ARDUINO BASED ECG MONITORING HEALTHCARE SYSTEM

Thesis submitted to the SASTRA Deemed to be University
in partial fulfillment of the requirements
for the award of the degree of

B. Tech. EEE

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THANJAVUR – 613 401

Bonafide Certificate

This is to certify that the thesis titled "**Arduino based ECG monitoring healthcare system**" submitted in partial fulfillment of the requirements for the award of the degree of B. Tech. Electrical and electronics engineering to the SASTRA Deemed to be University, is a bona-fide record of the work done by **Mr.R.Kishore (221005032), Mr.R.Navaneedhakrishnan (221005042), Mr.M.SalmanFarose (221005051)** during the final semester of the academic year 2019-20, in the **School of Electrical and Electronics Engineering**, under my supervision. This thesis has not formed the basis for the award of any degree, diploma, associateship, fellowship or other similar title to any candidate of any University.

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Name with Affiliation :

Date :

Project *Viva voce* held on _____

Examiner 1 **Examiner 2**

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Declaration

I/We declare that the thesis titled "**Arduino based ECG monitoring healthcare system**" submitted by me/us is an original work done by me/us under the guidance of **M.Chandrasekaran, Assistant Professor-III, School of EEE, SASTRA Deemed to be University** during the sixth semester of the academic year 2019-20, in the **School of Electrical and Electronics Engineering**. The work is original and wherever I/We have used materials from other sources, I/We have given due credit and cited them in the text of the thesis. This thesis has not formed the basis for the award of any degree, diploma, associateship, fellowship or other similar title to any candidate of any University.

Signature of the candidate(s) :

Name of the candidate(s) :

Date :

Table of Contents

Title **Page No.**

LIST OF FIGURES

ABSTRACT

The ECG sensor with Arduino based monitoring system helps in measuring the ECG signals instantaneously. an integrated signal from ad8232 module for electrocardiograph picks,ampilifies and filters cardiac signals(electrical signals) from 3 electrodes. The output signal of the ad8232 is approximately 1.5 volts. The output signal is processed by the ArduinoUno microcontroller. sampling rate of signal by the Arduino is 1k samples/second.

The signal is again sent to the Wi-Fi module in the form of digital signal. The ECG wave us measured in bpm and the principal heart parameters p wave, PRinterval complex,st & qt interval and finally the t wave. if there are values measured out of normal range it indicates the heart abnormality of the patient. Heart rate, body temperature and blood pressure are very critical parameters of human body.

Doctors use various kinds of medical apparatus for measurement of these parameters like thermometer for checking body temperature, BP monitor for blood pressure measurement and heart rate monitor for heart rate measurement. In this paper, we have proposed ECG MONITORING SYSTEM based on Arduino . This system calculates heart rate of patient and sends the value of heart rate in beats per minute (bpm) to a database on cloud. Using this system doctors at hospital can analyze the critical parameters sent by this system.

Doctors can also analyze the real time health related parameters of a patients which are not admitted in hospital. This system can be integrated in ambulance wherein all the critical health related parameters of patients can be acquired and sent to the cloud. All these critical parameters can be analyzed by a doctor in advance while the patient is still in ambulance. The main objective of this system is to acquire the physiological parameter using sensors and uploading these parameters to cloud. We have integrated ECG sensor in this system.

CHAPTER 1

1.INTRODUCTION :

ECG monitoring using Arduino is introduced to provide health care to people no matter his or her proximity to the health care centers for patient monitoring analyzing ECG signal at initial stage health and preventing heart related disease. This system aims at improving accesiblity,affordablity and accuracy of a electrocardiogram monitoring system. This project depicts the design of Arduino based ECG monitoring and also demonstrates how it is possible to realize the ECG signal . The instantaneous measurement of heart rate is possible due to popularity of hardware like Arduino that makes us possible to build devices to sense virtually any physical quantities and display the results locally or remotely via Wi-Fi modules/Bluetooth monitoring using Arduino is introduced to provide health care to people no matter his or her proximity to the health care centers for patient monitoring. This system aims at improving accessibility, affordability and accuracy of a electrocardiogram monitoring system. This project depicts the design of Arduino based ECG monitoring and also demonstrates how it is possible to realize the ECG signal . The use of ECG sensors helps in collecting electrical signals from the patient's heart. It is designed for the extraction and amplification of the small signal is in presence of noisy background, the major sources of these noises are muscle's activities and motion artifacts produced by patient's body. ECGs can be extremely noisy, the AD8232 Single Lead Heart Rate Monitor acts as an op-amp to help obtain a clear signal from the PR and QT Intervals easily. So in this project, we will interface AD8232 ECG Sensor with Arduino and observe the ECG signal on a serial plotter or Processing IDE. The instantaneous measurement of heart rate is possible due to popularity of hardware like Arduino that makes us possible to build devices to sense virtually any physical quantities and display the results locally or remotely via Wi-Fi modules/Bluetooth. Once the code is uploaded, you can see the value on serial monitor and also on the serial plotter. This electrical activity can be charted as an ECG or Electrocardiogram. Electrocardiography is used to help diagnose various

heart conditions. The project aims in providing portability of electrocardiogram so as to provide immediate first-aid to the patient under emergency.

