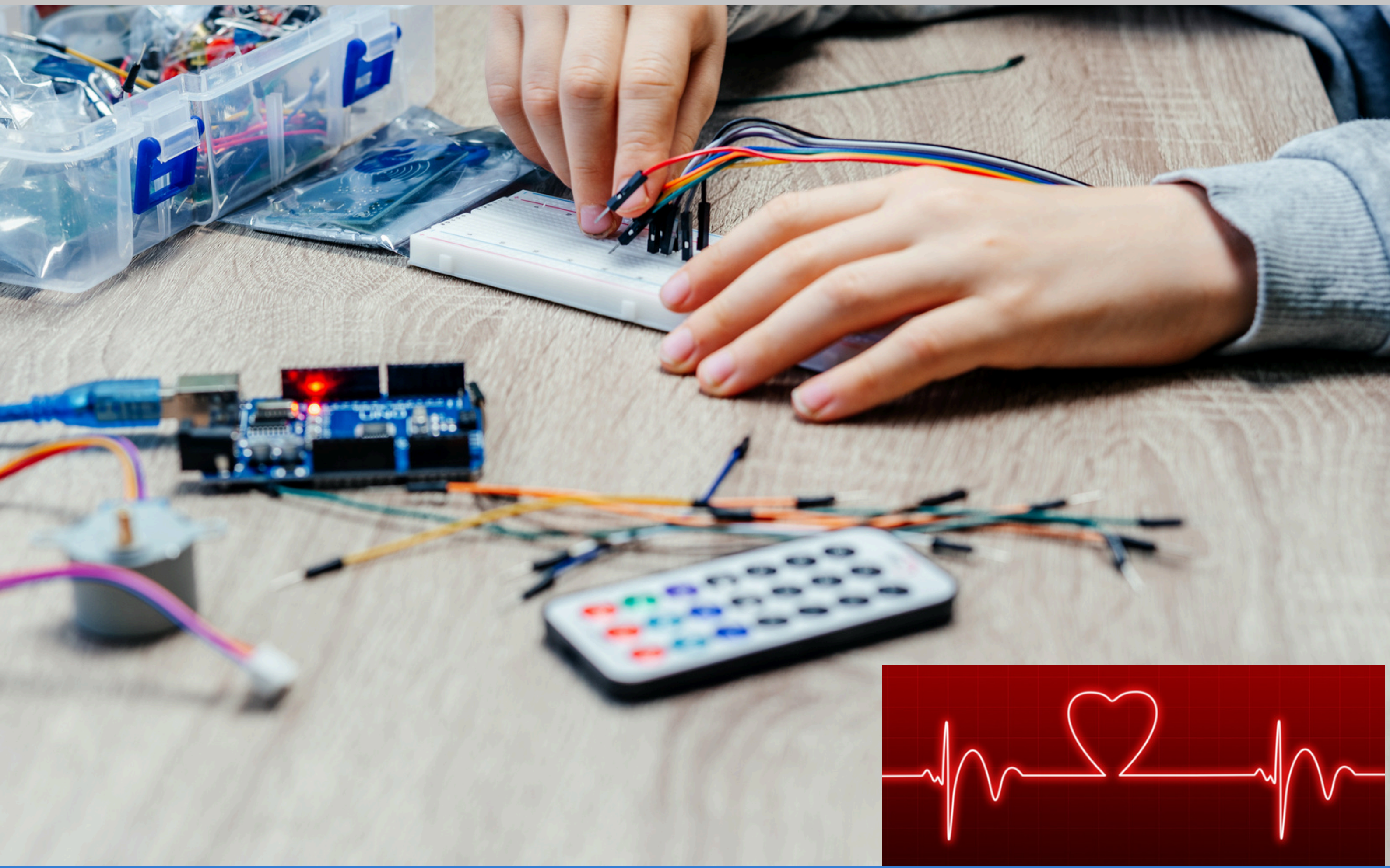
ISBN: 978-93-24228-47-8

Design and Implementation of Heart Beat Sensor using Arduino



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

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ACKNOWLEDGEMENTS

Be a scholar. If you cannot, then be a learner. If you cannot, then love scholars. If you cannot, then do not hate them. After a journey of research, effort and diligence that culminated in the completion of this research, we thank God Almighty for the blessings that He has bestowed upon us, for He is the Most High and Almighty. We can only express our deepest thanks and appreciation to our family and their support and prayers for the effort, advice and knowledge they have provided us throughout the completion of this research. We also extend our sincere thanks to everyone who contributed to providing a helping hand to complete this research, and we would like to mention in particular our honorable professors.

Abstract

This project focuses on real-time monitoring of patients' heart rate. The proposed method uses a heart rate sensor controlled by a microcontroller. Heart rate readings are displayed on the LCD screen. A heart rate monitor is used to record your heart rate over time and calculate your heart rate per minute. The main goal is continuous monitoring of the patient's heart rate, which should be available to the attending physician. Healthcare workers in hospitals are responsible for patient healthcare. The patient's heart rate is continuously monitored and records are kept. The main components of this system are the power supply, Atmega328 microcontroller, heart rate sensor and LCD display. This is very important as we can also use it for people with heart palpitations and to know the actual heartbeat.

Keywords ((Design ..Implement.. Heart beat sensor.. Arduino))

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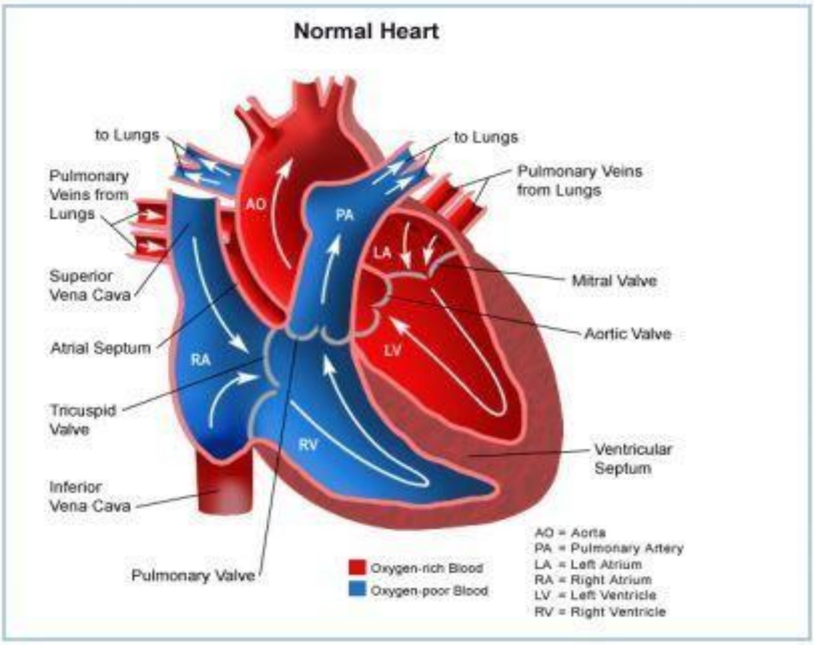
Chapter One

Introduction

1.1 Introduction

Patients living at home face many challenges due to significant differences in healthcare standards and availability of prompt care in emergency situations. This condition can be especially serious for those suffering from serious medical conditions such as heart disease or diabetes. The need for stable and reliable assistive technology is of paramount importance when caring for patients who are not at home. The situation becomes even more critical for those who are bedridden, as in addition to their existing disability, they face additional health problems that worsen their condition. This highlights the need for increased care and vigilance on the part of caregivers. A device that can address all of these issues would be of great benefit to patients confined to bed at home. The main objective of our project is to develop a working prototype of an assistive device specifically designed for bedridden people. This device will continuously monitor the patient's heart rate and will be connected to a sensor unit with a customizable app designed to activate an alarm system. The main components of this project are a heart rate sensor, an Arduino Uno, and an LCD screen.[2].

