HEARTBEAT ON THE GO: PORTABLE ECG MACHINE

Project report submitted in partial fulfillment of the requirement for the degree of

BACHELOR OF TECHNOLOGY

In
ELECTRONICS AND COMMUNICATION ENGINEERING

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DECLARATION

We hereby declare that the work reported in the B.Tech Project Report entitled "THE HEARTBEAT ON THE GO: PORTABLE ECG MACHINE" submitted at Jaypee University of Information Technology, Waknaghat, India is an authentic record of our work carried out under the supervision of DR.PARDEEP GARG. We have not submitted this work elsewhere for any other degree or diploma.

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This is to certify that the above statement made by the candidates is correct to the best of my knowledge.

Dr. PARDEEP GARG
DATE:

Head of the Department/Project Coordinator

ACKNOWLEDGEMENT

We would like to express our gratitude and appreciation to all those who have contributed to the successful completion of this major project Heartbeat on the go: portable ECG machine.

We would also like to thank our project supervisor Dr. Pardeep Garg for providing us with invaluable guidance, support and encouragement throughout the project. His knowledge in the field of electronics have been of immense help in designing and implementing the project.

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In conclusion we would like to express our heartfelt gratitude to all those who have contributed to the successful completion of this project.

LIST OF ACRONYMS AND ABBREVIATIONS

1. CVD: Cardiovascular diseases
2. ECG: Electrocardiogram
3. TFT LCD: Thin film transistor liquid crystal display
4. SD card: Secure digital card
5. ADC: Analog to digital converter
6. CPU: Central processing unit
7. OLED: Organic light emitting diode

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ABSTRACT

This work examines the importance of portable heart monitoring devices in cardiovascular healthcare. Portable ECG machines offer a simple and mobile way to monitor heart health, reducing the risk of arrhythmia. These devices are particularly useful for households with high-risk individuals and are now more affordable. The revolutionary potential of these devices opens the door to personalized, instantaneous, and seamless heart health monitoring. Portable ECG machines have revolutionized cardiovascular healthcare by offering simple and mobile monitoring. These devices are essential for patient outcomes, diagnosis, and personalized healthcare. Their small size and clear interface make them easy to monitor heart health at any time. Proactive health monitoring is particularly beneficial for households with individuals at higher risk of cardiovascular events. The affordability of portable ECG machines makes them more accessible to more people. These devices have the potential to become essential resources for healthcare professionals and those actively managing their heart health. The revolutionary potential of portable ECG machines opens the door to a future where personalized, instantaneous, and seamless heart health monitoring is possible.

CHAPTER 1:

1.1 INTRODUCTION

Cardiovascular diseases (CVDs) are among the leading causes of mortality worldwide. According to the World Health Organization (WHO), an estimated 17.9 million people died from CVDs in 2019, representing 32% of all global deaths. Timely and accurate diagnosis of cardiac abnormalities is crucial for effective management and prevention of CVD-related complications. Electrocardiography (ECG) is a fundamental diagnostic tool used to assess cardiac health by recording the electrical activity of the heart.

In India, the number of cases of cardiovascular diseases (CVD) has increased significantly over the last ten years. It is projected that by 2020, there will be 4.77 million CVD-related deaths nationwide, up from 2.26 million in 1990. Over the past few decades, estimates of the prevalence of coronary heart disease in India have fluctuated, ranging from 1.6% to 7.4% in rural and 1% to 13.2% in urban populations [1]. Notably, young people account for one-fifth of these deaths.

Major regional differences in cardiovascular mortality for men and women can be observed in India. The highest death rates are found in the southern, eastern, and northeastern Indian states, as well as in Punjab; the central Indian states of Rajasthan, Uttar Pradesh, and Bihar have comparatively lower death rates. The high rates of sickness, disability, and death associated with cardiovascular diseases are making the problem of treating them a national priority [2].These conditions often require long-term, sometimes lifetime, medication. Due to the significant expenses involved, early primary prevention strategies must receive more attention.

The rapid advancement of technology has made monitoring cardiac health while engaging in free activity a pertinent component of cardiovascular disease diagnostics. One significant development is the introduction of tiny wearables that can record functional parameters in real-world situations. The incorporation of these devices has instigated a more thorough investigation of techniques and algorithms for the processing of electrocardiograms, enhancing the potential of cardiac diagnostics in various contexts.

The progress of medical technology continues to change patient care in the arena of modern healthcare. The introduction of portable electrocardiogram (ECG) equipment is one notable advancement. These small and adaptable technologies have transformed cardiac monitoring by allowing users to check heart function at any time and from any location. A portable ECG machine allows healthcare practitioners to do on-the-spot diagnosis, allows for remote patient monitoring, and encourages consumers to actively participate in their cardiovascular health management [3].

ECG portable devices (shown in fig 1.1) represent an innovative advancement in cardiovascular medicine, going above the limits of traditional monitoring systems. As these developments continue, there is potential to improve patient outcomes, strengthen diagnostic capacities, and support the larger movement toward more individualized and easily available healthcare. The road to a healthier heart is now more mobile, immediate, and patient-centered thanks to the development of portable ECGs.

Fig. 1.1(Portable ECG Machine) (Ref. Digital Portable ECG Device, for Hospital (indiamart.com))

1.2 <u>Background</u>

An electrocardiogram (ECG) is a medical device used to record the electrical activity of the heart over time. The development of ECG technology dates back to the 19th century, when scientists first began investigating the electrical properties of the heart. In 1903, Willem Einthoven introduced the wire galvanometer, a device that could record the electrical activity of the heart more accurately and in more detail, laying the foundation for modern electrocardiography technology. > Over the years, advances in electronics and signal processing have led to the development of more efficient and effective electronics.

The introduction of state-of-the-art electronic equipment in the 1960s allowed electrocardiogram equipment to be smaller, making it more convenient and practical. These signals are amplified and filtered to remove noise and then digitized for analysis. Portable electrocardiographs often use a combination of analog and digital signal processing technology to provide accurate and reliable readings in a compact, portable form factor. Easy way to do this activity.

Portable ECG machines are now widely used in clinics, ambulances and hospitals to monitor patients with heart conditions such as arrhythmias, heart attacks and strokes.) further expanded the functionality of the portable electrocardiograph. The devices now connect to smartphones and tablets, enabling instant monitoring and remote dispatch to medical facilities.

It provides doctors with powerful tools to diagnose and monitor heart disease. As technology continues to advance, portable ECG devices will become more common, affordable, and easy to use, and the accessibility and impact of these devices on patient care will increase.

1.3 Evolution of ECG Machine

The history of ECG dates back to the late 19th century when the Italian physiologist, Luigi Galvani, discovered that electrical impulses are responsible for the contraction of muscles, including the heart. In 1901, Willem Einthoven, a Dutch physiologist, invented the first practical ECG machine, which consisted of a galvanometer and a string galvanometer. Einthoven's invention revolutionized the field of cardiology and laid the foundation for modern ECG technology.

Over the years, ECG machines have undergone significant advancements, evolving from bulky, analog devices to compact, digital systems. The introduction of digital signal processing (DSP) technology in the 1970s enabled the development of computerized ECG machines capable of recording, processing, and analyzing ECG signals with greater accuracy and efficiency. Subsequent innovations, such as wireless connectivity and cloud-based storage, further enhanced the functionality and utility of ECG devices.

