

# Design & Development of Cardio-vascular monitoring System using ECG Data



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Degree

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In

Electrical Engineering

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## ***MESSAGE FROM QURAN***

***“O ye who believe! When it is said unto ou, Make room! In assemblies, then make room; Allah will make way for you (here after), And when it is said, Come up higher! Go up higher; Allah will exalt those who believe among you, and those who have knowledge, to high rinks. Allah is informed of what ye do. ”***

***(Surah Al-Mujadila)***

## ***PROPHET MUHAMMAD (S.A.W)***

***“Let there be no envy, except in two things:***

- 1. A man whom Allah gave a wealth and guided him to spend it in righteous way.***
- 2. Or a man whom Allah gave wisdom and he acts wisely and teaches to the others”***

***(Al-Bukhari and Muslim)***

## **CERTIFICATE OF APPROVAL**

It is certified that the work contained in this project report, entitled

**“Design & Development of Cardio Vascular Monitoring System Using ECG Data”**

Was carried out by

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## DEDICATION

*To our respected parents who's utmost love, care and struggle against all odds brought us to this height of knowledge with the care and help of the ALMIGHTY*

## ACKNOWLEDGMENTS

First of all, we are grateful to ALMIGHTY ALLAH who gave us the strength to achieve our goals. Without HIS divine help, we could do nothing. Secondly, we would like to pay deep regard to our parents who, with their selfless and extreme love, were always there to give us the required motivation, courage and confidence to complete our tasks. We would like to salute them because of their patience in managing with our busy routines and tight schedules. We are also extremely thankful to Mr.Farhan Iqbal, our project advisor, who gave us the desired knowledge and right direction to move forward. He was really cooperative through our complete voyage and provided us with each and every facility whenever and whatever was required for our project. He remained with us from the start till the end and though he used to be busy with his own work, he never refused our calls and whenever we wanted to meet him, he was there for our help. In the end, we are grateful to our friends specially Ammar Ahmed who was always there to give us company whenever we were down on something. They created the right mix of work atmosphere in the university which led us all to complete our projects successfully. We would also like to thank Mr.Asmar Azar Khan for helping us endless discussions and fruitful suggestions.

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## ABSTRACT

In this report a practical multi sensor cardio vascular system is proposed, combining physiological data, acquired from ECG and Stethoscope. An Embedded Transmission Unit (ETU) combines the both sensors, signal conditioning circuitry, and micro controller. A PC receives the data from both sensors.

The ECG data and stethoscope audio is also analyzed (for heart rate and murmur detection), by an algorithmic methodology. Both signals and analysis results will be show graphically.

This report describes the major and clinical background areas relevant to the project. A discussion of hard ware implementation is presented, including component selection, with the majority of hardware implemented successfully. Major issues encountered are introduced, as areas of possible expansion of functionality.

## List of Figures

Figure 1 Functional Schematic .....	2
Figure 2 The Heart & Vessels [12] .....	3
Figure 3 heart Sounds [13] .....	4
Figure 4 Heart Murmur [14] .....	5
Figure 5 Heart Murmurs [15].....	6
Figure 6 ECG P Wave [16].....	6
Figure 7 P Wave Graphs [17] .....	7
Figure 8 Q Wave [18].....	7
Figure 9 Wave Graph [19].....	7
Figure 10 R Wave [20].....	7
Figure 11 R Wave Graph [21] .....	7
Figure 12 S wave [22] .....	8
Figure 13 S wave Graph [23].....	8
Figure 14 T wave Graph [25].....	8
Figure 15 ECG Wave Intervals [26] .....	8
Figure 16 Einthoven's Triangle [27].....	10
Figure 17 Three Lead Systems [28] .....	10
Figure 18 The electronic stethoscope [29].....	11
Figure 19 The Piezo sensor [33] .....	12
Figure 20 pic16F877A [30] .....	14
Figure 21 Design A [34].....	16
Figure 22 Design B [35] .....	17
Figure 23 Designs C [36].....	17
Figure 24 Block Diagram(Stethoscope) .....	18
Figure 25 Block Diagram (ECG) .....	19
Figure 26 Detailed Block Diagram .....	20
Figure 27 low pass filter (Stethoscope Circuit) .....	23
Figure 28 Input Supply .....	23
Figure 29 Digital Stethoscope [38] .....	24
Figure 30 PIC serial Interface .....	25
Figure 31 Stethoscope Breadboard .....	26
Figure 32 33 ECG breadboard .....	26
Figure 33 Digital Stethoscope.....	27
Figure 34 35 ECG Sensor and PIC .....	27
Figure 35 ECG Graph.....	28

