"EDUCATION OF HUMAN POWER FOR TECHNOLOGICAL EXCELLENCE"

SHRI GURU GOBIND SINGHJI INSTITUTE OF ENGINEERING AND TECHNOLOGY

" ECG MONITORING USING AD8232 MODULE"

For the MINI PROJECT

In

Electronics and telecommunication Engineering Department

Project Report

By

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Under the Guidance of

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(2023-2024)

SHRI GURU GOBIND SINGHJI INSTITUTE OF ENGINEERING AND TECHNOLOGY

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(An Autonomous Institute of Govt. of Maharashtra)

CERTIFICATE

This is to certify that the project entitled **"ECG MONITORING USING AD8232 MODULE"** in the partial fulfillment of the "Mini Project, 3rd year" for Shri Guru Gobind Singhji Institute of Engineering and Technology, Vishnupuri, Nanded. This bonafide work carried and completed under guidance and supervision of our guide Prof.Sachin Panchal & prof.A.P.Kuchan. during academic schedule 2023-2024.

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DECLARATION

We hereby declare that we have formed, completed, and written the Report entitled "**ECG MONITORING USING AD8232 MODULE**" It has not previously submitted for the basis of the Mini Project for 3rd year course.

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Date: 20/04/2023

ABSTRACT

The last decade has witnessed an increasing number of deaths caused by chronic and cardiovascular diseases (CVDs) in all countries across the world. CVDs are disorders affecting the blood vessels and the heart. CVDs involving the blood vessels are known as vascular diseases, such as coronary artery disease. Those involving the heart include heart failure, cardiomyopathy, rheumatic heart diseases, stroke, heart attack, and arrhythmias. According to the World Health Organization (WHO), CVDs are the number one cause of death globally, with 17.9 million deaths every year . It remains the number one cause of death of all Americans, claiming more than 840,000 lives in 2016 . Furthermore, the European Health Network European Cardiovascular Disease Statistics 2017 edition revealed that CVDs cause 3.9 million deaths in Europe and over 1.8 million deaths in the European Union (EU) yearly.
This accounts for 45% of all deaths in Europe and 37% of all deaths in the EU.
Continuous heart rate monitoring and immediate heartbeat detection are primary concerns in contemporary healthcare. Experimental evidence has shown that many of the CVDs could be better diagnosed, controlled,and prevented through continuous monitoring, as well as analysis of electrocardiogram (ECG) signals. Hence,the monitoring of physiological signals, such as electrocardiogram (ECG) signals, offers a new holistic paradigm for the assessment of CVDs, supporting disease control and prevention. With advances in sensor technology, communication infrastructure, data processing, and modeling as well as analytics algorithms the risk of impairments could be better addressed more than ever done before. This, in turn, would introduce a new era of smart, proactive healthcare especially with the great challenge of limited medical resources. Heart diseases are becoming a big issue for the last few decades and many people die because of certain health problems.Therefore, heart disease cannot be taken lightly. By analyzing or monitoring the ECG signal at the initial stage this disease can be prevented. So we present this project, ECG Monitoring with AD8232 ECG Sensor & Arduino with ECG Graph and also the displaying of heart beat on LCD display and also the normal and abnormal heart rate. The AD8232 is a neat little chip used to measure the electrical activity of the heart.

ACKNOWLEDGEMENT

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Lastly, we would like to thank all our friends and library staff members whose encouragement and suggestion helped us to complete our project. We are also thankful to all those persons, who have contributed directly or indirectly in the completion of this project.

Thank you!

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CHAPTER 1

INTRODUCTION

1.1Overview

ECG (Electrocardiogram) monitoring is a technique used to measure the electrical activity of the heart to analyze its health and diagnose any potential cardiac issues. At the present time, people suffering from heart diseases are increasing at an alarming rate. The ECG is one of the medical kits that can measure the heartbeat per unit time, convert it into a signal and display the data on a display device. An ECG is a recording of the electrical activity on the body surface generated by the heart muscles. ECG information is collected by electrodes placed at selected locations on the patient's body. It is the best way to monitor and diagnose abnormal rhythms of the heart muscles, mainly abnormal rhythms caused by damage to the conductive tissul that carries electrical signals. It is possible to be in cardiac arrest with a normal ECG signal (a condition known as pulseless electrical activity). Electrocardiogram (ECG) is one of the frequently used and accurate methods for monitoring the electrical activity of the heart. ECG is an high- priced equipment and its use for the measurement of the heart rate only below an economic level. Low-cost devices are available in the form of wrist watches for the instantaneous measurement of the heart rate. Such devices can give accurate data but they are expensive: Most hospitals and diagnostic centers in India use incorporated devices designed to measure the heart rate, temperature, and blood pressure of the patient. Although such devices are valuable, their cost is usually uneconomical. This paper depicts the design of an ECG monitoring using the module AD8232 and ARDUINO board. ECG monitoring involves placing electrodes on the chest, arms, and legs to measure the electrical signals produced by the heart. These signals are then recorded and analyzed to detect any abnormalities in the heart's rhythm or function. The AD8232 module is a popular integrated circuit (IC) that is specifically designed for acquiring and amplifying ECG signals. It can be interfaced with an Arduino microcontroller using the I2C (Inter-Integrated Circuit) communication protocol to display the ECG data on an LCD (Liquid Crystal Display) module.

1.1 Need and significance of the project:

- Early detection of cardiac issues: ECG monitoring can help in the early detection of various cardiac issues such as arrhythmias, heart block, and ischemia. By monitoring the electrical activity of the heart in real-time, any abnormal patterns or irregularities can be detected, allowing for timely medical intervention and potentially saving lives.

- Non-invasive and portable monitoring: The AD8232 module is a non-invasive and portable solution for ECG monitoring. It can be easily attached to the chest using electrodes, making it convenient for long-term monitoring in different settings, such as hospitals, clinics, or even at home. This allows for continuous monitoring of the heart's electrical activity without the need for invasive procedures.

- Cost-effective and accessible: The AD8232 module, along with an Arduino and LCD module, provides a cost-effective solution for ECG monitoring compared to traditional ECG machines. It is also highly accessible, as Arduino is an open-source platform with a large community of users and developers, making it easy to obtain and customize the necessary components for ECG monitoring.