The development of ECG (electrocardiogram) technology takes more than a century of advancement and medical discovery. Here are the details of its evolution:

1. Early Development (Late 19th Century):

The first electrocardiogram was recorded in 1887 by Augustus Waller, who used a capillary electrode to measure the electrical activity of the heart. Inside, he used a galvanometer array to record electrical signals from the heart. Einthoven also introduced standard limb extremities (I, II, III) and Einthoven's triangle concept. Developments in the Mid-20th Century:

The introduction of the vacuum tube in the 1920s made the ECG recording system more reliable. (V1-V6)) expands the diagnostic capabilities of electrocardiography. Digital Revolution (Late 20th Century):

The advent of digital signal processing in the 1970s and 1980s led to the development of computerized electrocardiographs that enabled better analysis and interpretation of electrocardiogram data. The 12-lead electrocardiogram has become standard practice, offering a more comprehensive view of the heart's electrical activity. Modern Era (21st Century):

Integration of electrocardiographs into the electronic health record (EHR) improves data management and ease of access. Remote monitoring and telemedicine. Future Trends:

Wearable ECG devices are becoming more common and provide continuous monitoring and instant data analysis. The integration of ECG technology into smartphones and smartwatches has made heart monitoring easier for the public.Continued advances in artificial intelligence and data analysis will improve the diagnostic capabilities of electrocardiogram machines, allowing for more personalized and effective treatment of heart pain.

1.4 MOTIVATION

The motivation for the development of a mobile electrocardiograph stems from the need for simple, practical and reliable monitoring of the heart. Some of the key motivations include:

Accessibility: Traditional ECG machines are large and immobile, limiting their use in hospitals and clinics. Portable electrocardiographs increase access to cardiac care by providing cardiac monitoring in many settings, including the home, ambulance, and clinic. This makes them ideal for mobile monitoring. Patients can take their ECG with them when necessary, without needing a doctor. ECG recording usually results in a short hospital stay. This is especially beneficial for patients with heart disease or at risk of heart disease. This is especially beneficial for patients in rural or underserved areas. Research and Innovation: The development of portable ECG machines has spurred innovation in ECG technology, leading to the development of advanced features and the ability to improve monitoring and heart management. Improving access to cardiac care, ensuring easy and consistent care, enabling early detection of heart disease, and enabling innovations in electrocardiography technology.

According to the World Health Organization, the alarming age-standardised CVD mortality rate in India is 272 per 100,000 people; This rate is above the world average of 235. High blood pressure, diabetes, dyslipidemia, smoking and obesity all play a role. . Nine risk factors, including lack of physical activity, inadequate fruit and vegetable consumption, and psychological stress, account for more than 90% of AMI in South Asians, according to the INTERHEART study. However, these factors do not explain the higher prevalence of CAD or earlier age of onset in Indians; this suggests the interplay of factors contributing to the burden on the Indian population.

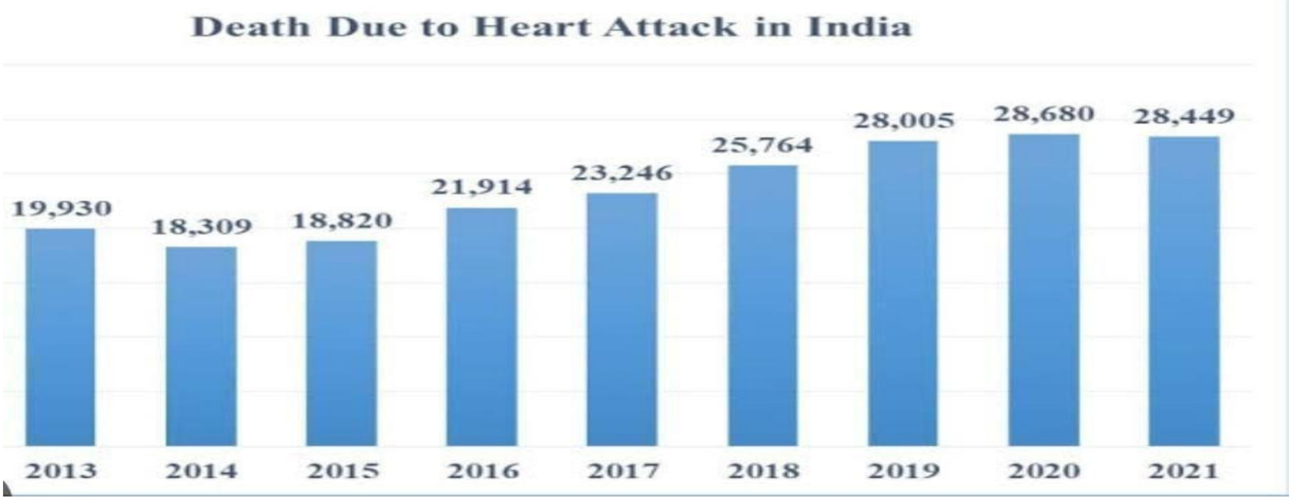


Fig. 1.2(Graph)(Ref. Google)

Dr. Sanjeev Gera, director and head of the cardiology department at Fortis Hospital in Noida, said Covid-19 or persistent Covid-19 infection can cause heart attacks. This pain can lead to a heart attack, especially after strenuous exercise such as lifting weights or running in cold weather. The risk increases with the presence of cardiovascular diseases such as high blood pressure, diabetes, high cholesterol, smoking or obesity, Guerra said. India is a country with a high incidence of cardiovascular disease (CVD). The annual death rate from heart disease increased significantly in 2020, from 2.2 million to 4.7 million. to explain. Effects on cardiovascular health are a major concern; 20% to 30% of patients hospitalized with COVID-19 develop heart damage.

CHAPTER 2:

2.1 Literature Review

Mohammad Mahmudur Rahman; Md. Azizul Hoque Rimon; Muhammad Armanul Haque et.al[7]: In this study, an Arduino and a Bluetooth module were used to record, and transmit cardiac activity to a mobile application. Current portable ECG technology is expensive and not everyone can use it at home in an emergency.

Muharrem Çelebi et.al [8]: In this work, a graphic display is used to detect and display the electrocardiogram (ECG) sign, one of the most fundamental symptoms of cardiac disease. ECG sensor card, wireless communication module, ARDUINO Nano, and TFT LCD panel are utilised to determine for this purpose. The concept is individually designed in two circuits, and each circuit is powered by a small battery to maintain its small size. The circuits are constructed in small sizes.

Prachi Kamble; Ashish Birajdar et.al [9]: The paper's goal is to develop a novel approach for ECG monitoring and recording. The ECG data is collected by a wearable monitoring node, wirelessly sent to an IoT cloud, and then stored on an SD card for offline use. The local LCD and newly created web interface/mobile application both display the ECG wave.

Rafaeal Hossain Rakin; Asad Siam; Md. Rafayet Hossain; et.al [10]: This study proposes a low-cost and portable ECG machine that, if successful in overcoming healthcare laws, might serve as a prototype for easy observation of electrocardiogram irregularities among the general public. An analogue circuit and a processing unit make up the overall system. Bio-electric-potential sensors are used primarily to detect bodily signals.

Tang Lili; Huang Wei et.al [11]: This article introduces the design of a low power portable ECG monitoring system in detail and methodically. ECG acquisition, signal conditioning, digital filtering, and dynamic ECG display are among the system functions.

Menq-Jion Wu; Sheau-Fang Shieh; Yi-Lin Liao; et.al [12]: The goal of this work is to provide a low-cost and efficient ECG measurement system that is integrated with mobile devices and uses non-invasive sensors to measure ECG signals. The non-invasive sensor approach is successful, although it is susceptible to noise.

E Priya; R Chitra et.al [13]: This work is based on the detection of electrical activity in the heart using a heart rate monitoring sensor connected to an Arduino microcontroller. This designed system has the capability of displaying ecg in a phone.

