EVEN SEMESTER-2021

Project Report on Topic

ELECTROCARDIOGRAM

Submitted by

R RADHIKA
2K20/EC/152

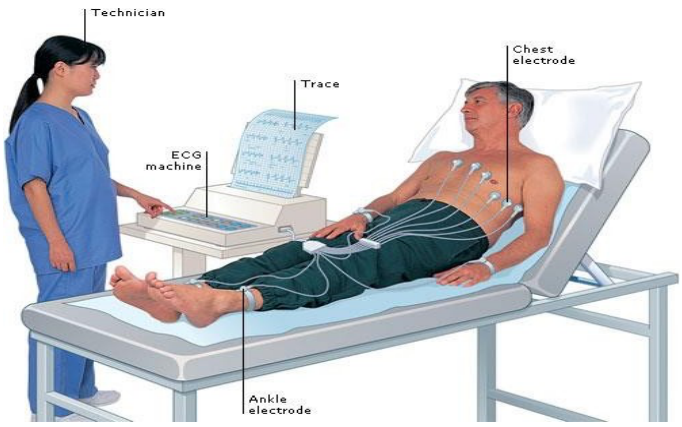
DELHI TECHNOLOGICAL UNIVERSITY

(Formerly Delhi College of Engineering)
Bawana Road, Delhi-110042

Table of Contents

ABSTRACT

In this project we are aiming to design an electrocardiogram or we can say an ECG using minimal components. At first, we designed the hardware using an operational amplifier but due to the extra noise caused by the electromagnetic radiations we eliminated the use of breadboard and designed the EKG using Arduino and EKG sensor. The use of AD8232 EKG sensor helped us to find the results with minimal Arduino coding and enabled us to see the detected heart signals in the serial plotter. The innovative part of the project is, the combination of both the EKGs made which resulted in quality output. Further, we researched a lot to eliminate the use of PC as well so as to make the work easier and portable.



INTRODUCTION

Electrocardiogram is the electrical activity of the heart. The process of producing an electrocardiogram (ECG/EKG) is known as electrocardiography. An EKG is used to represent or measure the electrical current moving through the heart during a heartbeat cycle. The current's movement is divided into different parts, and each part is given an alphabetic designation in the EKG. It is a graph between voltage and time of the electrical activity of the heart with the use of electrodes are placed on the body. These electrodes help us to detect the small electrical changes that are a consequence of cardiac muscle depolarization which is followed by repolarization during each cardiac cycle i.e., during each heartbeat.
In the conventional 12-lead EKG, 10 electrodes are attached to the patient's limbs and on the surface of the chest. The overall magnitude of the heart's electrical potential is then measured from 12 different angles i.e., leads and is recorded over a period of time (generally taken to be ten seconds). By this, the overall direction and magnitude of the heart's electrical depolarization is captured at each moment throughout the cardiac cycle.

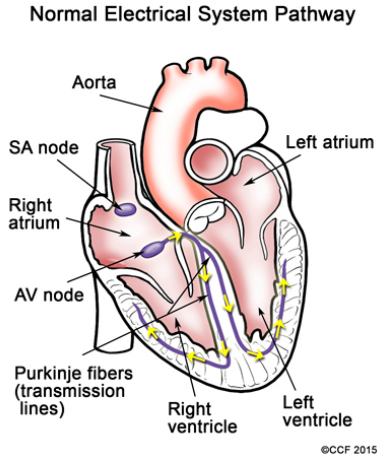
MEDICAL IMPLICATIONS

An electrocardiogram (EKG/ECG) is a test that can be used to check your heart's rhythm and electrical activity. Sensors attached to our body are used to detect the electrical signals produced by our heart, each time it beats. These signals are recorded by a machine and are supervised by a doctor to see if they're unusual or normal.

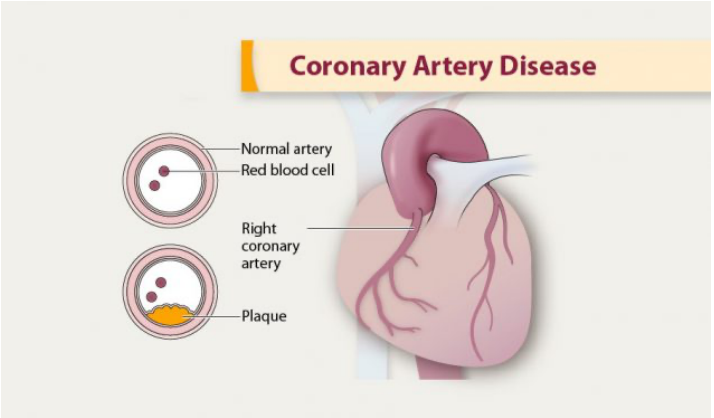
An EKG is often used alongside other tests to measure, diagnose and monitor conditions affecting the heart. It can be beneficial to investigate symptoms of a possible heart problem, like chest pain, palpitations i.e., noticeable heartbeats, shortness of breath and dizziness.

An EKG can help us to detect the heart problems mentioned below :

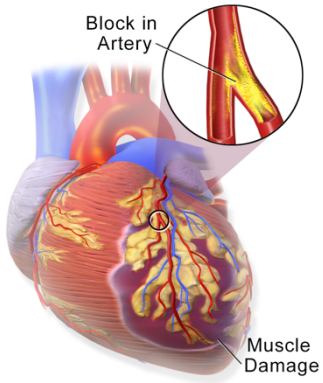
1) **Arrhythmias** – An arrhythmia is a problem with the rate or rhythm of the heartbeat. Arrhythmias is commonly described as improper beating of the heart, whether it is irregular, too fast or too slow. Cardiac arrhythmia or Arrythmias, occurs when the electrical impulses in the heart do not work properly.



2) **Coronary Artery Disease** – It is a disease which damages the heart's major blood vessels. Coronary Artery Disease happens majorly when the heart's blood supply is blocked or interrupted by the build-up of fatty substances in the coronary arteries of the heart.

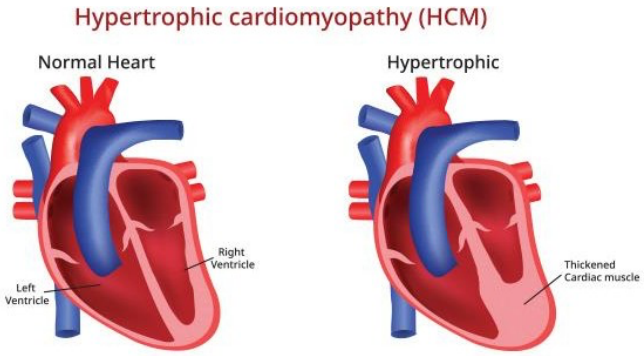


3) **Heart Attacks** – A Heart Attack is defined as a blockage of the flow of blood to the heart muscles. A Heart Attack is considered a medical emergency. A heart attack generally occurs when a blood clot blocks blood flow to the heart due to this tissue loses oxygen and dies without blood.