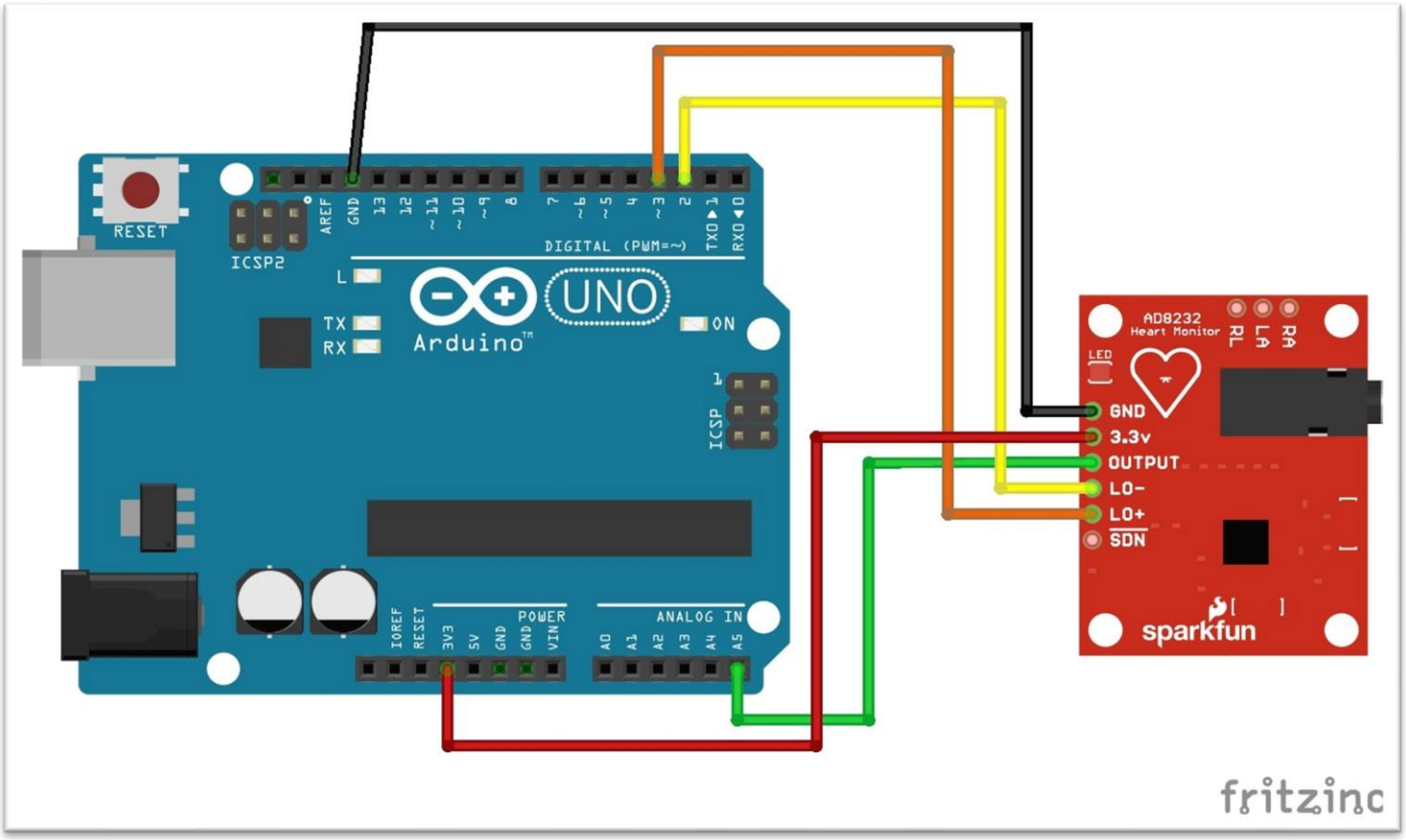
- Health monitoring and fitness tracking: ECG monitoring using the AD8232 module can also be used for health monitoring and fitness tracking purposes. It can provide insights into an individual's heart rate, heart rate variability, and overall cardiac health, which can be useful for tracking fitness progress, managing stress, and improving overall well-being.

- Educational and research purposes: ECG monitoring using the AD8232 module can also be used for educational and research purposes. It can be integrated into educational projects or research studies related to cardiology, biomedical engineering, and health sciences, allowing for hands-on learning and data collection.

CHAPTER 2

2-Methodology

2.1-BLOCK DIAGRAM:



- AD8232 ECG Sensor: The AD8232 is a single-lead ECG sensor that measures the electrical activity of the heart. It has three main pins: LO+ (output for the positive half of the ECG signal), LO- (output for the negative half of the ECG signal), and 3.3V (power supply).
- Amplification Circuit: The AD8232 sensor output is a low-level analog signal, which needs to be amplified for further processing. The block diagram shows an op-amp-based amplification circuit that amplifies the ECG signal from the AD8232 sensor to a suitable level for the Arduino to read.
- Arduino: The Arduino is a popular microcontroller platform that can process analog and digital signals. It is used to receive the amplified ECG signal from the AD8232 sensor and perform signal processing and analysis.
- Analog-to-Digital Converter (ADC): The Arduino has built-in ADCs that can convert the amplified analog ECG signal from the AD8232 sensor into digital values that can be processed by the microcontroller. The ADC converts the continuous analog signal into discrete digital samples.
- Power Supply: The AD8232 sensor and Arduino both require a power supply to operate. The block diagram shows a single power supply (3.3V) for both the AD8232 sensor and the Arduino, but separate power supplies may also be used depending on the application requirements.