Haydar Ozkan; Orhan Ozhan; Yasemin Karadana; et.al [14]: This work describes a unique architecture for a wearable Tele-ECG and heart rate (HR) monitoring system that includes a flexible singlet modified with textile electrodes (TEs), textile threads, snap closures, Velcro, sponges, and an ECG circuit. In addition, for remote monitoring, a Bluetooth low energy (BLE), a smartphone, a server, and a web page have been added to the system.

Brian A. Walker; Ahsan H. Khandoker; Jim Black et.al [15]: The goal of this paper is to design and build at least two of the four essential components of a basic modern ECG data logging system: the patient's electrodes and the amplifier.

Hassan Ali ; Ben Villaneouva; Raziq Yaqub, et.al [16]: In this study, they have focused on the design and implementation of a low-cost real-time wireless ambulatory ECG monitoring system. A microprocessor filters and amplifies the detected ECG signals before digitally converting them.

Qiwei Chen ,Sanja Kastratovic et.al [17]: This article introduces a portable, wearable, low-voltage, non-contact electrocardiogram monitoring device that may aid in the early detection of heart disease. The device is placed in a shirt pocket and sends data to the user's phone via Bluetooth Low Energy (BLE). The device has only three non-contact electrodes to detect the heart signal, the AD8232 AFE chip to extract ECG signals, and the CC2650 microcontroller to read, filter and send ECG signals.

Zhadyra Alimbayeva ,Zhadyra Alimbayeva et.al [18]: This study describes and reviews new designs and systems for “invisible” electrocardiography. Designed in the shape of a toilet seat, this device brings a new path to better healthcare by providing free femoral ECG data. A special sensor and polymer dry electrodes with different textures were created to record the electrocardiogram signal on the toilet seat.

Wei Xiong,and Yongjian Li et.al [19]: The new wearable ECG measurement system, based on smart clothes, has three subsystems: smart clothes, smartphones and PC terminals. Three textile ECG electrodes woven into the fabric of smart clothes can send the received ECG signals to the smartphone via Bluetooth. The smartphone then sends the ECG signal to the PC terminal via WiFi, cellular network or Internet.

Vincenzo Randazzo Jacopo Ferretti et.al [20]: The smart ring VITAL-ECG was developed by Politecnico di Torino's Neuronica Laboratory and can record vital signs such as heart rate and electrocardiogram, SpO2, skin temperature and humidity.

Zhaoji Fu, Shenda Hong et.al [21] : The mobile phone is designed to improve patients' ability to manage heart disease and reduce doctors' work, including hardware and cloud software technology based on the latest advances in the Internet of Things (IoT) and artificial intelligence (AI). A small device has been developed to collect high-quality electrocardiogram (ECG) data from humans. A new cloud service based on deep learning will be deployed to diagnose heart disease. Supports twenty diagnostic tests such as sinus rhythm, tachycardia, and bradycardia.

Alessandro Zompanti, Anna Sabatini et.al [22]: This study investigates the feasibility of multi-lead ECG data using dry electrodes and specialized equipment designed to investigate the feasibility of wearable ECG equipment with clothing with embedded electrodes. The main disadvantage of this equipment is that the signal is not accurate compared to ECG equipment that uses wet electrodes.

Shriya Puranik 1, Christopher Harlow et.al [23]**:**This study investigated the AliveCor portable device for recording and measuring the QTc interval of 6-lead electrocardiograms. Automated QTc profiles from the 12-lead ECG of each patient (n = 13) were compared with the QTc value calculated from each patient's corresponding AliveCor data. AliveCor underestimates QTc – in 92% of cases AliveCor's QTc number is lower than the 12-lead QTc reading.

Miguel Bravo-Zanoguera ,Daniel Cuevas-González et.al [24]: Indonesian researchers have developed a portable and inexpensive ambulatory electrocardiogram to record electrocardiogram signals throughout the day. The main board includes a preamplifier, a bandpass filter, a notch filter, an amplifier, an Arduino microcontroller, an SD memory card, and a Bluetooth transmitter. ECG signals are taken from the body according to standard LEAD II measurement. Sample level and size in the laboratory.

Lorenzo Bachi ,Lucia Billeci et.al [25] : The software was developed using MATLAB for QRS detection as a simple unweighted moving average combination. In particular, the main component of ECG signal processing is the moving average cascade (MAC). Our algorithm enhances the QRS complex by selecting a MAC from a set of noise-robust MAC variants.

Jin-Woo Jeong,Woochan Lee et.al [26] : Adaptive digital filtering is used to eliminate background noise that may be present in the home environment while reducing run time. Bland Altman analysis was used to evaluate the accuracy of the ECG and EMG signal program by comparing it to the equipment used to record physical signals.

2.2 Applications

Portable electrocardiographs have many uses due to their simplicity, ease of use, and ability to provide rapid heart rate measurements. Some important applications include:

Remote monitoring: Patients with chronic heart disease can use electrocardiographs to monitor their heart rates at home. This allows for ongoing care without the need for frequent hospital visits.

Ambulatory monitoring: Portable ECG machines are used for dynamic monitoring and patients wear the device during their daily work. This provides a more complete picture of the heart's function in a clinical setting than short-term ECG data.

Emergency Medical Services: Doctors and emergency room physicians use a portable electrocardiogram machine to measure a patient's heart rate in the event of an emergency, such as a heart attack or arrhythmia. This will help improve performance and detect abnormalities that may require treatment. Heart function is normal at the time of surgery. Clinical research: Portable electrocardiographs are used in clinical studies to collect data about heart diseases from different people and in different conditions. The data could help researchers learn more about heart health and disease. Multifunctional tool.

CHAPTER 3:

3.1 Objective

In this proposed project, we have approached the problem with a solution that will not only help the people with heart diseases but also help those who want to keep a regular check on their health as it is easy to use and cost effective and most importantly, it can work in all weather conditions.

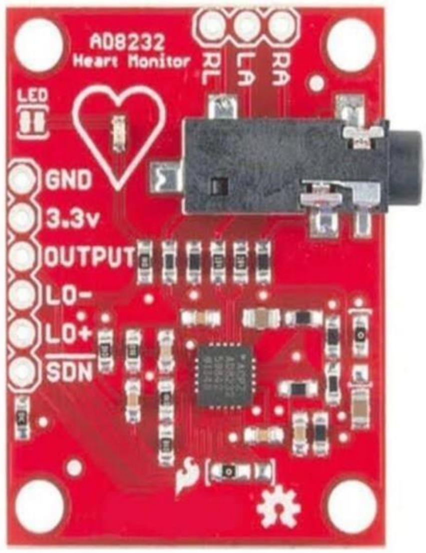
3.2 COMPONENTS

1. **ECG Electrodes:** These are the sensors that make direct contact with the patient's skin in order to detect the electrical impulses produced by the Heart. shown in fig(3.1) and (3.2);

Fig. 3.1 Electrodes (Ref. Slaney (ECG01) ECG Electrode Stickers - 50's Pack (kogland.com))

Fig 3.2 Electrodes Sensor (Ref. Slaney (ECG01) ECG Electrode Stickers - 50's Pack (kogland.com))

2. **A microcontroller:** Often known as a CPU, manages the overall operation of the ECG equipment(shown in fig 2.3). It handles data storage, processes



digital signals, and manages user interface elements.

Fig. 3.3 (Microcontroller) (Ref. Microcontroller Programming (build-electronic-circuits.com))

3. **Arduino NANO:** It has 16 pins that are used for different purposes(shown in fig 2.4). It can be used in every small or big task such as from minor to major industrial scale projects.