# Table of Contents

ACKNOWLEDGMENTS .....	vii
ABSTRACT.....	viii
Table of Contents .....	x
1 CHAPTER NO 1.....	1
1.1 Introduction.....	1
1.2 Project Specification .....	1
1.3 Areas of Application .....	1
1.4 Functional Schematic .....	2
2 CHAPTER 2 .....	3
2.1 KEY CONCEPT AND BACKGROUND INFORMTION.....	3
2.2 The Heart .....	3
2.3 Heart Sounds.....	4
2.4 Heart Murmurs.....	5
2.5 ECG Wave form.....	6
2.6 COMPONENTS OF ECG WAVEFORM.....	6
2.6.1 The P Wave.....	6
2.6.2 The Q Wave .....	7
2.6.3 The R Wave .....	7
2.6.4 The S wave .....	7
2.6.5 The T Wave .....	8
2.7 Key Terms of ECG Waveform .....	8
2.7.1 Baseline .....	9
2.7.2 Interval.....	9
2.7.3 Segment .....	9
2.8 Einthoven's Triangle.....	9
2.9 The Standard Lead System .....	10
3 CHAPTER 3 .....	11
3.1 THE EMBEDED TRANSMISSION UNIT (ETU) .....	11
3.2 Components .....	11
3.2.1 The Stethoscope Sensor.....	11
3.3 The ECG Sensor.....	12

3.4	MICROCONTROLLER.....	13
3.4.1	Introduction to micro controller.....	13
3.4.2	What is a micro controller? .....	13
3.4.3	Usage of micro controller .....	13
3.4.4	Microcontroller we used PIC16F877A .....	13
3.4.5	Features of PIC16F877A.....	14
4	CHAPTER 4 .....	16
4.1	Design Description.....	16
4.1.1	Different Scenarios.....	16
4.2	Design B .....	17
4.3	Design C .....	17
4.4	Heart Patient Monitoring System.....	18
4.4.1	Design Description.....	18
4.5	Block Diagrams.....	18
4.5.1	Block Diagram for Stethoscope .....	18
4.5.2	Block Diagram for ECG.....	19
4.5.3	Block Diagram Description .....	19
4.5.4	Detailed Schematic.....	20
5	CHAPTER 5 .....	21
5.1	THE INTERFACING CIRCUITS .....	21
5.2	Analog Filters.....	21
5.2.1	Cut-Off Frequency .....	21
5.2.2	Real Filters.....	22
5.3	WHY WE USE ANALOG FILTERS .....	22
5.4	Why we use analog low pass filtering in our circuit .....	22
5.5	DESIGN Circuits .....	23
5.5.1	General design procedure for low pass filter .....	23
5.6	Design of input Supply .....	23
5.6.1	Complete Design of Stethoscope Circuit .....	24
5.7	Design of DB-9 Female Circuit Using Microcontroller .....	25
5.8	BREAD BOARD IMPLEMENTATION .....	26
5.8.1	Design of Stethoscope Circuit .....	26
5.8.2	Design of ECG Circuit .....	26

5.9	PCB IMPLEMENTATION .....	27
5.10	Graphical Representation .....	28
6	CHAPTER 6 .....	29
6.1	Conclusions.....	29
6.1.1	Analysis of Results.....	29
6.1.2	Achievements.....	29
6.2	Areas of Project Expansions .....	29
6.3	In Conclusion.....	30
7	References.....	31
8	Appendix .....	32
8.1	C # Coding for Graphical Interface.....	32
8.2	Code for Microcontroller PIC16F877A .....	55

# 1 CHAPTER NO 1

## 1.1 Introduction

## 1.2 Project Specification

The aim of this project is to accomplish the completed design of a cardio vascular designing system ,using data from two common sensors from the medical domain, named an ECG(Electrocardiogram) , and stethoscope(will be implemented electronically).The monitoring system incorporates both *ECG* and *Stethoscope* analysis. Both sensors measure differing ‘outputs’ of the cardio system. Consequently the data from both sensors can be used to consolidate some common measurements, (i.e. heart rate) but due to their separate sources, each can be used to identify conditions not apparent in the other, expanding the possible range of diagnosis.

