KEMENTERIAN PENDIDIKAN MALAYSIA

POLITEKNIK SULTAN SALAHUDDIN ABDUL AZIZ SHAH

# E-CARDIO STETHO KIT

FATIN NUR FARHAH NAJIHAH BINTI HARNAPI
08DEU14F1063
NUR LIYANA BINTI HASHIM 08DEU14F1073
NUR IZZATI KHAIRANI BINTI KAMAR 08DEU14F1027
NURHAYATI BINTI MOHD HAMZAH 08DEU14F1043

POLITEKNIK SULTAN SALAHUDDIN ABDUL
AZIZ SHAH

# E-CARDIO STETHO KIT

**FATIN NUR FARHAH NAJIHAH BINTI HARNAPI 08DEU14F1063**
**NUR LIYANA BINTI HASHIM 08DEU14F1073**
**NUR IZZATI KHAIRANI BINTI KAMAR 08DEU14F1027**
**NURHAYATI BINTI MOHD HAMZAH 08DEU14F1043**

This Report Is Submitted In Partial Fulfillment Of The
Requirements For Diploma Electronic Engineering (Medical)

Jabatan Kejuruteraan Elektrik
Politeknik Sultan Salahuddin Abdul Aziz Shah

**DEC 2016**

# ENDORSEMENT

**"I hereby acknowledge that I have read this report and I find that its contents meet the requirements in terms of scope and quality for the award of the Diploma in Electronic Engineering (Medical)"**

Signature : ..................................................

DR. HJ. ZUNUWANAS BIN MOHAMAD
KETUA PROGRAM
IJAZAH SARJANA MUDA TEKNOLOGI KEJURUTERAAN ELEKTRONIK
(ELEKTRONIK PERUBATAN)
POLITEKNIK SULTAN SALAHUDDIN
ABDUL AZIZ SHAH

Name of Supervisor : ..................................................

Date : 29/3/17

Signature : ..................................................

Name of Supervisor : ..................................................

Date : ..................................................

Signature : ...............................................

Name of Supervisor : ...............................................

Date : ...............................................

# DECLARATION

"We hereby declare that the work in this report is our own except for quotation and summaries which have been duly acknowledge"

Signature : ..........................................

Name : FATIN NUR FARHAH NAJIHAH BINTI HARNAPI

Registration No. : 08DEU14F1063

Date : 13.3.2017

Signature : ..........................................

Name : NUR LIYANA BINTI HASHIM

Registration No. : 08DEU14F1073

Date : 13.3.2017

Signature : ......................................

Name : NUR IZZATI KHAIRANI BINTI KAMAR

Registration No. : 08DEU14F1027

Date : 13.3.2017

Signature : ......................................

Name : NURHAYATI BINTI MOHD HAMZAH

Registration No. : 08DEU14F1043

Date : 13.3.2017

# ACKNOWLEDGEMENT

Firstly, we would like to praise our gratitude to Allah S.W.T. for giving us the strength during the development of the project. Individuals, lectures, practitioners, colleagues, and family members had helped us throughout the process of completing the project. They had been patience and understand upon my mistake, misinterpretation, and misdirection and had guided us back towards the right path.

We are heartily thankful to our supervisors Engr. Dr. Zunuwanas Bin Mohammad, Puan Fariza Binti Zahari and Puan Mariana Binti Rosdi whose encourage, guidance and support from the initial to the final level, enabled us to develop and improve the understanding of the subject.

Lastly, we offer our regard and blessing to all of those who supported us in any aspect during the completion of the project.

## ABSTRACT

Learning process is an important thing in student's life and sometimes it was not easy to go through it. For students with medical related field such as medical practitioner and biomedical engineering, heart auscultation and interpretation is a compulsory knowledge for them. Acoustic stethoscope is a medical device used for heart auscultation. However, the low sound level of acoustic stethoscope give a limit to new medical field students to recognizing the real heart sound. Interpretation of heart is gained based on heart rhythm by the recording of Electrical activity of the heart (Electrocardiography or ECG). An Electrocardiogram (ECG) is a complex device with the high price. It is not going to be used oftenly by students for the learning purpose as it has a high tendency for the machine to broken and thus can lead to the lost. A few researches such as survey has been carried out in order to find the idea and recommendation. Therefore, we intend to develop a new device with capability to amplify the low sound level of stethoscope and displaying heart rhythm (ECG) signal. The stethoscope was innovated with amplifier to produce the amplified sound of heart beat. At the same time, Arduino UNO was programmed to receive data from ECG module while Bluetooth module was used to transfer the data from ECG module to smart phone. The result will be displayed by the application on the smart phone simultaneously. The data contains ECG waveform and heart rate reading. This ideas combines a stethoscope and an Electrocardiogram (ECG) into one device called E-Cardio Stetho. Thus, the students and users can analyze the heart rhythm in the real time with the heart sound. This combination of ideas can bring a new method in learning process to medical field students and trainee.

# ABSTRAK

Bagi pelajar jurusan yang berkaitan dengan perubatan seperti doktor, pengamal perubatan dan jurutera biomedikal, auskultasi dan interpretasi jantung adalah pengetahuan dan kemahiran asas yang perlu ada dan diketahui oleh mereka . Stetoskop akustik adalah satu alat perubatan yang digunakan untuk auskultasi jantung. Walau bagaimanapun, tahap bunyi stetoskop yang rendah mempunyai had yang tertentu yang mana memberi masalah kepada pelajar baru untuk mengenali bunyi jantung yang sebenar. Interpretasi jantung pula diperoleh daripada paparan rentak jantung oleh aktiviti elektrikal jantung (yang dikenali sebagai Elektrokardiograf atau EKG). Elektrokardiogram (EKG) adalah satu alatan perubatan berkos tinggi. Dan tidak sesuai digunakan oleh pelajar dengan terlalu kerap kerana mempunyai kecenderungan yang tinggi untuk rosak. Beberapa kajian seperti soal selidik telah dijalankan dalam usaha untuk mendapatkan idea dan cadangan. Oleh itu, kami membuat keputusan untuk mencipta satu alat yang mempunyai keupayaan untuk menguatkan tahap bunyi stetoskop yang rendah dan memaparkan rentak jantung (EKG). Stetoskop diinovasikan dengan penguat untuk menghasilkan bunyi degupan jantung yang kuat. Pada masa yang sama, Arduino UNO diprogramkan untuk menerima data dan maklumat daripada modul EKG. Modul Bluetooth pula digunakan untuk menghantar maklumat tersebut ke telefon pintar. Keputusan akan dipaparkan oleh aplikasi yang terdapat di dalam telefon pintar. Maklumat tersebut mengandungi bentuk gelombang EKG dan bacaan kadar degupan jantung. Idea ini menggabungkan stetoskop dan Elektrokardiogram (EKG) di dalam satu alat yang diberi nama 'E-Cardio Stetho Kit'. Oleh itu, pelajar dan pengguna boleh menganalisa ritma jantung dalam masa sebenar dengan bunyi degupan jantung. Gabungan idea ini membawa satu kaedah baru dalam proses pembelajaran kepada pelajar dan pelatih bidang perubatan.

# TABLE OF CONTENT

# CHAPTER 1

# INTRODUCTION

## 1.1 Background of study

Stethoscope is an acoustic device used for auscultation, or listening to the internal sounds of an animal and human body. Heart auscultation is a way for a doctor or medical practitioner to determine and early diagnose of heart disease of a patient. Heart diseases also can be diagnosed by recording the Electrical activity of the heart (Electrocardiography or ECG). Chest pains may indicate a heart problem but if symptoms are not there while the test is done in a hospital, the ECG could turn out absolutely normal.

This project are going to present a new low cost learning device for new medical field students. This device was a combination of two simple devices with latest technology to give the overview of the heart condition to the student. This learning device can help to amplify the low sound level of stethoscope so that can produce amplified sound of heart beat. At the same time, it will also visualized the real time electrical activity of the heart (known as Electrocardiograph) and heart rate reading on the application of smartphone. So, the students can listen to heart beat and watch heart rhythm simultaneously.

In this project, we combine a stethoscope, an ECG device and application of smartphone in order to produce a new beneficial device. E-Cardio Stetho Kit is a new implementation for learning purpose.

## 1.2 Problem statement

Heart auscultation has been very important method for early diagnosis f heart beat disease by capturing the abnormal heart sounds. A stethoscope is an acoustic medical device used for heart auscultation. However, there were several weakness that need to be improved. Despite of the advantages, auscultation of the heart has been traditionally limited by a few factors. The interpretation of the heart sound is very subjective and it depends largely on the experienced, skills and hearing ability of the physician. The low sound level of the stethoscope give a limit to new medical field students or trainee to recognizing the real heart sound.

The other problem is that an ECG device is a complex device with the high price. It is not going to be used by students frequently for the learning purpose as it has a high tendency for the machine to broken and thus can lead to the lost. Developed from this understanding of the problem, there is need a simple device that can amplified the sound of heart beat in order to help the student to learn the real \sound of heart beat, showing the relationship between heart beat and real time Electrocardiograph and enhancing their understanding between the sound of heart beat and ECG.

## 1.3 Objective

There were several objectives regarding the project which consist of:

i. To develop amplifier for low sound level of acoustic stethoscope
ii. To innovate a device that amplified the low sound level of stethoscope.
iii. To produce a new device for learning purpose

## 1.4 Study population

In order to complete the task, a few researches was carried out through the internet, studies and interviews. A survey has also been done within some medical students from a medical institution in Shah Alam. And a few medical practitioner from several clinics around Shah Alam. Questionnaires were given to them to fill in. From the survey, we get a good feedback and also some opinion from them regarding our project. Through the research and the opinion that we gained, it's allowed the team to begin compiling problem statements pertaining to the specific observation logged during rounds.

## 1.5 Sample size & sampling technique

Upon completing the product, evaluation test has been carried out in order to analyses and determine the usability and safety of our product. Krejcie and Morgan table was used in order to determine the size of sample for the test.

**Table 1.1:** Krejcie & Morgan Sample Size Determination Table

*Table for Determining Sample Size of a Known Population*

| N | S | N | S | N | S | N | S | N | S |
|---|---|---|---|---|---|---|---|---|---|
| 10 | 10 | 100 | 80 | 280 | 162 | 800 | 260 | 2800 | 338 |
| 15 | 14 | 110 | 86 | 290 | 165 | 850 | 265 | 3000 | 341 |
| 20 | 19 | 120 | 92 | 300 | 169 | 900 | 269 | 3500 | 346 |
| 25 | 24 | 130 | 97 | 320 | 175 | 950 | 274 | 4000 | 351 |
| 30 | 28 | 140 | 103 | 340 | 181 | 1000 | 278 | 4500 | 354 |
| 35 | 32 | 150 | 108 | 360 | 186 | 1100 | 285 | 5000 | 357 |
| 40 | 36 | 160 | 113 | 380 | 191 | 1200 | 291 | 6000 | 361 |
| 45 | 40 | 170 | 118 | 400 | 196 | 1300 | 297 | 7000 | 364 |
| 50 | 44 | 180 | 123 | 420 | 201 | 1400 | 302 | 8000 | 367 |
| 55 | 48 | 190 | 127 | 440 | 205 | 1500 | 306 | 9000 | 368 |
| 60 | 52 | 200 | 132 | 460 | 210 | 1600 | 310 | 10000 | 370 |
| 65 | 56 | 210 | 136 | 480 | 214 | 1700 | 313 | 15000 | 375 |
| 70 | 59 | 220 | 140 | 500 | 217 | 1800 | 317 | 20000 | 377 |
| 75 | 63 | 230 | 144 | 550 | 226 | 1900 | 320 | 30000 | 379 |
| 80 | 66 | 240 | 148 | 600 | 234 | 2000 | 322 | 40000 | 380 |
| 85 | 70 | 250 | 152 | 650 | 242 | 2200 | 327 | 50000 | 381 |
| 90 | 73 | 260 | 155 | 700 | 248 | 2400 | 331 | 75000 | 382 |
| 95 | 76 | 270 | 159 | 750 | 254 | 2600 | 335 | 1000000 | 384 |

*Note: N is Population Size; S is Sample Size* *Source: Krejcie & Morgan, 1970*

All respondents selected for the evaluation test are from Polytechnic of Sultan Salahuddin Abdul Aziz Shah, Shah Alam. Two samples were obtained. The sample included of 40 students of Medical Electronic Engineering Course that were randomly chosen. These students are semester six students that have undergoing their practical training in either hospitals or biomedical company. In this sample, a questionnaire was distributed to the students. From the sample, 65% from them were female students while another 35% were male students.

## 1.6 Significant of study

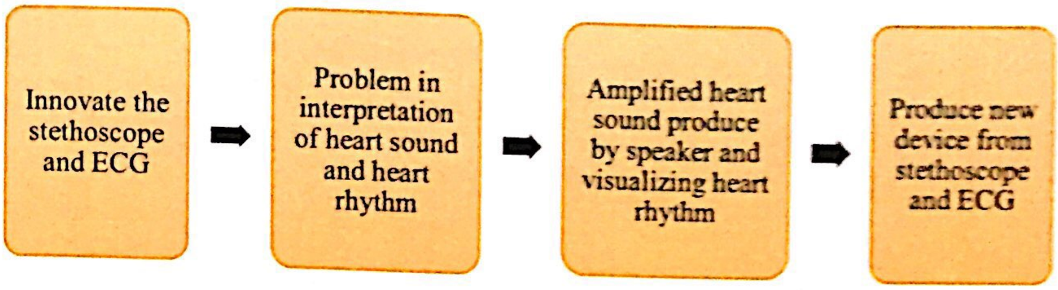



**Figure 1.1:** Significant of Study

## 1.7 Theoretical of study

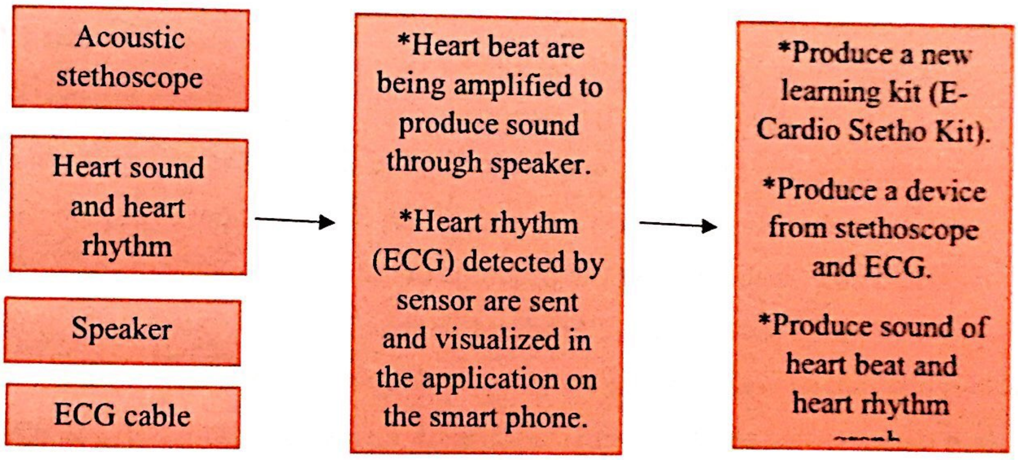



**Figure 1.2:** Theoretical of Study

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Introduction

A literature review is a body of text that aims to review the critical points of current knowledge or methodological approaches on a particular topic. Literature review are secondary sources, and as such, do not report any new or original experimental work. Most often associated with academic-oriented literature, such as these, a literature review usually precedes a research proposal and result section. Its ultimate goal is to bring the reader up to date with current literature on a topic and forms the basis for another goal, such as future research that may be needed in the area.

## 2.2 Clinical Information

### 2.2.1 Sound

Sound detected by ears. An ear has an eardrum inside, connected to three small bones. The vibrations in the air make the eardrum vibrate, and these vibrations are passed through the three small bones (called ossicles) to a spiral structure called the cochlea. Signals are passed from the cochlea to the brain through the auditory nerve, and our brain interprets these signals as sound.The ear has external, middle, and inner portions. The outer ear is called the pinna and is made of ridged cartilage covered by skin. Sound funnels through the pinna into the external auditory canal, a short tube that ends at the eardrum (tympanic membrane).

Sound causes the eardrum and its tiny attached bones in the middle portion of the ear to vibrate, and the vibrations are conducted to the nearby cochlea. The spiral-shaped cochlea is part of the inner ear; it transforms sound into nerve impulses that travel to the brain.The fluid-filled semicircular canals (labyrinth) attach to the cochlea and nerves in the inner ear. They send information on balance and head position to the brain. The eustachian (auditory) tube drains fluid from the middle ear into the throat (pharynx) behind the nose.