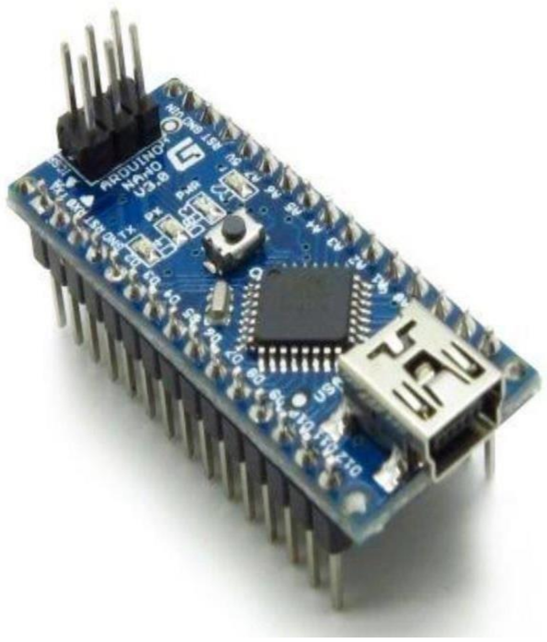


Fig 3.4 (Arduino NANO) (Ref. Arduino Nano V3 ATmega328 Development Board | EtechRobot)

4. **Display:** A screen or display is used to show healthcare. An ECG the machine records this activity via electrodes on the skin and displays it graphically (shown in fig 2.5)

Fig 3.5 (ECG Display) (Ref. Handheld ECG Monitor. [SB48020] – Nasco Healthcare

Components List

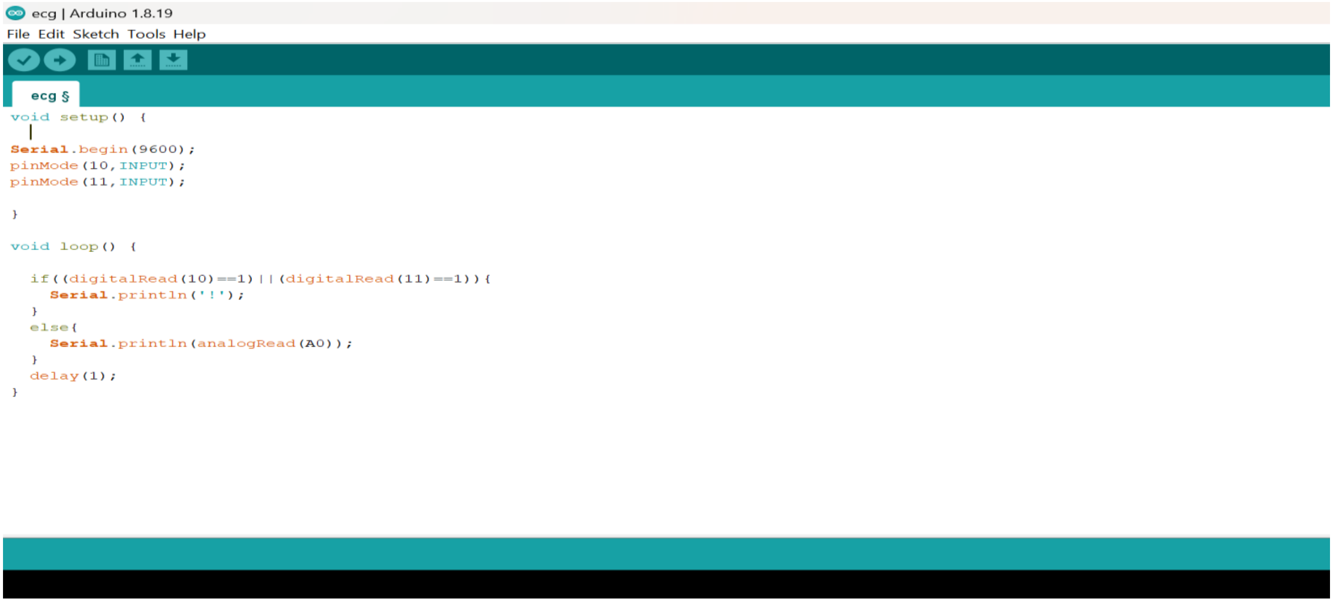
Component	Part number	Quantity	Specification
ECG Electrodes		3	Ag/AgCl, Disposable, 10mm diameter, Pre-gelled
A microcontroller	AD8232	1	4 mm × 4 mm, 20-lead LFCSP and a LFCSP_SS package
Arduino NANO	ATmega328	1	ATmega328P, 16MHz clock speed, 32KB Flash, 2KB SRAM
Display	QLED	1	0.96 inch, 128x64 pixels, I2C Interface
Battery	Li-ion 3.7v	1	Capacity: 1000mAh, Rechargeable
Resistor	-	-	1/4W, 1% tolerance
Capacitors	-	-	Ceramic, Electrolytic

Table1:

3.3 Software Used:

The software we used in this project is Arduino 1.8.19.

CODE :




```
void setup() {

Serial.begin(9600);
pinMode(10,INPUT);
pinMode(11,INPUT);

}

void loop() {

  if((digitalRead(10)==1)||(digitalRead(11)==1)){
    Serial.println('!');
  }
  else{
    Serial.println(analogRead(A0));
  }
  delay(1);
}
```

This Arduino code sets up a simple program to read input from two digital pins (10 and 11) and one analog pin (A0) and communicate through the communication interface the 9600 bits per second Baud rate sent for reading. Initiates serial communication at the specified baud rate (9600 bits per second). and pinMode(11, input); Check whether pin 10 or pin 11 is high (i.e. whether the input is 1). If both pins are high, "!" will be published. If neither pin 10 nor pin 11 is high, use AnalogRead (A0) to read the analog value of pin A0 and print the value of the communication. Add a short delay (1ms) to check the value of the text. This prevents communication flooding of programs. It processes digital signals, makes the necessary calculations and controls all functions of the device. Store in memory for future reference or analysis. Add products or features to improve functionality and usability.

CHAPTER-4:

4.1 Block Diagram

This is the block diagram of our proposed system (Portable ECG machine) shown in fig 4.6