Heart Attack

4) **Cardiomyopathy** – Cardiomyopathy is an acquired or hereditary disease of the heart muscle. In Cardiomyopathy conditions, it is hard for the heart to deliver blood to the body, and can lead to heart failure.



ELECTROCARDIOGRAPH MACHINES

Electrocardiograms are recorded by machines that consist of a number of electrodes connected to a central unit. Initially, EKG machines were constructed employing the use of analog electronics, where the signal was used to drive a motor to print out the signal onto paper. Nowadays, electrocardiographs utilize analog-to-digital converters in order to convert the electrical activity of the heart to a digital signal.
Many EKG machines are now portable and commonly include a screen, keyboard, and printer on a small wheeled cart. Recent technological advancements in electrocardiography include developing even smallerdevices for inclusion in fitness trackers and smart watches. These smaller devices often depend on only two electrodes to deliver a single lead. Portable 6-lead devices are also increasingly available.

Recording an EKG is a safe and painless procedure. The machines are plugged by the mains power but theyare designed with several safety features including a grounded lead. Other factors include :

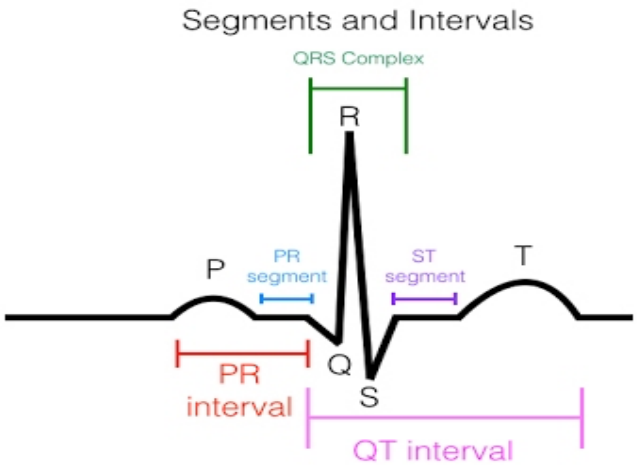
- Defibrillation protection: Any EKG employed in healthcare may be attached to a person who requires defibrillation and due to this, the EKG has to protect itself from this particular source of energy.
- Additional circuitry called the right leg driver can be used to reduce common-mode interference.
- EKG voltages measured across the body are very small. This low voltage results a low noisecircuit, electromagnetic shielding and amplifiers.

- Simultaneous lead recordings : Earlier designs recorded each lead sequentially, but current models record multiple leads simultaneously.

INTERPRETATION OF THE ECG

Interpretation of the EKG is fundamentally about knowing the electrical conduction system of the heart. traditional physical phenomenon starts and propagates during a sure pattern, and deviation from this pattern may be a standard variation or be pathological. An EKG does not equate with mechanical pumping activity of the heart, for example, pulseless electrical activity produces an EKG that should pump blood but no pulses are felt and constitutes a medical emergency and CPR should be performed.

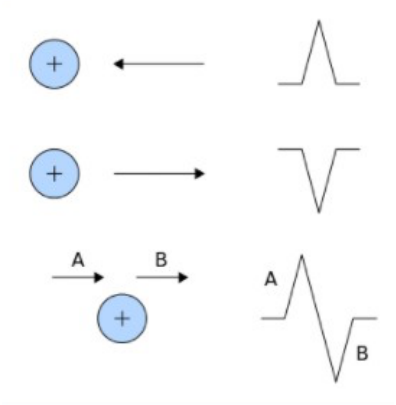
Ultimately, associate sonogram or different anatomical imaging modality is helpful in assessing the mechanical operate of the guts. Like all medical tests, what constitutes "normal" relies on population studies. the guts rate vary of between sixty and one hundred beats per minute (bpm) is taken into account traditional since knowledge shows this to be the standard resting rate.



THEORY

Interpretation of the EKG is ultimately that of pattern recognition. To acknowledge the patterns, it is important to examine the theory of what EKG's represent. The theory is rooted in electromagnetics and the four following points mentioned below:

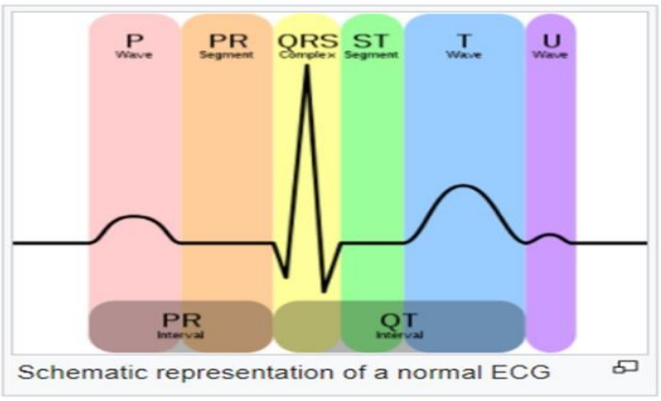
- Positive deflection is produced by the depolarization of the heart towards the positive electrode.
- Negative deflection is produced by the depolarization of the heart away from the positive electrode.
- A negative deflection is produced during the repolarization of the heart towards the positive electrode.
- Positive deflection is produced during the repolarization of the heart away from the positive electrode.



Thus, the overall direction of repolarization and depolarization produces negative or positive deflection on each lead's trace. For instance, depolarizing from right to left would produce a **+ deflection** in lead I because the two vector point is in the same direction. In contradiction, that same depolarization would produce least deflection in V1 and V2 because the vectors are at right angles, and this aspect is known as isoelectric.

Normal rhythm produces four entities – A **P-wave**, A **QRS-complex**, A **T-wave**, and A **U-wave** each of them has a unique pattern.

- The atrial depolarization represents P wave.
- The ventricular depolarization represents QRS complex.
- The ventricular repolarization represents T wave.
- The papillary muscle repolarization represents U wave.