## 1.3 Areas of Application

Both the ECG and cardio auscultation (i.e. diagnosis by heart sound) are firmly established as the primary tools for the physician wishing to determine the state of a patients cardio vascular system. Human analysis of this sensor data requires a high level of experience as a prerequisite for accurate diagnosis.

Thus the main possible applications are those in which a source of clinical expertise is absent. These include ambulatory monitoring, or perhaps as a first line of warning for out-patients with pre diagnosed conditions. The former case is applicable if paramedics are not trained in ECG or heart sound analysis, and in the latter the system could be tailored (by alerting the set of detectable conditions) to the patient’s needs.

The ECG and stethoscope sensor data are obtained by the ETU. This comprises ECG and stethoscope sensors, suitable signal pre-processing circuitry, a microcontroller performing sampling and digital filtering.

Thus the sensor data is collected and transmitted; however the main computation is performed using the remote pc. Algorithmic and non-linear classification accomplish the detection of medical conditions , and a Graphical user interface displays plots of the acquired wave forms ,annotated with analysis results and noted.

## 1.4 Functional Schematic

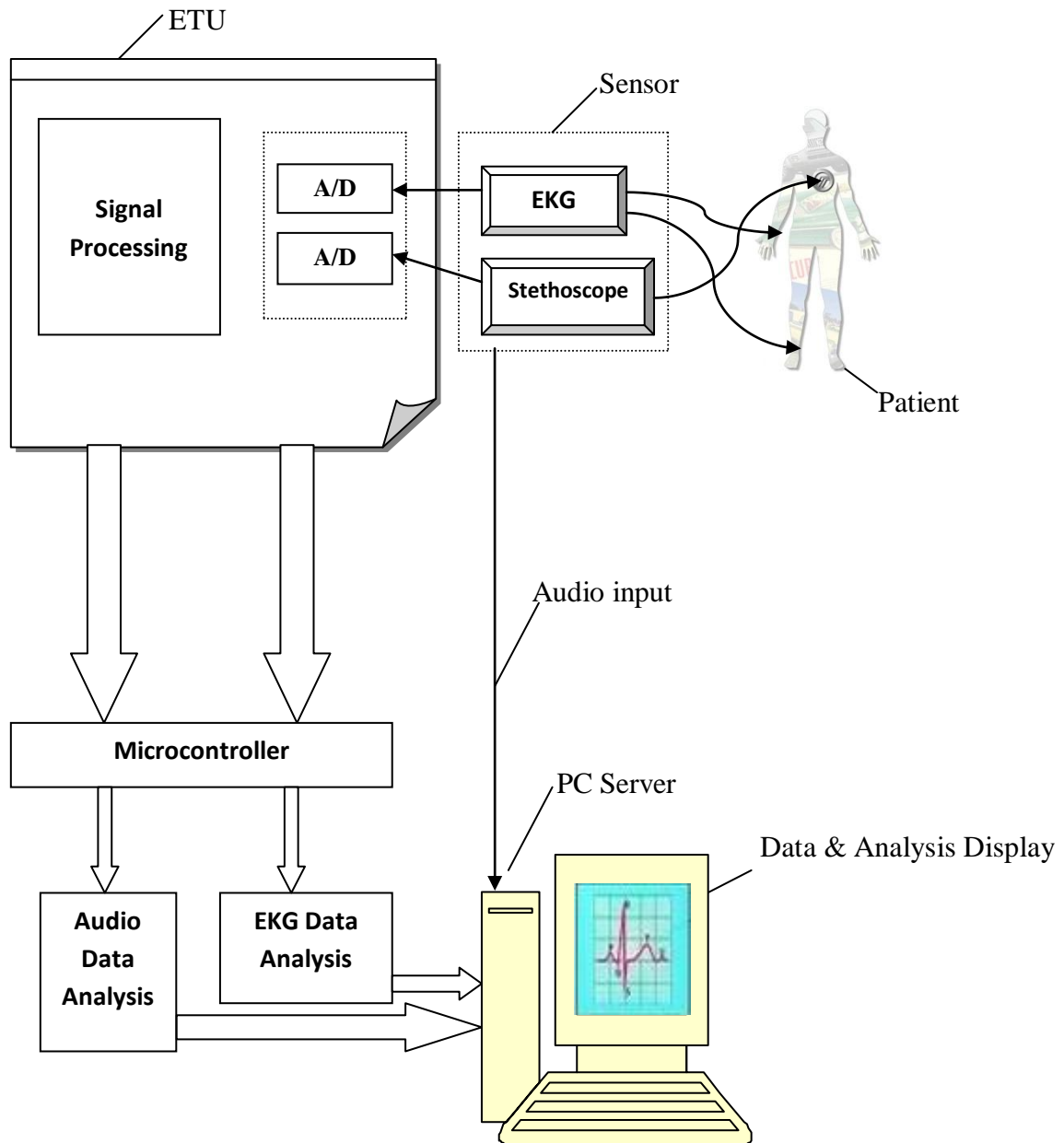


Figure 1 Functional Schematic

## 2 CHAPTER 2

### 2.1 KEY CONCEPT AND BACKGROUND INFORMATION

An overview of basic cardio operation is given; both the physical pumping action and the bioelectrical systems are discussed.

A description of Cardio auscultation, this diagnosis technique of listening to the sounds of the heart, is given. The sources of these sounds and the effects of certain Cardio vascular conditions upon them are summarized.