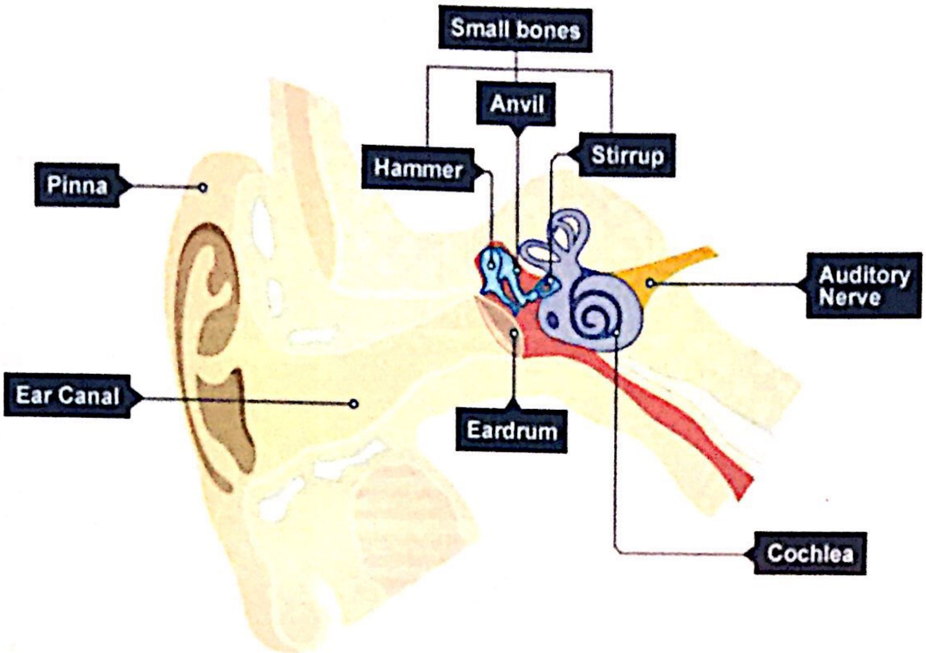



**Figure 2.1:** The inner structure of the ear

#### 2.2.1.1 Microphones

Mobile phones and telephones contain microphones. These devices contain a diaphragm, which does a similar job to an ear drum. The vibrations in air make the diaphragm vibrate, and these vibrations are changed to electrical impulses. In the lab, the electrical impulses can be sent to an oscilloscope, which represents them as a graph on a screen.

#### 2.2.1.2 Oscilloscope Traces

The graphs shown by an oscilloscope are called oscilloscope traces. The diagrams show some typical oscilloscope traces for sound:

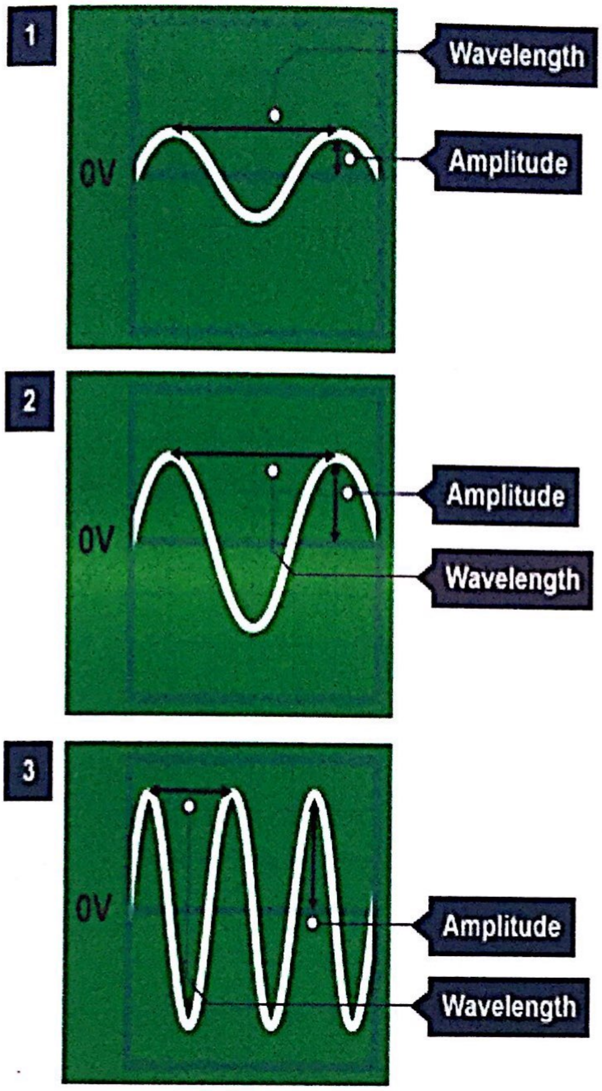



**Figure 2.2:** Oscilloscopes traces for sound waves

**For a wave:**

1. the **amplitude** is the maximum height of the wave from its resting position – the greater the amplitude, the louder the sound
2. the **wavelength** is the distance between the crests (tops) of two waves next to each other (or any other two identical point on waves next to each other)
3. the **frequency** is the number of waves per second – the higher the frequency, the closer together the waves are and the higher the pitch

Diagrams 1 and 2 show two sounds with the same wavelength and frequency, so they will have the same pitch. The sound in diagram 2 has a greater amplitude than the one in diagram 1, so it will be louder.

Diagrams 2 and 3 show two sounds with a different wavelength and frequency. The sound in diagram 3 has a higher frequency than the one in diagram 2, so its pitch will be higher.

### 2.2.2 Heart

#### 2.2.2.1 How the Heart Works

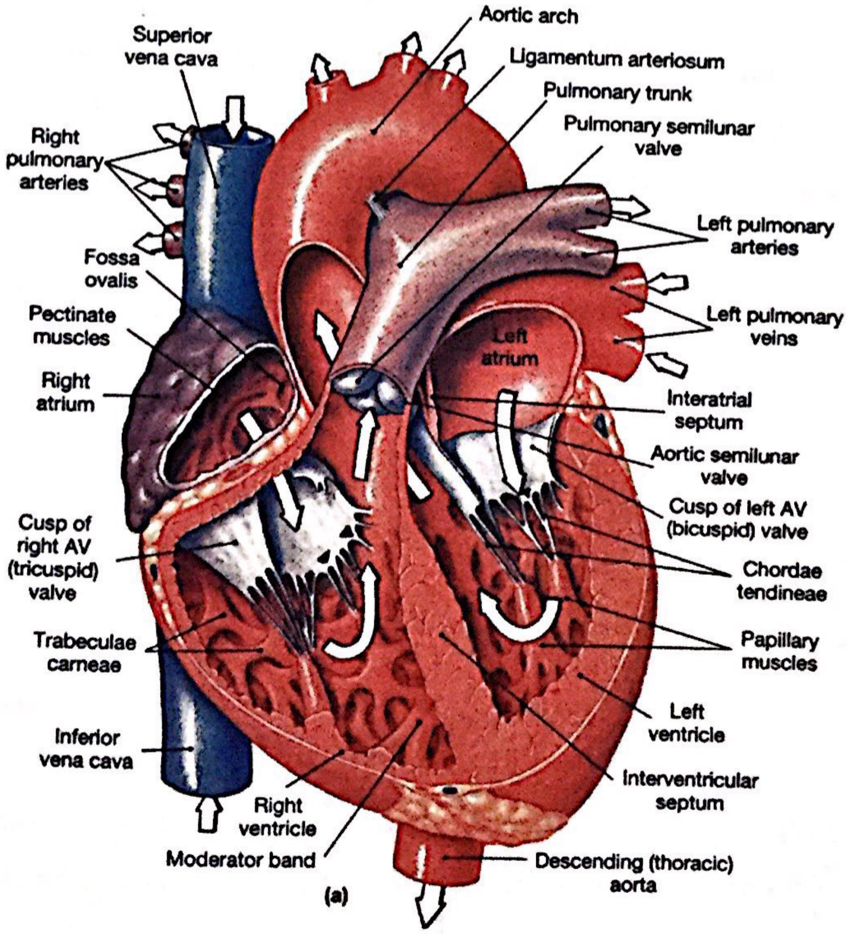



**Figure 2.3:** Anatomy of Heart

Heart is a pump. It's a muscular organ about the size of fist, situated slightly left of centre in chest. Heart is divided into the right and the left side. The division protects oxygen-rich blood from mixing with oxygen-poor blood. Oxygen-poor blood returns to the heart after circulating through body. The right side of the heart, comprising the right atrium and ventricle, collects and pumps blood to the lungs through the pulmonary arteries. The lungs refresh the blood with a new supply of oxygen. The lungs also breathe out carbon dioxide, a waste product. Oxygen-rich blood then enters the left side of the heart, comprising the left atrium and ventricle. The left side of the heart pumps blood through the aorta to supply tissues throughout the body with oxygen and nutrients.

#### 2.2.2.2 Heart valves

Four valves within hearts, blood will moved in right way by opening only one way and only when they need to. To function properly, the valve must be formed properly, must open all the way and most close tightly so there's no leakage. The four valves are:

1. Tricuspid
2. Mitral
3. Pulmonary
4. Aortic

#### 2.2.2.3 Heartbeats

A beating heart contracts and relaxes in a continuous cycle. During contraction (systolic), ventricles are contracted, forcing blood into the vessels to lungs and body. During relaxation (diastole), the ventricles are filled with blood coming from the upper chambers (left and right atria).

#### 2.2.2.4 Electrical system

Heart's electrical wiring keeps it beating, which controls the continuous exchange of oxygen-rich blood with oxygen-poor blood. This exchange keeps people alive. Electrical impulses begin high in the right atrium and travel through specialized pathways to the ventricles, delivering the signal for the heart to pump. The conduction system keeps heart beating in a coordinated and normal rhythm, which keeps blood circulating.

#### 2.2.2.5 Heart Disease

Heart disease describes a range of conditions that affect your heart. Diseases under the heart disease umbrella include blood vessel diseases, such as coronary artery disease; heart rhythm problems (arrhythmias); and heart defects you're born with (congenital heart defects), among others.

The term "heart disease" is often used interchangeably with the term "cardiovascular disease." Cardiovascular disease generally refers to conditions that involve narrowed or blocked blood vessels that can lead to a heart attack, chest pain (angina) or stroke. Other heart conditions, such as those that affect your heart's muscle, valves or rhythm, also are considered forms of heart disease.

##### 2.2.2.5.1 Symptom of Disease

Heart disease symptoms depend on what type of heart disease of patient:

1. Symptoms of heart disease in blood vessels (atherosclerotic disease)
   Cardiovascular disease is caused by narrowed, blocked or stiffened blood vessels that prevent your heart, brain or other parts of your body from receiving enough blood. Cardiovascular disease symptoms may be different

for men and women. For instance, men are more likely to have chest pain; women are more likely to have symptoms such as shortness of breath, nausea and extreme fatigue.

Symptoms can include:

a) Chest pain (angina)
b) Shortness of breath
c) Pain, numbness, weakness or coldness in your legs or arms if the blood vessels in those parts of your body are narrowed
d) Pain in the neck, jaw, throat, upper abdomen or back

Patient might not be diagnosed with cardiovascular disease until you have a heart attack, angina, stroke or heart failure. It's important to watch for cardiovascular symptoms and discuss concerns with your doctor. Cardiovascular disease can sometimes be found early with regular exams.

2. Heart disease symptoms caused by abnormal heartbeats (heart arrhythmias)

A heart arrhythmia is an abnormal heartbeat. Heart may beat too quickly, too slowly or irregularly. Heart arrhythmia symptoms can include:

a) Fluttering in chest
b) Racing heartbeat (tachycardia)
c) Slow heartbeat (bradycardia)
d) Chest pain or discomfort
e) Shortness of breath
f) Light headedness
g) Dizziness
h) Fainting (syncope) or near fainting

3. Heart disease symptoms caused by heart defects

   Serious congenital heart defects — defects if were born with — usually become evident soon after birth. Heart defect symptoms in children could include:

   a) Pale grey or blue skin colour (cyanosis)
   b) Swelling in the legs, abdomen or areas around the eyes

4. In an infant, shortness of breath during feedings, leading to poor weight gain

   Less serious congenital heart defects are often not diagnosed until later in childhood or during adulthood. Signs and symptoms of congenital heart defects that usually aren't immediately life-threatening include:

   a) Easily getting short of breath during exercise or activity
   b) Easily tiring during exercise or activity
   c) Swelling in the hands, ankles or feet

5. Heart disease symptoms caused by weak heart muscle (dilated cardiomyopathy)

   Cardiomyopathy is the thickening and stiffening of heart muscle. In early stages of cardiomyopathy, patient may have no symptoms. As the condition worsens, symptoms may include:

   a) Breathlessness with exertion or at rest
   b) Swelling of the legs, ankles and feet
   c) Fatigue
   d) Irregular heartbeats that feel rapid, pounding or fluttering
   e) Dizziness, light headedness and fainting

6. Heart disease symptoms caused by heart infections. There are three types of heart infections:
   a) Pericarditis, which affects the tissue surrounding the heart (pericardium)
   b) Myocarditis, which affects the muscular middle layer of the walls of the heart (myocardium)
   c) Endocarditis, which affects the inner membrane that separates the chambers and valves of the heart (endocardium)
   d) Varying slightly with each type of infection, heart infection symptoms can include:
      i. Fever
      ii. Shortness of breath
      iii. Weakness or fatigue
      iv. Swelling in your legs and abdomen
      v. Changes in your heart rhythm
      vi. Dry or persistent cough
      vii. Skin rashes or unusual spots

7. The heart has four valves — the aortic, mitral, pulmonary and tricuspid valves — that open and close to direct blood flow through your heart. Valves may be damaged by a variety of conditions leading to narrowing (stenosis), leaking (regurgitation or insufficiency) or improper closing (prolapse).

### 2.2.2.5.2 Cause of Diseases

The causes of heart disease vary by type of heart disease.

1. Causes of cardiovascular disease
   While cardiovascular disease can refer to different heart or blood vessel problems, the term is often used to mean damage to your heart or blood

vessels by atherosclerosis (ath-ur-o-skluh-ROE-sis), a buildup of fatty plaques in your arteries. Plaque buildup thickens and stiffens artery walls, which can inhibit blood flow through your arteries to your organs and tissues. Atherosclerosis is also the most common cause of cardiovascular disease. It can be caused by correctable problems, such as an unhealthy diet, lack of exercise, being overweight and smoking.

2. Common causes of abnormal heart rhythms (arrhythmias) or conditions that can lead to arrhythmias include:
    a) Heart defects were born with (congenital heart defects)
    b) Coronary artery disease
    c) High blood pressure
    d) Diabetes
    e) Smoking
    f) Excessive use of alcohol or caffeine
    g) Drug abuse
    h) Stress
    i) Some over-the-counter medications, prescription medications, dietary supplements and herbal remedies

3. Valvular heart disease

In a healthy person with a normal, healthy heart, it's unlikely for a fatal arrhythmia to develop without some outside trigger, such as an electrical shock or the use of illegal drugs. That's primarily because a healthy person's heart is free from any abnormal conditions that cause an arrhythmia, such as an area of scarred tissue. However, in a heart that's diseased or deformed, the heart's electrical impulses may not properly start or travel through the heart, making arrhythmias more likely to develop.

4. Causes of congenital heart defects

Heart defects usually develop while a baby is in the womb. Heart defects can develop as the heart develops, about a month after conception, changing the flow of blood in the heart. Some medical conditions, medications and genes may play a role in causing heart defects. Heart defects can also develop in adults. As age, heart's structure can change, causing a heart defect.

5. Causes of cardiomyopathy

The cause of cardiomyopathy, a thickening or enlarging of the heart muscle, may depend on the type:

a) Dilated cardiomyopathy: The cause of this most common type of cardiomyopathy often is unknown. It may be caused by reduced blood flow to the heart (ischemic heart disease), infections, toxins and certain drugs. It also may be inherited from a parent. It usually enlarges (dilates) the left ventricle.
b) Hypertrophic cardiomyopathy: This type, in which the heart muscle becomes abnormally thick, usually is inherited. It can also develop over time because of high blood pressure or aging.
c) Restrictive cardiomyopathy: This least common type of cardiomyopathy, which causes the heart muscle to become rigid and less elastic, can occur for no known reason. Or it may be caused by diseases, such as connective tissue disorders or excessive iron build up in your body (hemochromatosis), or by some cancer treatments, such as chemotherapy and radiation.

6. Causes of heart infection

Heart infections, such as pericarditis, endocarditis and myocarditis, are caused when an irritant, such as a bacterium, virus or chemical, reaches your heart muscle. The most common causes of heart infections include:

a) Bacteria
b) Viruses
c) Parasites
d) Causes of valvular heart disease

There are many causes of diseases of heart valves. People may be born with valvular disease, or the valves may be damaged by conditions such as:

a) Rheumatic fever
b) Infections (infectious endocarditis)
c) Connective tissue disorders

### 2.2.2.6 Arrhythmias, Bradychardia, Tarchycardia

#### 2.2.2.6.1 Normal Heart Rate

What is a Normal Heart Rate?

Heart rate, also known as pulse, is the number of times a person's heart beats per minute. A normal heart rate depends on the individual, age, body size, heart conditions, whether the person is sitting or moving, medication use and even air temperature. Even emotions can have an impact on heart rate. For example, getting excited or scared can increase the heart rate. But most importantly, getting fitter lowers the heart rate, by making heart muscles work more efficiently.

#### 2.2.2.6.2 Categories of Arrhythmias

Arrhythmias are generally divided into two categories: ventricular and supraventricular. Ventricular arrhythmias occur in the lower chambers of the heart, called the ventricles. Supraventricular arrhythmias occur in the area above the ventricles, usually in the upper chambers of the heart, called the atria. The irregular beats can either be too slow (bradycardia) or too fast (tachycardia).