1.1 Necessity of ECG:

In some cases, it can be important to get this test. You should probably have an ECG if you have risk factors for an enlarged heart such as high blood pressure or symptoms of heart disease, such as chest pain, shortness of breath, an irregular heartbeat or heavy heartbeats. You may need the test for screening or occupational requirements, or if you have a personal or family history of heart disease, diabetes or other risks and you want to start exercising.

Some reasons for your doctor to request an electrocardiogram (ECG) include,

- To look for the cause of chest pain
- To evaluate problems which may be heart-related, such as severe tiredness, shortness of breath, dizziness, or fainting
- To identify irregular heartbeats
- To help determine the overall health of the heart before procedures such as surgery; or after treatment for conditions such as a heart attack (myocardial infarction, or MI), endocarditis (inflammation or infection of one or more of the heart valves); or after heart surgery or cardiac catheterization
- To see how an implanted pacemaker is working
- To determine how well certain heart medicines are working
- To get a baseline tracing of the heart's function during a physical exam; this may be used as a comparison with future ECGs, to determine if there have been any changes

1.2 TYPES OF ECG:

There are 3 Types of ECG :

- **A RESTING ECG –** carried out while you're lying down in a comfortable position
- **A STRESS OR EXERCISE ECG –** carried out while you're using an exercise bike or treadmill
- **AN AMBULATORY ECG –** The electrodes are connected to a small portable machine worn at your waist so your heart can be monitored at home for 1 or more days

  The type of ECG you have will depend on your symptoms and the heart problem suspected.

CHAPTER 2

2.EINTHOVEN'S TRIANGLE:

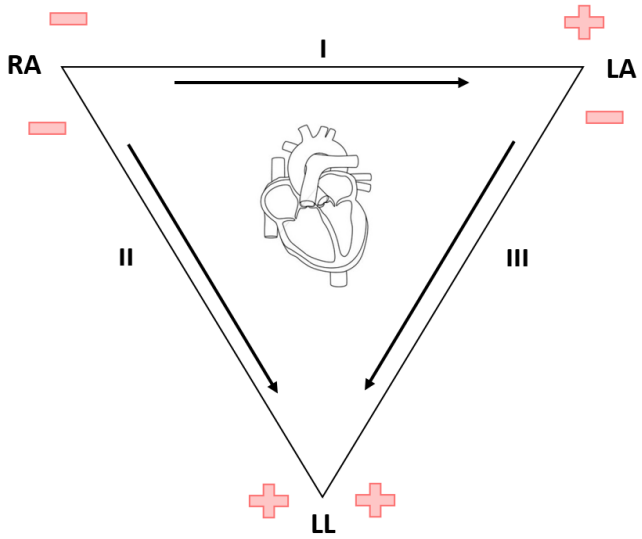

FIG-2.1

Einthoven's triangle is an imaginary formation of three limb leads in a triangle used in electrocardiography, formed by the two shoulders and the pubis. The shape forms an inverted equilateral triangle with the heart at the center. It is named after Willem Einthoven, who theorized its existence. Einthoven used these measuring points, by immersing the hands and foot in pails of salt water, as the contacts for his string galvanometer, the first practical ECG machine.

2.1 MISPLACEMENT OF ELECTRODES:

Though Einthoven's triangle is no longer used in contemporary ECGs, Einthoven's triangle can be helpful in the identification in incorrect placement of leads. (Incorrect placement of leads can lead to error in the recording, which can ultimately lead to misdiagnosis.)

If the arm electrodes are reversed, lead I changes polarity, causing lead II and lead III to switch. If the right arm electrode is reversed with the leg's electrode, lead II changes polarity, causing lead I to become lead III.

CHAPTER 3

3.ECG PARAMETERS:

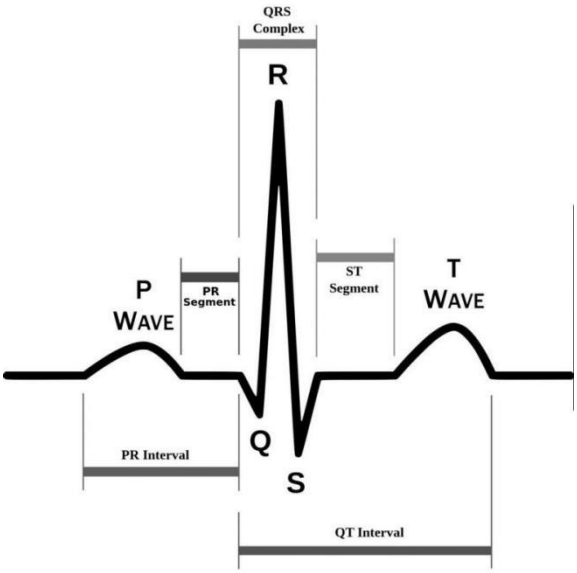

FIG-3.1

The figure above display of standard one cycle ECG signal from a heart beat. From the figure one cycle consist of P wave, QRS wave until T wave. P wave offers benefit information about the propagation time of the impulse to both atria. Then, follow with a flat trend called with the PR segment which is in consequence of propagation of the electric impulse from atria to ventricles. And follow with QRS complex wave which you can look in above figure. Q,R and S complex contains of three small wave i.e. small Q wave, the high R wave and the small S wave. The QRS complex give information about the ventricular systole in consequence of the impulse propagation to the ventricles (Q wave), whereas the transmission to the whole tissue is caused by the R and S wave. The QRS complex provides information about fibrillation and arrhythmias, it can be helpful to analyze heart attacks. And then ST interval, it is following by the S wave and including with the T wave, it can point out the ischemia occurrences. It represents the period during which ventricles are contracting. The T wave permits one to have information about the cardiac hypertrophy, heart attacks, and ischemia. Moreover, others parameters, such as the QT interval, allow specific further pathologies to be characterized. Finally, the ECG signal ended with a small peak, U wave.