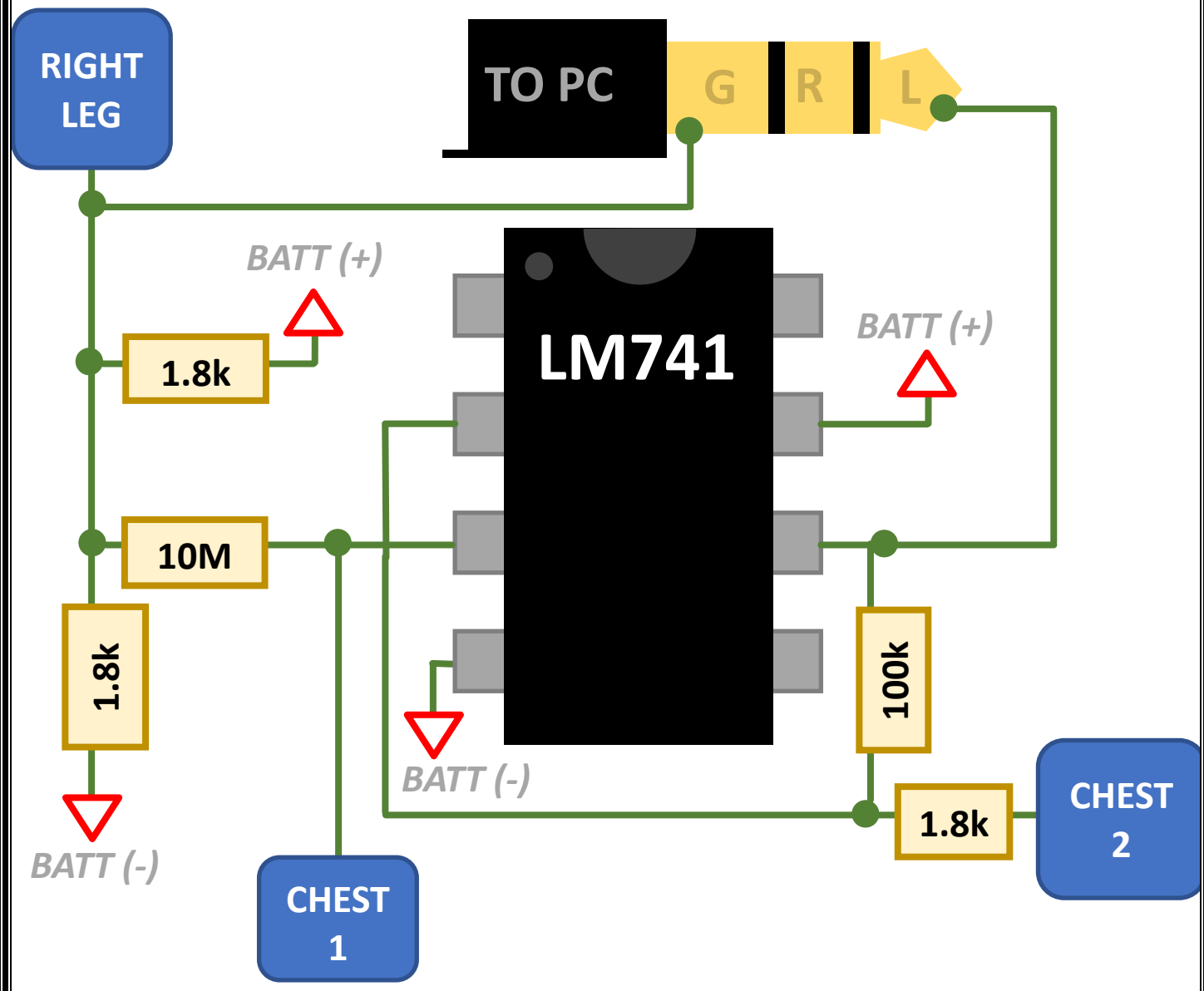


Schematic representation of a normal ECG

DIY ECG - SINGLE OP-APM VERSION

Hardware -1

Circuit Diagram

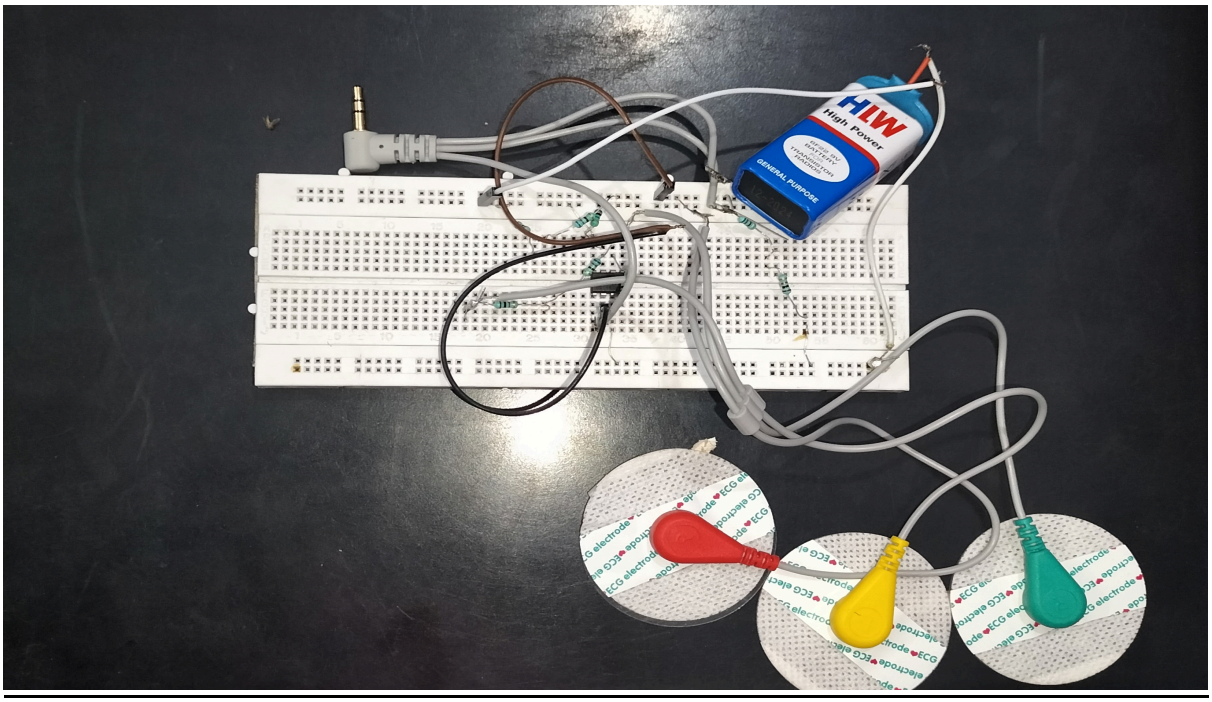


Output is rich in 60Hz noise, but when sharply low-pass filtered to around 45Hz the ECG becomes very clear.