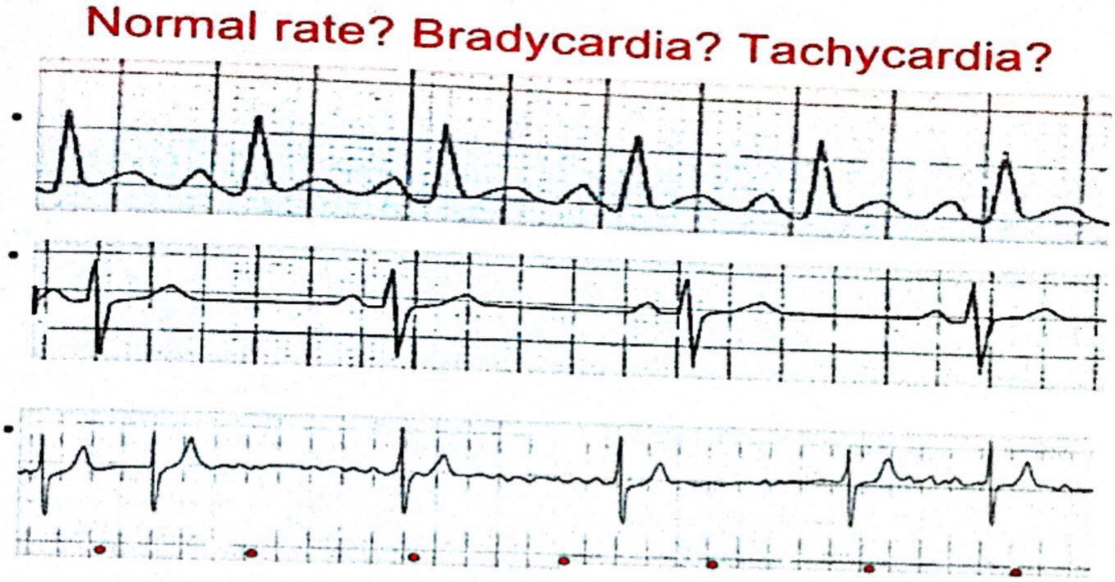



**Figure 2.4:** Heart Rhythm

Bradycardia: Bradycardia is a very slow heart rate of less than 60 beats per minute. It happens when the electrical impulse that signals the heart to contract is not formed in your heart's natural pacemaker, the sinoatrial node (SA node), or is not sent to the heart's lower chambers (the ventricles) through the proper channels. Bradycardia most often affects elderly people, but it may affect even the very young. It may be caused by one of two sources: The central nervous system does not signal that the heart needs to pump more, or the SA node may be damaged. This damage might be related to heart disease, aging, inherited or congenital defects, or it might be caused by certain medicines—including those used to control arrhythmias and high blood pressure.

Tachycardia: Tachycardia is a very fast heart rate of more than 100 beats per minute. The many forms of tachycardia depend on where the fast heart rate begins. If it begins in the ventricles, it is called ventricular tachycardia. If it begins above the ventricles, it is called supraventricular tachycardia.

1. Ventricular Arrhythmias

a) Ventricular Tachycardia

Ventricular tachycardia is a condition in which the SA node no longer controls the beating of the ventricles. Instead, other areas along the lower electrical pathway take over the pacemaking role. Since the new signal does not move through your heart muscle along the regular route, the heart muscle does not beat normally. Your heartbeat quickens, and you feel as if your heart is "skipping beats." This rhythm may cause severe shortness of breath, dizziness, or fainting (syncope).

b) Ventricular Fibrillation

The most serious arrhythmia is ventricular fibrillation, which is an uncontrolled, irregular beat. Instead of one misplaced beat from the ventricles, you may have several impulses that begin at the same time from different locations—all telling the heart to beat. The result is a much faster, chaotic heartbeat that sometimes reaches 300 beats a minute. This chaotic heartbeat means very little blood is pumped from the heart to the brain and body and can result in fainting. Medical attention is needed right away. If cardiopulmonary resuscitation (CPR) can be started, or if electrical energy is used to "shock" the heart back to a normal rhythm, then the heart may not be too damaged. About 220,000 deaths from heart attacks each year are thought to be caused by ventricular fibrillation. People who have heart disease or a history of heart attack have the highest risk of ventricular fibrillation.

c) Premature Ventricular Contractions

A less serious type of ventricular arrhythmia is a premature ventricular contraction (PVC). As the name suggests, the condition happens when the ventricles contract too soon, out of sequence with the normal heartbeat. PVCs (sometimes called PVB for premature ventricular beat) generally are not a cause for alarm and often do not need treatment. But if you have heart disease or a history of ventricular tachycardia, PVCs can cause a more serious arrhythmia. Although most PVCs happen quickly and without warning, they can also happen in response to caffeine, which is found in coffee, tea, sodas, and chocolate. Some kinds of over-the-counter cough and cold medicines may also cause PVCs.

2. Supraventricular Arrhythmias:

Supraventricular arrhythmias begin in the areas above the heart's lower chambers, such as the upper chambers (the atria) or the atrial conduction pathways. Generally, supraventricular or "atrial arrhythmias" are not as serious as ventricular arrhythmias. Sometimes, they do not even require treatment. Like PVCs, atrial arrhythmias can happen in response to a number of things, including tobacco, alcohol, caffeine, and cough and cold medicines. The disorder also may result from rheumatic heart disease or an overactive thyroid gland (hyperthyroidism). Supraventricular arrhythmias can cause shortness of breath, heart palpitations, chest tightness, and a very fast pulse.

i. Supraventricular Tachycardia (SVT) or Paroxysmal Supraventricular Tachycardia (PSVT)

Supraventricular tachycardia (SVT) is a rapid, regular heart rate where the heart beats anywhere from 150-250 times per minute in the atria. Another name for SVT is paroxysmal supraventricular tachycardia (PSVT). The word "paroxysmal" means occasionally or from time to time. Supraventricular tachycardia or PVST happens when electrical signals in the heart's upper chambers fire abnormally, which interferes with electrical signals coming from the SA node (the heart's natural pacemaker). The beats in the atria then speed up the heart rate. This type of arrhythmia is more common in infants and young people. It is also more likely to occur in women, anxious young people, and people who are extremely tired (fatigued). People who drink a lot of coffee or alcohol or who are heavy smokers also have a greater risk.

ii. Atrial Fibrillation

Atrial fibrillation is a fast, irregular rhythm where single muscle fibers in your heart twitch or contract. It is a main cause of stroke, especially among elderly people. Atrial fibrillation may cause blood to pool in the heart's upper chambers. The pooled blood can lead to the formation of clumps of blood called blood clots. A stroke can occur if a blood clot travels from the heart and blocks a smaller artery in the brain (a cerebral artery). For this reason, many patients with atrial fibrillation need antiplatelet therapy. These medicines can prevent blood clots from forming and causing a stroke.

### 2.1.3 ECG Paste


**Figure 2.5:** ECG Paste

#### 2.2.3.1 Operation of Electrodes

The bio-electric potentials generated in the body are ionic in nature and need to be converted into electronic voltages. Devices that convert ionic potentials into electronic potentials are called Electrodes. The voltage developed at an electrode-electrolyte interface is designated as the "Half Cell Potential" or "Electrode Potential".In the case of a metal solution interface, an electrode potential results from the difference in rates between two opposing processes, viz, the passage of ions from the metal into the solution and ii) the combination of metallic ion in solution with electron in the metal to form the atoms of the metal. So when a metal electrode comes in contact with an electrolyte (body fluid), there is a tendency for the electrode to discharge ions into solution and for ions in the electrolyte to combine with the electrodes. The net result is the creation of a charge gradient, the spatial arrangement of which is called the "Electric Double Layer".

Electrodes in which no net transfer of charge occurs across the metal electrolyte interface are called "Perfectly Polarised Electrodes". Electrodes I which unhindered exchange of charge is possible across the metal electrolyte interface are known as "Perfectly Non Polarised Electrodes". Practical electrodes have the properties that lie between these two idealised limits. The following circuit shows the electrical equivalent circuit of a surface electrode when it is in contact with the body surface.

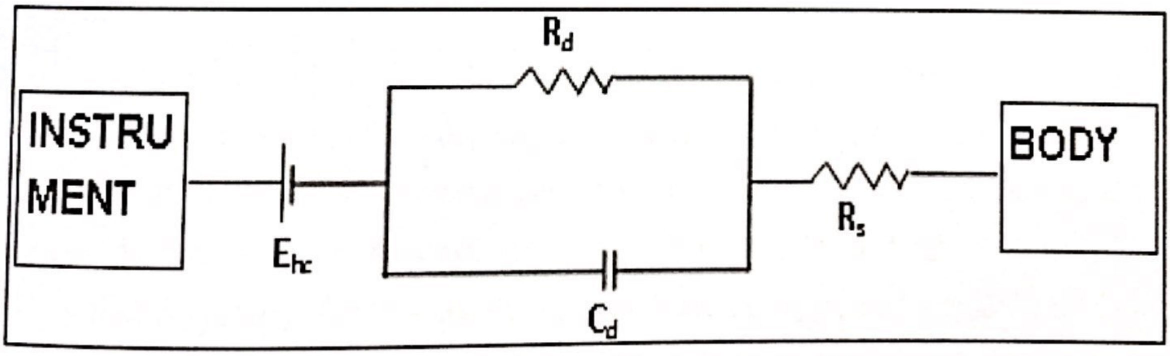



**Figure 2.6:** Equivalent Circuit of Surface Electrode

The electrode electrolyte interface resembles a voltage surface having half cell potential "Ehc" which is developed due to charge gradient and a capacitor "Cd" in parallel with a leakage resistance "Rd". Thus it is obvious from the above expression that the impedance will largely depend upon the electrode metal, its area, the electrolyte, charge density and frequency of the ionic current which is to be converted into electronic potential. The capacitance represents the charge developed at the phase boundary whereas the resistance depends upon the conditions associated with ion migrating along phase boundaries and inside the diaphragm. However, due to above arrangement there is a possibility of the presence of voltages of non-physiological origin. These voltages are called "Contact Potentials".

The electrical equivalent circuit of the surface electrode suggests that voltage applied to the measuring instrument from the electrode consists of two main components[3]: Contact Potential and the Biological signal of interest. The contact potential is found to be a function of the type of skin, skin preparation and composition of the electrolyte. Therefore the differences in skin characteristics can vary widely even on the same body. The emotional state of the patient also affects the electrode potential. When bioelectric events are recorded, interference signals are produced by the differences of metal electrolyte and the electrolyte skin interface. Therefore, in order to minimize this contact potential two electrodes are connected in the opposite directions at two different parts of the body.

### 2.2.3.2 Purpose of Electrode Paste

The outer skin of the body is highly non-conductive and can not establish a good electrical contact with an electrode. The skin should therefore be cleaned thoroughly and rubbed briskly to remove some of the outer cells. This area should then be coated with an electrically conductive paste called "Electrode Paste" that should be "worked in" by further rubbing. The electrode is then applied to the prepared site and held in place with a rubber strap or a length of tape. Thus the electrode paste decreases the impedance of the contact and it also reduces the artefacts resulting from movement of the electrode or the patient.

#### 2.2.3.3 Pasteless ECG Recording Electrodes

The ECG monitoring electrodes – in a majority of cases, are metal plates applied to the skin after preliminary preparation of the skin. Such preliminary preparation may some time rise to poor baseline drift and poor quality signals. Another disadvantage of using electrode paste is that during long term monitoring there is likely to be patient skin reactions as the electrode-skin interface dries out in few hours the electrodes need to be periodically removed for paste replacements., thus causing further discomfort due to repetitive worn over long periods. Also, in conductive electrodes, shift in electrode position at the electrode site causes a drift in the baseline particularly when the subject moves. Therefore the present work of using a dry electrode may dispense with the preparation of skin would definitely look attractive.

#### 2.2.3.4 Fabrication of Dry Electrode (Pasteless electrode)

Anodization: Anodization is a process where by a hard, non-corroding oxide film is deposited on to the pure aluminium. This film is harder and far more scratch-resistant than the pure aluminium itself. It also protects against finger prints which can be areal nuisance.

Ingredients and Equipments Required: Caustic Soda lye (1:10), Nitric acid, Sulphuric acid (1:7), distilled water, a piece of lead, suitable tank, a variable mains power supply or a heavy duty battery.

Processing: First the aluminium is smoothed with grade 400 wet and dry emery paper. Proper care should be taken for not to overheat the aluminium for not more than 10 minutes in the caustic Soda lye to remove al the grease. Decolouration often occurs, but this can be removed if etched in 1:10 nitric soda solution. Electrolysis process is to be carried out in a solution of sulphuric acid with a sheet of lead suspended and connected to negative terminal of the battery. The electrolysis process is to be carried out for about an hour at a constant temperature of 16 – 200C. The aluminium work piece is then to be rinsed thoroughly with distilled water. Finally the aluminium is to be condensate for about 15 minutes in boiling water.

### 2.3 Technical Information

#### 2.3.1 Stethoscope

**Figure 2.7:** Stethoscope

The stethoscope is an instrument used by doctors and other health professionals to listen to body sounds. It is mainly designed to listen to the lungs and heart, although it is also used to listen to the bowels and blood flow in other parts of the body. Most stethoscopes are designed from Y-shaped rubber tubing that allows sound to enter at one end and heard through earpieces at the other. Many modern stethoscopes have a two-sided sound-detecting head that can be reversed, allowing high or low frequencies to be heard, depending which side is used.

Lub-dubs and wooshes: Listening to the lungs requires different listening skills from those used when listening to the heart. Normal heart sounds are often described as 'lub-dub', and are caused by the beating of the heart. Sometimes 'whooshing' sounds called heart 'murmurs' are heard, caused by irregularities in blood flow through the heart. These may be loud, or so faint that they are scarcely audible. Many people have heart murmurs that are harmless and cause no health problems, though sometimes a murmur is a sign of a heart problem that needs treatment. A stethoscope is also used to listen to the pulse in the arm during blood pressure measurement.

Wheezes and crackles: When examining the lungs with a stethoscope, a doctor will listen for wheezes and crackles. Wheezes occur when the airways are constricted, and crackles occur when there is fluid in the lungs. These sounds should not be present in normal lungs. The stethoscope is placed on the chest over the lungs and the patient breathes slowly in and out. This is repeated with the stethoscope placed on different parts of the chest.

Gurgles: Sometimes a doctor will use a stethoscope to listen to the abdomen for the gurgling sounds of bowel activity. These are called borborygmi and they are completely normal, being produced by the movement of food and gas. There are no risks involved and it is painless having a health professional listen to parts of the body with a stethoscope. It gives valuable clinical information that can help to confirm normal body functions or make a diagnosis of the cause of health problems.

### 2.3.2 Electrocardiograph (ECG)

#### 2.3.2.1 Introduction


**Figure 2.8:** ECG Device

Electrocardiography (ECG or EKG*) is the process of recording the electrical activity of the heart over a period of time using electrodes placed on the skin. These electrodes detect the tiny electrical changes on the skin that arise from the heart muscle's electrophysiology pattern of depolarizing during each heartbeat. It is a very commonly performed cardiology test.

During each heartbeat, a healthy heart has an orderly progression of depolarization that starts with pacemaker cells in the sinoatrial node, spreads out through the atrium, passes through the atrioventricular node down into the bundle of His and into the Purkinje fiber, spreading down and to the left throughout the ventricles. This orderly pattern of depolarization gives rise to the characteristic ECG tracing. To the trained clinician, an ECG conveys a large amount of information about the structure of the heart and the function of its electrical conduction system.[2] Among other things, an ECG can be used to measure the rate and rhythm of heartbeats, the size and position of the heart chambers, the presence of any damage to the heart's muscle cells or conduction system, the effects of cardiac drugs, and the function of implanted pacemakers.

#### 2.3.2.2 Electrodes and Leads

Proper placements of the limb electrodes are very important. The limb electrodes can be far down on the limbs or close to the hips/shoulders as long as they are placed symmetrically.

#### 2.3.2.3 Rate and rhythm

In a normal heart, the heart rate is the rate in which the sinoatrial node depolarizes as it is the source of depolarization of the heart. Heart rates, like other vital signs like blood pressure and respiratory rate which is change with age. In adults, a normal heart rate is between 60 and 100 beats per minute (normocardic) where in children is higher. A heart rate less than normal is called bradycardia (<60 in adults) and higher than normal is tachycardia (>100 in adults). A complication of this is when the atria and ventricles are not in synchrony and the "heart rate" must be specified as atrial or ventricular (e.g., atrial rate in atrial fibrillation is 300–600 bpm, whereas ventricular rate can be normal (60–100) or faster (100–150)).

In normal resting hearts, the physiologic rhythm of the heart is normal sinus rhythm (NSR). Normal sinus rhythm produces the prototypical pattern of P wave, QRS complex, and T wave. Generally, deviation from normal sinus rhythm is considered a cardiac arrhythmia. Thus, the first question in interpreting an ECG is whether or not there is a sinus rhythm. A criterion for sinus rhythm is that P waves and QRS complexes appear 1-to-1, thus implying that the P wave causes the QRS complex. Once sinus rhythm, or not, is established the second question is the rate. For a sinus rhythm this is either the rate of P waves or QRS complexes since they are 1-to-1. If the rate is too fast then it is sinus tachycardia and if it is too slow then it is sinus bradycardia.

If it is not a sinus rhythm, then determining the rhythm is necessary before proceeding with further interpretation. Some arrhythmias with characteristic findings:

i. Absent P waves with "irregularly irregular" QRS complexes is the hallmark of atrial fibrillation
ii. A "saw tooth" pattern with QRS complexes is the hallmark of atrial flutter
iii. Sine wave pattern is the hallmark of ventricular flutter
iv. Absent P waves with wide QRS complexes with fast rate is ventricular tachycardia
v. Determination of rate and rhythm is necessary in order to make sense of further interpretation.

