RESEARCH PROJECT REPORT

Heart Beat Analyzer

By

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M Farooq Shibli

Bachelor of Computer Engineering

Institute of Management & Computer Science

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2006

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Project Advisor: Aley Imran Rizvi

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Submission Performa

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Title of Project : Heart Beat Analyzer

Name of Supervisor : Mr. Aley Imran Rizvi

This report is submitted as required for the Project in accordance with the rules laid down by the Bahira University as part of the requirements for the award of the degree of Bachelor of Engineering. I declare that the work presented in this report is my own except where due reference or acknowledgement is given to the work of others.

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Acknowledgment

First and foremost, we would like to thank Almighty Allah who gave us courage and strength to complete this Project within time then the most beautiful and loving, our parents, we owe them very much for their sincere prayers, encouragement, cooperation.

We would like to give especial thankful to Engr. Aley Imran Rizvi for his helpful suggestions, extraordinary decision, supervision and guidance. Our Director Captain (retd) Farid –uz-Zaman and Head of Department Dr. Shakeel Khoja for the allocation of labs, PC and other facilities for the accomplishment of our Final Project.

Our Labs staff for their cooperation during the working hours and finally our parents for their constant encouragement, morale support.

We are also thankful to our project coordinator Dr. Bilal Alvi for the guidance throughout the project development and gave us valuable suggestions.

Finally, we are thankful to our beloved class fellows and lab assistants who have been a source of encouragement and support throughout project.

Dedication

We would like to dedicate this Project to Engr. Aley Imran Rizvi & Dr. Shakeel Khoja of Bahria University Karachi Campus, from whom we have learnt a lot About the Real time implementation of theoretical Concepts of Computer Engineering.

Abstract

Portable real-time ECG monitor has to resolve many problems related to normal activity and physical exercise as compared to clinical monitors or Normal printing monitors. The most important problems include baseline wandering, muscle activity noise, changing electrode resistance (gel drying), lead problems, lead resistances etc. All these problems lead to decreased monitor reliability. In this project we have reduced these issues involved in development of a real-time, portable, PC based ECG monitoring device. The most important issues include reliable real-time processing of ECG morphology and power efficient processing.

We have improved the reliability of real time ECG monitoring system with the help of high gain instrumentation amplifiers like AD624AD & AD620. After processing the ECG signal from our circuit, we moved it into the parallel port of computer where Heart Beat Analyzer's software already waits for the ECG signal. This code brings the ECG signal and then plots these signals into three different graphs for three different Leads.

We have improved the reliability using redundant signal processing procedures. For example, detection of R-peak is implemented using several known techniques. The number of detected R-peaks in the time/amplitude window that is defined using statistical expectations determines if the detection was reliable. In the time domain, R-peak is expected within 70-160% of the average RR (R to R peak) period, and within the expected amplitude range. With the help of these R-R Peaks, we have determined the Heart rate. If the single peak is detected in the given window no alternative processing methods are necessary.

Additional experiments related to energy consumption and battery life were conducted using our energy? Profiling environment. Due to non-ideal battery characteristics, only experimental approach can provide valid data for prototype evaluation. Our environment consists of a PC, high resolution digital Oscilloscope, Rims emulator (for checking purposes), and a workstation that controls devices and stores the traces. We use AD624AD Instrumentation Amplifiers (to amplify the 2mV signal into 1-2V).

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CHAPTER 1

INTRODUCTION

Introduction

Among others, heart failure is the major reason of the death, but it has been difficult to diagnose that whether the cause of death or illness is due to heart disease or patient is suffering from some other disease. With the invention of the electrocardiogram, or ECG (also known as EKG, abbreviated from the German world), it becomes easier for the doctors to diagnose the problem on time so life of the patients could be saved. Initially, the size of the machine was too large to handle, but with the passage of time the machine became more and more compact.

The biomedical equipment are very expensive and it is difficult for most of the hospitals in Pakistan to afford such equipment like an ECG machine, so we decided to design an ECG machine (EKG) that will be of low cost and of compact size. To design a biomedical machine, the most important factor is that the machine should meet the medical standards because these types of equipment are in direct contact with the patients. So the safety and protection of patient is the main issue.