3.1TYPES OF INTERVAL:

PR Interval:
The PR interval is the initial wave generated by an electrical impulse traveling from the right atrium to the left. The right atrium is the first chamber to see an electrical impulse. This electrical impulse causes the chambers to "depolarize". This forces it to contract and drain deoxygenated blood from both the Superior and Inferior vena cava into the right ventricle. As the electrical impulse travels across the top of the heart it then triggers the left atrium to contract. The left atrium is responsible for receiving newly oxygenated blood from the lungs into the left ventricle via the left and right pulmonary veins. The pulmonary veins are red in the diagram because they are carrying oxygenated blood. They are still called veins because veins carry blood towards the heart. Science!

QT Interval:
The QT Interval is where things get really interesting. The QRS is a complex process that generates the signature "beep" in cardiac monitors. During QRS both ventricles begin to pump. The right ventricle begins to pump deoxygenated blood into the lungs through the left and right pulmonary arteries. The pulmonary arteries are blue in the diagram because they are carrying deoxygenated blood.

Table Normal ECG Parameters :
Phase Duration Amplitude
1..P Wave 0.06-0.11 <0.25 PR
2.Interval 0.12-0.20 -
3.PR Segment 0.08 -
4.QRS Complex <0.12 0.8-1.2
5.ST Segment 0.12 -
6.QT Interval 0.36-0.44 -
7.T Wave 0.16 <0.5

Abnormal Parameter Effect on Heart:
1.Short QT Interval Hypercalcemia, Hyperkalemia
2.Long QT Interval Hypocalcemia
3.Flat or inverted T waves Coronary ischemia, hypokalemia,

left ventricular hypertrophy
4.Peaked T wave, Long PR,
QRS wide, QT short Hyperkalemia
5.Prominent U waves Hypokalemia
6.Increased HR Tachycardia
7.Decreased HR Bradycardia
8.Increased QRS Bundle branch block
9.Increased PR AV block

3.2 PROCEDURE –ELECTRODE PLACEMENT:

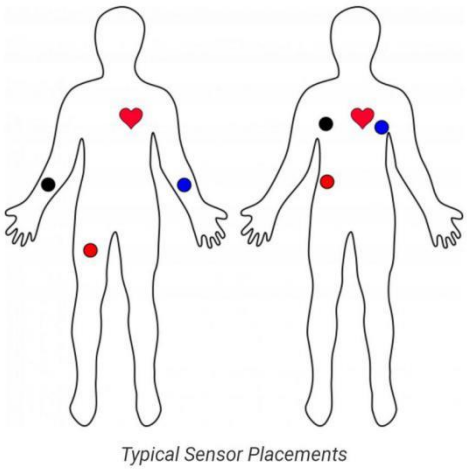

FIG-3.2

The closer to the heart the pads are, the better the measurement. The cables are color coded to help identify proper placement as shown in the table based on Einthoven's triangle. The sensors can be placed on the forearms and leg as shown on the diagram on the left. Or they can be placed on the chest near the arms and above the right, lower abdomen (i.e. just above the right hip) as shown on the diagram on the right.

Cable Colour	Signal
BLACK	RA
BLUE	LA
RED	RL

CHAPTER 4

4.COMPONENTS REQUIRED

Hardware Requirements :

1)Arduino Uno/Mega/Nano-Any one

2)ECG Module (AD8232)

3)ECG Electrodes - 3 pieces

4)ECG Electrode Connector -3.5 mm

5)Power supply

6)Connecting Wires

Software Requirement :

1) Arduino IDE - Download from (https://www.arduino.cc)

2)Processing IDE - Download from (https://www.processing.org)

4.1 ARDUINO UNO:

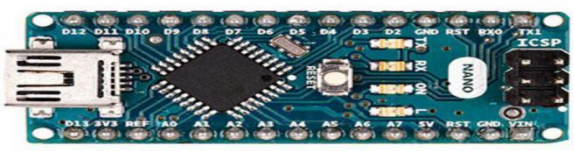

FIG-4.1

The **Arduino UNO** is frequently used **microcontroller board** in the family of an Arduino. This is the latest third version of an Arduino board and released in the year 2011. The main advantage of this board is if we make a mistake we can change the microcontroller on the board. The main features of this board mainly include, it is available in DIP (dual-inline-package), detachable and ATmega328 microcontroller. The programming of this board can easily be loaded by using an Arduino computer program.

4.1.1 ARDUINO UNO SPECIFICATIONS:

The **Arduino Uno board** includes the following specifications.