**2.3.2.4 Axis**

The heart has several axes, but the most common by far is the axis of the QRS complex (references to "the axis" implicitly means the QRS axis). Each axis can be computationally determined to result in a number representing degrees of deviation from zero, or it can be categorized into a few types.

The QRS axis is the general direction of the ventricular depolarization wavefront (or mean electrical vector) in the frontal plane. It is often sufficient to classify the axis as one of three types: normal, left deviated, or right deviated. Population data shows that normal QRS axis is from $-30°$ to $105°$ with $0°$ being along lead I and positive being inferior and negative being superior (best understood graphically as the hexaxial reference system).[26] Beyond $+105°$ is right axis deviation and beyond $-30°$ is left axis deviation (the third quadrant of $-90°$ to $-180°$ is very rare and is an indeterminate axis). A shortcut for determining if the QRS axis is normal is if the QRS complex is mostly positive in lead I and lead II (or lead I and aVF if $+90°$ is the upper limit of normal).

The normal QRS axis is generally down and to the left, following the anatomical orientation of the heart within the chest. An abnormal axis suggests a change in the physical shape and orientation of the heart, or a defect in its conduction system that causes the ventricles to depolarize in an abnormal way.

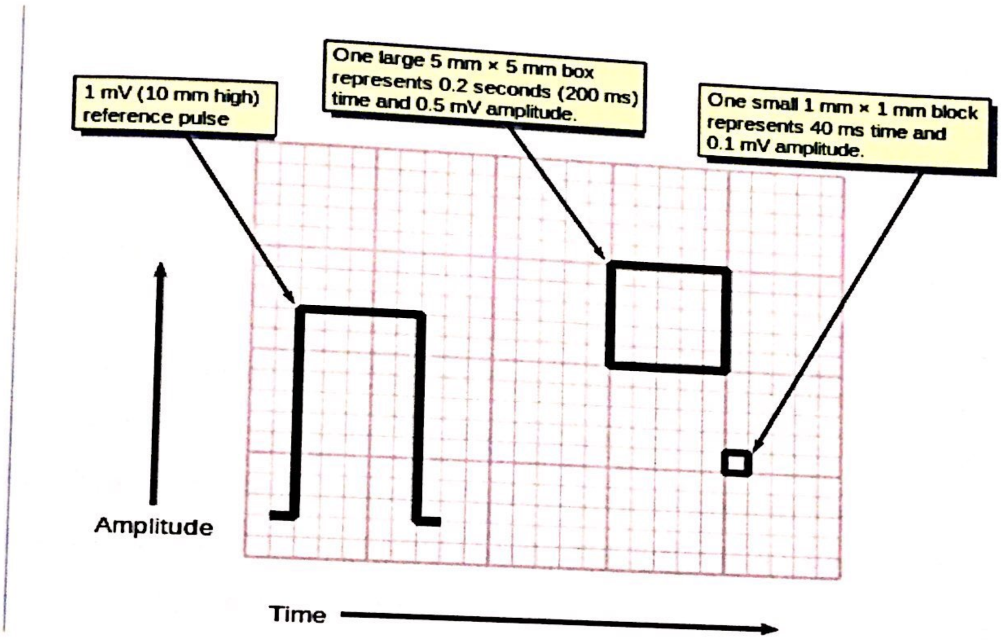



**Figure 2.9:** ECG Reading Graph

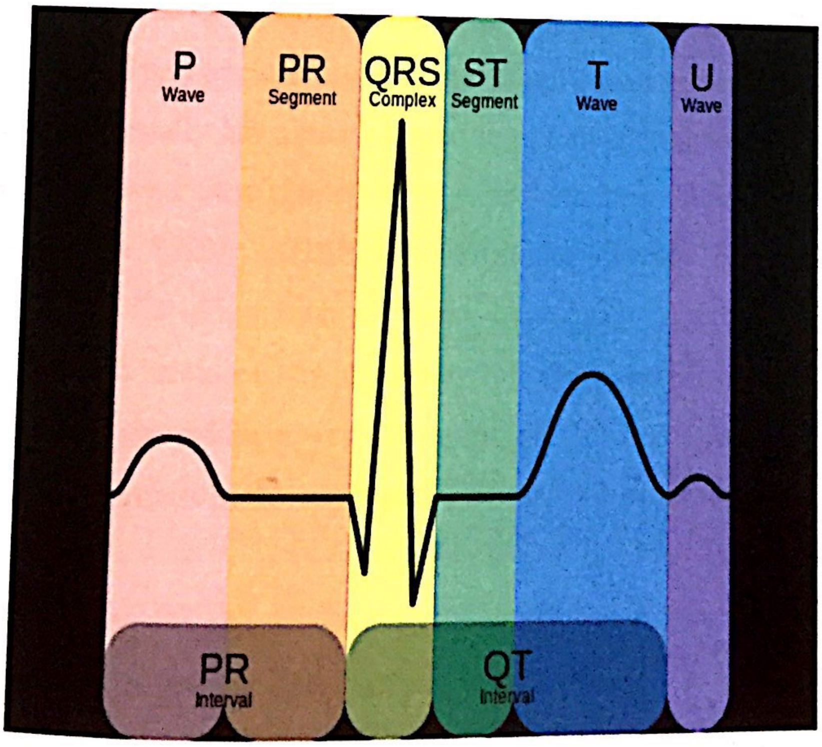



**Figure 2.10:** PQRST Wave

**P wave**: The p-wave represents depolarization of the atria. Atrial depolarization spreads from the SA node towards the AV node, and from the right atrium to the left atrium. The p-wave is typically upright in most leads except for aVR; an unusual p-wave axis (inverted in other leads) can indicate an ectopic atrial pacemaker. If the p wave is of unusually long duration, it may represent atrial enlargement. Typically a large right atrium gives a tall, peaked p-wave while a large left atrium gives a two-humped bifid p-wave. <80ms

**PR interval:** The PR interval is measured from the beginning of the P wave to the beginning of the QRS complex. This interval reflects the time the electrical impulse takes to travel from the sinus node through the AV node. A PR interval shorter than 120ms suggests that the electrical impulse is bypassing the AV node, as in Wolf-Parkinson-White syndrome. A PR interval consistently longer than 200ms diagnoses first degree atrioventricular block. The PR segment s(the portion of the tracing after the p-wave and before the QRS complex) is typically completely flat, but may be depressed in pericarditis.120 to 200ms

**QRS complex:** The QRS complex represents the rapid depolarization of the right and left ventricles. The ventricles have a large muscle mass compared to the atria, so the QRS complex usually has a much larger amplitude than the P-wave. If the QRS complex is wide (longer than 120ms) it suggests disruption of the heart's conduction system, such as in LBBB, RBBB, or ventricular rhythms such as ventricular tachycardia. Metabolic issues such as severe hyperkalemia, or TCA overdose can also widen the QRS complex. An unusually tall QRS complex may represent left ventricular hypertrophy while a very low-amplitude QRS complex may represent a pericardial effusion or infiltrative myocardial disease, 80 to 100ms.

**ST segment:** The ST segment connects the QRS complex and the T wave; it represents the period when the ventricles are depolarized. It is usually isoelectric, but may be depressed or elevated with myocardial infarction or ischemia. ST depression can also be caused by LVH or digoxin. ST elevation can also be caused by pericarditis, Brugada syndrome, or can be a normal variant (J-point elevation).

**T wave:** The T wave represents the repolarization of the ventricles. It is generally upright in all leads except aVR and lead V1. Inverted T waves can be a sign of myocardial ischemia, LVH, high intracranial pressure, or metabolic abnormalities. Peaked T waves can be a sign of hyperkalemia or very early myocardial infarction.160ms

**U wave:** The U wave is hypothesized to be caused by the repolarization of the interventricular septum. It normally has low amplitude, and even more often is completely absent. If the U-wave is very prominent, we can describe as hypokalemia, hypercalcemia or hyperthyroidism.

### 2.3.3 Bluetooth

#### 2.3.3.1 What is a bluetooth

Bluetooth is a standard used in links of radio of short scope, destined to replace wired connections between electronic devices like cellular telephones, Personal Digital Assistants (PDA), computers, and many other devices. Bluetooth technology can be used at home, in the office, in the car, etc. This technology allows to the users instantaneous connections of voice and information between several devices in real time. The way of transmission used assures protection against interferences and safety in the sending of information. Between the principal characteristics, must be named the hardiness, low complexity, low consume and low cost. The Bluetooth is a small microchip that operates in a band of available frequency throughout the world. Communications can realize point to point and point multipoint.

**Figure 2.11:** Bluetooth's Symbol

#### 2.3.3.2 How it works

Every device will have to be equipped with a microchip (transceiver) that transmits and receives in the frequency of 2.4 GHz that is available in the whole world (with some variations of bandwidth in different countries). Besides the information, there are three channels of voice available.

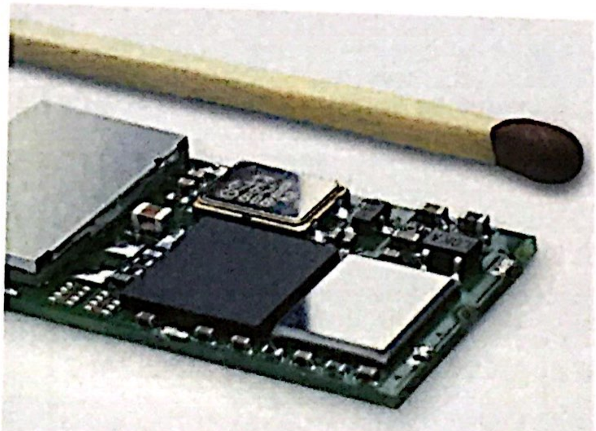


**Figure 2.12:** Channel of Bluetooth

The information can be exchanged to speeds of up to 1 megabit for second (2 megabits for second in the Second Generation of this Technology). A scheme of "frequency hop"(jumps of frequency) allows to the devices to communicate inclusive in areas where a great electromagnetic interference exists. Besides that is provided with schemes of encryptation and check.

#### 2.3.3.3 Frequency Bands

The standard Bluetooth operates in the band of 2,4 GHz. Though worldwide, this band is available, the width of the band can differ in different countries. This is the frequency of band of the scientific and medical industries 2.45 GHz (ISM*). The ranges of the bandwidth in The United States and Europe are between 2.400 to 2.483,5 MHz and it covers part of France and Spain. The ranges of the bandwidth in Japan are between 2.471 to 2.497 MHz. So the system can be used worldwide due to that the transmitters of radio covers 2.400 and 2.500 MHz and it is possible to select the appropriate frequency. This ISM* is opened for any system of radio and must take care of the interferences of monitors for baby, the controls for doors of garages, the wireless telephones and the microwave ovens (the source with higher interference).

**ISM:** *The **industrial, scientific and medical (ISM)** radio bands were originally reserved internationally for the use of RF electromagnetic fields for industrial, scientific and medical purposes other than communications. In general, communications equipment must accept any interference generated by ISM equipment.*

**Table 2.1:** Frequency Band of Bluetooth

| Country | Frequency Range | RF Channels | |
|---|---|---|---|
| Europe* & USA | 2400 - 2483.5 MHz | f = 2402 + k MHz | k= 0,...,78 |
| Japan | 2471 - 2497 MHz | f = 2473 + k MHz | k= 0,...,22 |
| Spain | 2445 - 2475 MHz | f = 2449 + k MHz | k= 0,...,22 |
| France | 2446.5 - 2483.5 MHz | f = 2454 + k MHz | k= 0,...,22 |

#### 2.3.3.4 Power

The equipments of transmission are qualified in 3 groups according to the level of power of emission, as we can see below. The recipient equipment must possess a sensibility of at least 70 dBm, and the rate of admissible mistake must be a minor or equal to 0,1 %.

The chip is going to be incorporated in portable devices and powered by batteries, that´s why it must has a very limited consumption of power (up to 97 % less than a mobile telephone). If the Bluetooth devices do not exchange information, then they establish the way of "wait" to save energy, staying to the scout of messages. The power of transmission that is used as specification is of 1 mW for a scope of 10 m, 100 mW for a scope of up to 100 m.

#### 2.3.3.5 Scope

The connections have a maximum range of 10 meters, though using amplifiers it is possible to come up to 100 meters, but creating some distortion interferes. Maybe it doesn't look too much, but it is necessary to remember that these devices were created by the intention of using them in closed environments and little distances.

#### 2.3.3.6 Protocols

Different applications can operate under different sets of protocols; nevertheless, all of them have a link of information and a physical cap common Bluetooth.

#### 2.3.3.7 Interferences

In a look to interferences with other devices, it is necessary to have care with those who operate in the same band. For example the same as there is prohibited the use of mobile telephones in the planes, it is possible to prohibit the use of any another device that incorporates a Bluetooth chip, because it can interfere with the elements of navigation. But this can be a problem because it has been designed to maintain a constant communication, even in movement, and inside briefcases, and it can be working even inadvertently for the user.

### 2.3.4 Arduino

#### 2.3.4.1 Arduino Uno

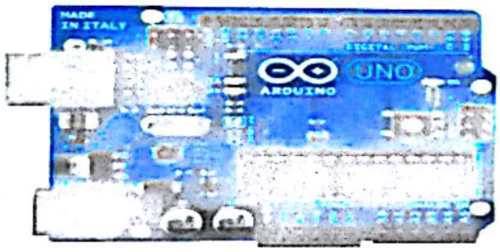



**Figure 2.13:** Arduino Uno

The Arduino Uno is a microcontroller board based on the ATmega328 (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analogue inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it feature the Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter.

"Uno" means one in Italian and is named to mark the upcoming release of Arduino 1.0. The Uno and version 1.0 will be the reference versions of Arduino, moving forward. The Uno is the latest in a series of USB Arduino boards, and the reference model for the Arduino platform; for a comparison with previous versions, see the index of Arduino boards.

**Table 2.2:** Arduino Uno Description

**Summary**

| | |
|---|---|
| Microcontroller | ATmega328 |
| Operating Voltage | 5V |
| Input Voltage (recommended) | 7-12V |
| Input Voltage (limits) | 6-20V |
| Digital I/O Pins | 14 (of which 6 provide PWM output) |
| Analog Input Pins | 6 |
| DC Current per I/O Pin | 40 mA |
| DC Current for 3.3V Pin | 50 mA |
| Flash Memory | 32 KB (ATmega328) of which 0.5 KB used by bootloader |
| SRAM | 2 KB (ATmega328) |
| EEPROM | 1 KB (ATmega328) |
| Clock Speed | 16 MHz |

### 2.3.4.2 Power

The Arduino Uno can be powered via the USB connection or with an external power supply. The power source is selected automatically. External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the Gnd and Vin pin headers of the POWER connector.

The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts.

The power pins are as follows:

i. **VIN.** The input voltage to the Arduino board when it's using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). You can supply voltage through this pin, or, if supplying voltage via the power jack, access it through this pin.
ii. **5V.**This pin outputs a regulated 5V from the regulator on the board. The board can be supplied with power either from the DC power jack (7 - 12V), the USB connector (5V), or the VIN pin of the board (7-12V). Supplying voltage via the 5V or 3.3V pins bypasses the regulator, and can damage your board. We don't advise it.
iii. **3V3.** A 3.3 volt supply generated by the on-board regulator. Maximum current draw is 50 mA.
iv. **GND.** Ground pins.

### 2.3.4.3 Memory

The ATmega328 has 32 KB (with 0.5 KB used for the bootloader). It also has 2 KB of SRAM and 1 KB of EEPROM (which can be read and written with the EEPROM library).

#### 2.3.4.4 Input and Output

Each of the 14 digital pins on the Uno can be used as an input or output, using pinMode(), digitalWrite(), and digitalRead() functions. They operate at 5 volts. Each pin can provide or receive a maximum of 40 mA and has an internal pull-up resistor (disconnected by default) of 20-50 kOhms. In addition, some pins have specialized functions:

i. **Serial: 0 (RX) and 1 (TX).** Used to receive (RX) and transmit (TX) TTL serial data. These pins are connected to the corresponding pins of the ATmega8U2 USB-to-TTL Serial chip.

ii. **External Interrupts: 2 and 3.** These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value. See the attachInterrupt() function for details.

iii. **PWM: 3, 5, 6, 9, 10, and 11.** Provide 8-bit PWM output with the analogWrite() function.

iv. **SPI: 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK).** These pins support SPI communication using the SPI library.

v. **LED: 13.** There is a built-in LED connected to digital pin 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it's off.

The Uno has 6 analog inputs, labeled A0 through A5, each of which provide 10 bits of resolution (i.e. 1024 different values). By default they measure from ground to 5 volts, though is it possible to change the upper end of their range using the AREF pin and the analogReference() function. Additionally, some pins have specialized functionality:

vi. **TWI: A4 or SDA pin and A5 or SCL pin.** Support TWI communication using the Wire library.

There are a couple of other pins on the board:

vii. **AREF.** Reference voltage for the analog inputs. Used with analogReference().

viii. **Reset.** Bring this line LOW to reset the microcontroller. Typically used to add a reset button to shields which block the one on the board.