Being computer systems engineer students, interfacing the device is not a big task but the main problem we faced during the project was to acquire the weak signals (± 5mV) coming from body.

1.1 Overview

The flow of any PC based ECG machine can be seen below.

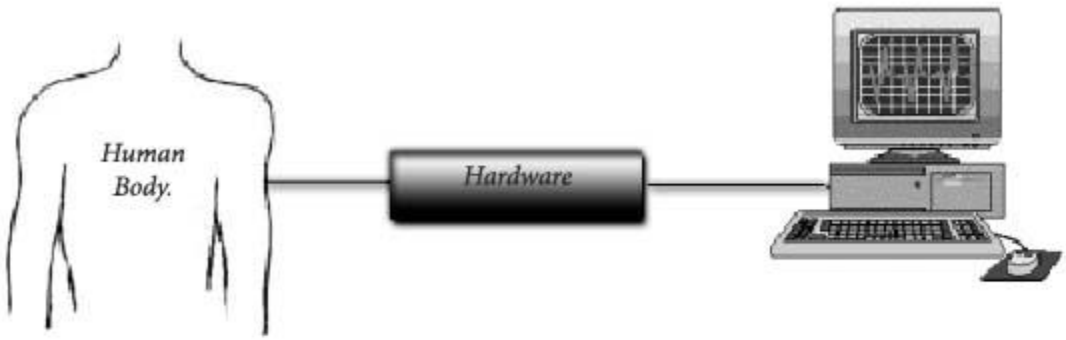


Fig. 1.1 Block Diagram of Computer Based ECG Machine

In the project we have followed the same path. After acquiring the signal from human body, the signal is processed through the device (hardware) where the signals are amplified, filtered and converted in to digital form so that they can be transmitted to the PC.

1.2 System Functionality

The main functions of the system are following:

- To amplify input wave voltage form milli-volts to volts.
- To filter the signal so that noise can be reduced.
- To convert analog signal to digital signal, so that it can be transferred to computer system.
- To retrieve digital signal from parallel port in computer system.
- To save, reload and print ECG signal.

1.3 System

HBA system consist of two major part i.e. software and hardware part. Hardware is use to take input directly from human body. Software is use to plot the ECG wave save, print and save in soft form.

1.3.1 Hardware

In hard side we use Instrumentation Amplifier, because it has high value of gain. After amplifying, 8-channel 8-bits Analogue-to-Digital converter (i.e. AD624AD) is use to convert analog signal to digital signal. In A-to-D at a time only one channel will work, so it doesn't need any selection criteria.

1.3.2 Software

We use simple, straightforward and comprehensible code. And for this we choose Visual Basic language. To learn a new language was a big deal, but VB was so simple to implement. In software side we use parallel port to take ECG wave from hardware. VB gives easy access to draw run time graphics. It also provide functionality to create, update, delete and read file system. VB also provide easy way to access default printer of the system.

1.4 Block Diagram of HBA

Heart Beat Analyzer takes input from human body through electrodes that passing through lead to reach input signal to the hardware circuit. In hardware circuit about 0.1Volts input analog signal first amplified through operational amplifier. After amplification it will filter the noise added during amplification. When the signal is detectable to ADC (Analog to Digital Circuit) it will convert to Digital Form So that it will pass to Computer system.