2.2. Component list:-

I. Arduino mega

II. AD8232 ECG module

III. Electrodes(3 electrodes)

IV. Connecting jumper wires

V. I2C converter

VI. LCD display(16x2)

I. Arduino mega:-

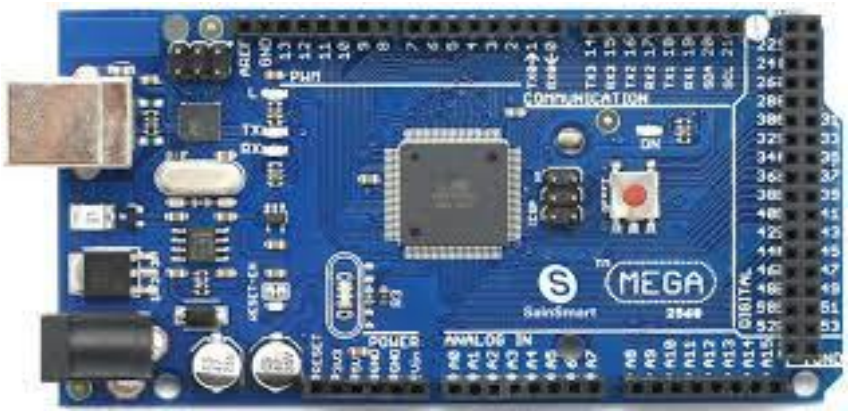


Fig-Arduino Board

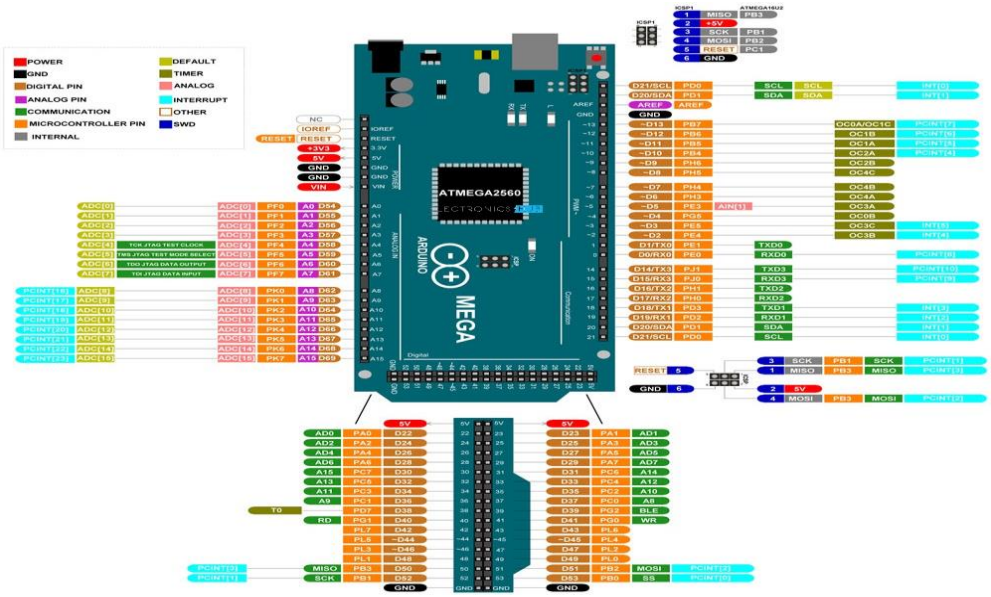


Fig-Pinout of Arduino mega

Arduino Mega 2560 is an open source development board based on Atmega2560 AVR microcontroller. This microcontroller is an 8- bit Microcontroller. It uses ATmega16U2 Microchip Technology. This board can be programmed using programmed using wiring/ processing language. It includes:-

1. 54 digital input/ output pins out of which 14 pins can be used as PWM outputs
2. 16 analog pins
3. 4 UARTs (hardware serial ports)
4. A 16 MHz crystal oscillator
5. A USB connection
6. A power Jack

7. An ICSP Header
8. A reset button
9. SDA and SCL pins besides AREF pin
10. IOREF and one more extra pin besides RESET

II. AD8232 Module

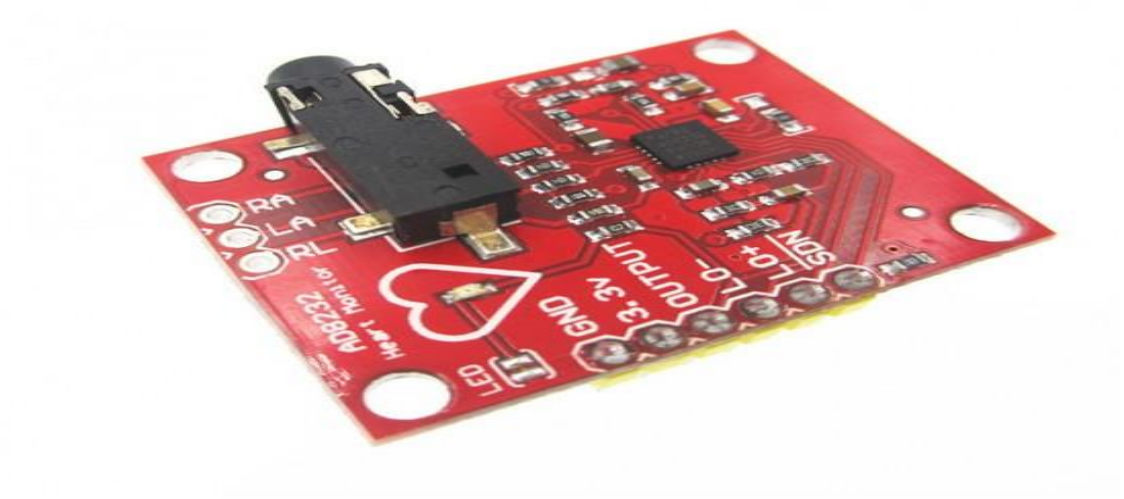


Fig-AD8232 module

The AD8232 is a single-lead heart rate monitor front-end module developed by Analog Devices Inc. It is used for monitoring heart rate and detecting heart rate-related events in various applications such as fitness trackers, wearable devices, and portable health monitoring devices. Here are the specifications of the AD8232 module:

1. ECG Signal Conditioning: The AD8232 module is specifically designed for amplifying, filtering, and processing the weak biopotential signals obtained from the human body, such as electrocardiogram (ECG) signals. It provides a high common-mode rejection ratio (CMRR) of typically 80 dB, which helps in reducing interference from the power line and other external sources.