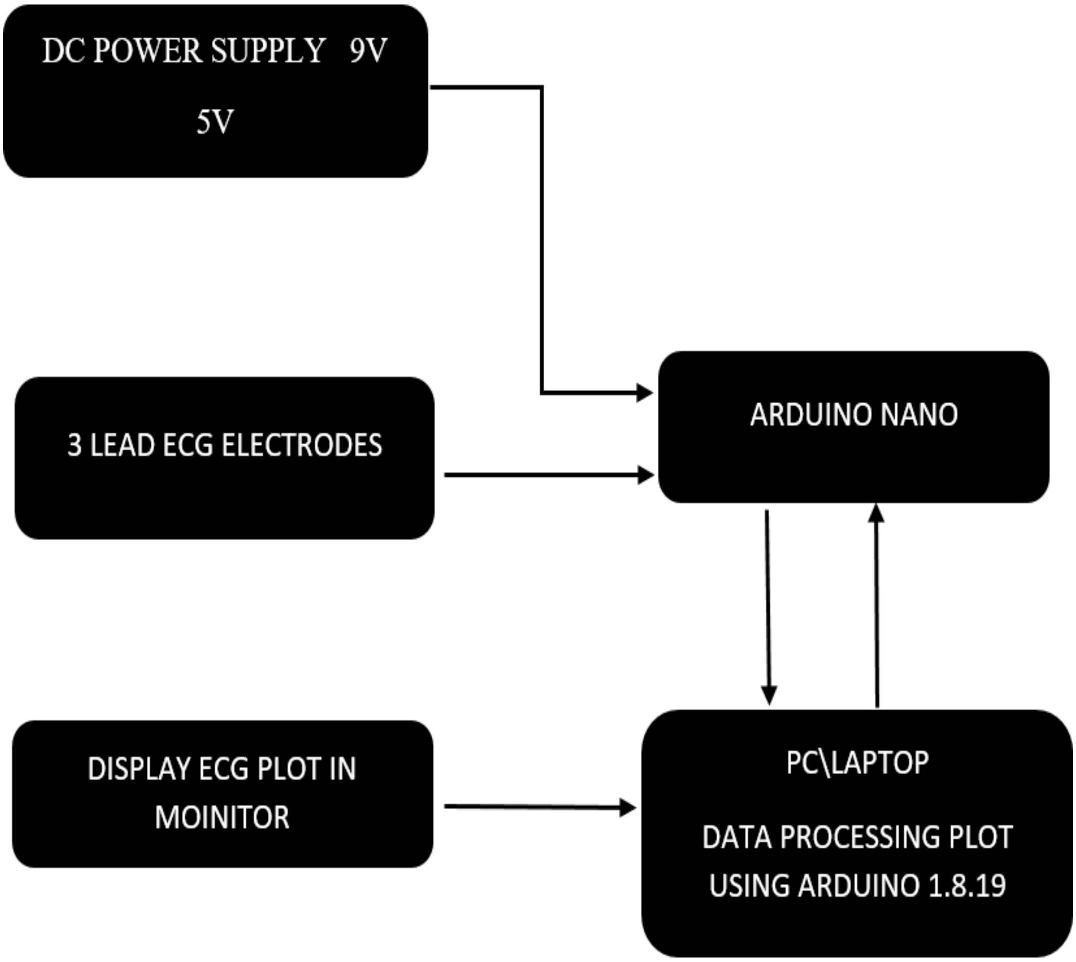


Fig. 4.6(Block diagram of our project)

1. Electrodes: These sensors are placed on the patient's body to detect the heart's electrical activity. ECG electrodes are typically positioned on the chest, arms, and legs.
2. Instrumentation Amplifier: This component amplifies the weak signals detected by the electrodes, making them suitable for further processing. It also helps in rejecting common-mode noise and interference.
3. Low Pass Filter: To ensure that the ECG signal is not distorted by high-frequency noise, a low-pass filter is used to remove this noise. It allows only the low-frequency components of the signal, which are relevant to the ECG, to pass through.
4. ADC (Analog-to-Digital Converter): The amplified and filtered analog signal is converted into a digital format using an ADC. This digital signal can then be processed and analyzed by the microcontroller.
5. Microcontroller: Responsible for processing the digital ECG signal, the microcontroller performs various calculations such as heart rate calculation and rhythm analysis. It also controls the overall operation of the ECG machine and interfaces with other components like the display and memory.
6. Display: The processed ECG signal is displayed on a screen for visual observation by the user. The display may also provide additional information such as heart rate, signal quality, and battery status.
7. Memory: Some ECG machines have internal memory to store ECG

data for later analysis or transfer to another device. This allows for monitoring changes in the ECG over time and comparing with previous recordings.

8. Battery/Power Supply: Typically powered by a battery or external power supply, the ECG machine is designed to be portable and suitable for use in various settings. The battery provides the necessary power for the device to operate.

4.2 Implementation of ECG Machine

Putting on Electrodes:

People attach small pads called electrodes to specific spots on their body, like the chest, arms, and legs. These pads pick up the electrical signals made by the heart.

Getting Signals:

The portable ECG machine then captures and records these electrical signals. These signals show what the heart is doing throughout its pumping cycle.

Making Signals Stronger and Clearer:

Sometimes, the signals are weak. The machine boosts them to make them easier to measure. It also uses filters to remove unwanted noise or interference.

Changing Signals to Digital:

The strengthened and filtered signals change from analog (wave-like) to digital (computer language) so the machine can analyze them.

Analysing Data:

The digital signals go through more steps to find important info about the heart's electrical activity. Special programs might find issues or patterns linked to heart conditions.

Showing Results:

The processed information is displayed on the machine's screen in an easy-to-understand way. Users can see a live representation of their heart's activity.

Storing and Sending Data:

Some portable ECG machines store recorded data inside. Others can send the information wirelessly to a computer or a healthcare pro for remote checking.

Easy to Use:

The machine is made with simple controls and a clear display. Users can start recording, check results, and do basic tasks without any tech problems.

Battery-Powered:

Portable ECG machines usually run on batteries for convenience and moving around.

Reducing Interference:

Steps are taken to lower interference from outside things, making sure the ECG measurements are accurate.

Connecting to Healthcare:

Certain portable ECG devices can link up with electronic health record systems or healthcare apps. This makes it easy to share data and talk to healthcare providers.

In summary, a portable ECG machine is designed to be user-friendly, helping people monitor their heart health in different places, not just in regular healthcare spots [27].

Steps involved in working of ECG:

1. If you are wearing any jewellery you will be asked to take off because it can cause interference in the reading.
2. Also, you will be asked to remove your clothes from the waist up so that electrodes can be placed to your chest.
3. To make it possible for the electrodes to attach to the skin properly, the areas where the electrode patches are implanted are cleaned, and in certain cases, hair may need to be trimmed or cut.
4. Then the electrodes will be attached to your body. The readings can be shown on the laptop or on the ECG monitor.

CHAPTER -5:

5.1 ADVANTAGES AND DISADVANTAGES OF PORTABLE ECG MACHINE

5.1.1 ADVANTAGES

(i) Easy to Use: Regardless of technical experience, anyone can operate the portable ECG machine because of its simple interface, clear display and simple controls.

(ii) Precise ECG Measurements: The project's main goal is to make sure the machine can produce ECG readings that are as accurate as those obtained from the ECG machines which are used in the clinics and hospitals.

(iii) Accessibility: It may become more widely available because of its low cost ease of use mainly in underserved and distant areas.

(iv) Better quality of life: Having a portable ECG machine can improve the quality of life not only for those people having heart related problems but also for those who want to keep regular checks on their health.

5.1.2 DISADVANTAGES

The electrodes may be difficult to keep attached to the skin and may require additional tape. Removing the sticky electrodes and tape will cause discomfort. Prolonged use of electrodes may cause skin irritation or tissue irritation at the application site.Depending on your particular medical condition, there can be additional dangers.

There are certain conditions that may cause interference and affect the readings of portable ECG machine such as:

(i) Being near metal detectors, magnets, high-voltage electrical wires, and electrical devices like shavers, microwaves, toothbrushes can affect the monitor.

(ii) Keep cell phones and MP3 players at least 6 inches away from the monitor box because they can also interfere with signals.

(iii) Using tobacco or smoking or any other drugs.

(iv) Specific medications and too much sweating can make the leads on the monitor loosen or come off.