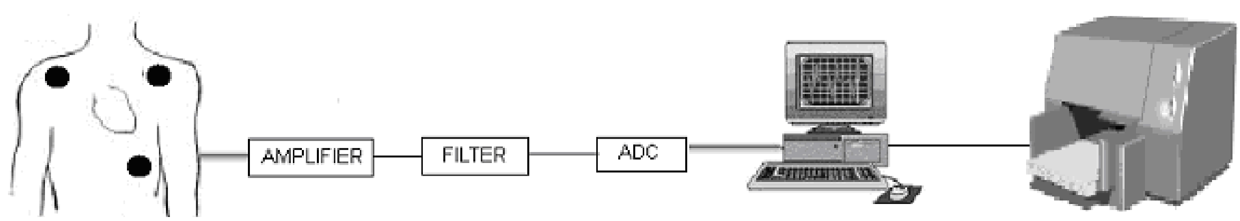


Fig. 1.2 Blocked Diagram of Heart Beat Analyzer

CHAPTER 2

BACKGROUND & LITERATURE REVIEW

Introduction

There were 17 billion deaths occurs in 1999 through heart disease. Many of them were just because of unawareness of patient's condition at the right time. The other problem can be the unavailability of right measuring device at right time because of its great price. So we need a cheep and portable device to solve these problems.

2.1 Background

The already existing system that built for analyze the heart beats of patients, developed by Siemens namely Data scope passport 2. It's an isolated system that performs the analysis of Heart without using any other device. It's an embedded system that requires a small amount of computing power. It works independently, to do complete job. But this system has some problem in it. First, it is too much expensive so that small hospitals and clinic can't afford it. The second problem is that if any problem occurs in hardware it required imported engineering that's also too expensive. Third the output of Data Scope Passport 2 can be seeing on its display screen. But you can't save records of several patients in soft form. As it is expensive it is not for all type of patients. It only works for serious patients. And some time some diseases or problems can't be solve by our local doctor, so for this we required foreign doctors whom pay are generally very high.

H.B.A (Heart Beat Analyzer) is the solution of all above mentioned problems. As it uses software to analyze the heart beats, it's not as much expensive. It gives user the facility to maintain the past record of several patients. Print out of E.C.G of patients can also be taken. Because of its cheapness doctors can use it for daily heart test of his normal patients also.

It cans also use by heart patients themselves for their daily heart beat test or when doctors are not available. Sometime it might occur that patient can't assemble their previous records for a long period. HBA provide a facility to maintaining the records of numbers of patients, so that at any instant doctor can recognize current or future results. Heart Beats Analyzer (H.B.A) provide the utility to records heart beats at any time and see the condition of patient instantly.

H.B.A can also use when patient wants to consult Online Foreign Doctors because through this you can also access the soft copy of heart beats.

2.2 A brief history of electrocardiography

In 1775 scientist find out how electrocuting chickens, In 1887 getting laboratory assistants to put their hands in buckets of saline, In 1909 takes the ECG of a horse and following it to the slaughterhouse, induction of indiscriminate angina attacks were done in 1931, afterward in 1953 hypothermic dogs have helped to improve our understanding of the ECG as a clinical tool. And then ECG labeled as PQRST in 1895. This gives a right direction to scientist for more research on ECG.

1950

John Hopps, a Canadian electrical engineer and researcher for the National Research Council, together with two physicians (Wilfred Bigelow, MD of the University of Toronto and his trainee, John C. Callaghan, MD) show that a coordinated heart muscle contraction can be stimulated by an electrical impulse delivered to the sino-atrial node. The apparatus, the first cardiac pacemaker, measures 30cm, runs on vacuum tubes and is powered by household 60Hz electrical current. *Bigelow WG, Callaghan JC, Hopps JA. "General hypothermia for experimental intracardiac surgery." Ann Surg 1950; 1132: 531-539.*

1953

Osborn, whilst experimenting with hypothermic dogs, describes the prominent J (junctional) wave which has often been known as the "Osborn wave". He found the dogs were more likely to survive if they had an infusion of bicarbonate and supposed the J wave was due to an injury current caused by acidosis. *Osborn JJ. Experimental hypothermia: respiratory and blood pH changes in relation to cardiac function. Am J Physiol 1953;175:389.*

1955

Richard Langendorf publishes the "rule of bigeminy" whereby ventricular bigeminy tends to perpetuate itself. *Langendorf R, Pick A, Winternitz M. Mechanisms of intermittent ventricular bigeminy. I. Appearence of ectopic beats dependent upon the length of the ventricular cycle, the "rule of bigeminy." circulation 1955;11:442.*

1956

Paul Zoll, a cardiologist, uses a more powerful defibrillator and performs closed-chest defibrillation in a human. *Zoll PM, Linenthal AJ, Gibson P: Termination of Ventricular Fibrillation in Man by Externally Applied Countershock . NEJM 1956; 254: 727-729*

1958

Professor Ake Senning, of Sweden, places the first implantable cardiac pacemaker designed by Rune Elmqvist into a 43-year-old patient with complete heart block and syncope (Arne Larsson).