#### 2.3.4.5 Communication

The Arduino Uno has a number of facilities for communicating with a computer, another Arduino, or other microcontrollers. The ATmega328 provides UART TTL (5V) serial communication, which is available on digital pins 0 (RX) and 1 (TX). An ATmega16U2 on the board channels this serial communication over USB and appears as a virtual com port to software on the computer. The '16U2 firmware uses the standard USB COM drivers, and no external driver is needed. However, on Windows, a .inf file is required.

The Arduino software includes a serial monitor which allows simple textual data to be sent to and from the Arduino board. The RX and TX LEDs on the board will flash when data is being transmitted via the USB-to-serial chip and USB connection to the computer (but not for serial communication on pins 0 and 1). A SoftwareSerial library allows for serial communication on any of the Uno's digital pins. The ATmega328 also supports I2C (TWI) and SPI communication. The Arduino software includes a Wire library to simplify use of the I2C bus; see the documentation for details. For SPI communication, use the SPI library.

#### 2.3.4.6 Programming

The Arduino Uno can be programmed with the Arduino software (download). Select "Arduino Uno from the **Tools** > **Board** menu (according to the microcontroller on board). For details, see the reference and tutorials. The ATmega328 on the Arduino Uno comes preburned with a bootloader that allows to upload new code to it without the use of an external hardware programmer. It communicates using the original STK500 protocol (reference, C header files). Can also bypass the bootloader and program the microcontroller through the ICSP (In-Circuit Serial Programming) header; see these instructions for details.

i. The ATmega16U2 (or 8U2 in the rev1 and rev2 boards) firmware source code is available The ATmega16U2/8U2 is loaded with a DFU bootloader, which can be activated by:

ii. On Rev1 boards: connecting the solder jumper on the back of the board (near the map of Italy) and then resetting the 8U2.

iii. On Rev2 or later boards: there is a resistor that pulling the 8U2/16U2 HWB line to ground, making it easier to put into DFU mode.

#### 2.3.4.7 Automatic (Software) Reset

Rather than Rather than requiring a physical press of the reset button before an upload, the Arduino Uno is designed in a way that allows it to be reset by software running on a connected computer. One of the hardware flow control lines (DTR) of the ATmega8U2/16U2 is connected to the reset line of the ATmega328 via a 100 nanofarad capacitor. When this line is asserted (taken low), the reset line drops long enough to reset the chip. The Arduino software uses this capability to allow you to upload code by simply pressing the upload button in the Arduino environment. This means that the bootloader can have a shorter timeout, as the lowering of DTR can be well-coordinated with the start of the upload.

This setup has other implications. When the Uno is connected to either a computer running Mac OS X or Linux, it resets each time a connection is made to it from software (via USB). For the following half-second or so, the bootloader is running on the Uno. While it is programmed to ignore malformed data (i.e. anything besides an upload of new code), it will intercept the first few bytes of data sent to the board after a connection is opened. If a sketch running on the board receives one-time configuration or other data when it first starts, make sure that the software with which it communicates waits a second after opening the connection and before sending this data.

The Uno contains a trace that can be cut to disable the auto-reset. The pads on either side of the trace can be soldered together to re-enable it. It's labeled "RESET-EN". You may also be able to disable the auto-reset by connecting a 110 ohm resistor from 5V to the reset line; see this forum thread for details.

### 2.3.4.8 USB Overcurrent Protection

The Arduino Uno has a resettable polyfuse that protects computer's USB ports from shorts and overcurrent. Although most computers provide their own internal protection, the fuse provides an extra layer of protection. If more than 500 mA is applied to the USB port, the fuse will automatically break the connection until the short or overload is removed.

### 2.3.4.9 Physical Characteristics

The maximum length and width of the Uno PCB are 2.7 and 2.1 inches respectively, with the USB connector and power jack extending beyond the former dimension. Four screw holes allow the board to be attached to a surface or case. Note that the distance between digital pins 7 and 8 is 160 mil (0.16"), not an even multiple of the 100 mil spacing of the other pins.

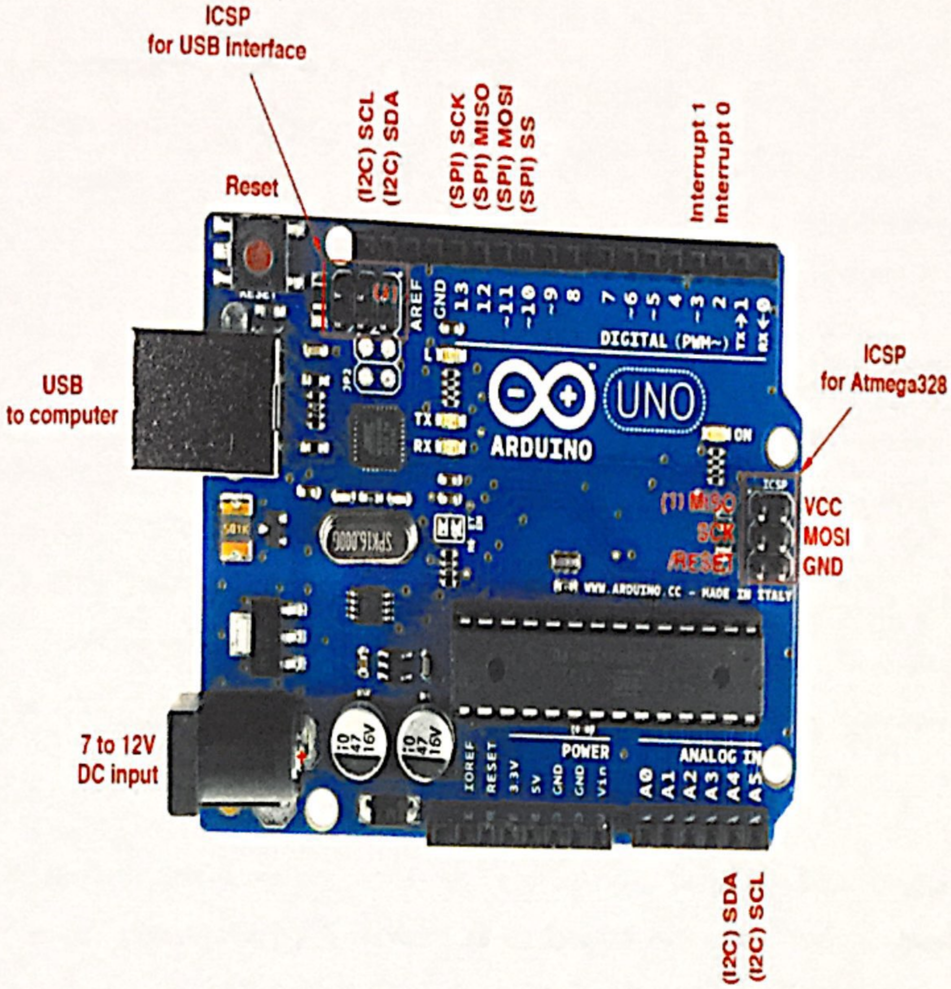



**Figure 2.14:** Arduino UNO Configuration Pin

## 2.4 Electrical Information

### 2.4.1 Electrical Safety Test

#### 2.4.1.1 Normal Condition and Single Fault Condition

A basic principle behind the philosophy of electrical safety is that in the event of a single abnormal external condition arising or of the failure of a single means of protection against a hazard, no safety hazard should arise. Such conditions are called "single fault conditions" (SFCs) and include such situations as the interruption of the protective earth conductor or of one supply conductor, the appearance of an external voltage on an applied part, the failure of basic insulation or of temperature limiting devices.

Where a single fault condition is not applied, the equipment is said to be in "normal condition" (NC). However, it is important to understand that even in this condition, the performance of certain tests may compromise the means of protection against electric shock. For example, if earth leakage current is measured in normal condition, the impedance of the measuring device in series with the protective earth conductor means that there is no effective supplementary protection against electric shock.

Many electrical safety tests are carried out under various single fault conditions in order to verify that there is no hazard even should these conditions occur in practice. It is often the case that single fault conditions represent the worst case and will give the most adverse results. Clearly the safety of the equipment under test may be compromised when such tests are performed. Personnel carrying out electrical safety tests should be aware that the normal means for protection against electric shock are not necessarily operative during testing and should therefore exercise due precautions for their own safety and that of others. In particular the equipment under test should not be touched during the safety testing procedure by any persons.

#### 2.4.1.2 Protective Earth Continuity

The resistance of the protective earth conductor is measured between the earth pin on the mains plug and a protectively earthed point on the equipment enclosure. The reading should not normally exceed 0.2Ω at any such point. The test is obviously only applicable to class I equipment.

In IEC60601, the test is conducted using a 50Hz current between 10A and 25A for a period of at least 5 seconds. Although this is a type test, some medical equipment safety testers mimic this method. Damage to equipment can occur if high currents are passed to points that are not protectively earthed, for example, functional earths. Great care should be taken when high current testers are used to ensure that the probe is connected to a point that is intended to be protectively earthed.

HEI 95 and DB9801 Supplement 1 recommended that the test be carried out at a current of 1A or less for the reason described above.

Where the instrument used does not do so automatically, the resistance of the test leads used should be deducted from the reading.If protective earth continuity is satisfactory then insulation tests can be performed.

**2.4.1.3 Insulation Test**

IEC 60601-1 (second edition), clause 17, lays down specifications for electrical separation of parts of medical electrical equipment compliance to which is essentially verified by inspection and measurement of leakage currents. Further tests on insulation are detailed under clause 20, "dielectric strength". These tests use AC sources to test equipment that has been pre-conditioned to specified levels of humidity. The tests described in the standard are type tests and are not suitable for use as routine tests.

HEI 95 and DB9801 recommended that for class I equipment the insulation resistance be measured at the mains plug between the live and neutral pins connected together and the earth pin. Whereas HEI 95 recommended using a 500V DC insulation tester, DB 9801 recommended the use of 350V DC as the test voltage. In practice this last requirement could prove difficult and it was acknowledged in a footnote that a 500 V DC test voltage is unlikely to cause any harm. The value obtained should normally be in excess of 50MΩ but may be less in exceptional circumstances. For example, equipment containing mineral insulated heaters may have an insulation resistance as low as 1MΩ with no fault present. The test should be conducted with all fuses intact and equipment switched on where mechanical on/off switches are present.

#### 2.4.1.4 Leakage Current Measuring Device

The leakage current measuring device recommended by IEC 60601-1 loads the leakage current source with a resistive impedance of about 1 kΩ and has a half power point at about 1kHz. The recommended measuring device was changed slightly in detail between the 1979 and 1989 editions of the standard but remained functionally very similar. Figure 11 shows the arrangements for the measuring device. The millivolt meter used should be true RMS reading and should have an input impedance greater than 1 MΩ. In practice this is easily achievable with most good quality modern multimeters. The meter in the arrangements shown measures 1mV for each µA of leakage current.

#### 2.4.1.5 Earth Leakage Current

For class I equipment, earth leakage current is measured as shown in figure 12. The current should be measured with the mains polarity normal and reversed. HEI 95 and DB9801 Supplement 1 recommended that the earth leakage current be measured in normal condition (NC) only. Many safety testers offer the opportunity to perform the test under single fault condition, neutral conductor open circuit. This arrangement normally gives a higher leakage current reading.

One of the most significant changes with regard to electrical safety in the 2005 edition of IEC 60601-1 is an increase by a factor of 10 in the allowable earth leakage current to 5mA in normal condition and 10mA under single fault condition. The rationale for this is that the earth leakage current is not, of itself, hazardous.

Higher values of earth leakage currents, in line with local regulation and IEC 60364-7-710 (electrical supplies for medical locations), are allowed for permanently installed equipment connected to a dedicated supply circuit.

### 2.4.1.6 Enclosure Leakage Current and Touch Current

Enclosure leakage current is measured between an exposed part of the equipment which is not intended to be protectively earthed and true earth as shown in figure 13. The test is applicable to both class I and class II equipment and should be performed with mains polarity both normal and reversed. HEI 95 recommended that the test be performed under the SFC protective earth open circuit for class I equipment and under normal condition for class II equipment. DB9801 Supplement 1 recommended that the test be carried out under normal condition only for both class I and class II equipment. Many safety testers also allow the SFC's of interruption of live or neutral conductors to be selected. Points on class I equipment which are likely not to be protectively earthed may include front panel fascias, handle assemblies etc.

In practice, if a piece of equipment has accessible conductive parts that are protectively earthed, then in order to meet the new requirements for touch current, the earth leakage current would need to meet the old limits. This is due to the fact that when the touch current is tested from a protectively earthed point with the equipment protective earth conductor disconnected, the value will be the same as that achieved for earth leakage current under normal condition.

Hence, where higher earth leakage currents are recorded for equipment designed to the new standard, it is important to check the touch current under single fault condition, earth open circuit, from all accessible conductive parts.

#### 2.4.1.7 Patient Leakage Current

Under IEC 60601-1, for class I and class II type B and BF equipment, the patient leakage current is measured from all applied parts having the same function connected together and true earth (figure 14). For type CF equipment the current is measured from each applied part in turn and the leakage current leakage must not be exceeded at any one applied part. (figure 15).

HEI 95 adhered to the same method, however, DB9801 Supplement 1 recommended that patient leakage current be measured from each applied part in turn for all types of equipment, although the recommended leakage current limits were not revised to take into account the changed test method for B and BF equipment.

Great care must be taken when performing patient leakage current measurements that equipment outputs are inactive. In particular, outputs of diathermy equipment and stimulators can be fatal and can damage test equipment.

#### 2.4.1.8 Patient Auxiliary Current

Patient auxiliary current is measured between any single patient connection and all other patient connections of the same module or function connected together. Where all possible combinations are tested together with all possible single fault conditions this yields an exceedingly large amount of data of questionable value.

#### 2.4.1.9 Mains on Apllied Parts (Patient Leakage)

By applying mains voltage to the applied parts, the leakage current that would flow from an external source into the patient circuits can be measured. Although the safety tester normally places a current limiting resistor in series with the measuring device for the performance of this test, a shock hazard still exists. Therefore, great care should be taken if the test is carried out in order to avoid the hazard presented by applying mains voltage to the applied parts.

Careful consideration should be given as to the necessity or usefulness of performing this test on a routine basis when weighed against the associated hazard and the possibility of causing problems with equipment. The purpose of the test under IEC 60601-1 is to ensure that there is no danger of electric shock to a patient who for some unspecified reason is raised to a potential above earth due to the connection of the applied parts of the equipment under test. The standard requires that the leakage current limits specified are not exceeded. There is no guarantee that equipment performance will not be adversely affected by the performance of the test. In particular, caution should be exercised in the case of sensitive physiological measurement equipment. In short, the test is a "type test".

Most medical equipment safety testers refer to this test as "mains on applied parts", although this is not universal. One manufacturer refers to the test simply as "Patient leakage - F-type". In all cases there should be a hazard indication visible where the test is selected.

#### 2.4.1.10 Leakage Current Summary

The following table summarises the leakage current limits (in mA) specified by IEC60601-1 (second edition) for the most commonly performed tests. Most equipment currently in use in hospitals today is likely to have been designed to conform to this standard, but note that the allowable values of earth leakage current have been increased in the third edition of the standard as discussed above.

The values stated are for d.c. or a.c. (r.m.s), although later amendments of the standard included separate limits for the d.c. element of patient leakage and patient auxiliary currents at one tenth of the values listed below. These have not been included in the table since, in practice, it is rare that there is a problem solely with d.c. leakage where that is not evidenced by a problem with combined a.c and d.c. leakage.

# CHAPTER 3

# METHODOLOGY

## 3.1 Introduction

Methodology is the systematic, theoretical analysis of the methods applied to a field of study. It comprises the theoretical analysis of the body of methods and principles associated with a branch of knowledge. Typically, it encompasses concepts such ad paradigm, theoretical model, phases and quantitative or qualitative technique.

Research methodology is a process used to collect information and data for the purpose of making business decisions. The methodology may include publication research, interviews, surveys and other research technique, and could include both present and historical information.