5.2 <u>Snapshots of our Work</u>

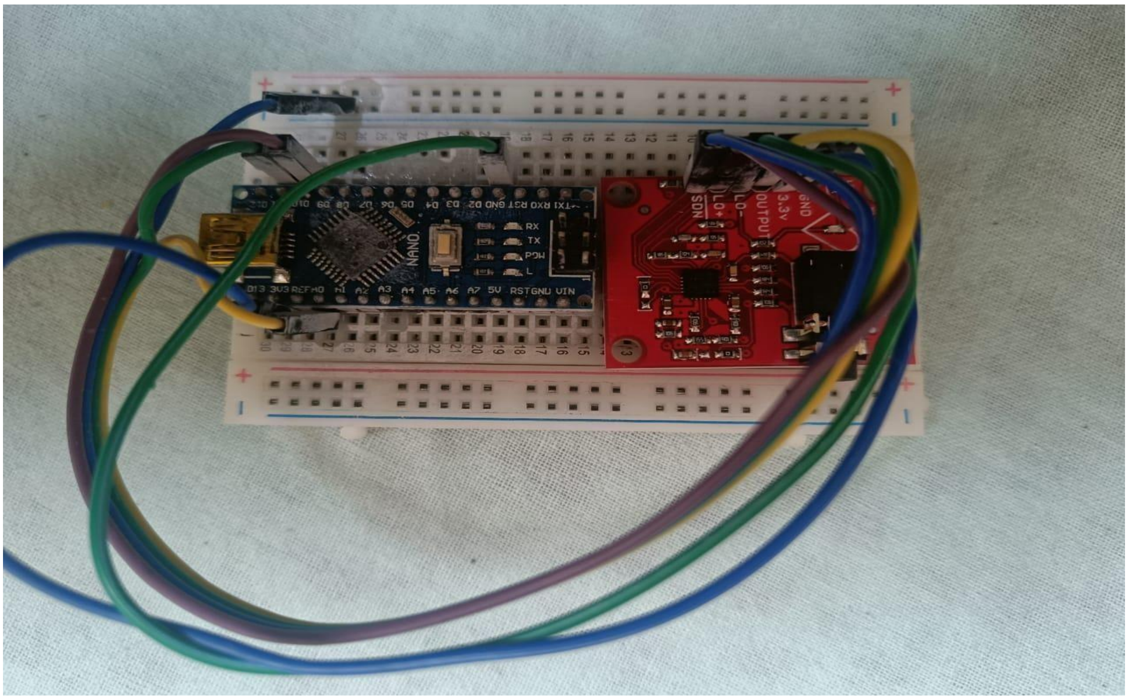


Fig. 5.1(Project implementation)

Fig 5.2(Electrodes)

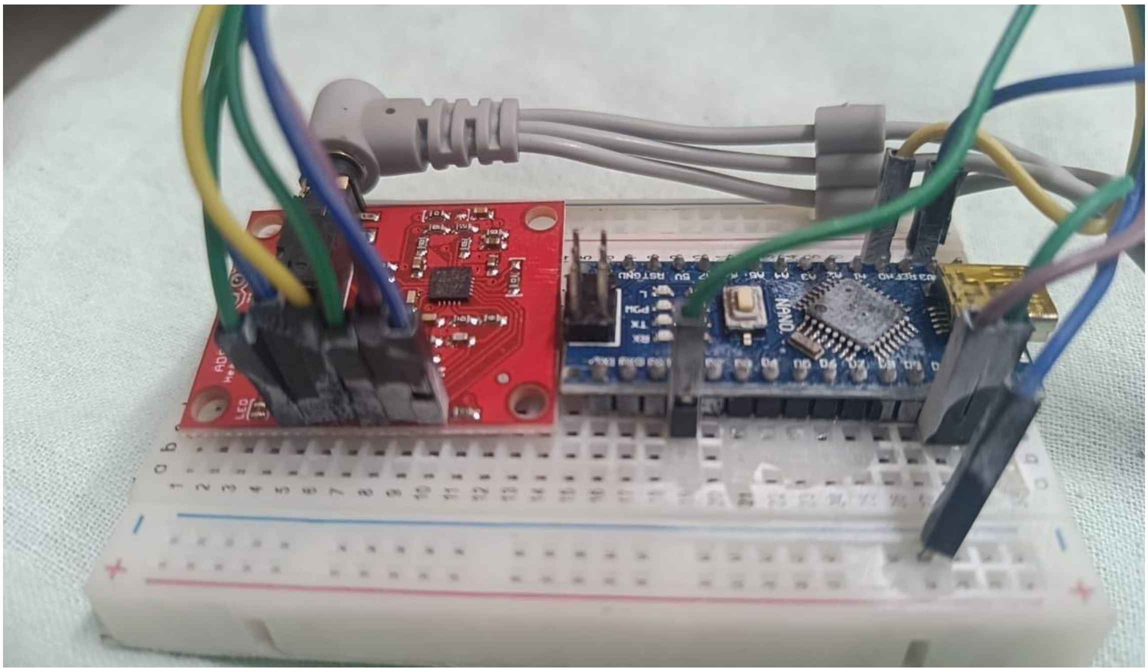


Fig 5.3(Implemented circuit)

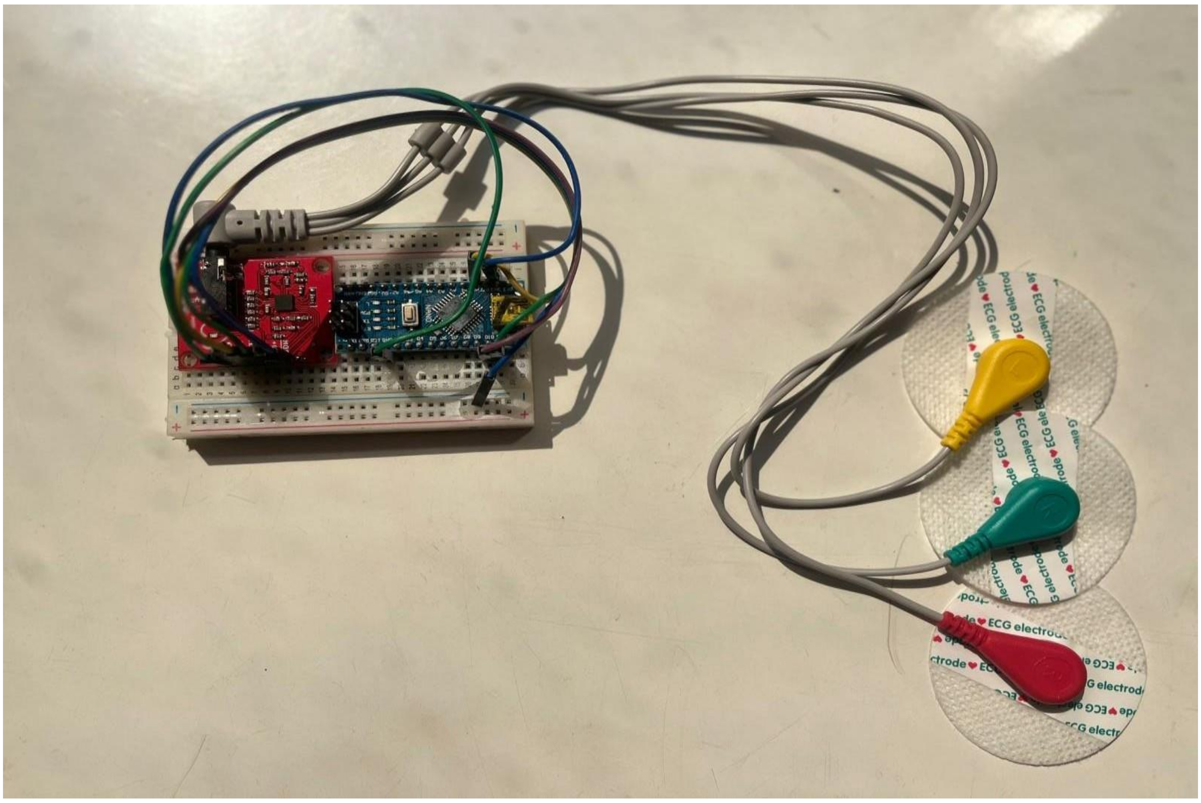


Fig 5.4(ECG Model)