- It is an ATmega328P based Microcontroller
- The Operating Voltage of the Arduino is 5V
- The recommended input voltage ranges from 7V to 12V
- The i/p voltage (limit) is 6V to 20V
- Digital input and output pins-14
- Digital input & output pins (PWM)-6
- Analog i/p pins are 6
- DC Current for each I/O Pin is 20 mA
- DC Current used for 3.3V Pin is 50 mA
- Flash Memory -32 KB, and 0.5 KB memory is used by the boot loader
- SRAM is 2 KB
- EEPROM is 1 KB
- The speed of the CLK is 16 MHz
- In Built LED
- Length and width of the Arduino are 68.6 mm X 53.4 mm
- The weight of the Arduino board is 25 g

4.2.2 PINOUT CONFIGURATION:

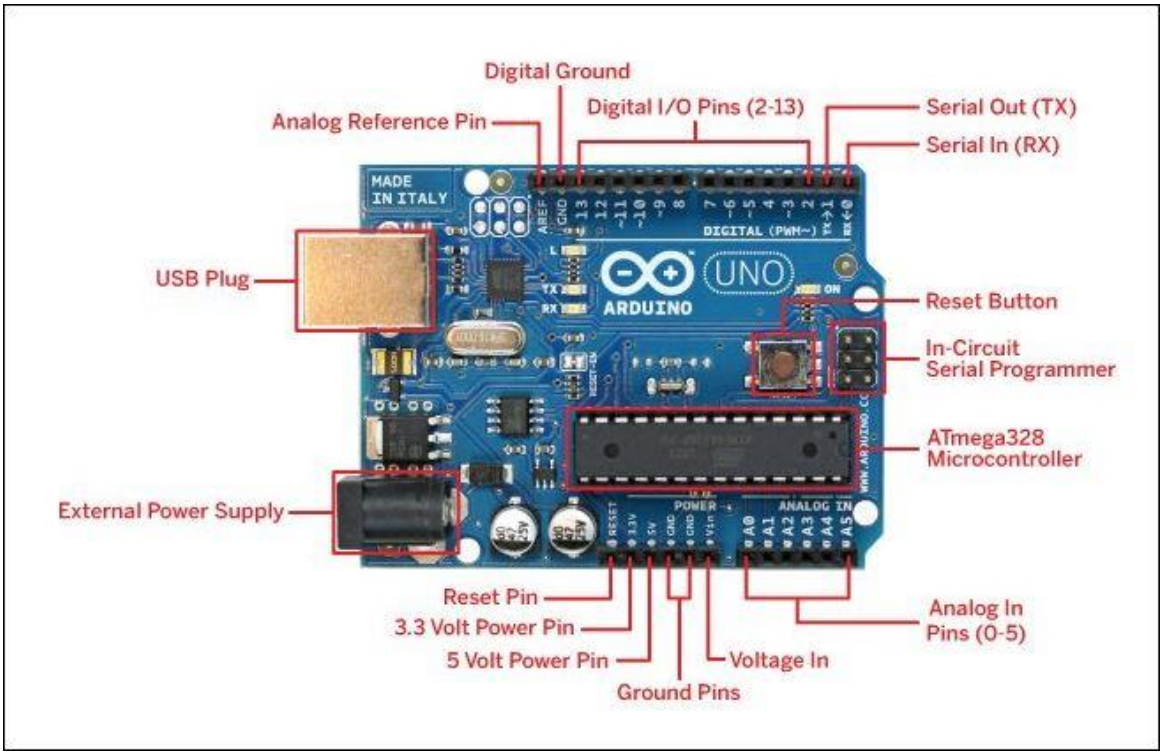

FIG-4.2

Power Supply

The power supply of the Arduino can be done with the help of an exterior power supply otherwise USB connection. The exterior power supply (6 to 20 volts) mainly includes a battery or an AC to DC adapter. The connection of an adapter can be done by plugging a center-positive plug (2.1mm) into the power jack on the board. The battery terminals can be placed in the pins of Vin as well as GND. The power pins of an **Arduino board** include the following.

Vin: The input voltage or Vin to the Arduino while it is using an exterior power supply opposite to volts from the connection of USB or else **RPS (regulated power supply)**. By using this pin, one can supply the voltage.

5Volts: The RPS can be used to give the power supply to the microcontroller as well as components which are used on the Arduino board. This can approach from the input voltage through a regulator.

3V3: A 3.3 supply voltage can be generated with the onboard regulator, and the highest draw current will be 50 mA.

GND: GND (ground) pins

Memory

The memory of an ATmega328 microcontroller includes 32 KB and 0.5 KB memory is utilized for the Boot loader), and also it includes SRAM-2 KB as well as EEPROM-1KB.

Input and Output

We know that an arguing Uno R3 includes 14-digital pins which can be used as an input otherwise output by using the functions like pin Mode (), digital Read(), and digital Write(). These pins can operate with 5V, and every digital pin can give or receive 20mA, & includes a 20k to 50k ohm pull up resistor. The maximum current on any pin is 40mA which cannot surpass for avoiding the microcontroller from the damage. Additionally, some of the pins of an Arduino include specific functions.

Serial Pins

The serial pins of an Arduino board are TX (1) and RX (0) pins and these pins can be used to transfer the TTL serial data. The connection of these pins can be done with the equivalent pins of the ATmega8 U2 USB to TTL chip.

External Interrupt Pins

The external interrupt pins of the board are 2 & 3, and these pins can be arranged to activate an interrupt on a rising otherwise falling edge, a low-value otherwise a modify in value

PWM Pins

The PWM pins of an Arduino are 3, 5, 6, 9, 10, & 11, and gives an output of an 8-bit PWM with the function analog Write ().

SPI (Serial Peripheral Interface) Pins

The SPI pins are 10, 11, 12, 13 namely SS, MOSI, MISO, SCK, and these will maintain the **SPI communication** with the help of the SPI library.