The heart is an important organ in the human body that is located in the middle area between the lungs in the chest cavity, especially behind the sternum and slightly inclined to the left. Its dimensions are slightly larger than a fist and its weight is between 200 and 425 grams. The heart beats about 100,000 times a day and acts as a double pump that circulates about 7,600 liters of blood a day. The right side of the heart receives deoxygenated blood from different parts of the body and then pumps it to the lungs for oxygenation. However, the left side of the heart receives oxygen-rich blood from the lungs and distributes it throughout the body. This continuous movement of blood through the heart and throughout the body is called the circulatory system. It is important to note that blood leaves the heart through arteries and returns through veins, where veins are the vessels that return blood to the heart, while arteries carry blood away. They do. As shown in fig (1.1).



Fig(1.1) the heart

Heart rate is a vital sign that doctors usually assess when a patient is admitted. Heart rate refers to the rate at which the heart contracts and relaxes over a period of time, usually measured per minute. This frequency varies depending on age. For adults 18 years and older, a normal resting heart rate is approximately 72 beats per minute (bpm). Heart efficiency can be determined by a lower heart rate during periods of rest. Infants have significantly higher heart rates, averaging around 120 beats per minute, while older children typically have heart rates around 90 beats per minute. A heart rate below normal indicates bradycardia, while a heart rate above normal indicates tachycardia. The output of the heart rate sensor is connected to a microcontroller that processes the information and displays it on the LCD screen.. [3,4]

If the heart rate is lower than the normal heart rate, it is an indication of a condition known as bradycardia and if the heart rate is higher than the normal heart rate, it is an indication of a condition known as tachycardia. The output of the heart rate sensor is connected to the microcontroller. The microcontroller processes this data and displays it in LCD. [5,6,7]

1.2 Aim of The Study

The goal is to create a high-precision heart rate monitor using Arduino that can display the heart rate on a 16x2 LED screen. This device is designed to track the heart rate of a patient, the results of which are available to the attending physician. In a hospital setting, monitoring the patient's health is carried out by medical personnel who constantly monitor and document the patient's heart rate. The most important components of this system are the power supply, the Atmega328 microcontroller, the heart rate sensor, and the LCD display..

Chapter Two

Review of Literature

2.1 Heart beat monitoring

A heart rate monitor is a personal device designed to measure your heart rate in real time or record it for later analysis. Early models included a monitoring unit attached to your chest with a series of electrode cables. The resting heart rate of a healthy adult is about 72 beats per minute, a child's heart rate is typically about 120 beats per minute, and older children's heart rate is about 90 beats per minute. During physical activity, your heart rate gradually increases and returns to your resting level more slowly after exercise. The time it takes for your heart rate to return to normal is an indicator of your fitness level. A heart rate lower than normal may indicate a condition called bradycardia, while a higher heart rate is called tachycardia. Your heart rate can be measured by placing your thumb on your arterial pulse and then timing it by counting your heartbeats at 30-second intervals. The heart rate in beats per minute is then calculated by multiplying the calculated beats by two. Although this method is simple, it lacks accuracy, especially at higher levels. More advanced methods of measuring heart rate use electronic methods, with the electrocardiogram (ECG) being one of the most commonly used methods, although more expensive. In addition, affordable wristwatches are available to monitor heart rate in real time. Although these devices can provide accurate measurements, they often cost more than a few hundred dollars, making them more affordable. Therefore, heart rate monitors are valuable tools for assessing the heart rate of individuals or patients.. [10,11,12]

2.1.1 Significance of Heart

The heart functions as a pump, circulating blood that is rich in oxygen and nutrients throughout the body to maintain its operations. During physical exertion, the heart rate fluctuates in direct relation to the level of effort being applied. By measuring the electrical signals generated by the heart's contractions, one can easily monitor its rate, which serves various health-related purposes. The heart beats vigorously to deliver oxygenated blood to the muscles while also facilitating the removal of metabolic waste products. Monitoring the heart rate during exercise provides valuable insight into the effectiveness of the workout in enhancing overall health. [13,14]

2.1.2 Measuring heartbeat

Modern technology encompasses both optical and electrical monitoring systems. The electrical approach necessitates a cumbersome strap that is worn around the chest. In contrast, the optical method eliminates the need for such a strap, offering a more convenient alternative. Several challenges exist in the development of heart monitors. Primarily, it is essential to identify the technology employed for pulse measurement. An economical solution for pulse detection involves the integration of a light-emitting diode (LED) and a photo-sensor.[15,16]

2.1.2.1 Electrical Method

Heart rate chest straps utilize electrodes to detect the electrical impulses produced by your heartbeat. This data is transmitted to a receiver Via radio signals emitted by the chest strap. The receiver subsequently analyzes this information to determine your heart rate. Certain monitors feature "encrypted signals," which embed a unique code within the radio transmission, thereby preventing receivers from picking up signals from other nearby devices. Although this concern may not always be critical, it can lead to inconvenience or data corruption. Furthermore, this approach has several drawbacks, including the possibility of inaccuracies and the complexity of wiring connections across the body.

2.1.2.2 Optical Method

This optical method uses the natural behavior of small subcutaneous blood vessels known as capillaries, located in well-perfused areas of the skin, such as the fingertips or the edges of the ears. These vessels undergo rhythmic expansion and contraction in tandem with the heartbeat. A combination of standard infrared LEDs and phototransistors can detect these subtle fluctuations as changes in skin contrast. This approach uses the principles of transmission and reflection. It is a non-invasive way to measure heart rate without the need for physical attachment or insertion into the body. It is also accurate and cost-effective.[17,18]. As shown in fig (2.1).

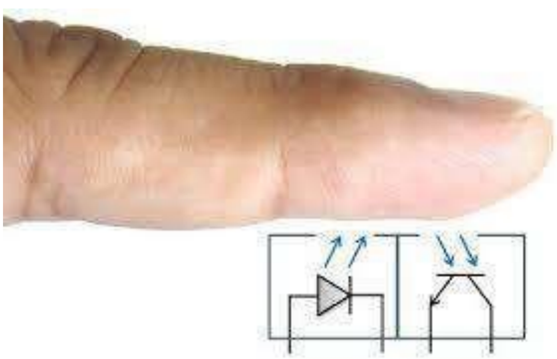


Fig (2.2) Optical measuring meth

Chapter Three

Materials and Methods

3.1 Materials

This Heartbeat system consists of four main parts which are:

power Supply

Microcontroller unit

Heart beat sensor

Display.