Circuit Highlights

1. The output goes to the microphone jack of the computer.
2. We used **LM741** operational amplifier.
3. The reason for choosing this particular value of the resistor is because the ratio between the two is about 50 seconds to move out of 50 times gain from the input to the output.
4. The node is connected to the computer and it's with respect to ground so the microphone input of the computer with respect to ground is what the output of the device is.
5. BAT+ and BAT- are the leads of 9V battery.
6. Note that the leg electrode is ground same as the computer's microphone ground.
7. R5 and R4 form a traditional voltage divider, we're expecting an op-amp with a gain of about 50dB.
8. There are three electrodes :
   8.1. One is connected to the **LEG** which is grounded.
   8.2. Second electrode is placed in the **CHEST 1** from which the signal is amplified.
   8.3. **CHEST 2** is replaced with the ground but if we see the circuit the **CHEST 2** is grounded indirectly.
9. Hence, in all respects, our body stays grounded, and the op-amp becomes powered by **(-4.5 and +4.5)Volts**, due to which our body is conveniently near the middle and ready to have small signals from **CHEST1** being amplified.
10. The voltage divider in the left side of the circuit is acting as the floating voltage of the battery which enables the battery to match the voltage of our body.
11. The use of **10Mohm resistor** is that the chest lead 1 wouldn't be free to oscillate with the heart so by connecting a 10Mohm resistor it keeps our chest approximately in the right region half way between the **+ and − terminal** of the battery so the amplifier can amplify it.
12. Amplification is with respect to **CHEST2** which can be said as roughly grounded, rather than actual ground, due to which the noise w.r.t ground is eliminated.

IMAGES OF WORKING MODEL-1



DRAWBACK & it's SOLUTION

1. Use of bread board should be eliminated to avoid noise. The holes in the bread board acts as a passage for electromagnetic radiation to interrupt the signal.
2. Noise Can be Eliminated to some instant by
   2.1. Improving the Construction technique.
   2.2. Improve the circuit as these are a lot of work that we could do with multiple operational amplitron that would improve the quality of a signal.

3. But our approach is to keep the circuit as simple as possible and get the ECG waveform on the output. Taking about the software section use took the signal from the ECG and connected it to the frequency domain with a function called FFT.

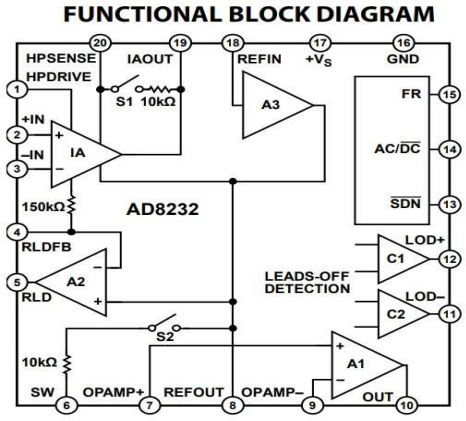
4. Then we eliminated the high frequency component and convert its back to the time domain and by doing so we could adjust a cut off frequency or a low pass frequency.
5. So, a signal with noise of (say 70Hz) can be low pass filtered to 45Hz and by that the 70Hz noise is getting eliminated and the ECG comes through.

Hardware -2

ECG USING ARDUINO
&
AD8232 SENSOR

The AD8232 is an integrated signal acquisition block for cardiogram and alternative biopotential activity applications. It's designed to extract, amplify, and filter little biopotential signals within the presence of shire conditions, like those created by motion or remote conductor placement. This style permits for associate degree ultralow power data converter (ADC) or associate degree embedded microcontroller to accumulate the signalling simply. The AD8232 will implement a two-pole high-pass filter for eliminating motion artifacts and therefore the conductor half-cell potential. This filter is tightly not to mention the instrumentation design of the electronic equipment to permit each massive gain and high-pass filtering in an exceedingly single stage, thereby saving house and price. An uncommitted operational electronic equipment allows the AD8232 to make a three-pole low-pass filter to get rid of extra noise. The user will choose the frequency cut-off of all filters to suit differing kinds of applications. To improve common-mode rejection of the road frequencies within the system and alternative unwanted interferences, the AD8232 includes associate degree electronic equipment for driven lead applications, like right leg drive (RLD). The AD8232 includes a quick restore operate that reduces the length of otherwise long subsidence tails of the high-pass filters. once associate degree abrupt signal modification that rails the electronic equipment (such as a leads off condition), the AD8232 mechanically adjusts to a better filter cut-off. This feature permits the AD8232 to recover quickly, and thus, to require valid measurements presently once connecting the electrodes to the topic. A grade models is nominative from 0°C to 70°C and therefore the models area unit operational from −40°C to +85°C. Performance for the W grade models area unit nominative over the automotive temperature vary of −40°C to +105°C.
Some Common application of this Sensor :

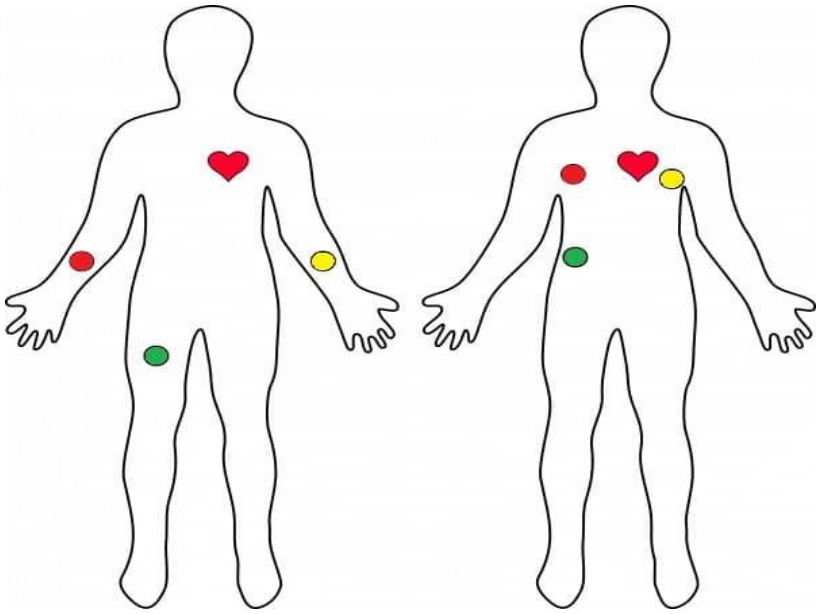
- Biopotential signal acquisition
- Gaming peripherals
- Fitness and activity heart rate monitors
- Portable EKG
- Remote health monitors