2. Heart Rate Detection: The AD8232 module includes a built-in heart rate detection feature that can detect the heart rate from the processed ECG signal. It utilizes a proprietary heart rate detection algorithm that provides reliable and accurate heart rate monitoring.
3. Analog Front-End: The AD8232 module has an analog front-end that includes a pre-amplifier with adjustable gain, a high-pass filter to remove motion artifacts and baseline wander, and a low-pass filter to remove high-frequency noise.
4. Lead-off Detection: The AD8232 module also features a lead-off detection circuit that can detect when the ECG electrode is not properly attached or has fallen off, providing an indication of the quality of the ECG signal.
5. Power Supply: The AD8232 module operates with a single power supply voltage in the range of 2.0 V to 3.5 V, making it suitable for low-power and battery-powered applications.
6. Interface: The AD8232 module provides an analog output for the processed ECG signal, which can be connected to an ADC for further processing or a microcontroller for heart rate calculation. It also includes a digital output for the heart rate detection status, which can be used to trigger alarms or notifications.
7. Package: The AD8232 module is available in a small form factor package, typically a 20-lead surface-mount package, making it easy to integrate into compact wearable devices and other portable applications.
8. Operating Temperature: The AD8232 module is designed to operate over a wide temperature range, typically from -40°C to +85°C, making it suitable for various environments.
9. Compliance: The AD8232 module is compliant with various regulatory

standards, such as the European Union's Restriction of Hazardous Substances (RoHS) directive, ensuring it meets environmental and safety requirements.

III. Electrodes

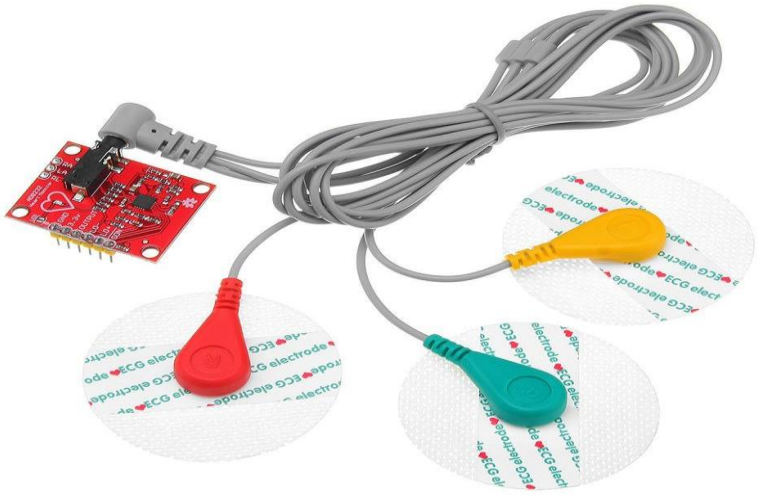


Fig-electrodes

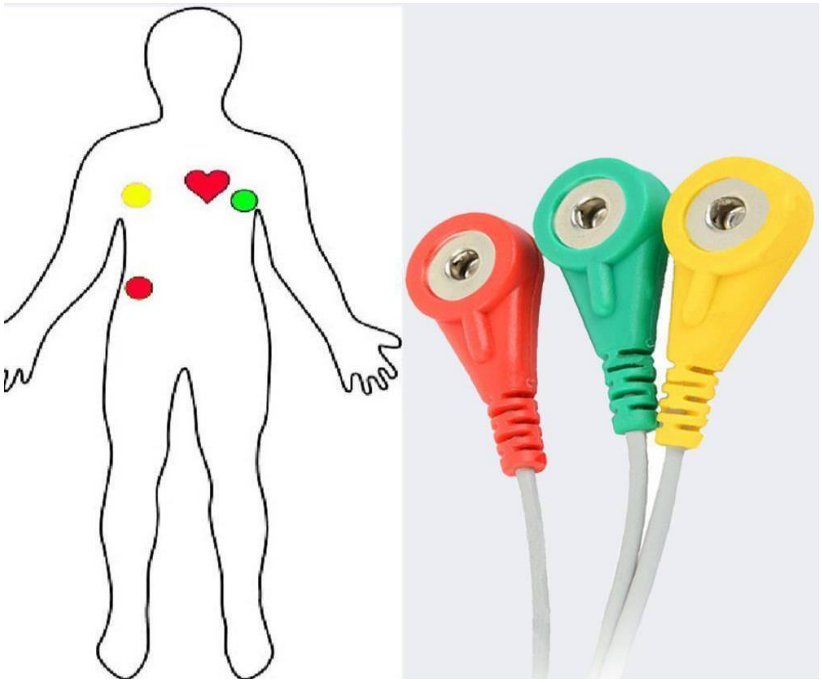


Fig-proper connections of electrodes

A standard ECG measurement typically requires at least three electrodes placed on specific locations of the body to form a lead. These three electrodes are typically placed on the right arm, left arm, and left leg (or right leg) to form a lead configuration known as Lead I, Lead II, or Lead III. However, the AD8232 module is designed to work with a single electrode, making it suitable for simplified ECG monitoring with a single lead.

The AD8232 module uses its built-in analog front-end to condition and amplify the ECG signal from the single electrode, and it includes a proprietary heart rate detection algorithm to detect the heart rate from the processed signal. The module then provides analog and digital outputs for further processing or display of the heart rate information.

It's important to note that while the AD8232 module provides a simplified approach to heart rate monitoring with a single electrode, it may not be suitable for all applications or provide the same level of accuracy as a standard 3-lead or 12-lead ECG system. The choice of electrode placement and lead configuration should be carefully considered based on the specific requirements of the intended ECG monitoring application. Consulting the AD8232 module's datasheet and following best practices for electrode placement and ECG measurement is recommended for accurate and reliable results.