### 2.2 The Heart

The role of the heart is to pump oxygen-rich blood to every living cell in the body. In order to achieve its goal, it must continuously beat for a person's entire lifespan. Because of its vital role, a non-beating heart always results in death. The human heart beats approximately 80,000 to 100,000 a day and pumps almost 2,000 gallons of blood. This means that in a person's life lasting 70 to 90 years, the heart beats approximately two to three billion times and pumps 50 to 65 million gallons of blood. Because the heart is so essential for human sustenance, it is made up of a muscle different from skeletal muscle that allows it to constantly beat. [3]

The heart is a fist-sized muscle, located in the chest between the lungs. It functions to pump blood throughout the body, so delivering oxygen & nutrients the tissues of the body. Carbon dioxide & other b-products of the metabolic process are also removed by this circulating blood.

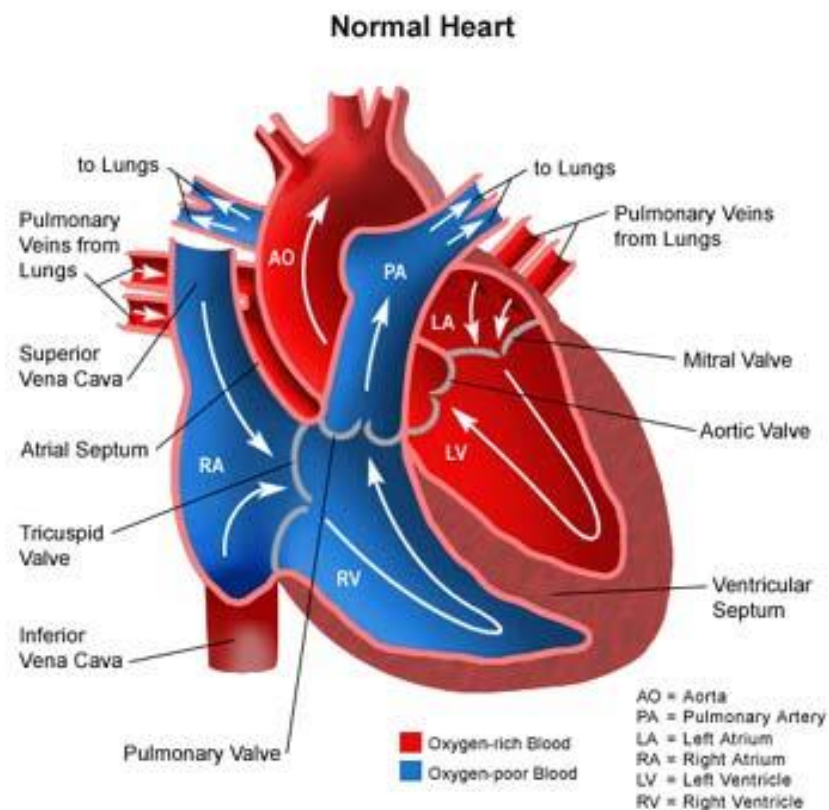


Figure 2 The Heart & Vessels [12]

The pumping action of the heart is dependent on a specific pattern of contraction of the heart muscle. Deoxygenated blood from systemic circulation (i.e. from the body) enters the heart through the right atrium, and is then forced through the tricuspid valve into the right ventricle. Contraction of right ventricle forces this blood through the pulmonary valve, where it exits the heart via pulmonary artery. The blood is the oxygenated in lungs, and returns to the heart into the left atrium. Contraction of the left atrium pumps the oxygenated blood through the mitral valve, into the left ventricle. Final contraction of the left ventricle pumps the blood through the aortic valve to the aorta, returning it to systemic circulation.