All these components are encased in a plastic box with the following dimensions:

1. 'Length = 11 cm
2. 'Width = 11 cm
3. 'Height = 6 cm

The volume for the box = 726 cm^3

3.1.1 The power Supply

The power supply unit of this device is rechargeable and consists of:

- Li-ion Battery 9volt
- 9V battery connector
- Charger
- Power Switch with LED indicator

3.1.1.1 Li-ion Battery 9volt

A nine-volt battery, commonly known as a 9-volt battery, serves as an electrical power source that provides a nominal voltage of 9 volts. The actual output can vary between 7.2 and 9.6 volts, depending on the particular technology utilized. These batteries are produced in various sizes and capacities, with the PP3 size being particularly prevalent. The PP3 battery features a rectangular prism design with rounded corners and is equipped with two polarized snap connectors located at the top. This type of battery is widely utilized across numerous applications.[19,20] As shown in fig (3.1).

Fig (3.1) Li-ion Battery 9volt

3.1.1.2 9V battery connector + DC jack (battery connector cover)

Fig(3.2) 9V battery connector

Fig(3.2) 9V battery connector

3.1.1.3 Charger

A battery charger, also known as a charger, is a device designed to supply power to a battery pack or rechargeable battery by passing an electric current through it. The charger used is a 5V 1A type with a micro USB port..[21] As shown in fig (3.3).

Fig (3.3) Battery charger

3.1.1.4 Power Switch with LED indicator

A three-ampere switch regulates the power supply to the device. Additionally, the system features a 5mm LED that illuminates when the system is activated. As shown in fig (3.4),(3.5).

Fig (3.4) Power switch

Fig (3.5) Light emitting diode (LED)

3.1.2 Microcontroller Unit

To control the input and output data, we used Arduino Uno, which is based on the ATMEGA328 microcontroller.

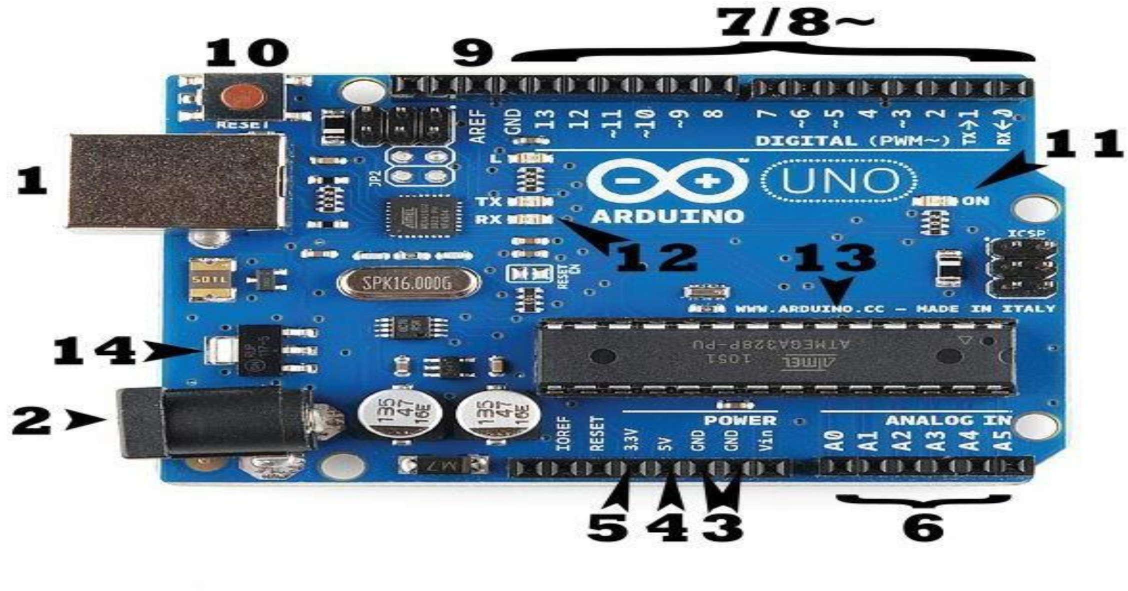
3.1.2.1 Arduino Uno

Arduino Uno is an open source microcontroller board that uses Microchip Atmega328P microcontroller and was developed by Arduino. The board has a large number of digital and analog input/output (I/O) pins that allow connection to a variety of shields and other electronic circuits. It includes 14 digital I/O ports, six of which support pulse width modulation (PWM), as well as 6 analog I/O ports. Programming is done through the Arduino Integrated Development Environment (IDE) using a USB Type-B cable. This board can be powered via a USB connection or an external 9V battery with a voltage range of 7-20V. This board is similar to the Arduino Nano and Leonardo models. The hardware reference design is available under the Creative Commons Attribution Share-All 2.5 license..[22] As shown in fig (3.6).

Fig(3.6) Arduino Uno

3.1.2.2 Arduino board contents

There are many Arduino boards available, each designed for a specific application.While some boards may look slightly different, most Arduino boards are made up of similar parts..[18]



Fig(3.7) Arduino sub-tokens

- **Power Input (CD/USB jack)**

  All Arduino boards need some way to be connected to a power source. Arduino Uno can be powered via a USB cable from a computer or from a wall outlet using a Barrel Jack. In the picture above, the number (1) refers to the USB connection, while the number (2) refers to the cylinder socket. Also, through the USB connection, the code was uploaded to the Arduino board. To learn more about how to program the Arduino, you can read this tutorial on Installing and Programming Arduino (coming soon).

- **Note**: Do not use any power supply greater than 20V because the Arduino cannot handle a voltage greater than that, and it will be destroyed. The recommended voltage for most versions of Arduino is between 6 and 12 volts. Ports (pins) (5V, 3.3V, GND), Analog, Digital, PWM, AREF.

  The ports on the Arduino are where you connect wires to build an electronic circuit (using a breadboard and wires). These ports often have black, plastic "heads" that allow you to attach a wire to the breadboard. There are different types of ports, each with a name or symbol next to it written on the board to differentiate them, and they have many different functions.

- **GND(3):**

abbreviation for ground. There are several GND ports on the Arduino board, any of them can be used to ground the circuit.

        - 5V (4) and 3V (5): These are the two ports for powering the components
        - that connect to the Arduino. The 5V port supplies 5V, while the 3.3V

    - port supplies 3.3V. Most of the simple components that are used with
    - Arduino work fine at 5 or 3.3 volts

- **Analog (6):**

The ports in the area below the word "Analog In" (A0 through A5 on the Arduino Uno) are the analog inputs. These ports can read the signal coming from the analog sensors (such as a temperature sensor) and then convert it into a digital value that we can read.