5.3 Real time working of our machine

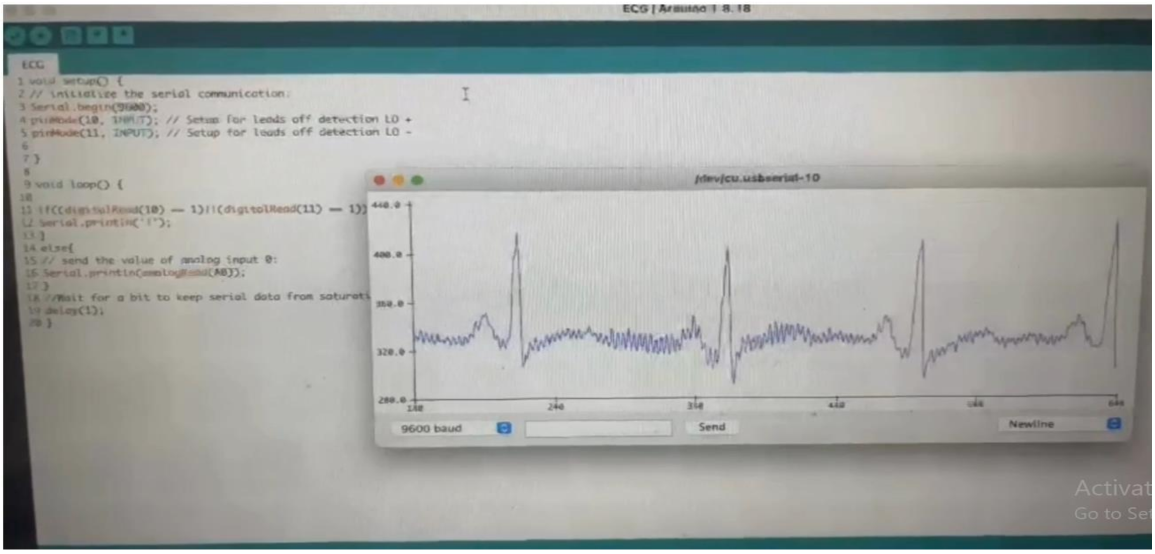


Fig 5.10 (ecg readings)

We tested our system by connecting two electrodes to the subjects' wrists, one on the right wrist and the other on the left wrist. A third electrode was placed on the

Subject’s right leg. Allows easy movement of radio components. Real-time ECG and exercise data are displayed on the laptop screen simultaneously. The main value in determining dangerous arrhythmias is heart rate. In order to calculate the heart rate, our device must receive an ECG within 60 seconds, this is sufficient. Since we already know the formula for determining heart rate, we rewrite the formula as a function similar to the following:where 60 is the number of seconds. A minute is a period of time expressed in R-R’ seconds.

$$\text{heart rate} = \frac{60}{R\text{-}R'}$$

The heart rate measurement model written in JavaScript programming language is as follows:

```
if (self.seconds >= 60) {
self.chss = parseInt(len / 360);
self.rr = 60 / parseInt(len / 360);
```

After receiving these results, we can easily identify two dangerous diagnoses: "sinus bradycardia" and "sinus tachycardia". More precisely, if the heart rate is very low, that is, below 45 beats per second, "sinus bradycardia" is diagnosed.

5.4 Some existing portable ECG machines:

1. Sunfox Spandan ECG: The founder of spandan ECG is Rajat Jain. He is a social entrepreneur. He came to shark tank India to promote Spandan where all the sharks invested Rs.1 crore in exchange for 6% equity of the company. It is a 12 lead ECG Device. It weighs only 12 grams and has an accuracy of 99.7%.

Fig. 5.5(Spandan ECG) (Ref.www.sSunfox Spandan ECG.com)

2. Omron portable ECG machine: The founder of Omron is Kazuma Tateise. Its price starts from Rs.9000

Fig.5.6 (Omron portable ECG Machine) (Ref. https://www.omronbrandshop.com/ecg-machine

3. Dr. Trust portable smart Bluetooth connect digital ECG pen: Indian cricketer Rohit Sharma is the brand ambassador of Dr. Trust. It is very cheap as it costs only RS.3500

Fig 5.7 (Dr. Trust portable smart Bluetooth connect digital ECG pen)
(Ref. https://drtrust.in/products/dr-trust-usa-portable-smart-bluetooth-connect-Digital-ecg-pen-handheld-heart-rate-measurement-monitor-machine- electrocardiogram-medical-grade-electrotherapy-device?

3. **Sanketlife 2.0:** This is the smallest portable ECG machine. It is a 12 lead ECG Device. Their main motive is to empower individuals to take charge of their health and keep a regular check on their heart.

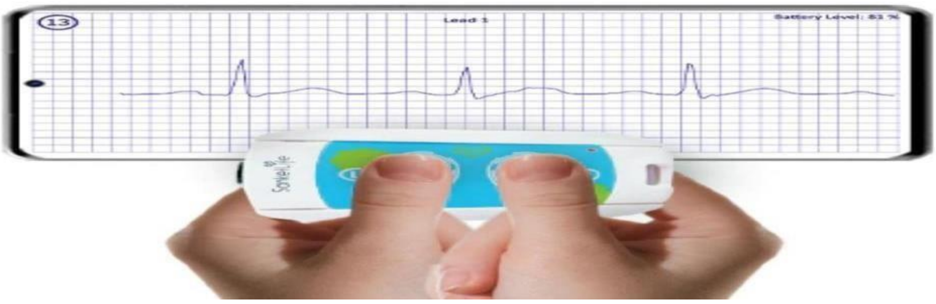


Fig.5.8 (Snakelike 2.0) (Ref. https://www.sanketlife.in/)

5.5 Discussion

Out of the fifteen devices that we analysed, only six have undergone evaluation and been documented in the fields of biomedicine. Despite a limited number of publications, there is enough material to demonstrate the principle and benefit of these devices. There are a variety of devices which are available, which can be genetically classed as single foot lead and multiple lead devices. Single lead devices can identify aberrant rhythms and can be used with or without an ECG monitor. Multiple lead devices use chest patches/electrodes and may be useful in detecting aberrant rhythms as well as localizing ischemia problems.

This discovery is positive because it might improve a measurement's ease of use in a variety of contexts [28].These include primary care clinics, particularly in areas with low health resources; the health promotion industry (e.g., fitness centers, sports teams, and physical activity advancement centers); and households with people who are more likely to experience cardiovascular events. Even though technology might need to advance before it can be utilized widely, it's important to consider and talk about potential risks, especially in cases where it might be difficult to get medical care in an emergency.

5.6 Cost Analysis Table:

Cost Item	**Portable ECG machine (in rupee)**	**Traditional ECG machine (in rupee)**	**Cost Saving**
ECG Electrodes	300	6000	70%
A microcontroller	400	-	-
Arduino NANO	600	-	-
Display	500	20000	-
Battery	900	-	-
Another components	1000	-	-
total manufacturing cost	3700	90,000	88.7%

Table 2:

CHAPTER-6:

6.1 Conclusion

One important innovation that allows users to conveniently and flexibly monitor their heart health is the portable ECG equipment. With its electrodes, this small device records the electrical activity of the heart, providing important information about how it works. Because of its user-friendly design, people with different levels of technical proficiency can access it.

With just one button press, users can quickly attach the electrodes to their chest and start the ECG recording process. The heart's electrical impulses are then clearly displayed graphically by the device, emphasizing any unusual behaviors. Those who are interested in prepared health monitoring or who are managing ongoing heart disease will find this information useful.

Additionally, the gadget frequently syncs easily with mobile apps, enabling users to store, examine, and share their ECG data with medical experts. This skill allows for more rapid interventions and enhances overall cardiovascular health management. The mobility and simplicity of the ECG equipment represent a big step towards democratizing heart health, permitting individuals to maintain a healthy and well-functioning heart on their own.