### 2.3 Heart Sounds

The heart sounds are the noises (sound) generated by the beating heart and the resultant flow of blood through it. This is also called a heartbeat. In cardiac auscultation, an examiner uses a stethoscope to listen for these sounds, which provide important information about the condition of the heart. [4]

In healthy adults, there are two normal heart sounds often described as a lub and a dub (or dup), that occur in sequence with each heart beat. These are the first heart sound (S1) and second heart sound (S2)

Both sounds are caused by the operation of the heart's valves. This is in contrast with the ECG, which has an entirely different origin.

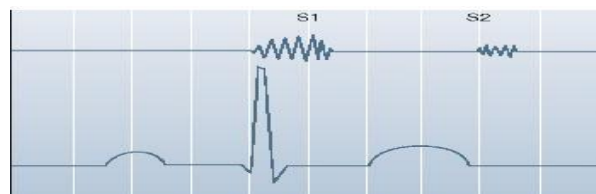


Figure 3 heart Sounds [13]

The following explanations of both sounds are found in [4]

- S1: The first heart tone, or S1, forms the "lubb" of "lubb-dub" and is composed of components M1 and T1. It is caused by the sudden block of reverse blood flow due to closure of the atrioventricular valves, i.e. mitral and tricuspid, at the beginning of ventricular contraction, or systole.
- S2: The second heart tone, or S2, forms the "dub" of "lubb-dub" and is composed of components A2 and P2. It is caused by the sudden block of reversing blood flow due to closure of the aortic valve and pulmonary valve at the end of ventricular systole, i.e. beginning of ventricular diastole.

Two more heart sounds, lower in frequency and amplitude, are also identified in some cases. These are denoted S3 (protodiastolic gallop) & S4 (presystolic gallop), [4] and (depending on patient age and other factors) are considered to be pathological in nature.

*In this project the above periodic pattern will be used to compute an instantaneous heart rate, this will be compared with that from ECG analysis.*

## 2.4 Heart Murmurs

A heart murmur is an extra or unusual sound heard during a heartbeat. Murmurs range from very faint to very loud. They sometimes sound like a whooshing or swishing noise. [5]

Heart murmurs are believed to result from turbulences in blood flow in the heart & the surrounding great vessels. These are usually subcategorized based on their position and duration in the heart cycle: [5]

- A systolic murmur is heard when the heart is squeezing and pumping blood out of the heart. Accordingly they occur between S1 and S2.
- A diastolic murmur is heard when the heart is relaxing and filling with blood. Diastolic murmurs often are a sign of a heart defect or heart disease, and further checking is likely needed. Thus they appear between S2 and the next S1.
- Continuous murmurs occur in both the systolic and the Diastole, and are so uninterrupted by the closure of valves. This signifies permanent pressure different between chambers – vessel pair.

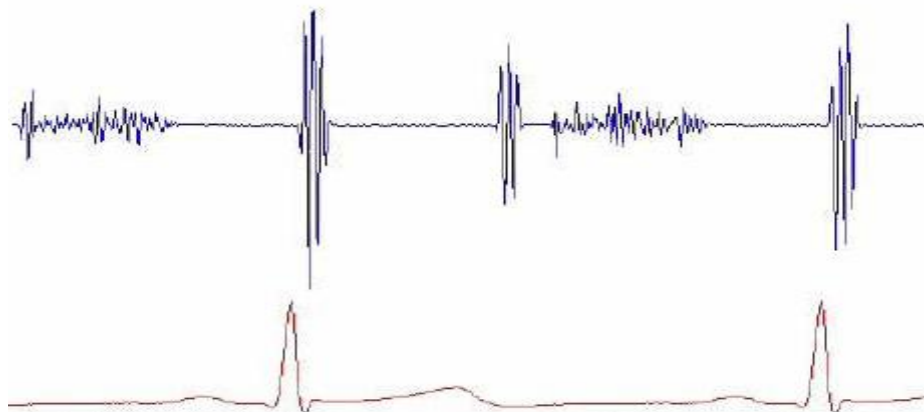


Figure 4 Heart Murmur [14]

Although the above outline of heart murmurs is sufficient in detail for application presented here, the situation is more complex in clinical practice. Other non-murmur sounds may appear (including clicks, snaps & high pitched fiction generated sounds), serving to confuse the issue the diagnosis is often based on matching a distinctive murmur pattern to a known condition.