- **Digital (7):**
  On the other side of the analog pins are the digital pins (0 to 13 on the Arduino Uno). These ports can be used for both digital input (eg telling you if a button is pressed) and digital output (eg LED lighting).
- **PWM (8):**
        - You may have noticed the (~) sign next to some of the digital ports (3, 5, 6, 9, 10, 11 on the Arduino Uno). These ports can function as regular digital ports, but they can also be used for something called pulse-width modulation. There is a lesson on PWM (coming soon), but now imagine that these ports can simulate an analog output port.
- **AREF (9):** An abbreviation for "Analog Reference," this port is typically non-functional. However, it may occasionally be utilized to establish a maximum external reference voltage, ranging from 0 to 5 volts, for the analog input ports.

- **Reset Button (10)**

Similar to the original Nintendo console, the Arduino is equipped with a reset button. When this button (10) is activated, the reset port is momentarily grounded, resulting in the deletion of any code currently loaded onto the Arduino and the restoration of the device's original driver as it was at the time of purchase. This feature can be beneficial if your code is not recursive, although it may require several attempts to achieve the desired outcome. In contrast to the Nintendo, blowing into the Arduino will not resolve any issues.[23,24]

- **Power LED Indicator (11)**

At the bottom right of the word “ONO” on the Arduino board, there is a small LED next to the word “ON” (indicated in the picture as the number 11). This LED lights up when you connect the Arduino to a power source. If this light does not work, there may be a problem, and you should check the circuit you installed.

- **TX and RX LEDs (TX RX LEDs)**

TX stands for transmit, while RX denotes receive. These abbreviations are commonly used in electronics to identify the ports designated for serial communication. In our case, there are two places on the Arduino Uno where TX and RX appear - the first is next to the digital pins 0 and 1, and the second is next to the illuminated transceiver diodes (12). These diodes give us an appropriate indication to know if the Arduino is sending or receiving data (such as while loading a new program to the Arduino board).

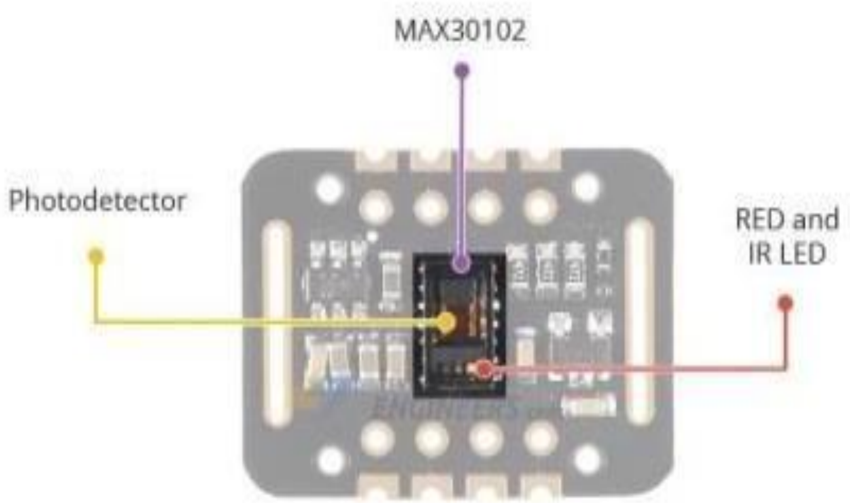
- **main integrated circuit**

The black thing with metal legs (13) An integrated circuit serves as the core component of the Arduino, functioning similarly to a brain. The specific type of integrated circuit utilized in an Arduino board can differ, with many boards featuring components from ATMEL's Atmega series.

Prior to uploading any new software to the Arduino, it is crucial to identify the type of integrated circuit in conjunction with the specific Arduino board being used. This information is typically inscribed on the upper surface of the integrated circuit. For a deeper understanding of the distinctions among various integrated circuits, consulting the data sheets provided with the boards may prove beneficial.

3.1.3 Heart rate sensor

The MAX30102 Pulse Oximeter and Heart Rate Sensor are low-power, I2C-based biometric sensors designed for easy integration. It can be used by students, hobbyists, engineers, and makers, as well as game and mobile developers who want to integrate real-time heart rate data into their applications. This module replaces the MAX30100 with the MAX30102, an advanced integrated analog package. It combines dual diodes, photodetectors,optimized optical components, and analog signal processing to accurately measure pulse oximetry (SpO2) and heart rate (HR).[25,26]. As shown in fig (3.8).

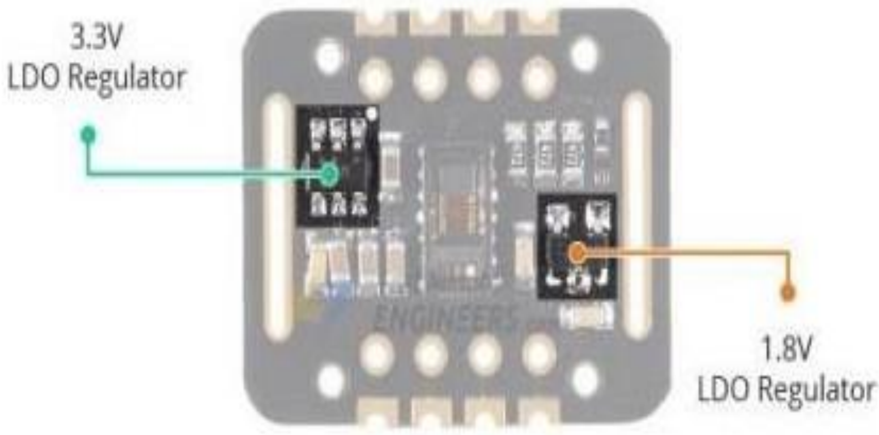


Fig(3.8)The MAX30102 has two LEDs - red and IR LED.

On either side of the window, the MAX30102 is equipped with two LEDs: red and infrared. In front of these LEDs is a very sensitive photodetector. The principle is to illuminate one LED at a time and measure the intensity of the light reflected back to the detector. This light signature analysis can be used to determine blood oxygen levels and heart rate..

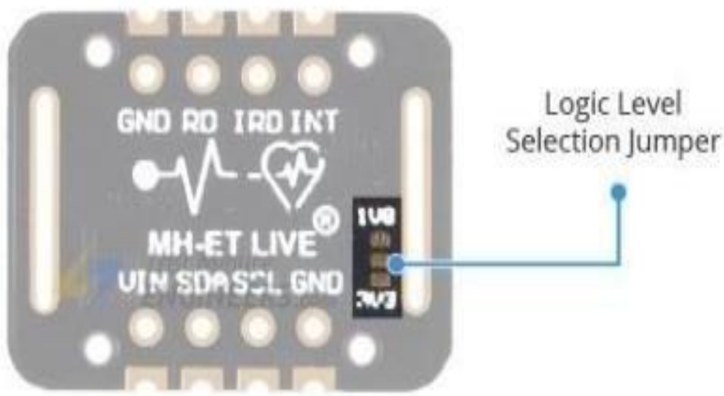
3.1.3.1 Power Requirement

The MAX30102 chip necessitates two distinct supply voltages: 1.8V for the integrated circuit and 3.3V for the red and infrared LEDs. Consequently, the module is equipped with both a 3.3V and a 1.8V regulator.As shown in fig (3.9).