1959

Myron Prinzmetal describes a variant form of angina in which the ST segment is elevated rather than depressed. *Prinzmetal M, Kennamer R, Merliss R, Wada T, Bor N. Angina pectoris. I. A variant form of angina pectoris. Am J Med 1959;27:374.*

1960

Smirk and Palmer highlight the risk of sudden death from ventricular fibrillation particularly when ventricular premature beats occur at the same time as the T wave. The 'R on T' phenomenon. *Smirk FH, Palmer DG. A myocardial syndrome, with particular reference to the occurrence of sudden death and of premature systoles interrupting antecedent T waves. Am J Cardiol 1960;6:620.*

1963

Italian paediatrician C. Romano and Irish paediatrician O. Conor Ward (the following year) independently report an autosomal dominant syndrome of long-QT interval later known as the Romano-Ward syndrome. *Romano C, Gemme G, Pongiglione R. Aritmie cardiache rare dell'eta pediatrica. Clin Pediatr.*

1963

Baule and McFee are the first to detect the magnetocardiogram which is the electromagnetic field produced by the electrical activity of the heart. It is a method that can detect the ECG without the use of skin electrodes. Although potentially a useful technique it has never gained clinical acceptance, partly because of its greater expense.

1966

Mason and Likar modify the 12-lead ECG system for use during exercise testing. The right arm electrode is placed at a point in the infraclavicular fossa medial to the border of the deltoid muscle, 2 cm below the lower border of the clavicle. The left arm electrode is placed similarly on the left side. The left leg electrode is placed at the left iliac crest. Although this system reduces the variability in the ECG recording during exercise it is not exactly equivalent to the standard lead positions. The Mason-Likar lead system tends to distort the ECG with a rightward QRS axis shift, a reduction in R wave amplitude in lead I and aVL, and a significant increase in R wave amplitude in leads II, III and aVF. *Eur Heart J. 1987 Jul;8(7):725-33*

1968

Journal of Electrocardiography, the Official Journal of the International Society for Computerized Electrocardiology and the International Society of Electrocardiology, is founded by Zao and Lepeschkin.

1968

Henry Marriott introduces the Modified Chest Lead 1 (MCL1) for monitoring patients in Coronary Care.

1969

Rosenbaum reviews the classification of ventricular premature beats and adds a benign form that arises from the right ventricle and is not associated with heart disease. This becomes known as the 'Rosenbaum ventricular extrasystole'. *Rosenbaum MB. Classification of ventricular extrasystoles according to form. J Electrocardiol 1969;2:289.*

1974

Jay Cohn, of University of Minnesota Medical School, describes the 'syndrome of right ventricular dysfunction in the setting of acute inferior wall myocardial infarction'. *Cohn JN, Guiha NH, Broder MI. Right ventricular infarction. Am J Cardiol 1974:33:209-214*

1974

Gozensky and Thorne introduce the term 'Rabbit ears' to electrocardiography. Rabbit ears describe the appearence of the QRS complex in lead V1 with an rSR' pattern (good rabbit) being typical of Right Bundle Branch Block and an RSr' (bad rabbit) suggesting a ventricular origin i.e. ventricular ectopy / tachycardia. *Gozensky C, Thorne D. Rabbit ears: an aid in distinguishing ventricular ectopy from aberration. Heart Lung 1974;3:634.*

1976

Erhardt and colleagues describe the use of a right-sided precordial lead in the diagnosis of right ventricular infarction which had previously been thought to be electrocardiographically silent. *Erhardt LR, Sjogrn A, Wahlberg I. Single right-sided precordial lead in the diagnosis of right ventricular involvement in inferior myocardial infarction. Am Heart J 1976;91:571-6*

1988

Professor John Pope Boineau of Washington University School of Medicine publishes a 30-year percpective on the modern history of electrocardiography. *Boineau JP. Electrocardiology: A 30-year Perspective. Ah Serendipity, My Fulsome Friend. Journal of Electrocardiology 21. Suppl (1988): S1-9*

1992

Cohen and He describe a new non-invasive approach to accurately map cardiac electrical activity by using the surface Laplacian map of the body surface electrical potentials.