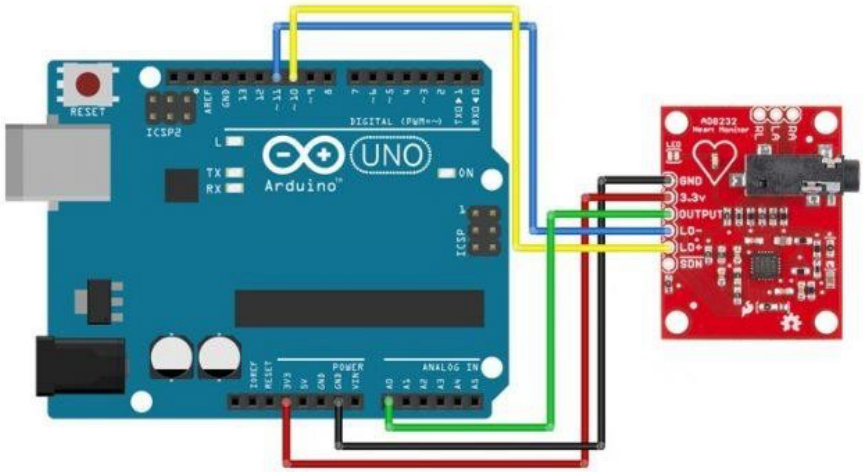
AD8232 EKG SENSOR POSITIONING ON THE BODY

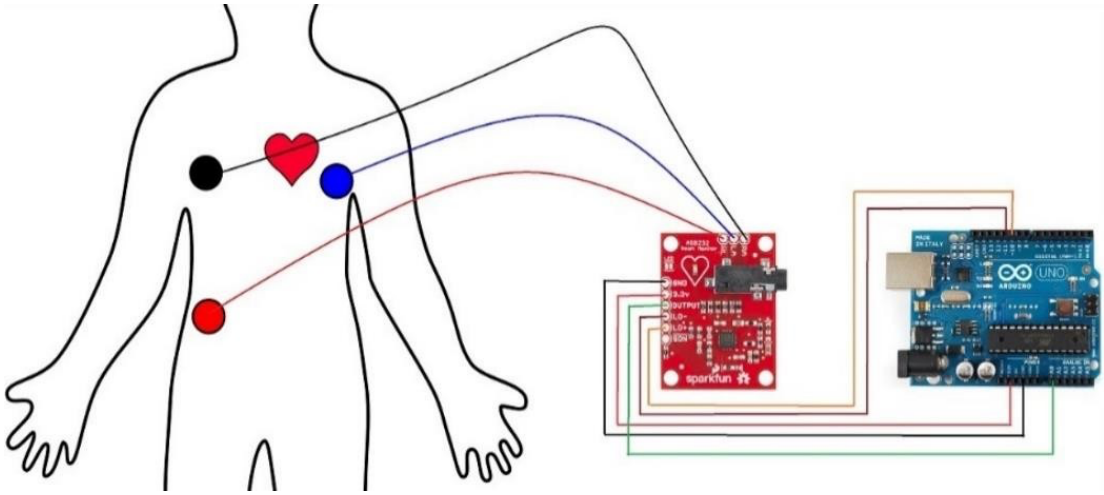
It is advised to snap the sensor pads on the leads before attaching it to the body. Better measurements can be seen if we place the pads closer to our body. The cables are color-coded to identify the proper placement.

Red: Right Arm
Yellow: Left Arm
Green: Right Leg



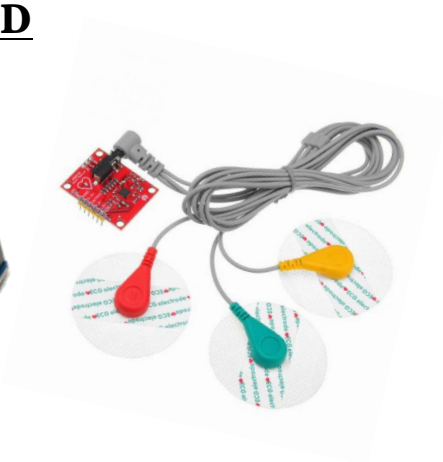
CIRCUIT DIAGRAM





COMPONENTS REQUIRED

- Arduino Uno x 1
- AD8232 Sensor x 1
- Jumper wires x 5
- Electrodes x 3
- Pin Headers