Fig(3.9) LDO regulator in sensor max 30102

There is solder on the back of the PCB that makes it easy to select between 3.3V and 1.8V logic levels. The standard power supply is 3.3V, which is the logic level used by Arduino. However, you have the option to switch to 1.8V logic level, depending on your needs. This feature allows you to connect the module to a microcontroller that operates at 5V, 3.3V or 1.8V I/O levels.



Fig(3.10)Transit select the logic level in the sensor max 30102

A key characteristic of the MAX30102 is its minimal power consumption, as it operates at less than 600µA during measurement. Additionally, the device can be placed in standby mode, reducing its consumption to merely 0.7µA. This efficient power usage facilitates its integration into battery-operated devices, including handsets, wearables, and smartwatches..[27,28] As shown in fig (3.10).

3.1.3.2 How MAX30102 Pulse Oximeter and Heart Rate Sensor Works?

The MAX30102, like all optical pulse oximeters and heart rate sensors, consists of two high-intensity light-emitting diodes (LEDs) that emit red and infrared light at different wavelengths, as well as an optical sensor. Specifically, the wavelength of these LEDs is 660 nm for red light and 880 nm for infrared light.[32,34] As shown in fig (3.11).

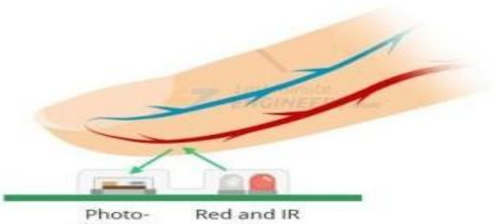


Fig (3.11) MAX30102 heart rate sensor

The MAX30102 works by shining two light sources onto the shoulder, earlobe, or other areas where the skin is too thin to allow effective light penetration. It then measures the amount of reflected light using an optical detector. This method of detecting pulses using light is called photoplethysmography.

Technical Specifications

Table of Here are the technical specifications:

Power supply	3.3V to 5.5V
Current draw	~600µA (during measurements) ~0.7µA (during standby mode)
Red LED Wavelength	660nm
IR LED Wavelength	880nm
Temperature Range	-40˚C to +85˚C
Temperature Accuracy	±1˚C

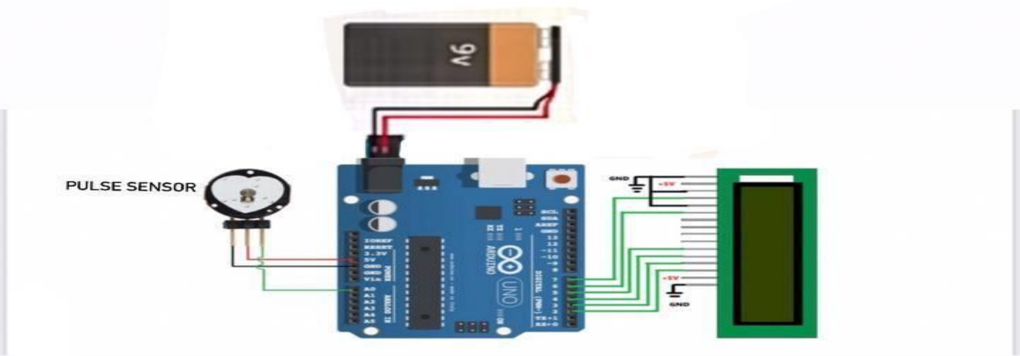
3.1.4 Display

An LCD (Liquid Crystal Display) screen is an electronic display module used in a variety of applications. A 16x2 LCD display is a basic module that is often used in a variety of devices and circuits. Specifically, the 16x2 LCD can display up to 16 icons across two rows.Each letter on this screen is represented by a 5x7 pixel matrix. This intelligent alphanumeric matrix dot display shows a total of 224 different signs and symbols. The blue backlit LCD is very useful for monitoring your heart rate and body temperature. Dimensions are 16 x 2..[35] As shown in fig (3.13).

Fig (3.12) LCD display 16x2

3.2 Working Principle

The proposed methodology aims to develop an automated health monitoring system. The purpose of this system is to continuously monitor the patient's heart rate and display the data to the doctor through technology. In healthcare facilities, the patient's health is usually monitored by hospital staff. The patient's heart rate is regularly monitored and detailed records are kept. The essential components of this system include a power supply, an ATmega328 microcontroller, a heart rate sensor, and an LCD display. An ATmega328 microcontroller acts as a central processor for monitoring the patient's heart rate. The functionality of this proposed health monitoring system can be illustrated using a block diagram.[36,37]. As shown in fig (3.14).



Fig(3.13) Device block diagram

This block diagram illustrates the connections of the LCD module, where the four data pins—D4, D5, D6, and D7—are linked to pins 1, 1, 1, and 1 on the Arduino UNO. Additionally, a 10KΩ resistor is attached to pin 3 of the LCD, which serves as the brightness adjustment pin. The RS and E pins of the LCD, designated as pins 3 and 5, are connected to pins 1 and 1 on the Arduino UNO. Furthermore, the output from the heart rate sensor module should be connected to the analog input pin (pin 1) of the Arduino.[38,39] As shown in fig (3.15).