Figure 5 Heart Murmurs [15]

## 2.5 ECG Wave form

The resting phase of the conduction cycle, or the polarized state, is visible on the ECG tracing as the base line. The base line is important because the beginning of a wave form is marked by a departure (or movement away from the base line). The ending of a wave form is marked in terms of a return to the base line. This is critical to understand because in order to be able to examine and measure a wave form, a clear understanding of where the waveform begins and ends is necessary.

When a SA node initiates the heart beat, it depolarize to initiate an action impulse that is rapidly propagated through the atria (causing atria contract), then slowly through the AV node and rapidly via the bundle branches to the ventricles, causing ventricular contraction.

The electrical activity of the heart can be recorded at the surface of the body using an electro diagram .The EKG (electro diagram) is simply a volt meter that uses up to 12 different leads (electrodes) placed on designated areas of the body. [6]

## 2.6 COMPONENTS OF ECG WAVEFORM

Each portion of heart beat produces a different deflection on the ECG. These reflections are recorded as a series of positive and negative waves [7]. On a normal ECG /EKG, there are typically up to five visible waveforms.

- The P wave
- The Q wave
- The R wave
- The S wave
- The T wave

### 2.6.1 The P Wave

The first Deflection of heart beat is a small upward wave called P wave. It indicates the atrial depolarization. The initial portion of P waves largely a reflection of right atrial depolarization and the terminal portion is largely a reflection of left atrial depolarization .A fraction of a second after the P wave starts, the atria contract.

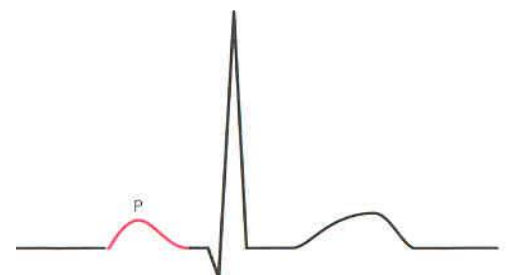


Figure 6 ECG P Wave [16]

The P waves should all look alike and be no larger than 0.3mV (3mm). Taller morphologies may indicate right atrial enlargement. Wider or 'm' shaped morphologies may be caused by left atrial enlargement.



Figure 7 P Wave Graphs [17]

### 2.6.2 The Q Wave

When visible the Q wave is any initial downward deflection after the P wave. The normal Q wave represents depolarization. The Q wave that is seen following a heart attack may be wide and deep. The dead muscle neither conducts nor produces current, so the ECG picks up current flowing away from this muscle, producing a strong negative deflection.

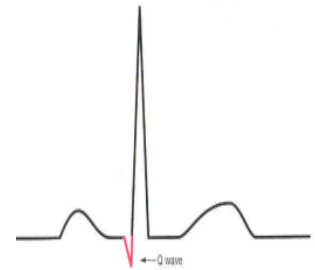


Figure 8 Q Wave [18]

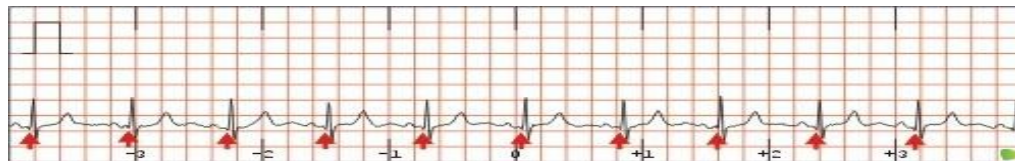


Figure 9 Wave Graph [19]

### 2.6.3 The R Wave

The R wave is the first upward deflection after the P wave (even when Q waves are absent). The R wave is normally the easiest wave form to identify on the ECG and represents early ventricular depolarization. The R wave may be enlarged with ventricular hypertrophy, a thin chest wall or with an athletic physique.