LED Pin

An arguing board is inbuilt with a LED using digital pin-13. Whenever the digital pin is high, the LED will glow otherwise it will not glow.

TWI (2-Wire Interface) Pins

The TWI pins are SDA or A4, & SCL or A5, which can support the communication of TWI with the help of Wire library.

AREF (Analog Reference) Pin

An analog reference pin is the reference voltage to the inputs of an analog i/ps using the function like analog Reference().

Reset (RST) Pin

This pin brings a low line for resetting the microcontroller, and it is very useful for using an RST button toward shields which can block the one over the Arduino R3 board.

Communication

The communication protocols of an Arduino Uno include SPI, I2C, and **UART serial communication**.

UART

An Arduino Uno uses the two functions like the transmitter digital pin1 and the receiver digital pin0. These pins are mainly used in UART TTL serial communication.

I2C

An Arduino UNO board employs SDA pin otherwise A4 pin & A5 pin otherwise SCL pin is used for I2C communication with wire library. In this, both the SCL and SDA are CLK signal and data signal.

SPI Pins

The SPI communication includes MOSI, MISO, and SCK.

MOSI (Pin11)

This is the master out slave in the pin, used to transmit the data to the devices

MISO (Pin12)

This pin is a serial CLK, and the CLK pulse will synchronize the transmission of which is produced by the master.

SCK (Pin13)

The CLK pulse synchronizes data transmission that is generated by the master. Equivalent pins with the SPI library is employed for the communication of SPI. ICSP (in-circuit serial programming) headers can be utilized for programming **ATmega microcontroller** directly with the boot loader.

4.2 AD3282 MODULE:

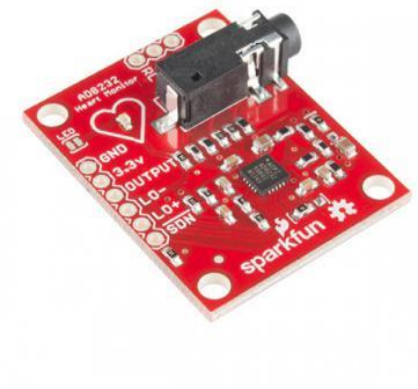

FIG4.3

The AD8232 is an integrated signal conditioning block for ECG and other biopotential measurement applications. It is designed to extract, amplify, and filter small biopotential signals in the presence of noisy conditions, such as those created by motion or remote electrode placement.The AD8232 is a neat little chip used to measure the electrical activity of the heart. This electrical activity can be charted as an ECG or Electrocardiogram. Electrocardiography is used to help diagnose various heart conditions.

4.2.1 FEATURES:

- Fully integrated single-lead ECG front end
- Low supply current: 170 µA (typical)
- Common-mode rejection ratio: 80 dB (dc to 60 Hz)
- Two or three electrode configurations
- High signal gain (G = 100) with dc blocking capabilities
- 2-pole adjustable high-pass filter
- Accepts up to ±300 mV of half cell potential
- Fast restore feature improves filter settling
- Uncommitted op amp
- 3-pole adjustable low-pass filter with adjustable gain
- Leads off detection: ac or dc options
- Integrated right leg drive (RLD) amplifier
- Single-supply operation: 2.0 V to 3.5 V
- Integrated reference buffer generates virtual ground
- Rail-to-rail output
- Internal RFI filter
- 8 kV HBM ESD rating
- Shutdown pin
- 20-lead 4 mm × 4 mm LFCSP package

4.2.2 PINOUT CONFIGURATION:

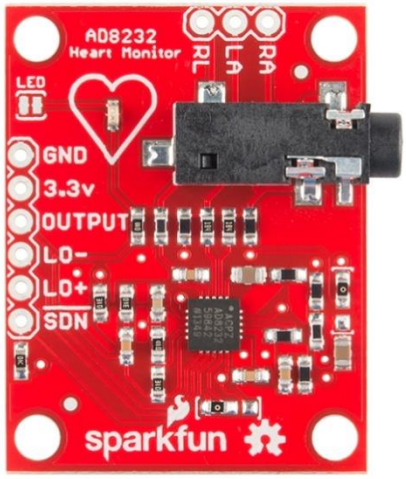

FIG4.4

4.2.3 APPLICATIONS:

- Fitness and activity heart rate monitors

- Portable ECG Remote health monitors
- Gaming peripherals
- Biopotential signal acquisition

4.3 ECG ELECTRODES:

FIG-4.5

An electrode is a conductive pad which is attached to the skin and enables recording of electrical currents. An ECG lead is a graphical description of the electrical activity of the heart and it is created by analysing several electrodes.Each electrode consists of an electrically conductive electrolyte gel and a silver/silver chloride conductor. The gel typically contains potassium chloride – sometimes silver chloride as well – to permit electron conduction from the skin to the wire and to the electrocardiogram.ECG records the electrical activity generated by heart muscle depolarizations, which propagate in pulsating electrical waves towards the skin. ECG electrodes are typically wet sensors, requiring the use of a conductive gel to increase conductivity between skin & electrode.