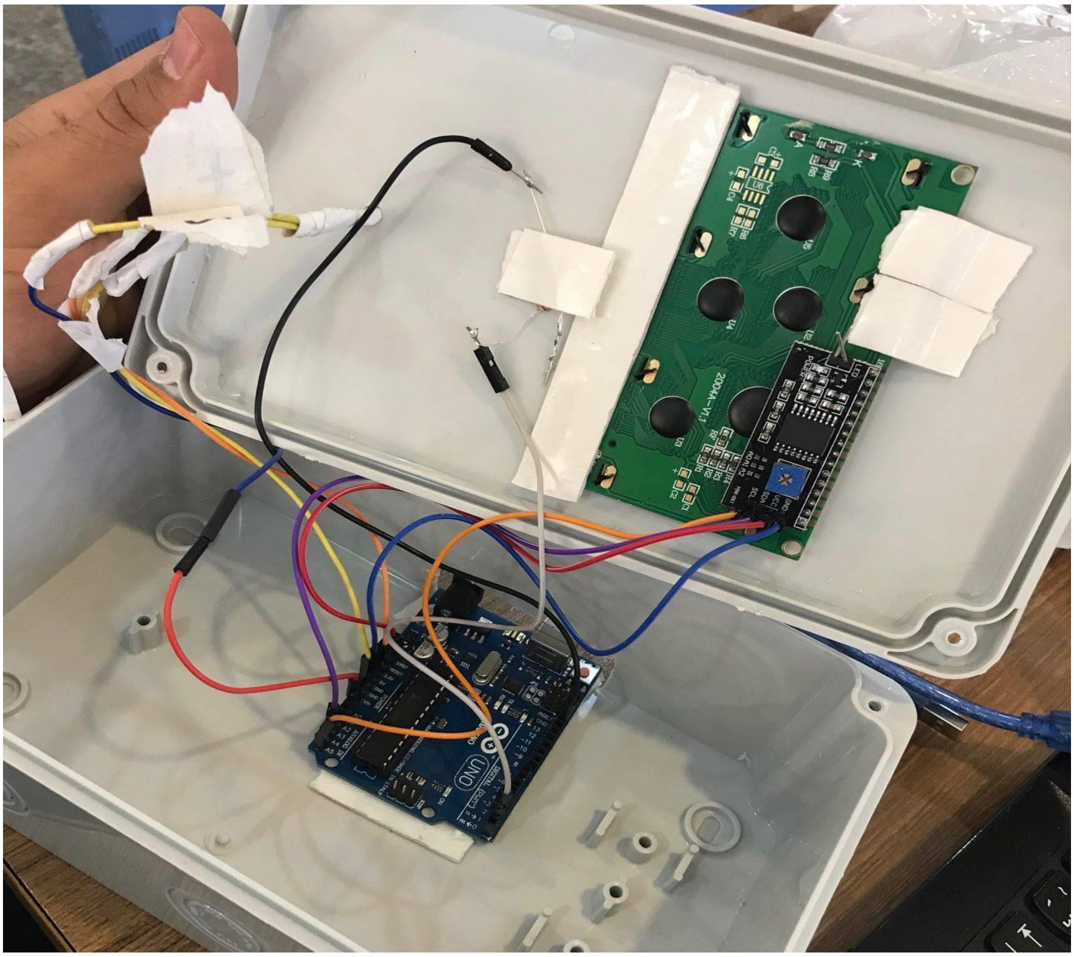


Fig (3.14) Internal components of the device

To start the process, insert any finger (except the thumb) into the sensor clamp and press the switch (button).The Arduino will analyze the data received from the sensor to determine your heart rate, which will be displayed in beats per minute (bpm). During the data collection phase, it is recommended to sit comfortably and avoid any movement of the wire as this can lead to inaccurate readings. Once the results are displayed on the LCD, you can perform another test by simply pressing the reset button on the Arduino and repeating the procedure.[40,41,42]

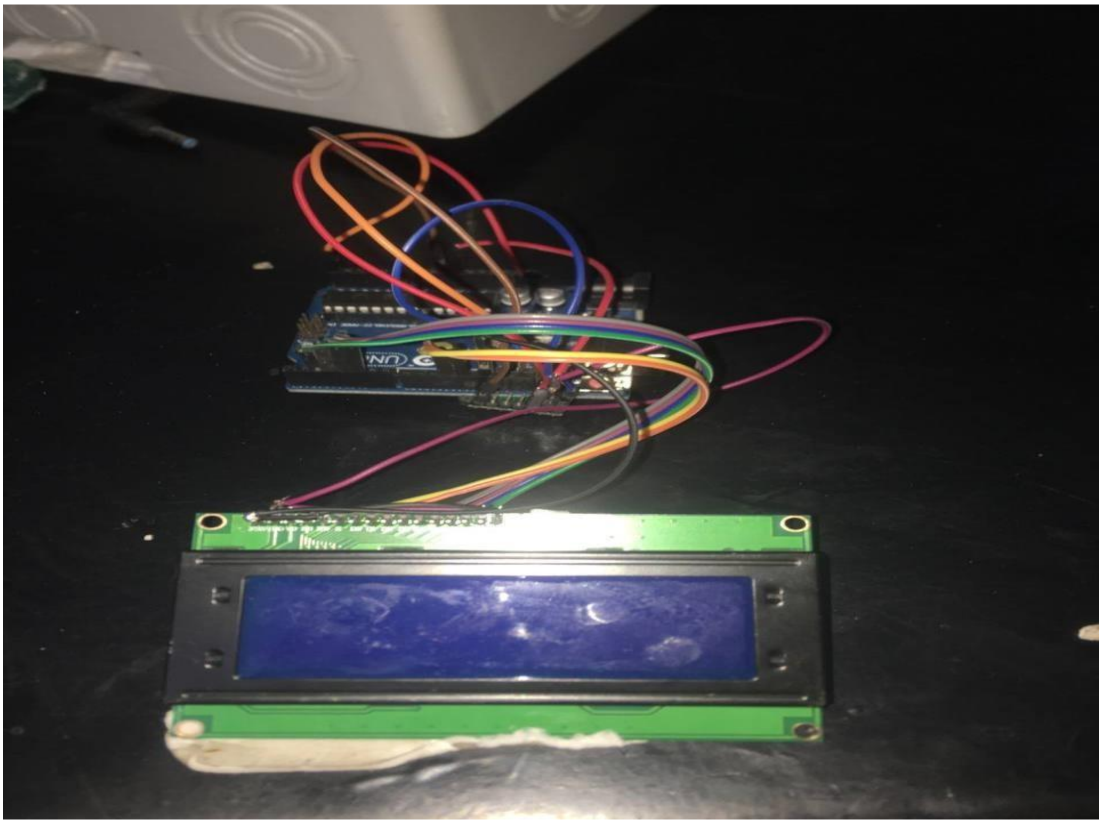


Fig (3.15) Another photo for the internal components of the device.

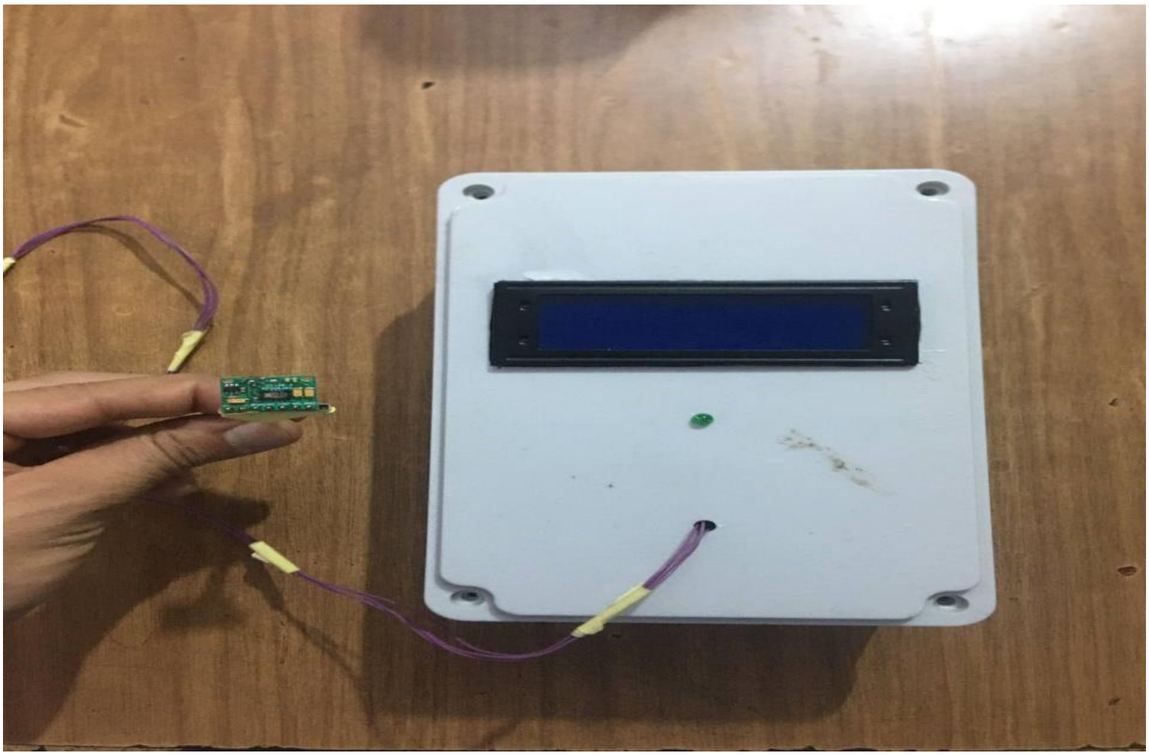


Fig (3.16) External components of the device.