VII. I2C (Inter-Integrated Circuit)

Fig-I2C converter

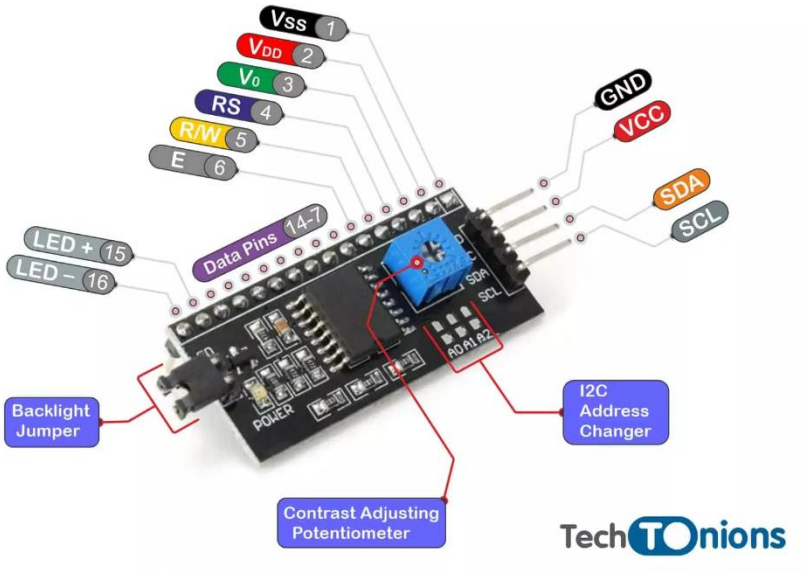


Fig-pinout of I2C converter

I2C (Inter-Integrated Circuit) is a communication protocol that allows digital devices to communicate with each other using a serial interface. An I2C converter is a device that allows for communication between different devices that use I2C, but may have different voltage levels or signaling levels. Here are some general specifications of an I2C converter:

Voltage levels: An I2C converter may support different voltage levels, such as 3.3V, 5V, or other levels, depending on the devices it is intended to interface with.

Signal levels: An I2C converter may support different signaling levels, such as standard mode (up to 100 kbps), fast mode (up to 400 kbps), or high-speed mode (up to 3.4 Mbps), depending on the I2C devices it is designed to connect.

Number of channels: An I2C converter may have one or multiple channels to allow for communication between multiple devices simultaneously.

Pin configuration: An I2C converter may have different pin configurations, such as through-hole or surface-mount, and may have different pin assignments for SDA (Serial Data Line), SCL (Serial Clock Line), Vcc (power supply), GND (ground), and other control or configuration pins.

Operating temperature range: An I2C converter may have an operating temperature range specified by the manufacturer, such as -40°C to +85°C, which indicates the temperature range within which the device is designed to

operate reliably.

Features: An I2C converter may have additional features, such as level shifting, bus buffering, or other functionalities to enable reliable communication between devices with different I2C specifications.

Compliance: An I2C converter may comply with industry standards, such as the I2C specification as defined by NXP Semiconductors, which outlines the electrical and protocol characteristics of the I2C bus.

1) I2c interfacing with LCD DISPLAY and Arduino mega

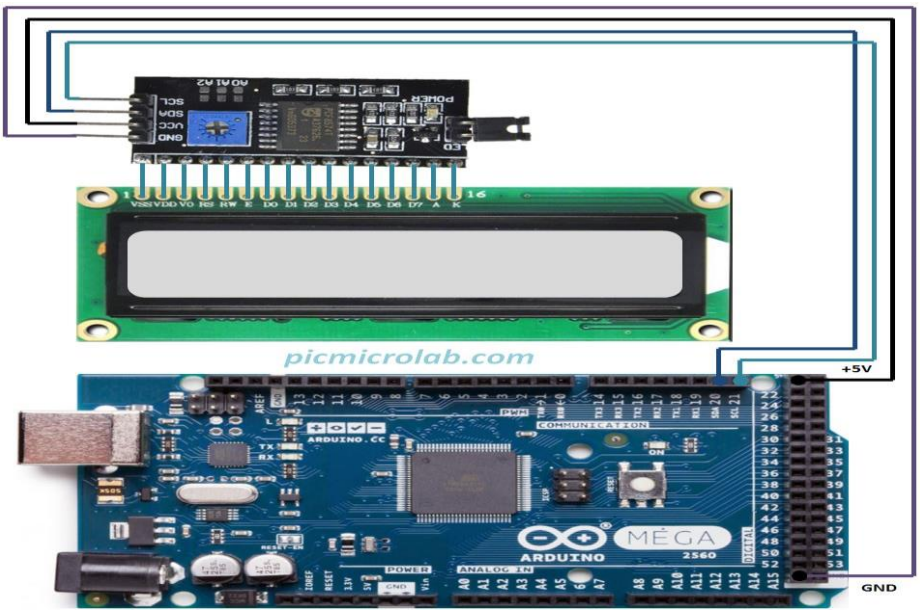


Fig-Interfacing of I2c with Arduino and LCD display

We can use an I2C module with an LCD to interface it with Arduino to display the output of Arduino on the LCD screen. The different Arduino boards have different pins of SCL and SDA so it's better to read the datasheet of the board. We are using Arduino Uno, which has the A4 pin for SDA and A5 pin for SCL, so by connecting these pins with the pins of I2C, we can start the I2C communication with LCD. Besides this, in the sketch of Arduino IDE, we have to include the library of "LiquidCrystal_I2C.h" to use the I2C with LCD.

VIII. LCD display(16x2)

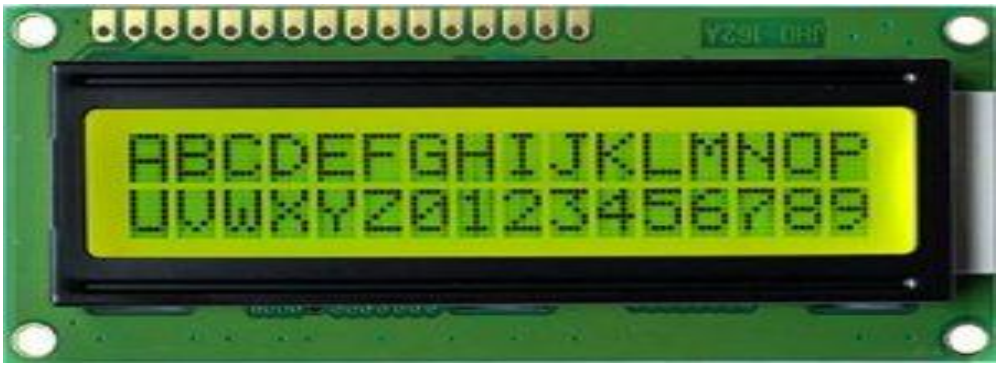


Fig. LCD Display

16×2 LCD is named so because; it has 16 Columns and 2 Rows. There are a lot of combinations available like, 8×1, 8×2, 10×2, 16×1, etc. But the most used one is the 16*2 LCD, hence we are using it here.