## 3.2 Planning

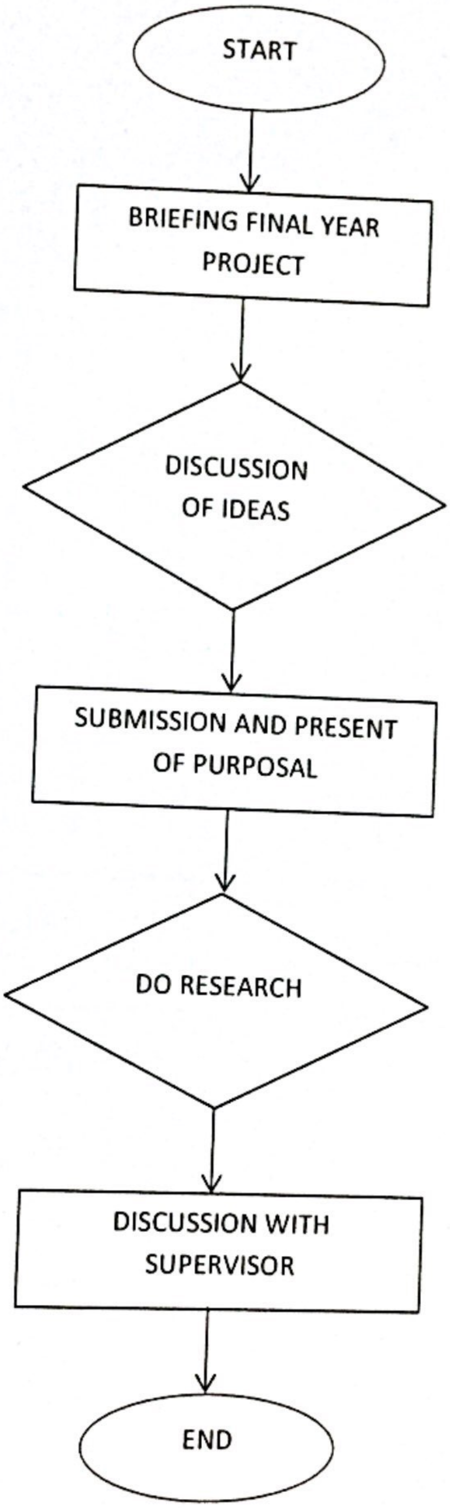



**Figure 3.1:** Planning Flowchart

### 3.3 Implementing

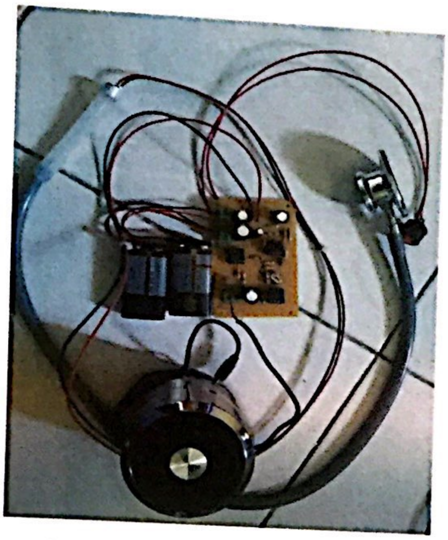


**Figure 3.2:** Electronic Stethoscope Circuit

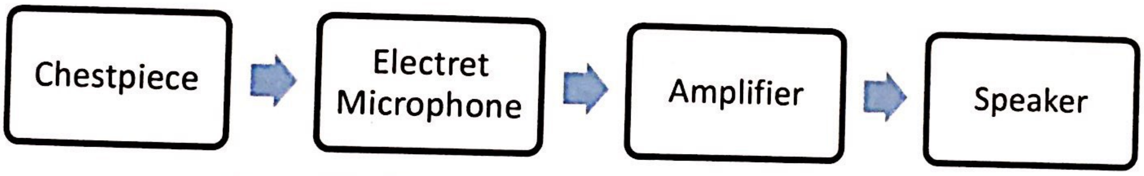



**Figure 3.3:** Electronic Stethoscope Block Diagram

Figure above explain about the producing of heart beat sound through speaker. The chest piece will detect heart beat from patient's chest. The speaker will produces the amplified sound of heart beat as the amplifier's function to amplifies the heart beat captured by electret microphone.

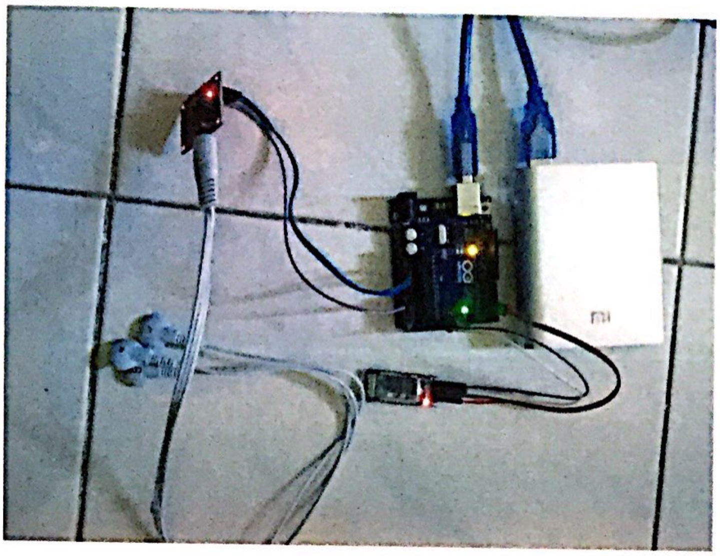


**Figure 3.4:** ECG and Bluetooth Circuit

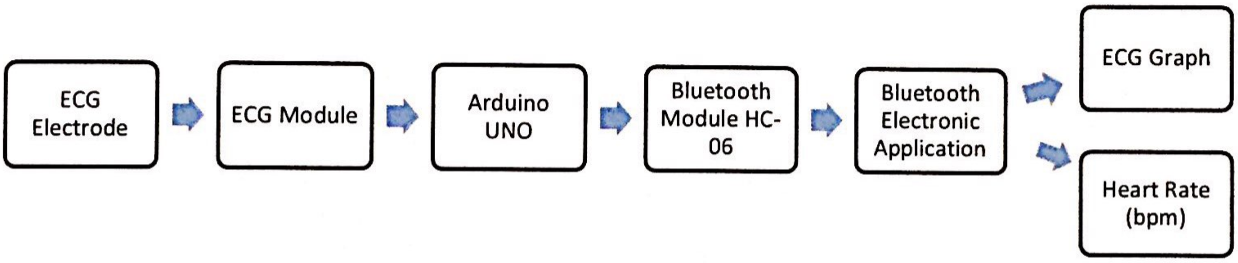



**Figure 3.5:** ECG and Bluetooth Block Diagram

From figure above, the ECG pad will attach to the certain part of human body. It will transfer a electric signal of the body to ECG sensor module AD8232. Then, the elecrical signal will transfer to Arduino UNO to interprete the data. Bluetooth Module will transfer the data and ECG graph and heart rate reading will be produce in the smart phone via Bluetooth Electronic Applications.

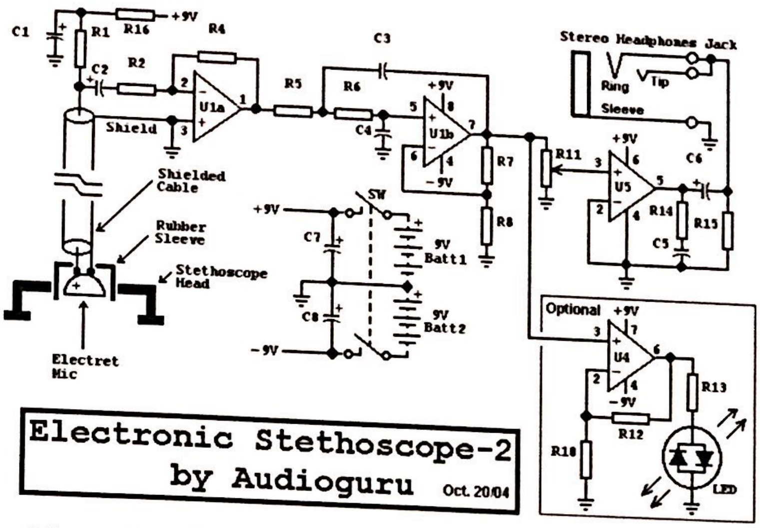



**Figure 3.6**: Electronic Stethoscope Schematic Circuit

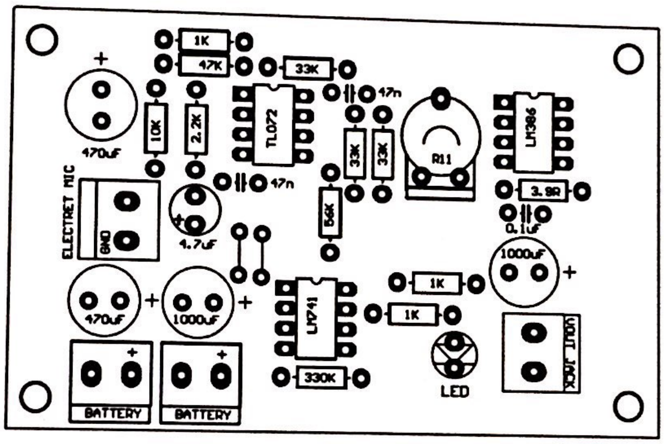



**Figure 3.7**: Electronic Stethoscope PCB Layout

Circuit Description:

1. U1a operates as a low-noise microphone preamp. Its gain is only about 3.9 because the high output impedance of the drain of the FET inside the electret microphone causes U1a's effective input resistor to be about 12.2K. C2 has a fairly high value in order to pass very low frequency (about 20 to 30Hz) heartbeat sounds.

2. U1b operates as a low-noise Sallen and Key, Butterworth low-pass-filter with a cut off frequency of about 103Hz. R7 and R8 provide a gain of about 1.6 and allow the use of equal values for C3 and C4 but still producing a sharp Butterworth response. The roll off rate is 12dB/octave. C3 and C4 can be

reduced to 4.7nF to increase the cut off frequency to 1KHz to hear respiratory or mechanical (automobile engine) sounds.

3. The U4 circuit is optional and has a gain of 71 to drive the bi-colour LED.

4. U5 is a 1/4W power amplifier IC with built-in biasing and inputs that are referred to ground. It has a gain of 20. It can drive any type of headphones including low impedance (8 ohms) ones.

### 3.3.1 ECG Sensor Module AD8232

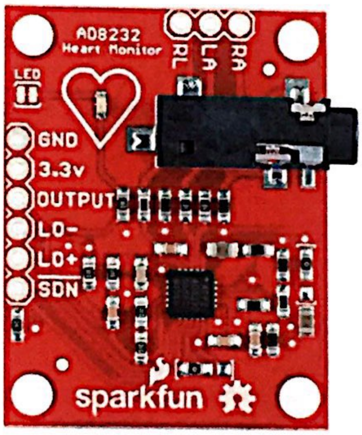



**Figure 3.8:** ECG Sensor Module AD8232

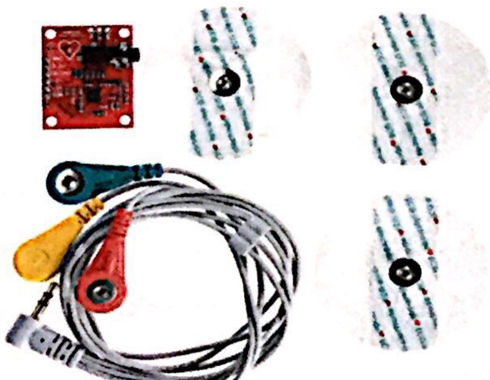


**Figure 3.9:** ECG Module Kit

The AD8232 SparkFun Single Lead Heart rate Monitor is a cost-effective board used to measure the electrical activity of the heart. This electrical activity can be charted as an ECG and output as an analog reading. 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. The AD8232 is an integrated signal conditioning block for ECG and other bio potential measurement applications.

It is designed to extract, amplify and filter small biopotential signals in the presence of noisy conditions. It also breaks out nine connections from IC to provide 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 ad use custom sensor. Additionally, there is an LED indicator light that will pulsate to the rhythm of a heart beat. Biomedical Sensor Pads and Sensor cable are required to use the heart monitor.

Features:

a) Operating Voltage 3.3V
b) Analog Output
c) Leads-Off Detection
d) Shutdown Pin
e) LED Indicator
f) 3.5mm Jack for Biomedical Pad connection

### 3.3.2 Arduino Uno

The Arduino Uno is a microcontroller board based on the ATmega328. "Uno" means one in Italian. It has 14 digital input/output pins of which 6 can be used as PWM outputs, 6 analog outputs, a 16MHz ceramic resonator, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The Arduino Uno allow the energy to amplified and optimized for listening at various frequencies, allows the sound energy to be digitized, encoded and decoded, to have the ambient noise reduces or eliminated, and sent through speaker

### 3.3.3 Electret Microphone

**Figure 3.10:** Electret Microphone

Electret microphone is a type of electrostatic capacitor-based microphone, which eliminates the need for a polarizing power supply by using a permanently charged material. An electret is a stable dielectric material with a permanently embedded static electric dipole moment which due to the high resistance and chemical stability of the material. The names comes from electrostatic and magnet; drawing analogy to the formation of a magnet by alignment of magnetic domains in a piece of iron. Electrets are commonly made by first melting a suitable dielectric material such as a plastic or wax that contains polar molecules, and then allowing it to re-solidify in a powerful electrostatic field.

### 3.3.4 Bluetooth Electronics Application

This project controlled with an Android device. This app communicates using Bluetooth to an HC-06 or HC-05 Bluetooth module in project. This app comes with a library containing 10 Bluetooth examples for Arduino. Large selection of controls available including buttons, switches, sliders, pads, lights, gauges, terminals, accelerometers and graphs.

Some advantages of Bluetooth Electronics Apps:

a) Ideal for learning electronics in a fun way.
b) Ideal for rapid prototyping a new idea.
c) Ideal for exhibiting project.

Steps to use Bluetooth electronics applications:

1. Open Bluetooth electronics apps on Android.
2. Discover, Pair and connect to Bluetooth devices.
3. Drag and drop them onto the panel grid.
4. Click Run to use the panel.
5. Import/Export panels to share them.

Description of Bluetooth Electronics Application:

a) LED Brightness - PWM with a Slider control
b) RC Car demo – Basic Button controls
c) Persistence of Vision – Text control
d) Repeater Demo – Send and Receive Terminals
e) Ultrasonic Distance Sensor - Light Indicator
f) MEGA Monitor – Graphs
g) UNO Monitor – More graphs
h) Temperature and Humidity – Temperature Gauge
i) Configure HC-06 Demo – In-case you want to change Baud rate
j) Motor Control Demo – Accelerometer and pad controls

**Figure 3.11:** Bluetooth Electronics Apps

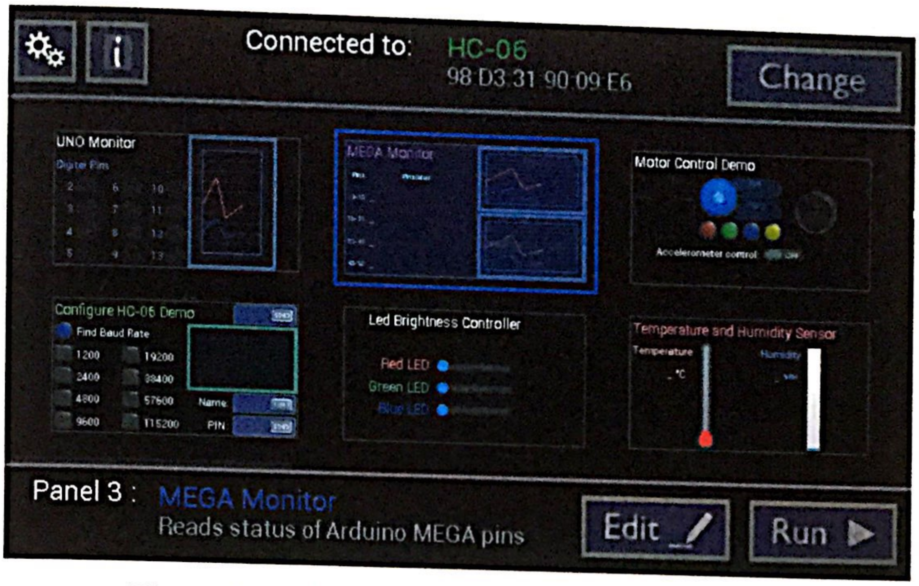



**Figure 3.12:** Bluetooth Electronic Apps Interface

### 3.3.5 Speaker

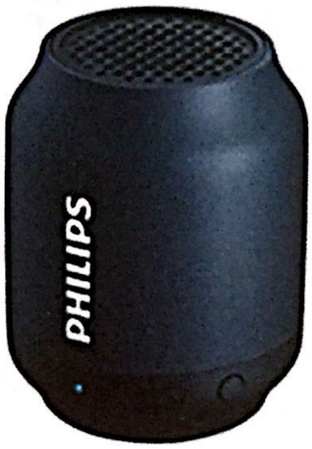



**Figure 3.13:** Speaker

Speakers are one of the most common output devices used with computer systems. Some speakers are designed to work specially with computers, while others can be hooked up to any type of sound system. Regardless of their design, the purpose of speakers is to produce audio output that can be heard by the listener. Speakers are transducers that convert electromagnetic waves into sound waves.

The speakers receive audio input from a device such as a computer or an audio receiver. This input may be either in analog or digital form. Analog speakers simply amplify the analog electromagnetic waves into sound waves. Since sound waves are produced in analog form, digital speakers must first convert the digital input to an analog signal, and then generate the sound waves. The sound produced by speakers is defined by frequency and amplitude. The frequency determines how high or low the pitch of the sound is.

### 3.3.6 Stethoscope

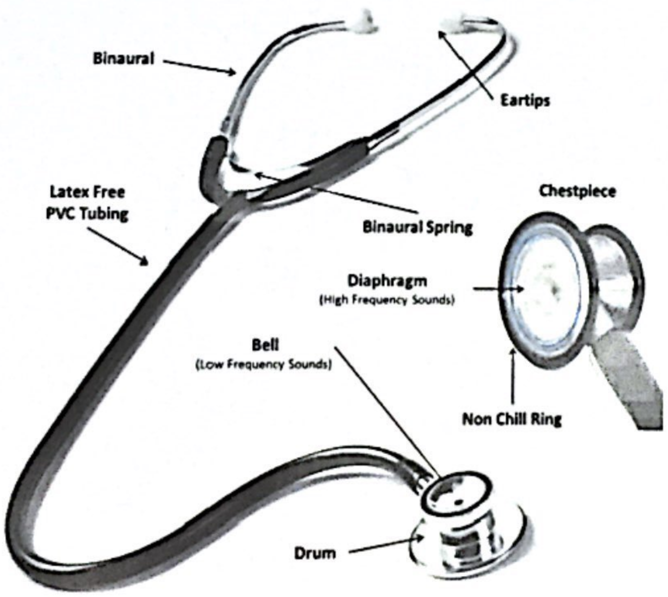



**Figure 3.14:** Parts of Stethoscope

Stethoscope is an acoustic medical device for auscultation, or listening to the internal sounds of an animal or human body. It typically has a small disc-shaped resonator that is placed against the chest, and two tubes connected to earpieces. It is often used to listen to lung and heart sounds.