Chapter Four

Results and Conclusion

4.1 Comparison of readings between a heart rate sensor and a pulse oximeter

Patients name	Patients age	Device heart rate	Pulse oximeter
karar ali	18	83	83
abd hasn	13	72	72
gheth ali	35	69	72
mohammed abbas	23	81	81
abrahem ali	25	61	72
hussan faez	22	68	74
kazem saker	40	88	88
Mustafa ali	24	78	80
ali hasn	52	82	74
greda nasr	56	85	85
aya akel	24	90	90
shkre krem	61	76	81
gder naser	23	81	81
noor ali	48	66	78
greba naem	56	69	69
twfek frag	39	70	70
ngah zher	41	84	112
ali bder	32	78	78
naser abbas	38	67	86
furqan nasser	23	65	71
hsnen ali	43	70	83
wsen kamel	37	72	72
adnan hwas	57	79	89
zahraa basem	19	72	75

$$\text{Accuracy} = \left(1 - \frac{total\ no.of\ \ values - total\ no.\ true\ value\ detect}{total\ no.of\ \ values}\right) * 100\%$$

$$= \left(1 - \frac{25-11}{25}\right) * 100\%$$

= 44%

4.2 Heart rate sensor diagram and oximeter

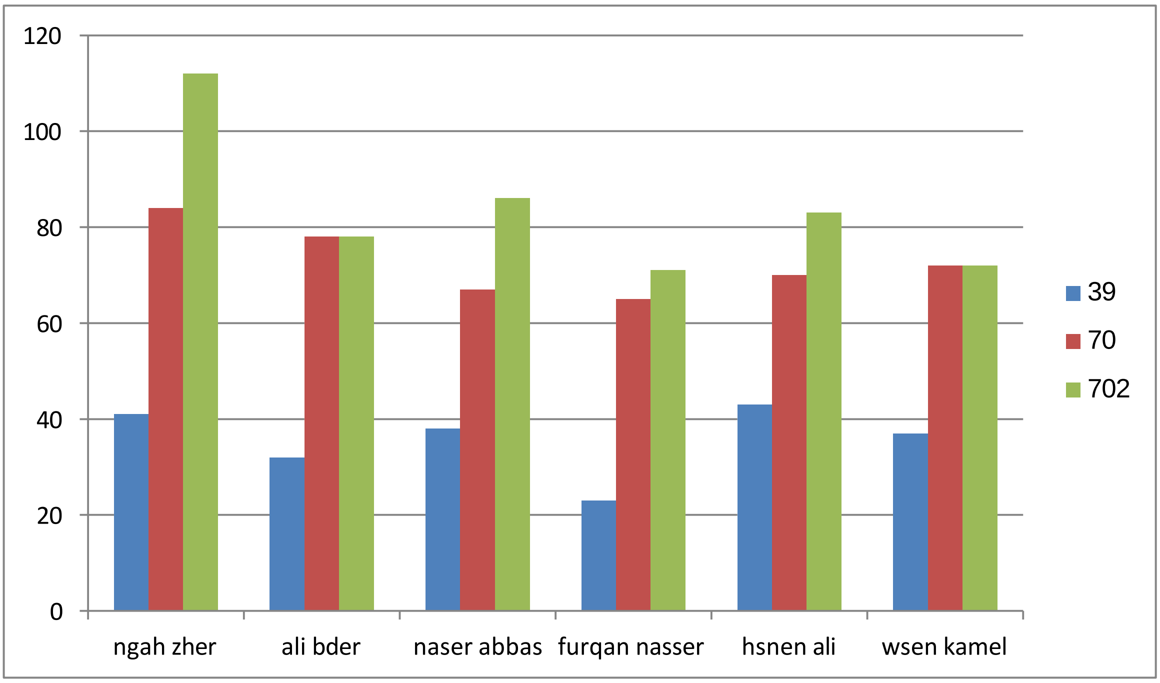


Fig (4.1) The first diagram of the heart rate sensor and oximeter

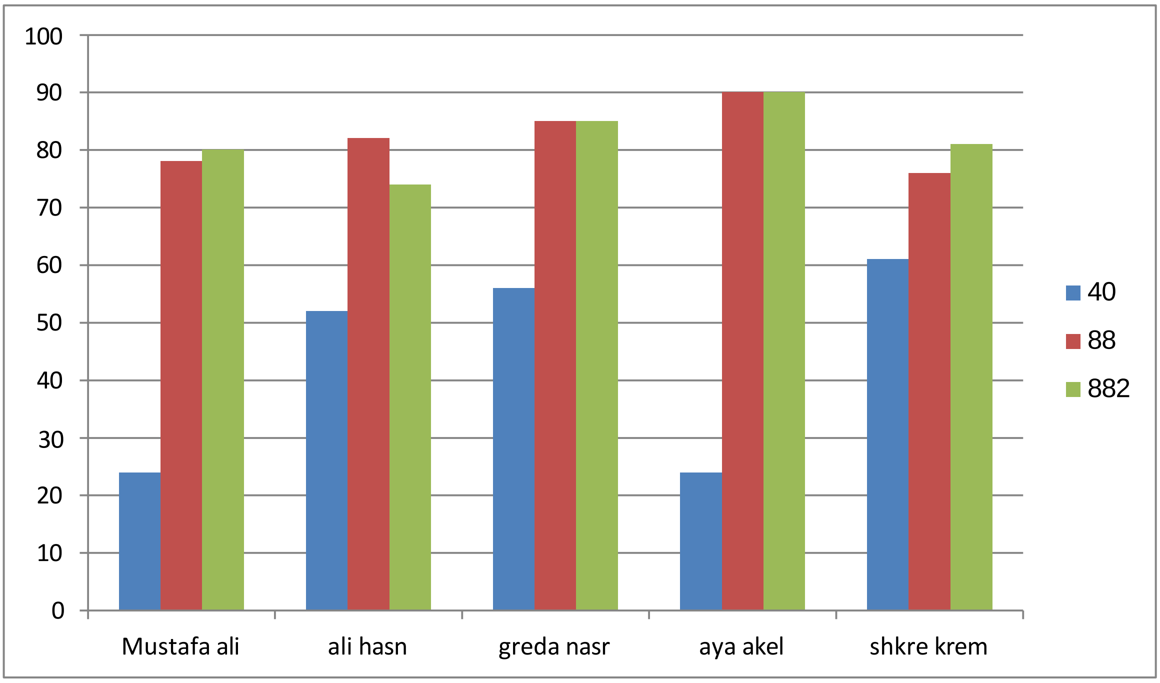


Fig (4.2) The second chart of the heart rate sensor and oximeter

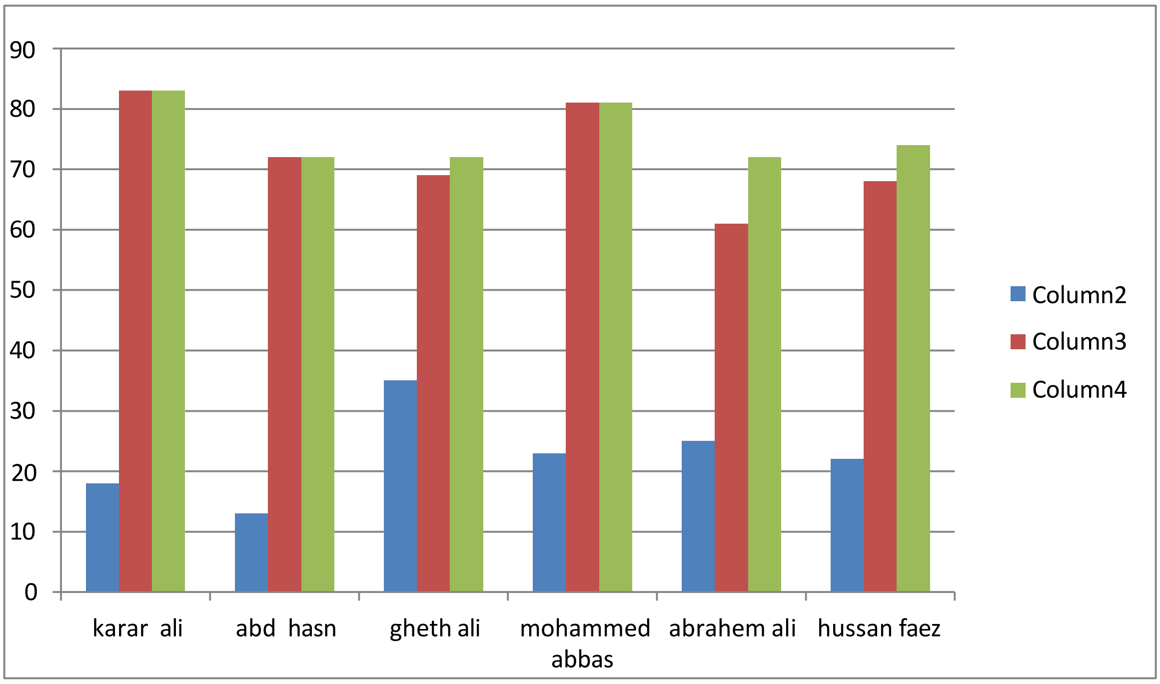


Fig (4.3) The third chart of the heart rate sensor and oximeter

4.3 Results

When the power supply is active, the green LED on the device will light up, indicating that the circuit is working properly. The system includes a heart rate sensor that measures your heart rate and then displays it on an LCD screen[.43,45,46] As shown in fig (4.1).

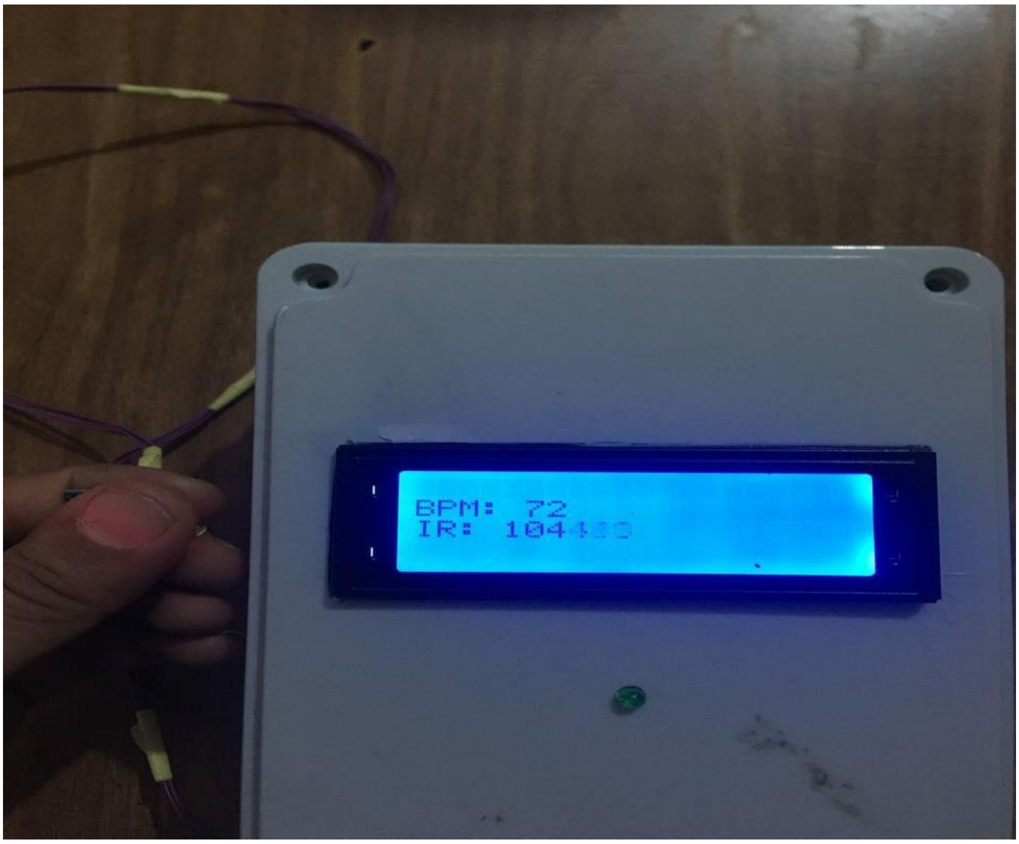


Fig (4.4) The device While working

The measured data is sent through the sensor, and the heart rate meter has a custom Arduino programmed that is used to display the data on the device screen.

4.4 Conclusion

This project involves the analysis of a patient health monitoring system focusing on human heart rate monitoring. Heart rate is assessed using a light emitting diode in conjunction with a lit LED. The data is processed by an Arduino Uno and displayed on a screen, allowing the doctor to evaluate the readings and determine if the person is experiencing a health crisis.

4.5 Future Applications and Developments

- The device is capable of connecting to a PC via serial output, allowing the measured heartbeat data to be transmitted for subsequent online or offline analysis. Notifications regarding any health abnormalities can be presented. Additionally, sound alerts can be enhanced to be more engaging. The output can also be transmitted to mobile devices using either a GSM module or a Bluetooth module for further examination. Furthermore, additional parameters, such as blood pressure, can be incorporated into the device. The system can be equipped with a GSM module, enabling it to send alert messages to healthcare providers. As new sensors become available or advancements in biomedical technology occur, more parameters can be monitored, significantly enhancing the effectiveness of the monitoring system within the biomedical sector.

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