These black circles consist of an interface IC and its associated components to help us use this LCD with the MCU. Because our LCD is a 16*2 Dot matrix LCD and so it will have (16*2=32) 32 characters in total and each character will be made of 5*8 Pixel Dots. A Single character with all its Pixels enabled.

It will be a hectic task to handle everything with the help of MCU, hence an Interface IC like HD44780 is used, which is mounted on LCD Module itself. The function of this IC is to get the Commands and Data from the MCU and process them to display meaningful information onto our LCD Screen.

16 X2 displays mostly depend on multi-segment LEDs. There are different types of displays available in the market with different combinations such as 8×2, 8×1, 16×1, and 10×2, however, the LCD 16×2 is broadly used in devices, DIY circuits, electronic projects due to less cost, programmable friendly & simple to access.

1) Working principle of LCD display

The basic working principle of LCD is passing the light from layer to layer through modules. These modules will vibrate & line up their position on 90o that permits the polarized sheet to allow the light to pass through it.These molecules are accountable for viewing the data on every pixel. Every pixel utilizes the method of absorbing light to illustrate the digit. To display the value, the position of molecules must be changed

to the angle of light.So this light deflection will make the human eye notice the data that will be the ingredient wherever the light gets absorbed. Here, this data will supply to the molecules & will be there till they get changed.At present, LCDs are used frequently in CD/DVD players, digital watches, computers, etc. In screen industries, LCDs have replaced the CRTs (Cathode Ray Tubes) because these displays use more power as compared to LCD, heavier & larger.The displays of LCDs are thinner as compared to CRTs. As compared to LED screens, LCD has less power consumption because it functions on the fundamental principle of blocking light instead of dissipating.

2) LCD 16x2 Interfacing With Arduino

LCDs (Liquid Crystal Displays) are used in embedded system applications for displaying various parameters and status of the system.

LCD 16x2 is a 16-pin device that has 2 rows that can accommodate 16 characters each.

LCD 16x2 can be used in 4-bit mode or 8-bit mode.

It is also possible to create custom characters.

It has 8 data lines and 3 control lines that can be used for control purposes.

For more information about LCD 16x2 and how to use it, refer the topic LCD 16x2 module in the sensors and modules section.

The 16x2 LCDs are very popular among the DIY community. Not only that, but you can also find them in many laboratory and industrial equipment. It can display up to 32 characters at a time. Each character segment is made up of 40 pixels that are arranged in a 5x8 matrix. We can create alphanumeric characters and custom characters by activating the corresponding pixels. Here is a vector representation of a 16x2 LCD, in which you can see those individual pixels.

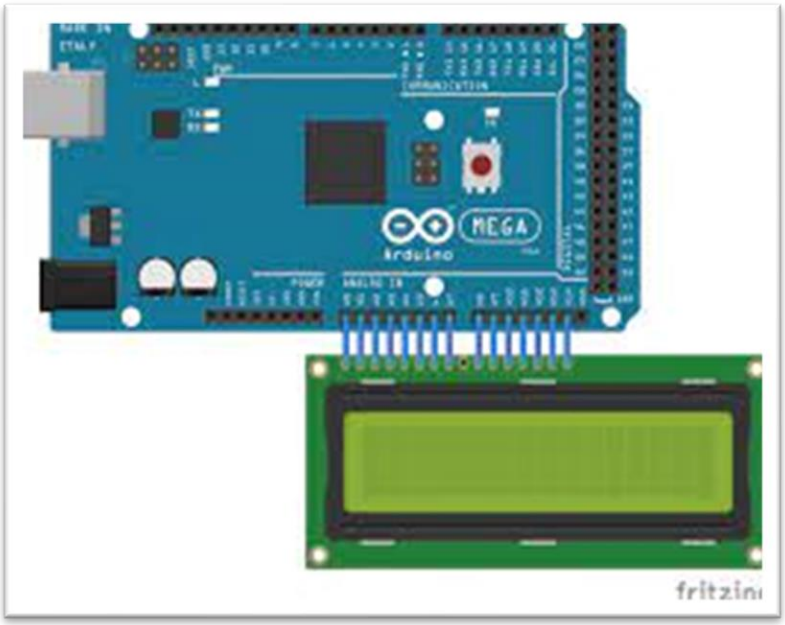


Fig- interfacing of Arduino with lcd

IX. Jumper wires

Generally, jumpers are tiny metal connectors used to close or open a circuit part. They have two or more connection points, which regulate an electrical circuit board.

Their function is to configure the settings for computer peripherals, like the motherboard. Suppose your motherboard supported intrusion detection. A jumper can be set to enable or disable it.

Jumper wires are electrical wires with connector pins at each end. They are used to connect two points in a circuit without soldering.

We can use jumper wires to modify a circuit or diagnose problems in a circuit. Further, they are best used to bypass a part of the circuit that does not contain a resistor and is suspected to be bad.

This includes a stretch of wire or a switch. Suppose all the fuses are good and the component is not receiving power; find the circuit switch. Then, bypass the switch with the jumper wire.

- Types of Jumper Wires

Jumper wires come in three versions:

- Male-to-male jumper
- Male-to-female jumper
- Female-to-female jumper

And two types of head shapes: square head and round head.

CHAPTER 3

3.1-Working principle:-

ECG monitoring using AD8232 in this we have interfaced this module with the Arduino Board and after inserting the code into it we got the ecg waveform and observed it on serial plotter then after this we have made the code to check the heart beat of the person is normal or not so after making this code we have inserted this code in Arduino through the Arduino ide software and interfaced AD8232,I2C and LCD display with each other and observed the output of code on LCD display. AD8232 is basically a instrumentation amplifier which has a gain 1000 so it can amplify every small signal.