Electronic stethoscope overcomes the low sound levels by electronically amplifying body sounds. Electronic stethoscope require conversion of acoustic sound waves to electrical signals which can then be amplified and processed for optimal listening. Because the sounds are transmitted electronically, an electronic stethoscope can be wireless device, can be a recording device and provide noise reduction, signal enhancement and both visual and audio output.

### 3.3.7 Potentiometer

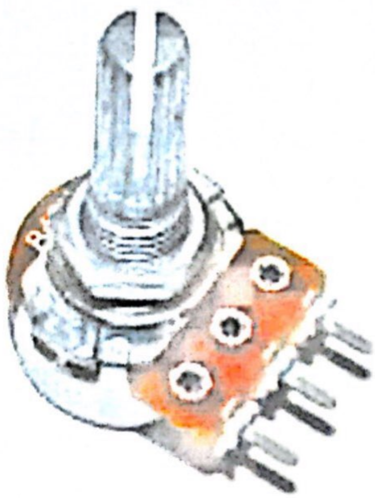


**Figure 3.15:** Potentiometer

A potentiometer is a three-terminal resistor with a sliding or rotating contact that forms an adjustable voltage divider. It commonly used to control electrical device such as volume control on audio equipment. Potentiometer operated by a mechanism can be used as position transducers. Different materials are used to construct potentiometer, including carbon composition, cermet, wire wound, and conductive plastic or metal film.

### 3.3.8 LM741

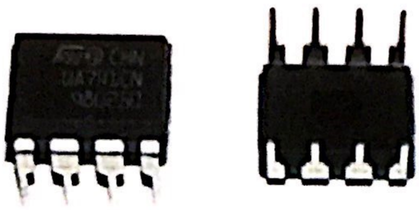


**Figure 3.16:** LM741

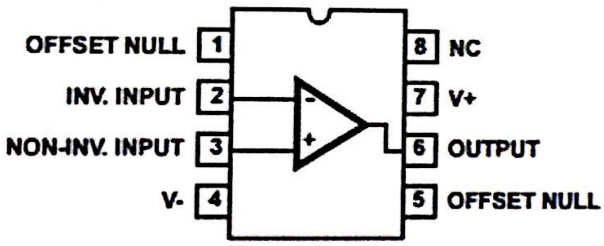



**Figure 3.17:** LM741 Pin Configuration

LM741 series are general-purpose operational amplifier which consists of three gain stage which is differential amplifier, voltage amplifier and output amplifier. The differential amplifier provides high differential amplification with rejection of common-mode signal, low noise and high input impedance. Voltage amplifier provides high voltage gain and a single-pole frequency roll-off. Output amplifier provides high current gain (low output impedance), along with output current limiting and output shirt-circuit protection.

### 3.3.9 LM386

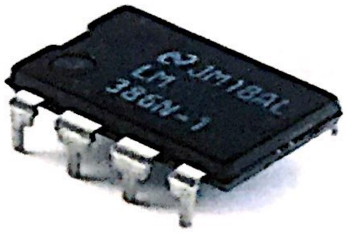



**Figure 3.18:** LM386

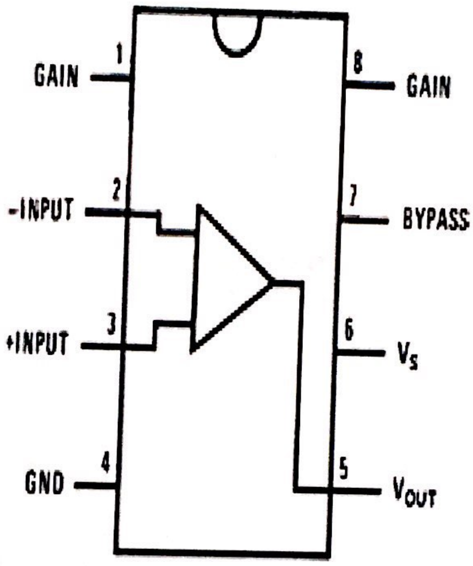



**Figure 3.19:** LM386 Pin Configuration

The LM386 is an integrated circuit containing a low voltage audio power amplifier. It is suitable for battery-powered device such as radios and electronic project. The IC consists of an 8 pin dual in-line package (DIP-8) and can output 0.25 to 1 watts of power.

### 3.3.10 TL072

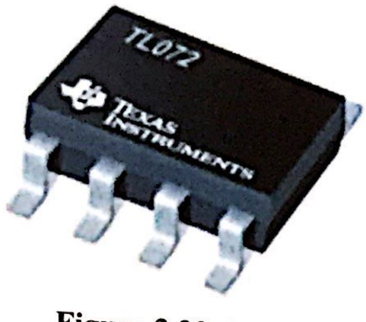



**Figure 3.20:** TL072

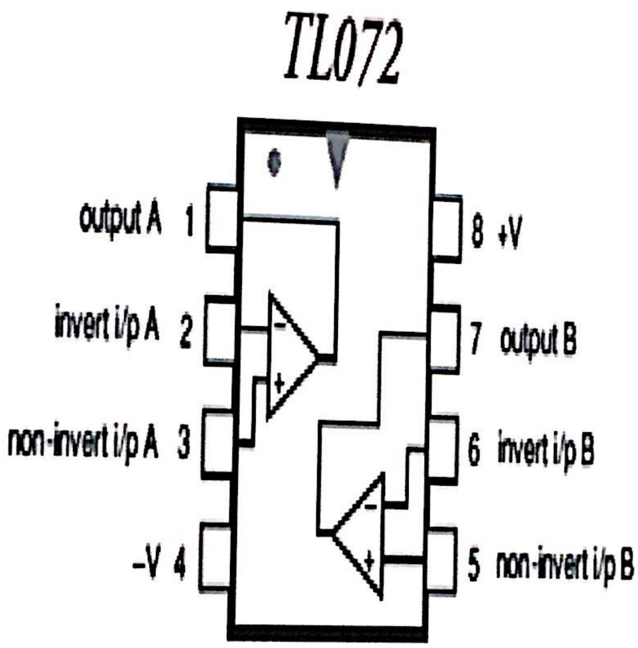



**Figure 3.21:** TL072 Pin Configuration

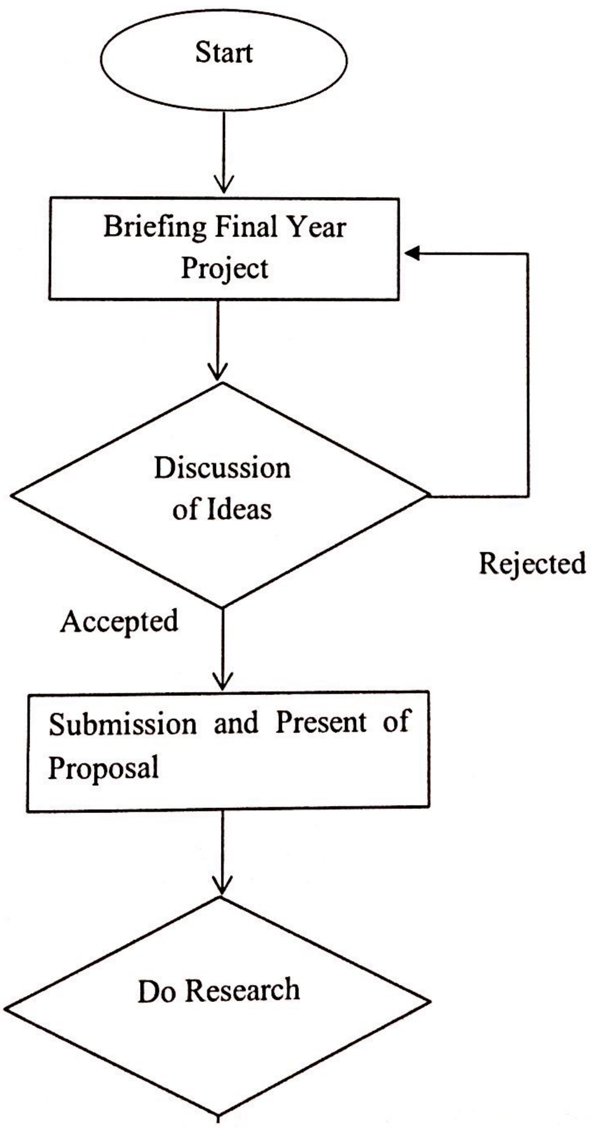
The JFET input operational amplifier in the TL072 with low input bias and offset currents and fast slew rate. The low harmonic distortion and low noise make the TL072 ideally suited for high-fidelity and audio preamplifier applications.

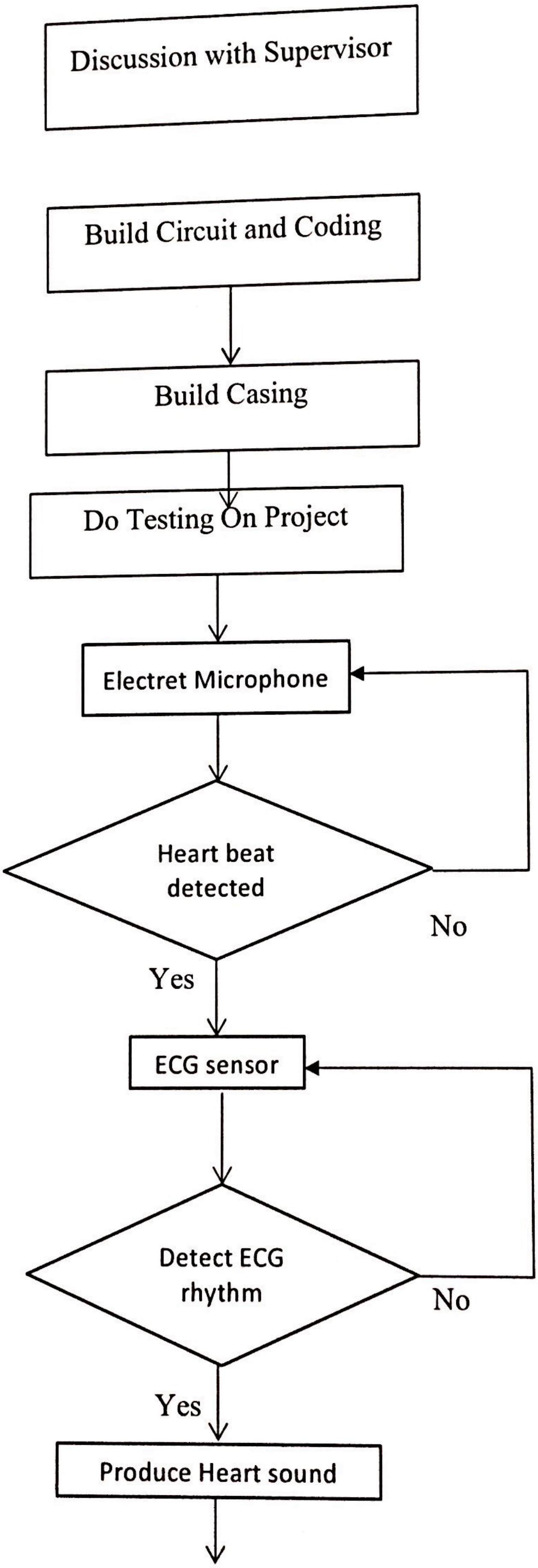
### 3.4 Data Collection

Data collection is the process of gathering and measuring information on targeted variables in an established systematic fashion, which then enables one to answer relevant questions and evaluate outcomes. The data collection component of research is common to all fields of study including physical and social sciences, humanities and business. It help scientists and analysts to collect the main points as gathered information.

While methods vary by discipline, the emphasis on ensuring accurate and honest collection remains the same. The goal for all data collection is to capture quality evidence that then translates to rich data analysis and allows the building of a convincing and credible answer to questions that have been posed. For this project, the data collection for our product was conducted involving 40 respondents of students from Electrical Engineering Department.

**3.5 Flowchart**




Discussion with Supervisor
Build Circuit and Coding
Build Casing
Do Testing On Project
Electret Microphone
Heart beat detected
No
Yes
ECG sensor
Detect ECG rhythm
No
Yes
Produce Heart sound

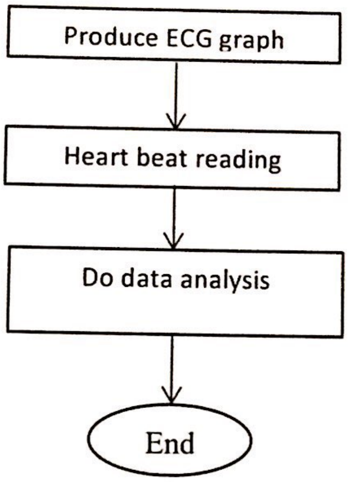



**Figure 3.22:** Methodology Flowchart

# CHAPTER 4

# RESULT AND DISCUSSION

In this chapter, the result and final accomplishment are explained. The analysis and problem encountered throughout the implementation of E-Cardio Stetho were also be discussed in this chapter. From the results of the study that we have conducted, the product can give benefit to the users. As, these product can helps students in the process of learning.

## 4.1 Hardware Design

The hardware design of the project has complete. All the components and switches used was implemented in the hardware.

All the components and switches were labeled as below:

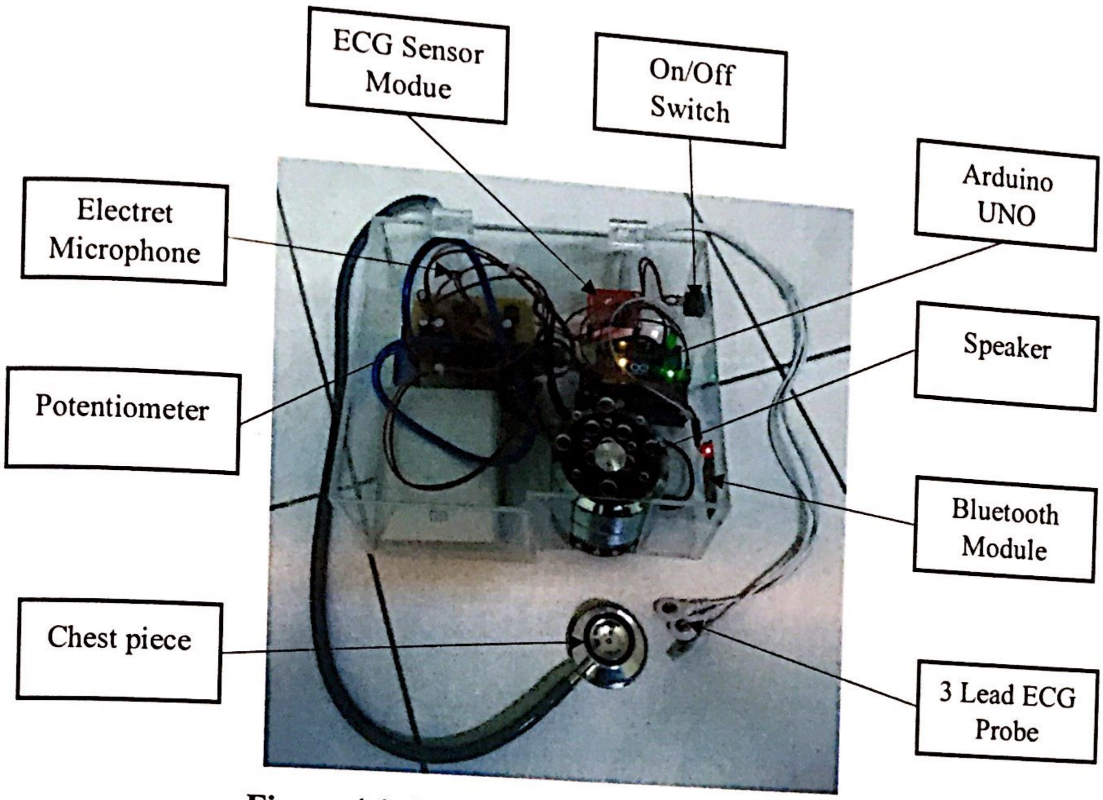



**Figure 4.1:** Labeled hardware and components

### 4.2 Data Analysis

A few analysis has been undergone for this product to ensure the reliability of the usage. It is also to ensure the product is safe to be use and can achieve the objectives of its implementation. Our analysis of this product is related to study about product safety, usability of the product and the design of the product. The analysis is important to ensure that this product is successful and accepted by users. Besides, ensuring the product is durable and easy to use.

#### 4.2.1 Technical Analysis

A few technical analysis has been done on this project. This was done to analyse the efficiency of the device are according to the standard.