4.4 ARDUINO SOFTWARE:

SOFTWARE 4.1 ARDUINO-1.8.1-R3-WINDOWS An IDE for the Arduino microcontroller. Arduino is a free software electronics prototyping platform based on flexible, easy-to-use hardware and software. It's intended for artists, designers, hobbyists, and anyone interested in creating interactive objects or environments. This IDE allows for program writing, code verification, compiling, and uploading to the Arduino development board. Libraries and example code will also be installed. The Arduino Software (IDE) on computer, according to its operating system. Windows, Mac OS x10.1, Linux 32 bits, Linux 64 bits, Linux ARM. The Arduino Serial Plotter function has been added to the Arduino IDE, allowing you to natively graph serial data from your Arduino to your computer in real time. If you're tired of seeing your Arduino's analog sensor input data pour onto your screen like The Matrix, this looks like a prettier way to visualize what's going on. The Serial plotter is an offline tool allowing you to visualize data and troubleshoot your code offline without having to use third parts services like Processing or Plotly.

CHAPTER 5

5. CIRCUIT CONNECTIONS:

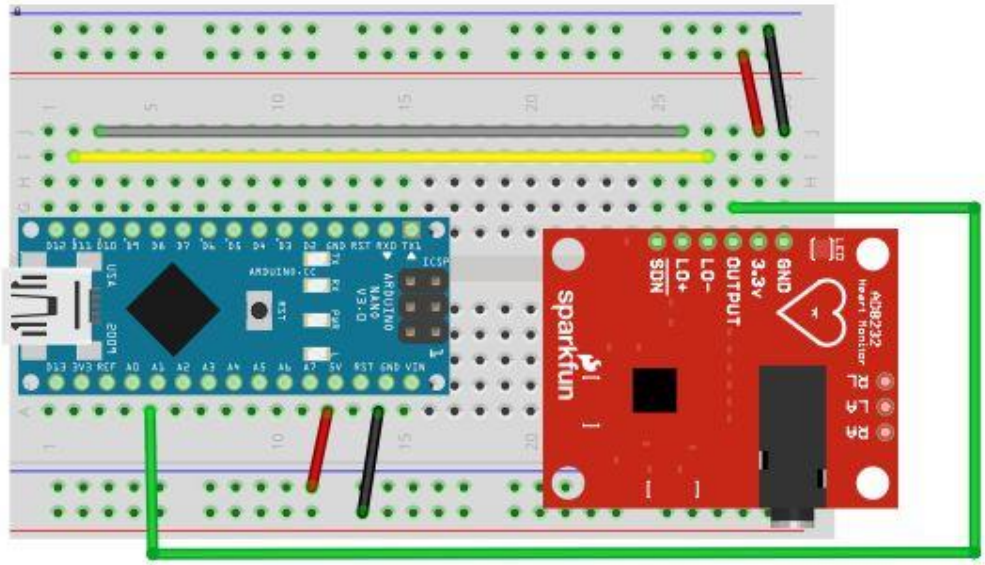

FIG-5.1

CONNECTION OF AD8232 WITH ARDUINO:

1.Arduino 3.3V --------- 3.3V pin

2.Arduino pin 10 -------- L0+

3.Arduino Pin 11 -------- L0-

4.Arduino Analog 1 (A1) ------- Output

5.Arduino Gnd ---------- Gnd

AD8232 Pins :

1.RA - Input 1

2.LA - Input 2

3.RL - Input 3

5.1 BLOCK DIAGRAM:

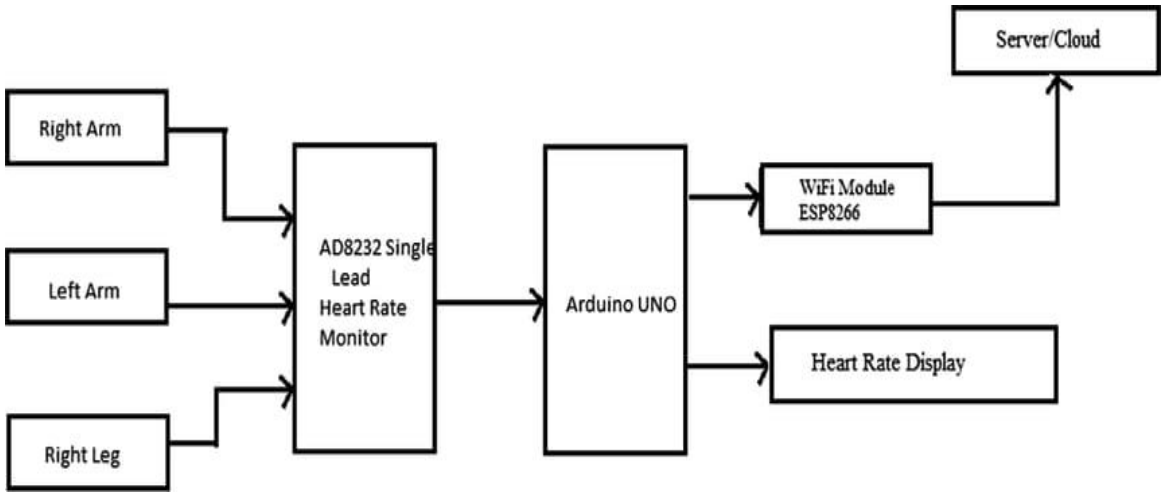

FIG-5.2

MECHANISM:

The electrodes that are placed in the patient's right arm,left arm,right leg is connected to the ECG sensor. It senses the heart beat of the patient in the form of electrical signals. Additionally, there is an LED indicator light that will pulsate to the rhythm of a heartbeat. Further to this , the electrical signals are taken as input by the arduino nano/uno microcontroller which contains the adc converter to convert the electrical signals in to the digital signals. The digital signal can be viewed in the serial monitor of the arduino software locally or the signals are sent to the remote location through a wifi module.The wifi module sends the data to aserver or to cloud to access them . The heart beat can also be viewed by using a heart rate display which shows the signal in beats per minute.