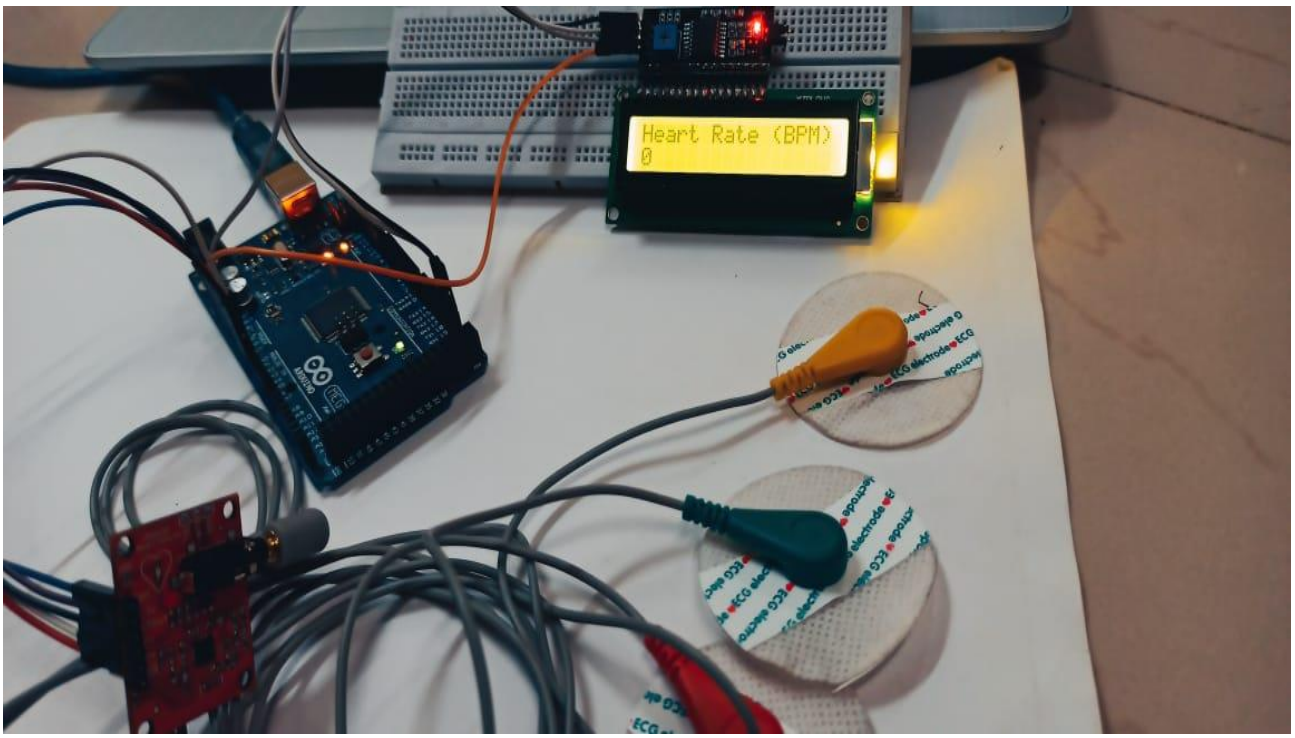


Fig-Photographic view of the hardware

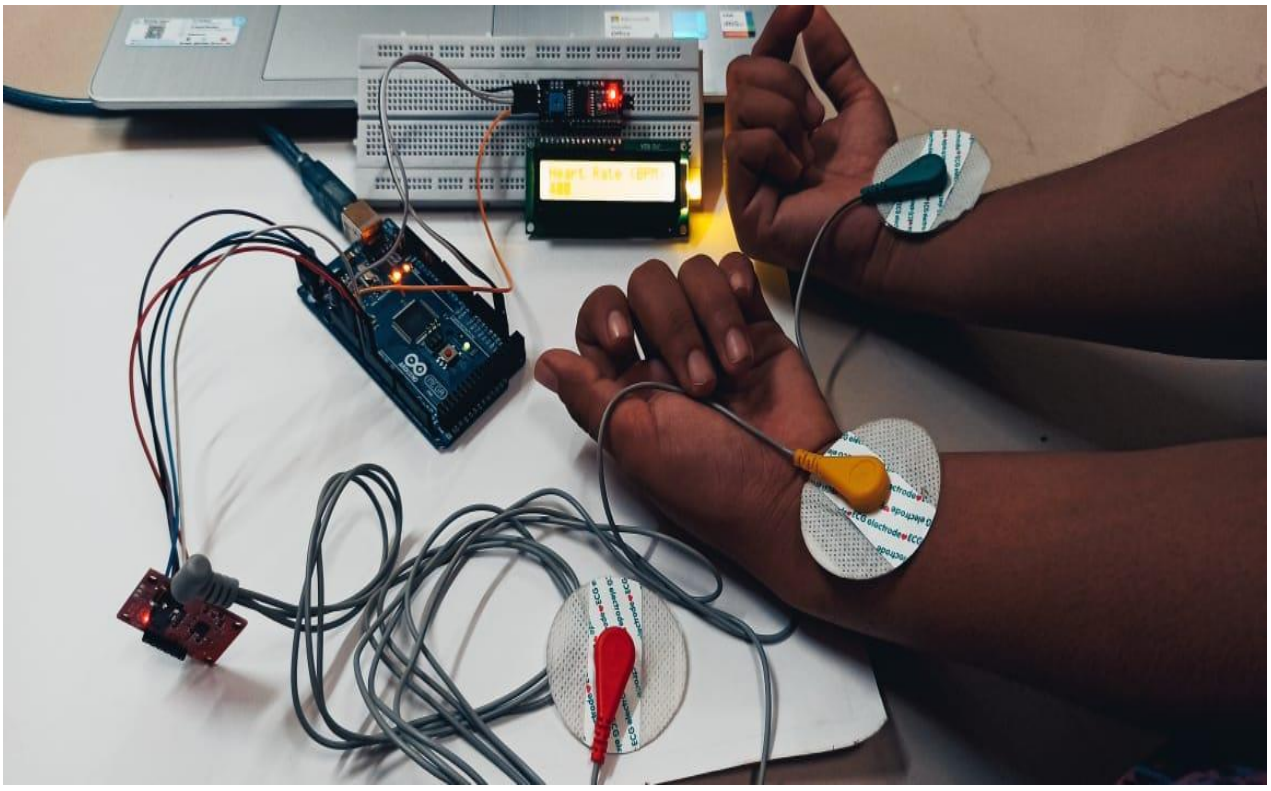


Fig-Photographic view of the hardware

Fig-ECG waveform

CHAPTER 4

4.1-Algorithm:-

1. Start
2. We give code to the Arduino , through Arduino Ide .
3. Then we give power supply to the circuit.
4. After the power supply is given we connect the AD8232 module with Arduino mega and given the input to it through the code.
5. According to the input given the AD8232 gives the ecg signal and display it on the serial plotter.
6. Then after this we connected the Arduino and AD8232 to the LCD display and I2C converter and taken the observations on LCD display.
7. We took the heart rate of the person whose ecg is visible on serial plotter and showed it on LCD display and gave one specified ideal range so on display it shows if the heart range is normal or it is abnormal

4.2-Code:-

mini | Arduino 1.8.19 (Windows Store 1.8.57.0)

File Edit Sketch Tools Help

Open

mini

```
#include <Wire.h>
#include <LiquidCrystal_I2C.h>

// AD8232 pins
#define AD8232_LO_PLUS_PIN A0
#define AD8232_LO_MINUS_PIN A1
#define AD8232_OUTPUT_PIN A2

// LCD pins
#define LCD_ADDRESS 0x27
#define LCD_ROWS 16
#define LCD_COLUMNS 2

// Global variables
int heartRate = 0;
unsigned long previousMillis = 0;

// Initialize LCD
LiquidCrystal_I2C lcd(LCD_ADDRESS, LCD_COLUMNS, LCD_ROWS);

void setup() {
  // Initialize Serial
  Serial.begin(9600);

  // Initialize LCD
  lcd.init();
  lcd.backlight();

  // Print initial message on LCD
  lcd.setCursor(0, 0);
  lcd.print("Heart Rate (BPM):");
}
```

mini | Arduino 1.8.19 (Windows Store 1.8.57.0)

File Edit Sketch Tools Help

mini

```
  // Print initial message on LCD
  lcd.setCursor(0, 0);
  lcd.print("Heart Rate (BPM):");
}

void loop() {
  // Read ECG signal from AD8232
  int ecgValue = analogRead(AD8232_OUTPUT_PIN);

  // Detect QRS complex
  if (ecgValue > 800) {
    unsigned long currentMillis = millis();
    if (currentMillis - previousMillis >= 200) {
      // Calculate heart rate
      heartRate = 60000 / (currentMillis - previousMillis);
      previousMillis = currentMillis;

      // Update LCD with heart rate
      lcd.setCursor(0, 1);
      lcd.print(ecgValue);
      lcd.setCursor(0, 1);
      lcd.print(heartRate);
    }
  } else {
    // Reset heart rate and clear LCD
    heartRate = 0;
    lcd.setCursor(0, 1);
    lcd.print(ecgValue);
  }

  // Print ECG value on Serial Monitor
  Serial.println(ecgValue);
}
```

CHAPTER 5

5.1- Conclusion:-

- The ECG monitoring project using AD8232 has successfully demonstrated the potential of this versatile and cost-effective sensor for accurate and reliable ECG measurements. The AD8232 sensor, with its integrated features such as amplification, filtering, and lead-off detection, has proven to be a valuable tool for monitoring heart health and detecting abnormal cardiac activity.
- Throughout the project, various steps were undertaken, including hardware setup, signal processing. The AD8232 sensor was integrated into a wearable device for continuous ECG monitoring, enabling real-time data acquisition and analysis. The acquired ECG signals were processed to remove noise and artifacts, and relevant features were extracted for further analysis and interpretation.