1999

Researchers from Texas show that 12-lead ECGs transmitted via wireless technology to hand-held computers is feasible and can be interpreted reliably by cardiologists. *Pettis KS, Savona MR, Leibrandt PN et al. Evaluation of the efficacy of hand-held computer screens for cardiologists' interpretations of 12-lead electrocardiograms. Am Heart J. 1999 Oct;138(4 Pt 1):765-70*

2000

Physicians from the Mayo Clinic describe a new hereditary form of Short QT syndrome associated with syncope and sudden death that they discovered in 1999. Several genes have since been implicated. *Gussak I, Brugada P, Brugada J, et al. Idiopathic short QT interval.*

2005

Danish cardiologists report the successful reduction in the time between onset of chest pain and primary angioplasty when the ECG of patients is transmitted wirelessly from ambulance to the cardiologist's handheld PDA (Personal Digital Assistant). The clinician can make an immediate decision to redirect patients to the catheter lab saving time in transfers between hospital departments.

2.3 Literature Review

Above history verified the Hugeness of Electrocardiography field. Our work is the advance application of Electrocardiography which is interfaced with computer. From the above history we have read the concepts and implementation of Biomedical equipments specially Electrocardiography.

CHAPTER 3

THE HEART

Introduction

The heart is one of the most important organs in the entire human body. The heart is about the size of its owners clenched fist and lies in the middle of the chest, composed of muscle which pumps blood throughout the body, beating approximately 72 times per minute of our lives. The heart pumps the blood, which carries all the vital materials which help our bodies function and removes the waste products that we do not need.

The heart weighs between 7 and 15 ounces (200 to 425 grams) and is a little larger than the size of your fist. By the end of a long life, a person's heart may have beaten (expanded and contracted) more than 3.5 billion times. In fact, each day, the average heart beats 100,000 times, pumping about 2,000 gallons (7,571 liters) of blood.

The heart is located between your lungs in the middle of your chest, behind and slightly to the left of your breastbone (sternum). A double-layered membrane called the pericardium surrounds your heart like a sac. The outer layer of the pericardium surrounds the roots of your heart's major blood vessels and is attached by ligaments to your spinal column, diaphragm, and other parts of your body. The inner layer of the pericardium is attached to the heart muscle. A coating of fluid separates the two layers of membrane, letting the heart move as it beats, yet still be attached to body.

3.1 Anatomy of the Heart

The heart consists of four chambers. The upper two chambers are the right and left atria. The right and left atria are thin-walled sacs, which receive blood from the body and the lungs, respectively. In both atria the upper half of their inside wall is smooth and forms the sinuses of the great veins that empty into it. The lower half of the inside surfaces of the atria is very rough.

The lower two chambers of the heart are the right and left ventricles. The ventricles have thick walls made up of cardiac muscle. Cardiac muscle is also present in the walls of the atria. This specialized type of muscle tissue is found only in the heart; its fibers branch in such a way that when they all contract, they squeeze the heart chamber and force blood out of it. The inner surfaces of both ventricles are covered with ridges called trabeculae. Irregular muscle bundles called papillary muscles give rise to chords which anchor the heart valves. Both the trabeculae and the papillary muscles make the inside walls of the ventricles very rough.

The right atrium and ventricle receive oxygen-poor blood from the body and send it to the lungs; they are therefore considered the pulmonary side of the heart. The left atrium and ventricle receive oxygenated blood from the lungs and pump it back into the body; they are therefore considered the systemic side of the heart.