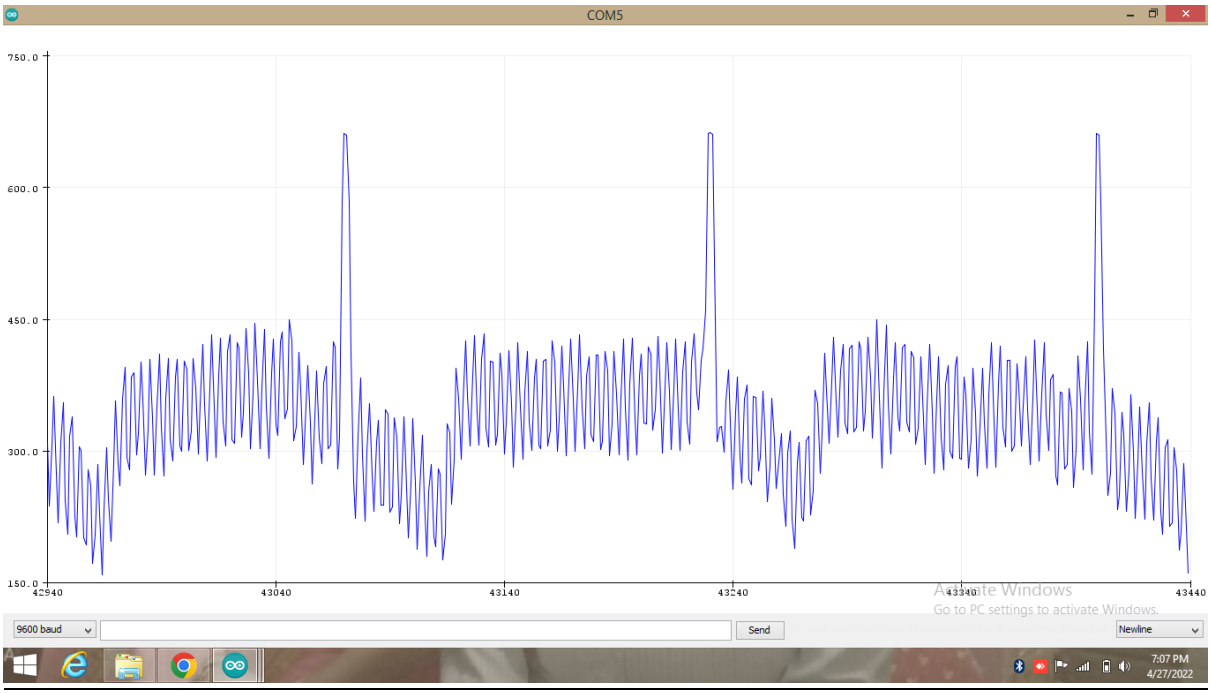
CODE WE IMPLIMENTED →

PROCEDURE FOR DEPLOYMENT

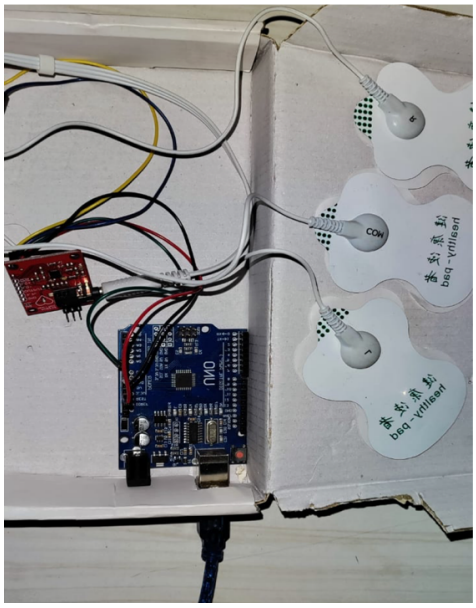
- The AD8232 Heart Rate Monitor breaks the 9 connections out from the Integrated Circuit.
- These connections are termed as pins , the reason behind this is that they come from the pins on the integrated circuit, but they are actually holes that can be used to solder wires or pin header to.
- Then we soldered some pin headers to the AD8232 sensor in order to connect it to the breadboard.
- LO+, LO-, SDN, OUTPUT, 3.3V, and GND are the essential pins for operating this monitor with an Arduino. Also, provided on this board are RA (Right Arm), LA (Left Arm), and RL (Right Leg) pins to attach and use any custom sensors.
- Furthermore, an LED indicator light can also be found that will palpitate to the rhythm of a heartbeat.
- We will connect 5-9 pins on the board to the Arduino. The 5 pins we needed were labelled as LO-, and LO+,GND, 3.3v, OUTPUT.

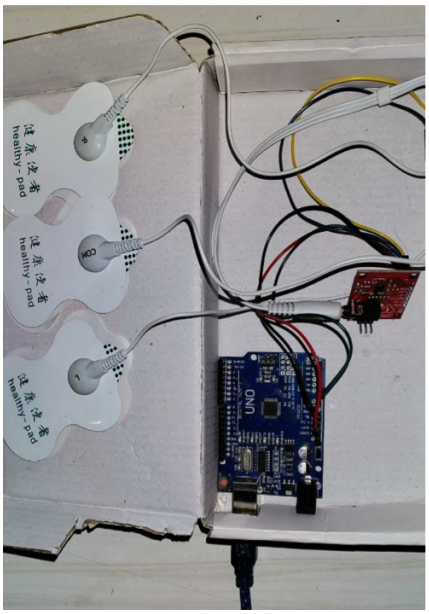
Board Label	Pin Junction	Arduino Connection
GND	Ground	**GND**
3.3v	3.3v Power Supply	**3.3v**
OUTPUT	Output Signal	**A0**
LO-	Leads-off Detect	**11**
LO+	Leads-off Detect	**10**
SDN	**Shutdown**	**Not Used**

ECG OBTAINED



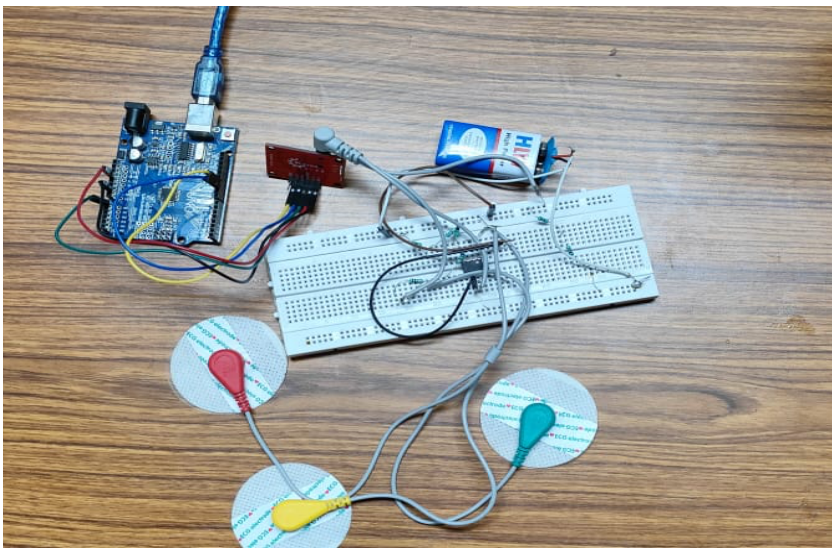
IMAGES OF WORKING MODEL-1



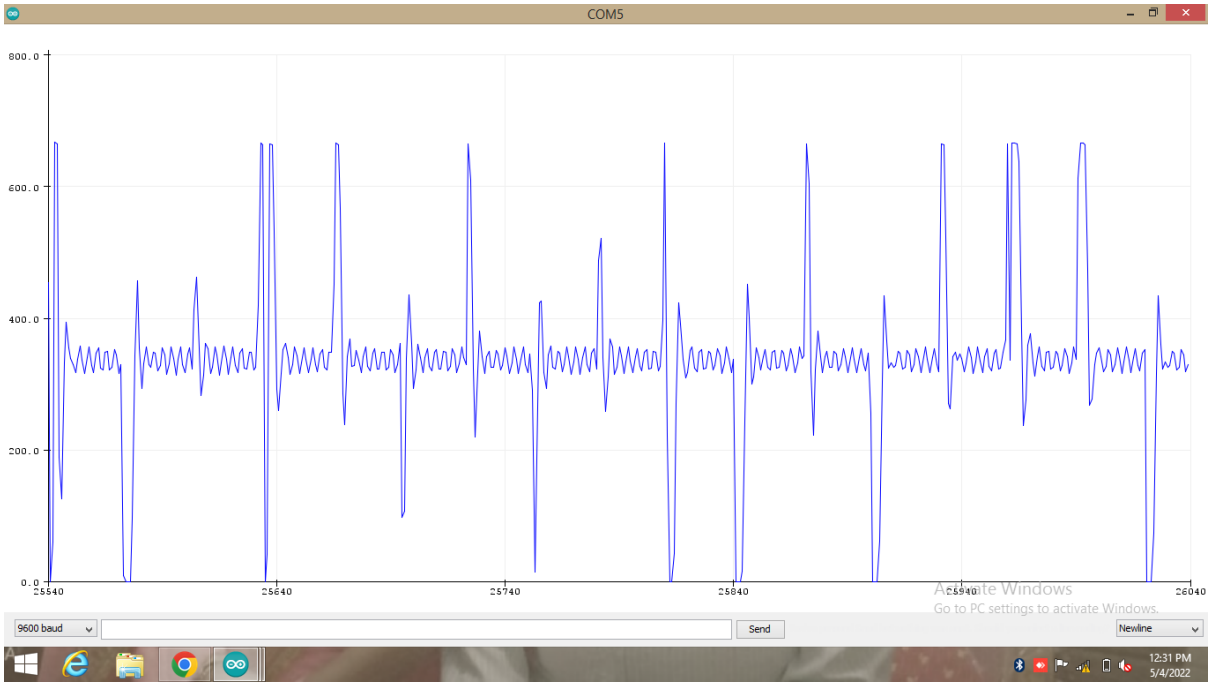


Innovative Section:

FINAL ECG with improved waveform



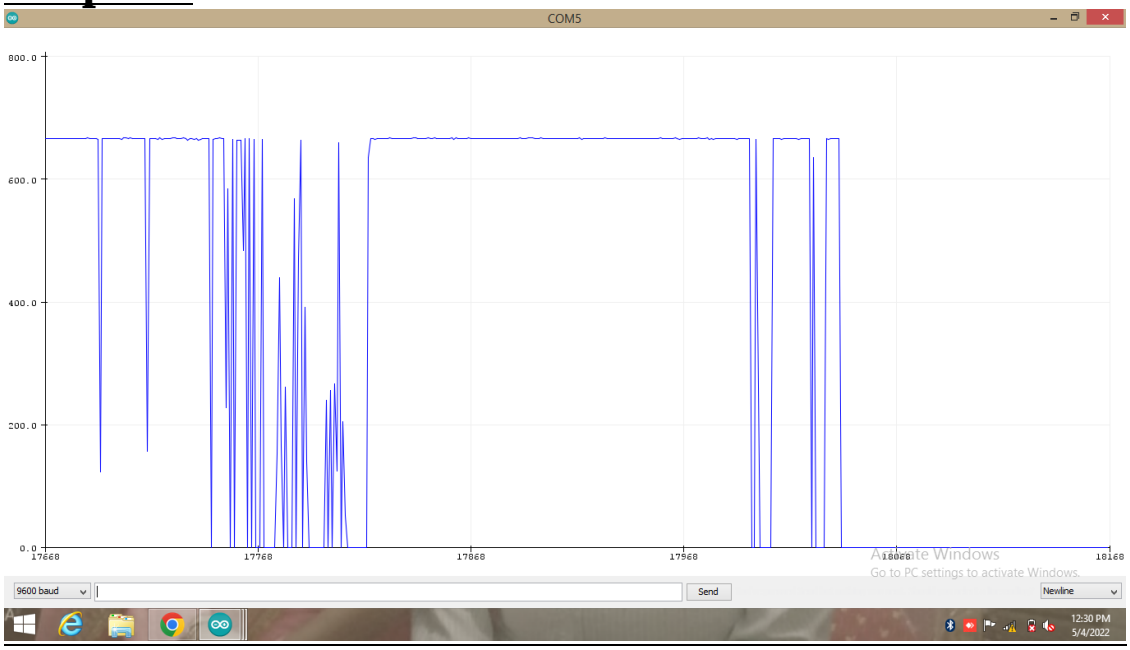
Waveform



- Modern EKG machines record EKG signal in the bandpass from **0.05 (or 0.5) Hz to 100 (or 150) Hz** as an industry standard.
- The minimum sampling rate for a digital EKG recording should be around **500 samples s-**
- Frequency range is under the range of **0.05-120 Hz**.

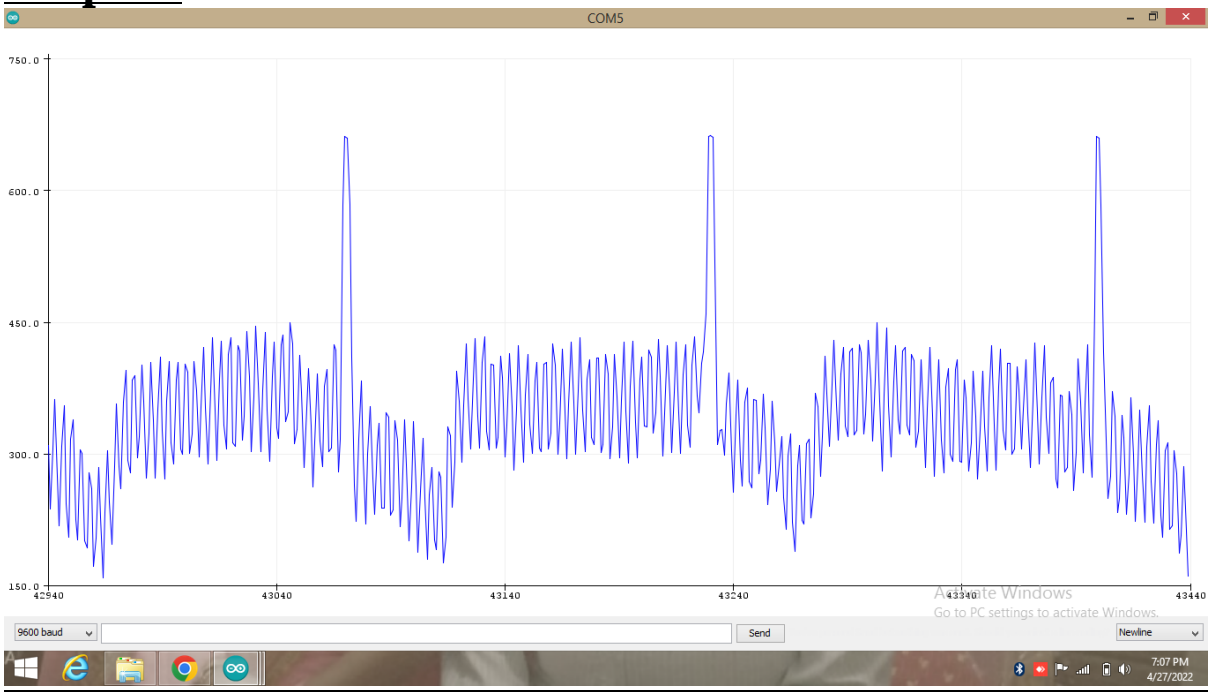
Different waveforms we obtained :

Graph 1 :