- The project has several applications, including remote patient monitoring, early detection of cardiac conditions, and preventive healthcare. It can be used for personal use to monitor heart health and provide timely interventions in case of any abnormalities. The AD8232 sensor's affordability, ease of use, and reliable performance make it a suitable choice for a wide range of ECG monitoring applications.
- However, it is important to note that the project has limitations, including the need for proper electrode placement and skin preparation, the possibility of motion artifacts, and the requirement for calibration and validation against standard medical-grade ECG devices for accuracy. Nevertheless, with proper precautions and validation, the AD8232-based ECG monitoring system holds great potential for improving cardiac health monitoring in a cost-effective and accessible manner.
- In conclusion, the ECG monitoring project using AD8232 has demonstrated the feasibility and effectiveness of using this sensor for ECG measurements. Further research and development in this area could lead to more advancements

in wearable ECG monitoring technology, benefiting individuals and healthcare providers alike in improving cardiac health outcomes.

5.2- Future Scope:-

- The AD8232 module can be further integrated with advanced algorithms for real-time ECG analysis, such as arrhythmia detection, heart rate variability (HRV) analysis, and ST-segment monitoring. This would enable the system to provide more comprehensive and accurate information about the patient's cardiac health in real-time, allowing for early detection and management of cardiac abnormalities.

- The project can be further extended by developing a mobile application that can communicate with the AD8232 module. The mobile application can provide a user-friendly interface for patients to monitor their own ECG data, set personalized alerts, and share data with healthcare providers for remote monitoring and analysis. Additionally, the mobile application can incorporate features such as health tracking, data visualization, and cloud-based storage for long-term data analysis.
- The AD8232 module can be integrated into wearable devices, such as smartwatches or fitness trackers, to enable continuous and non-intrusive ECG monitoring. This would allow individuals to monitor their cardiac health during daily activities, exercise, and sleep, providing valuable insights into their overall cardiovascular health and helping with early detection of cardiac abnormalities.
- The ECG monitoring system using the AD8232 module can be integrated into telemedicine platforms for remote patient monitoring. This would enable healthcare providers to remotely monitor and manage patients' cardiac health, especially for patients in remote or underserved areas. The system can also be integrated with electronic health record (EHR) systems to facilitate seamless data sharing and collaboration among healthcare providers.

5.2- Reference:-

https://ieeexplore.ieee.org/document/7913007

https://ieeexplore.ieee.org/document/8934622/