#### 4.2.1.1 Simulator Test

Another technical test has been carried out by using simulator to make sure/ find out the output of our product is rely on the input given. We were using the ECG Simulator to test the output of ECG reading and graph. The result of ECG reading tested are shown below:

**Table 4.1:** Result of ECG output reading

| DESCRIPTION | SET VALUE (BPM) | MEASURED VALUE (BPM) |
|---|---|---|
| ECG Simulator Test | 60 | 68 |
| | 80 | 84 |
| | 100 | 106 |
| | 120 | 126 |

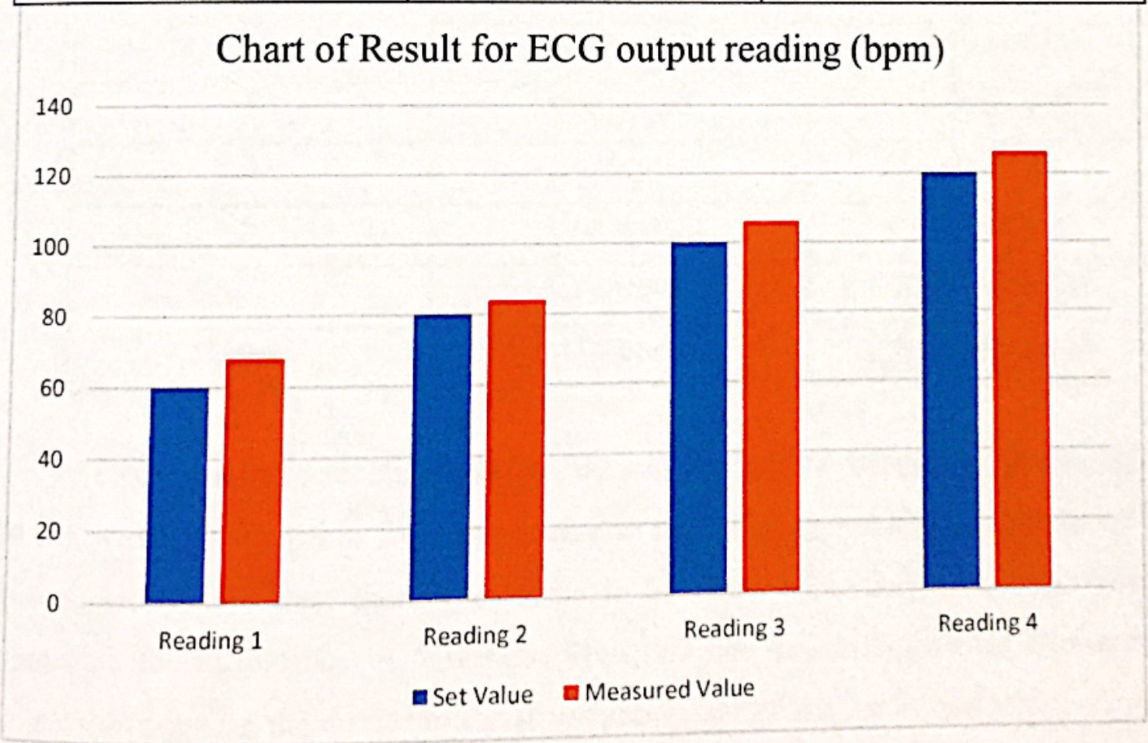



**Figure 4.2:** Result for ECG Output Reading

Based on the result that has been showed in the graph, the bit per minute (bpm) reading of heart beat recorded by the ECG is out of limit of tolerance. As the simulator give the input of 60bpm, the output on the smart phone is at the average of 68bpm. While, when the simulator give the input of 100 bpm, the result shows the reading of 106bpm. This show a bit differences of the reading as the limit of tolerance should only be by 2 or 3 bpm. This may occurs due to some error and interference occurred during the test.

#### 4.2.1.2 Bluetooth Connection Test

The third analysis was about the measurement of the length of Bluetooth connection. It is to analyse how far the connection of Bluetooth can be made from device to smart phone. Bluetooth module HC-06 were used to send data from ECG sensor to the smart phone application.

**Table 4.2:** Measurement of length for Bluetooth connection

| **Distance (m)** | **Connection** | |
|---|---|---|
| | **No Obstacle** | **Obstacle** |
| **1** | Connected | Connected |
| **3** | Connected | Connected |
| **5** | Connected | Connected |
| **7** | Connected | Not Connected |
| **9** | Not Connected | Not Connected |

Based on the result shown above, we can see that the Bluetooth Module HC-06 can make a connection from the device to the smart phone to the distance of 7 meters. However, when there was obstacle between both, they will only being connected to the distance of 5 meters. Thus, we can conclude that the Bluetooth connection between the device to the smart phone can be further when there were no obstacle than when there was obstacle.

### 4.2.2 Questionnaire

An evaluation test have been conducted on the usability of the product in order to obtain information on the user's feedback for this product. In addition, the distribution of evaluation forms were distributed level of customer satisfaction to ensure the information is correct in order to improve this product.

**Data Collection**

This evaluation test was conducted involving 40 respondents consisting of students from electrical departments.

**Table 4.3:** Number of Respondents

| Gender | Number Of Respondents |
|---|---|
| Male | 14 |
| Female | 26 |
| **Total** | **40** |

#### 4.2.2.1 Evaluation Test on the Effectiveness of the Kit

The result for the evaluation test are as shown in the table below:

**Table 4.4:** Evaluation Test on the Effectiveness of the Kit

| No | Questions | Strongly Agree | Agree | Neither | Disagree | Strongly Disagree |
|---|---|---|---|---|---|---|
| 1 | Effectiveness of the kit | | | | | |
| a) | Is this product able to detect and produce heart beat | 13 | 19 | 8 | 0 | 0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | and heart rhythm? | | | | | |
| b) | Is this product easy to be used? | 8 | 21 | 11 | 0 | 0 |
| c) | Is this product safe to be used? | 11 | 20 | 9 | 0 | 0 |
| d) | I found it is easy to understand the study of heart beat by using this product. | 11 | 18 | 11 | 0 | 0 |
| e) | Is this product really helps in learning process? | 16 | 19 | 5 | 0 | 0 |
| f) | I think that I would like to use this device to help me in study the heartbeat. | 15 | 22 | 3 | 0 | 0 |
| g) | This product is a new innovation for learning purpose? | 16 | 16 | 8 | 0 | 0 |

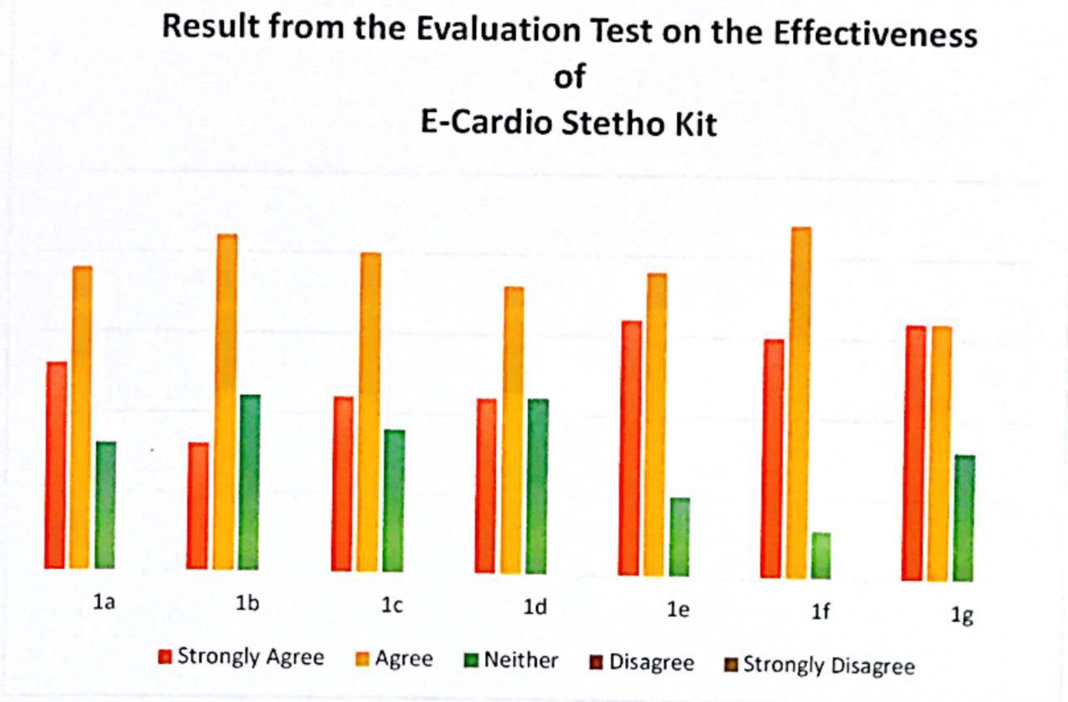



**Figure 4.3**: Result from the Evaluation Test on the Effectiveness of E-Cardio Stetho Kit

This particular bar chart above shows the responses of 40 students from Electrical Engineering Department which are from DEU6A and DEU6B about the effectiveness of our product.

This particular bar chart number 1 above shows the result about the ability of the product to detect and produce heart beat and heart rhythm. As stated in the bar chart above, we can conclude that 33% of the respondents were agree with the ability of the product. While, 48% were agree and 19% of them were neither agree or not to agree.

This particular bar chart number 2 above shows the result about the comfortability of using this product. At the bar chart above, we can see that 21 respondents were agree that this product are easy to be used, 8 respondents were strongly agree and the other 11 respondents were neither agree or not to agree.

This particular bar chart number 3 shows the result about the safety of the kit. From the chart, 11 respondents were strongly agree and 20 respondents were agree that the kit was safe to be used. While, another 9 respondents were neither agree or not to agree.

This particular bar chart number 4 above shows the result about the understanding of study the heart beat using this kit. As a result, 11 out of 40 respondents were strongly agree with it. At the same time, 18 of them were agree. Out of that, the other 11 respondents were neither agree or not to agree. We can conclude that most of the respondents found that it is easy to study the heart beat by using this kit.

This particular bar chart number 5 above shows the result about the ability of the product to helps students in learning process. As we can see, 16 respondents were strongly agree and 19 of them were agree. There were only 5 respondents that neither agree or not to agree with it. Thus, we can simplify that almost out of respondents found that this kit was really helping them in learning process.

This particular bar chart number 6 shows the result about the respondents willing in using the kit to help them in their study. Currently, 15 and 20 out of the all 40 respondents were strongly agree and agree that they would like to use this kit in order to help them study about the heartbeat. Only 3 of them against it.

This particular bar chart number 7 shows the result about the new innovation in learning purpose. There were the same amount of respondents listed that strongly agree and agree with it which was 16 of them for each choice respectively.

Overall, we can conclude that our kit can achieve the objectives of the implementation. As, most of the respondents were satisfied with the effectiveness of the kit, it can be introduced as a new learning kit for learning purpose.

#### 4.2.2.2 Evaluation Test on the Design of the Kit

The result for the evaluation test are as shown in the table below:

**Table 4.5:** Evaluation Test on the Design of the Kit

| No | Questions | Strongly Agree | Agree | Neither | Disagree | Strongly Disagree |
|---|---|---|---|---|---|---|
| 2 | Design of product | | | | | |
| a) | I think the design is nice and compatible. | 12 | 22 | 6 | 0 | 0 |
| b) | I think the size is too big. | 4 | 13 | 11 | 6 | 6 |
| c) | I think the design need to be modified(improved). | 6 | 17 | 13 | 3 | 1 |

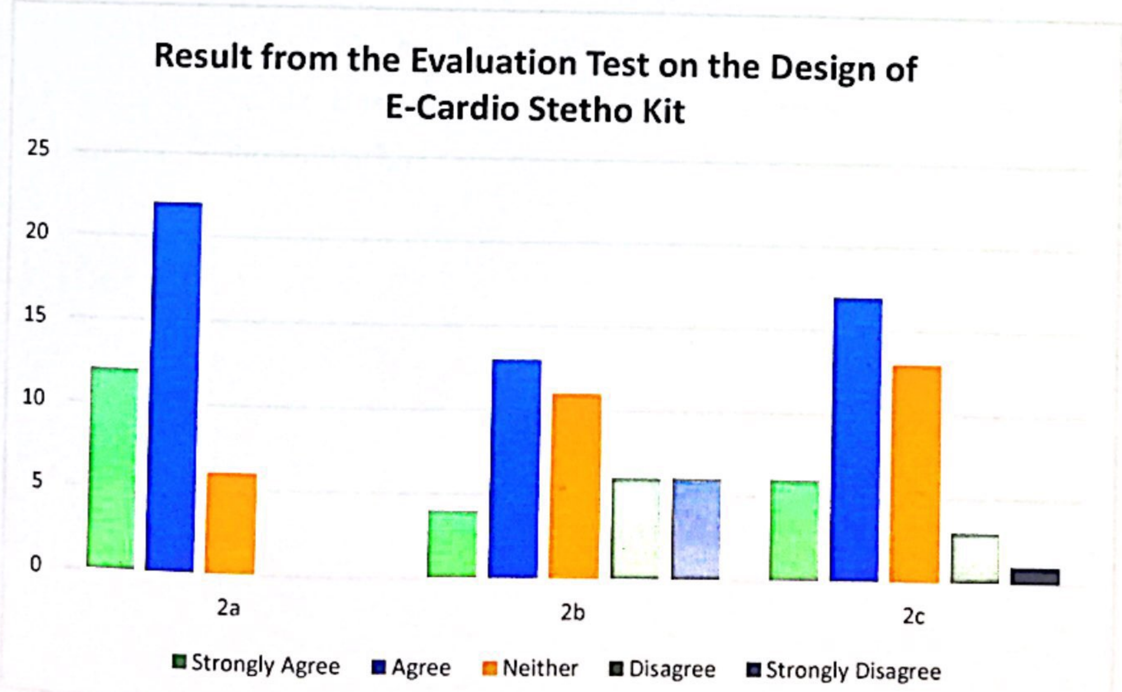



**Figure 4.4:** Result from the Evaluation Test on the Design of E-Cardio Stetho Kit

This particular bar chart above shows the responses from the respondents about the design of our product.

This particular bar chart number 1 shows the result about the compatibility design of the kit. As we can see, 12 respondents were strongly agree and 22 of them were agree with the design of the kit. However, there were 6 of them that were neither agree or not to agree with it. Here, we can conclude that most of the students found that the design of the kit was nice and compatible.

This particular bar chart number 2 shows the result about the size of the kit. As shown by the graph, 17 out of 40 respondents were agree that the size of the kit was too big. While, 11 of them were neither agree or not to agree and the rest were disagree with the statement of the size is too big.

This particular bar chart number 3 shows the result about recommendation on the improvement of the design. As stated in the bar chart, 23 of respondents were agree that the design of the kit need to be modified or improved. While, 4 of them were disagree about the modification and improvement of the kit.

Generally, we can conclude that most of the users found that the design was nice and compatible. However, some of them also agree with the recommendation about modification of the kit.

# CHAPTER 5

# CONCLUSION AND RECOMMENDATION

## 5.1 Conclusion

At the end, we have done our project successfully. We managed to produce a new implementation for learning purpose. We went through all odds succeeded patiently in setting up this product.

This product was meant to provide a device that can help students in the process of learning and teaching. It is also can accelerate the process of understanding the real heart sound and heart rhythm. In other way, we also create a cost-effective tool for studying.

As this showed the effectives specification for learning devices in medical field, we found that this project is very useful and rational.

## 5.2 Recommendation

Upon completing the project, we have done a survey to overcome any new recommendation from the users. A few suggestion have been received from the respondents through the survey. There were a few things are needed for improvement.

A few of them were suggested that the design of the kit need to be improved. As for them, the size of the kit is a quite big. They have suggest to make it little smaller in size. There was also a suggestion from a student to make the circuit of the kit more compact and less complicated.

There was also a student that suggest the added of an LCD on the kit. At first, we also decided to produce the output on LCD, but there were a few error that make the LCD is not compatible with our device. So, in order to make our product according to the latest technology, we decide to display the output on the application of the smart phone that being transmitted via Bluetooth.

Lastly, we hope that there will be individual or groups that will continue on research and development for this product so that it can give benefits to the other people based on the objectives.

# REFERENCES


[1] Scher, A.M., **The Electrocardiogram**, Scientific American, vol.205, No.5, pp.132–141, 1961.**254 Manoj Kumar Kowar**

[2] Khandpur, R.S., **Handbook of Biomedical Instrumentation**, Tata McGraw Hill Publishing Company, New Delhi, 1990.

[3] Aston, R., **Principles of Biomedical Instrumentation and Measurement**, Merrill Publishing Company, Ohio, 1990.

[4] W. H. Ko, M. R. Neuman, R.N. Wolfson and E.T. Yon, **Insulated Active Electrode,** IEEE Trans. Ind. Elect. Contr. Instrum., vol. IECI–17, pp. 195-198, 1970.

[5] G.E. Bergey, R.D. Squires and W.C. Sipple, **Electrocardiogram Recording with paste less Electrodes**, IEEE Trans Biomed Engg., vol. BME-18, pp. 206-211, 1971.

[6] M.J Burke and D.T. Gleeson, **A Micro power Dry-Electrode Preamplifier**, IEEE Trans. Biomed. Engg., vol. BME–47, pp. 155-162, 2000.

[7] Irny, S.I and Rose, A.A. (2005) "Designing a Strategic Information Systems Planning Methodology for Malaysian Institutes of Higher Learning (isp-ipta), Issues in Information System, Volume VI, No.1 , 2005.

# LIST OF APPENDICES

# LIST OF TABLES

# LIST OF FIGURES