Create a smart heart monitor that provides three levels of ECG analysis: automatic high-speed ECG analysis (mode: "autonomous"), automatic differential ECG analysis ("device-server" mode), and use the heart office to perform detailed treatment ("Device >Server" mode). Doctor). A detailed diagram of the operation of the equipment was created and produced according to the design requirements. The review was based on the design of the working block diagram, the product selection process and the base material for the selected hardware design of ECG device. After the base was selected, a drawing of the mobile electrocardiogram machine was created. Particular attention is paid to the functional composition of the device and reduced energy consumption.A printed circuit board was created for the device according to the design drawing.Mobile application software is designed to receive signals from the electrocardiogram recorder, perform preliminary processing, check vital signs, notify patients of examination disorders,send data to the application server. We evaluated the effectiveness of the design process.The signal-to-noise ratio of the output signal is good and all features required for clinical evaluation (P waves, QRS complexes and T waves in water) are clearly readable.

6.2 Future Scope:

The future of portable ECG machines looks promising, with ongoing advancements in technology and healthcare delivery. Some future prospects for portable ECG devices include:

1. Integration with Wearable Technology: Portable ECG devices are increasingly being integrated with wearable technology, such as smartwatches and fitness trackers, to provide continuous, real-time monitoring of cardiac activity. This integration allows for seamless and unobtrusive monitoring of cardiac health, empowering individuals to take proactive steps to improve their cardiovascular well-being.
2. Artificial Intelligence (AI) and Machine Learning: AI and machine learning algorithms are being developed to analyze ECG data and detect subtle patterns and abnormalities that may indicate underlying cardiac pathology. These algorithms can improve the accuracy and efficiency of ECG interpretation, enabling earlier diagnosis and intervention.

3. Remote Patient Monitoring Platforms: Portable ECG devices are expected to play a central role in the expansion of telemedicine and remote patient monitoring platforms. These platforms allow patients to perform ECG tests at home and transmit the data to their healthcare providers for analysis and interpretation. Remote monitoring enables timely intervention, reduces healthcare costs, and improves patient outcomes.

4. Personalized Medicine: The integration of portable ECG devices with other health monitoring technologies, such as genetic testing and biomarker analysis, holds promise for the development of personalized treatment strategies for cardiovascular disease. By combining multiple sources of health data, healthcare providers can tailor treatment plans to individual patients, optimizing therapeutic outcomes and reducing the risk of adverse events.

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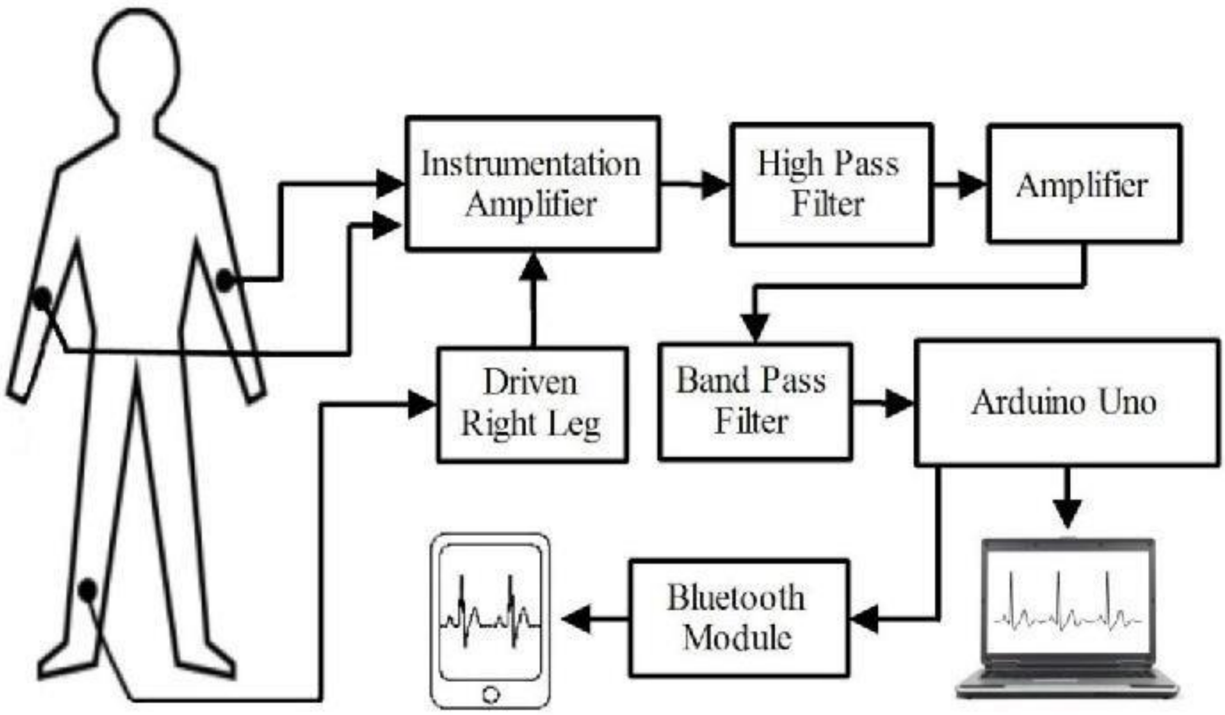
APPENDIX

A1: Circuit Diagram



A2: Code snippets

Signal Processing Algorithm (Arduino):

```
int ecgBuffer[100];
int ecgBufferIndex = 0;

void processECGSignal(int ecgValue) {
  // Store ECG value in the buffer
```

```
  ecgBuffer[ecgBufferIndex] = ecgValue;
  ecgBufferIndex++;

  // If buffer is full, process the data
  if (ecgBufferIndex == 100) {
    // Process ECG signal (e.g., calculate heart rate)
    int heartRate = calculateHeartRate(ecgBuffer, 100);

    // Print heart rate to serial monitor
    Serial.print("Heart Rate: ");
    Serial.println(heartRate);

    // Reset buffer index for next set of readings
    ecgBufferIndex = 0;
  }
}

int calculateHeartRate(int buffer[], int length) {
  // Example heart rate calculation
  // This is a simplified example and may not be accurate
  int sum = 0;
  for (int i = 0; i < length; i++) {
    sum += buffer[i];
  }
  int average = sum / length;

  // Assume heart rate is roughly 60 beats per minute
  // This is a placeholder for a more sophisticated algorithm
  int heartRate = 60;
```

```
  return heartRate;
}

void loop() {
  // Simulated ECG signal value (replace with actual signal reading)
  int ecgValue = analogRead(A0);

  // Process ECG signal
  processECGSignal(ecgValue);

  // Delay to simulate real-time signal processing
  delay(10);
}
```

A3: Instrumentation Amplifier Data Sheet

Manufacturer: Analog Devices
Model: AD620
Website: AD620 Data Sheet

Technical Specifications:

Supply Voltage: ± 2, 3 V to ± 18V
Input offset voltage: 50µV maximum
Gain range: 1 to 10,000
Bandwidth: 1.0MHz
Input bias current: 1.0nA maximum
Pin output information:

Pin 1 (REF): Amplifier reference

Pin 2 (IN-): Inverting input

Pin 3 (IN+): Non-inverting input

Pin 4 (VS-): Negative power 5 (OUT): Amplified output

Pin 6 (VS+): Positive power supply

Pin 7 (RG): Gain adjustment resistor connection

ADC Datasheet

>Hufacturer: Texas Instruments

Model: ADS1115 < br>Website: ADS1115 Datasheet

Specifications:

Resolution: up to 16 bit

Sampling rate: up to 860 Samples per second (SPS) Single shot mode

Input Voltage Range: ± 2,048V

Input Impedance: 10MΩ

Pin Information:

Pin 1 (A0): Address Selection Device

Pin 2 (A1)): Address Selection Input

Pin 3 (A2): Address Selection Input

Pin 4 (GND): Ground

Pin 5 (SCL): I2C Serial clock

Pin 6 (SDA): I2C data connection

Pin 7 (ALERT/RDY)): Output warning or ready indicator

Pin 8 (VDD): Supply has a good effect

draft8

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