CHAPTER 6

METHODOLOGY:

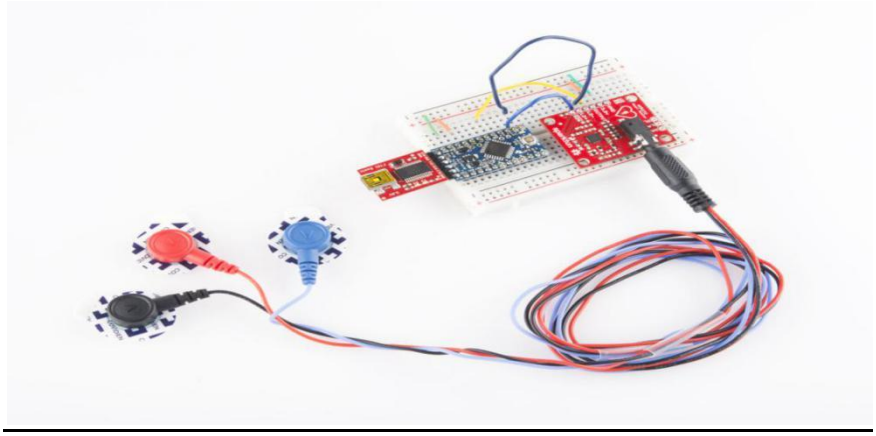

FIG-6.1

An ECG Sensor with disposable electrodes attaches directly to the chest to detect every heart beat. The electrodes of ecg sensor will conversion heart beat to electric signal. ECG Sensors is very light weight, slim and accurately to measures continuous heart beat and give rate data of heart beat. This device always use by trained doctor and medical assistances

.

Electrodes of ECG Sensor have 3 pins and connected by cable with 30 inches in length. It is make ECG sensor easy to connect with controller and placed at the waist or pocket. In additional, the plug-in for the cable is a male sound plug which will make the cable to easily removed or inserted into the amplifier board.The sensor assembled on an arm pulse and a leg pulse. All of every sensor electrodes have methods to assemble in body. So, training and tutorials are needed for user. You can choose type of electrode to measure heart beat.

CHAPTER 7

RESULTS AND CONCLUSION:

To verify that the heart rate monitor is working as expected, open the serial monitor at **9600 baud**. You should see values printed on the screen. Below is an example output with the sensors connected on the forearms and right leg. Your serial output should spike between +300/-200 around the center value of about ~500.

The serial data is hard to visualize if you are just viewing the values. If you are using Arduino IDE v1.6.6+, there is an option to view the data on a graph using the Arduino Serial Plotter as one option. In the Arduino IDE, select **Tools** > **Serial Plotter**. You should see a waveform similar to the image below when the sensors are placed correctly.

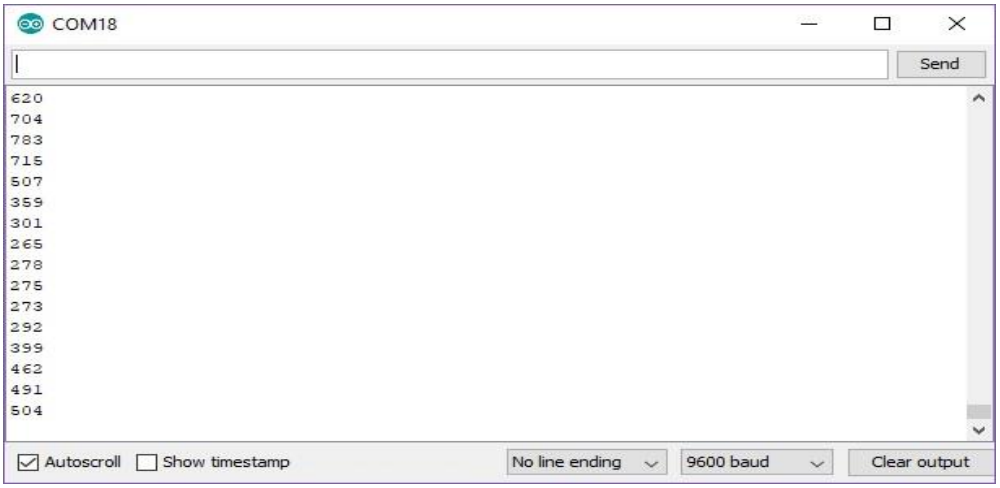

FIG-7.1

FIG-7.2

INFERENCE:

With this proposed method the monitoring of ecg signals is done easily with the doctor. Farther location of heart beat is made accurate by real time signal compression and data storage can be increased.

ADVANTAGES:

1) Data can be uploaded or directly sent to the doctors by using IOT Technology .
2) By using more electrodes measurement can be more accurate .
3)This device is quite useful for real time ECG monitoring. The emphasis must be laid on removing noise and it will then result in very efficient system.
4)Very small electrodes can be built in future so there will be no need to carry extra electronics.
5)Patient is not tethered to huge machines

DISADVANTAGES:

1)The noise may disturb the readings. The noise may deviate the actual graph of ECG to an undesired level.