Figure 10 R Wave [20]

It may be reduced by a variety of mechanisms including obesity.

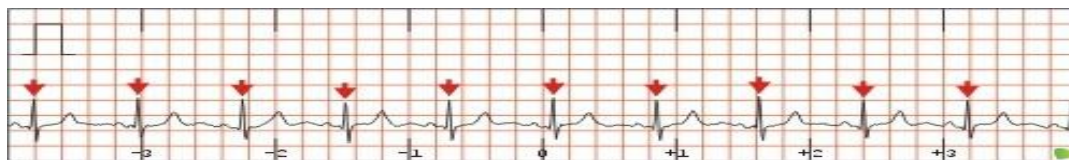


Figure 11 R Wave Graph [21]

### 2.6.4 The S wave

The S wave is the first negative deflection after the R wave. It represents the late ventricular depolarization



Figure 12 S wave [22]

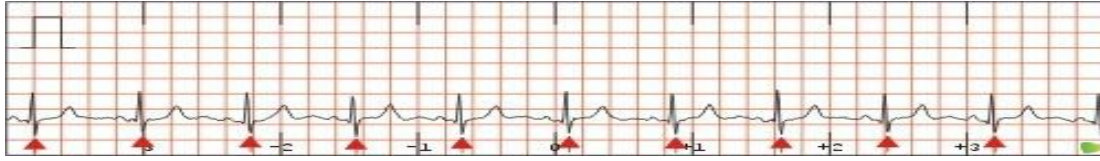


Figure 13 S wave Graph [23]

### 2.6.5 The T Wave

The T wave represents depolarization of the ventricles. It is normally upright, somewhat rounded, and slightly asymmetric. Its morphology will alter with breath holding and digitalis toxicity. The T wave may be inverted or flat with myocardial ischemia, bundle branch block, ventricular hypertrophy, and ventricular ectopic beats. It is tall and peaked with hyperkalaemia (potassium decreases the duration of the refractory period and enhances repolarisation). The T wave is flat and notched with conditions such as pericarditis, hypothyroid, and cardiomyopathies and flat with hypocalcaemia.[7]

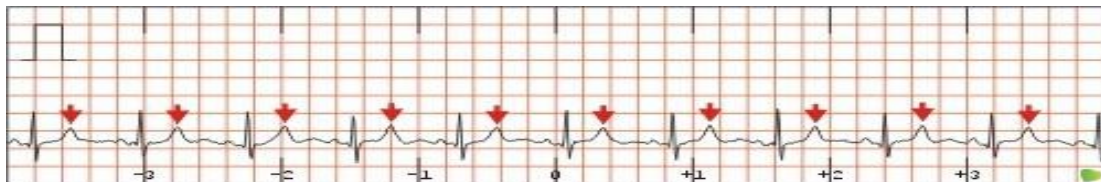


Figure 14 T wave Graph [25]

## 2.7 Key Terms of ECG Waveform

The electro diagram is composed of waves and complexes. Waves and complexes in the normal sinus rhythm are the P wave, PR Interval, PR Segment, QRS Complex, ST Segment, QT Interval and T wave.

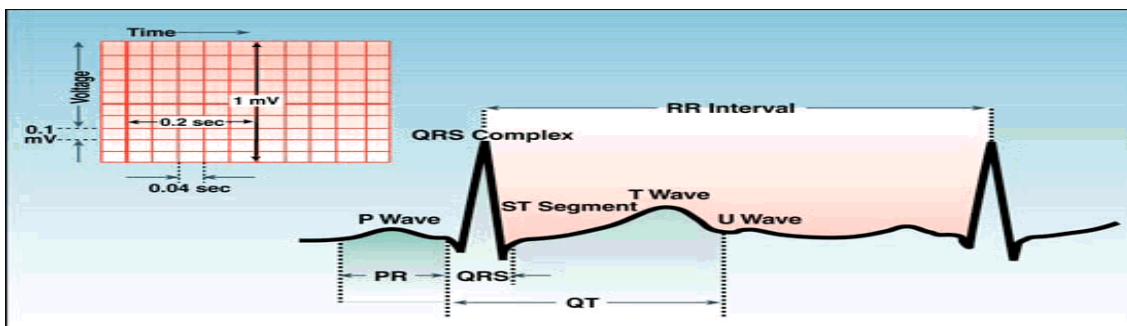


Figure 15 ECG Wave Intervals [26]