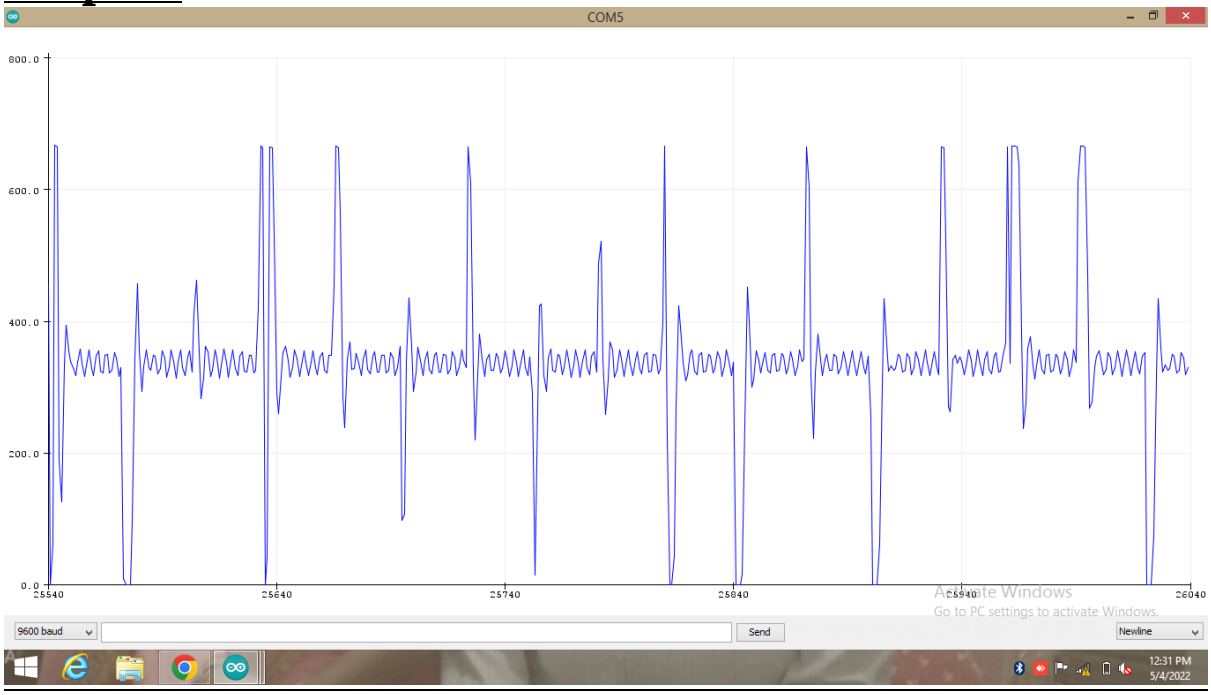
The graph between two peaks looks not so smooth. EKG graph should change smoothly but it gives certain peaks between two EKG peaks as shown in above figure.

Graph 2:



Noisy signal

Graph 3:

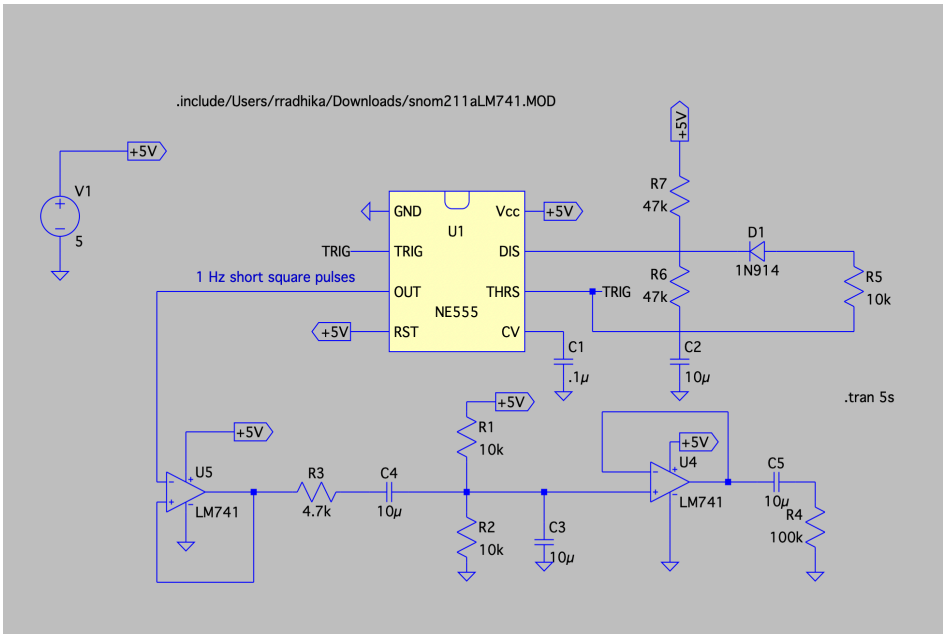


Improved high quality signal

- In graph 1, the graph between two peaks looks not so smooth, because of Sweat around the electrodes(probes) on the body.
- In graph 2, we experienced noisy signal due to electromagnetic radiations and noise around us.
- Graph 3 resulted more accurate and high quality signal due to the use of operational amplifier.

Future Implementation

New and improved circuit (Spice simulation)



Circuit explanation in brief :

1. 555 timer is used to generate the pulses for about one per second.
2. Diode D1 is used to cause the 555 timer to produce very short pulses.
3. Duty of pulses is controlled by the resistances in series with the diode R3, higher resistances results in longer duty.
4. The first operational amplifier is used to invert the polarity of the signal emitted by the 555 timer.
5. While the second operational amplifier is used to serve as a voltage buffer to stabilize the output to the final series capacitor which shifts the voltage so it is centralised around zero.
6. Here we are aiming to eliminate the use of computer so as to produce optimal results without any extra use of devices.

PRECAUTIONS

- While soldering the pin headers make sure that no two pins are shorted. Perform a flying probe test toensure no pins are shorted.
- Do not use a bench power supply!
- Ensure that the electrodes are placed on the specified locations otherwise the results may not beaccurate.
- Keep in mind to remove the plastic sheath on the electrodes to get accurate readings.

BIBLIOGRAPHY

- https://plux.info/sensors/277-electrocardiogram-ecg.html
- https://www.researchgate.net/publication/342075389_Development_of_ECG_sensor_using_arduino_uno_and_e-health_sensor_platform_mood_detection_from_heartbeat
- Recognizing Real Time **ECG** Anomalies **Using Arduino**, AD8232 and Java
- **ECG** measurement system based on **ARDUINO** and android devices
- https://www.scribd.com/document/436512533/Electrocardiography-Wikipedia
- To be implemented
  A wireless patient monitoring system **using** integrated **ecg** module, pulse oximeter, blood pressure and temperature sensor