2)The system requires good internet connectivity at all the times so that it can be accessed by doctors at any time.

APPLICATIONS:

1)Fitness and activity heart rate monitors.

2)Portable ECG Remote health monitors.

3)Gaming peripherals.

4)Biopotential signal acquisition.

CHAPTER 8

CODING:

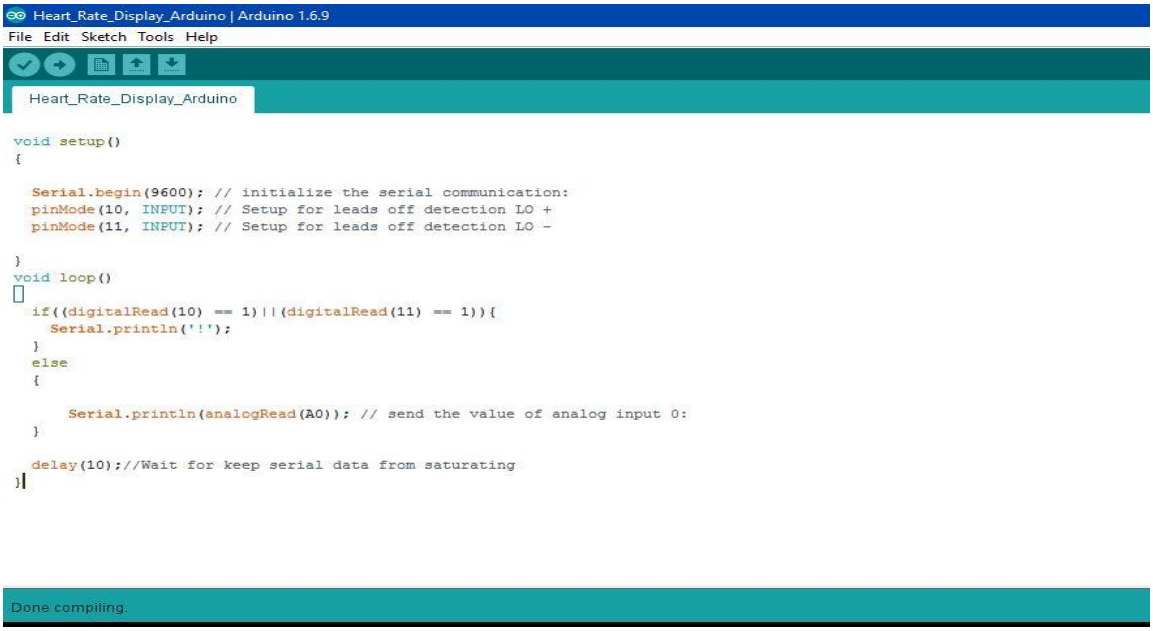

FIG-8.1

PREPOCESSING IDE:

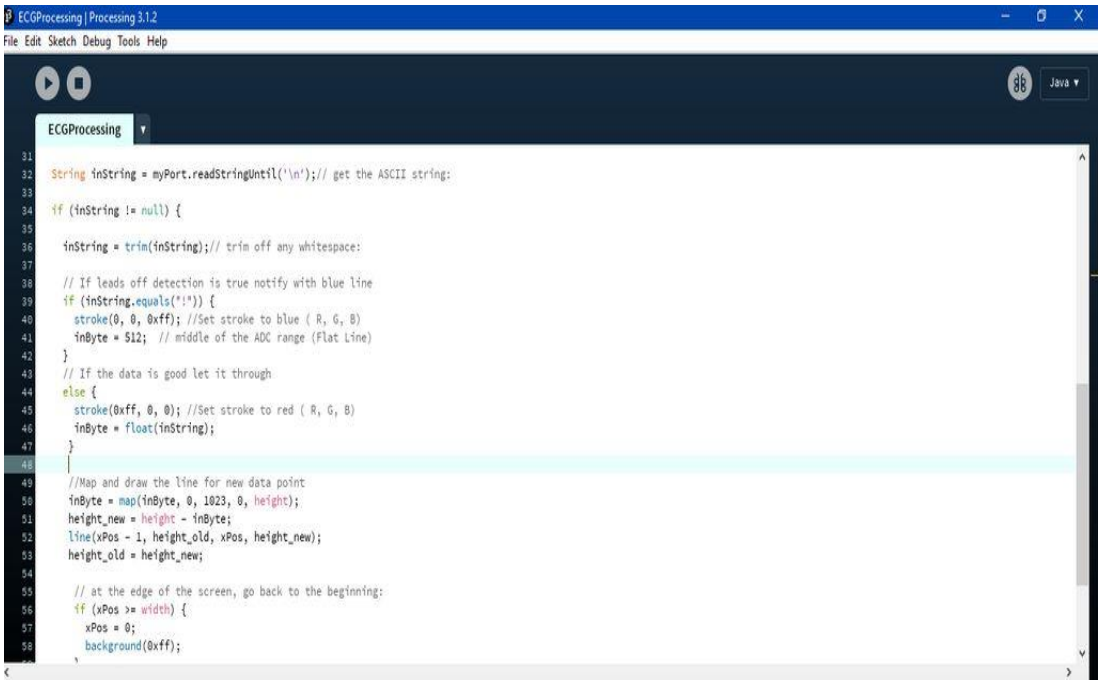

FIG-8.2

CHAPTER 9

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