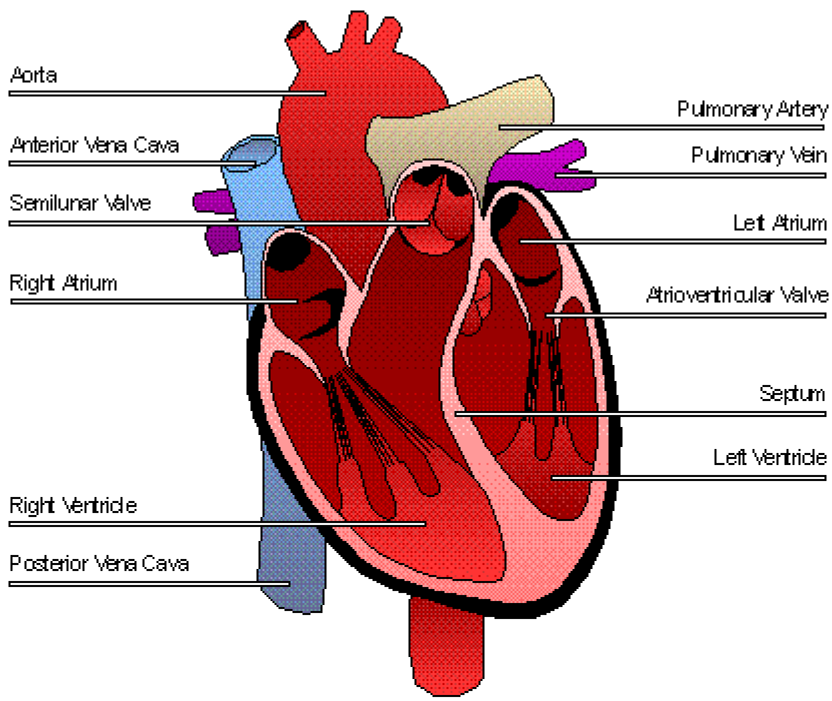


Fig. 3.1 Systematic Side of Heart [12]

Oxygen-poor blood (shown in blue) flows from the body into the right atrium. Blood flows through the right atrium into the right ventricle. The right ventricle pumps the blood to the lungs, where the blood releases waste gases and picks up oxygen. The newly oxygen-rich blood (shown in red) returns to the heart and enters the left atrium. Blood flows through the left atrium into the left ventricle. The left ventricle pumps the oxygen-rich blood to all parts of the body.

3.2 The Cardiovascular System

Your heart and circulatory system make up your cardiovascular system. Your heart works as a pump that pushes blood to the organs, tissues, and cells of your body. Blood delivers oxygen and nutrients to every cell and removes the carbon dioxide and waste products made by those cells. Blood is carried from your heart to the rest of your body through a complex network of arteries, arterioles, and capillaries. Blood is returned to your heart through venules and veins. If all the vessels of this network in your body were laid end-to-end, they would extend for about 60,000 miles (more than 96,500 kilometers), which is far enough to circle the earth more than twice!

The one-way circulatory system carries blood to all parts of your body. This process of blood flow within your body is called circulation. Arteries carry oxygen-rich blood away from your heart, and veins carry oxygen-poor blood back to your heart.

In pulmonary circulation, though, the roles are switched. It is the pulmonary artery that brings oxygen-poor blood into your lungs and the pulmonary vein that brings oxygen-rich blood back to your heart.

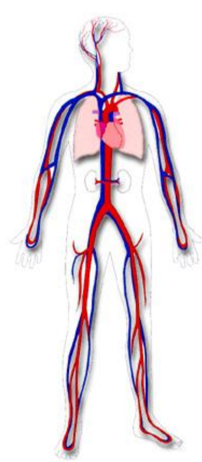


Fig. 3.2 Oxygen Rich Blood [13]

3.3 Cardiac Cycle

A single cycle of cardiac activity can be divided into two basic stages. The first stage is diastole, which represents ventricular filling and a brief period just prior to filling at which time the ventricles are relaxing. The second stage is systole, which represents the time of contraction and ejection of blood from the ventricles. To analyze these two stages in more detail, it is convenient to divide the cardiac cycle into seven phases.

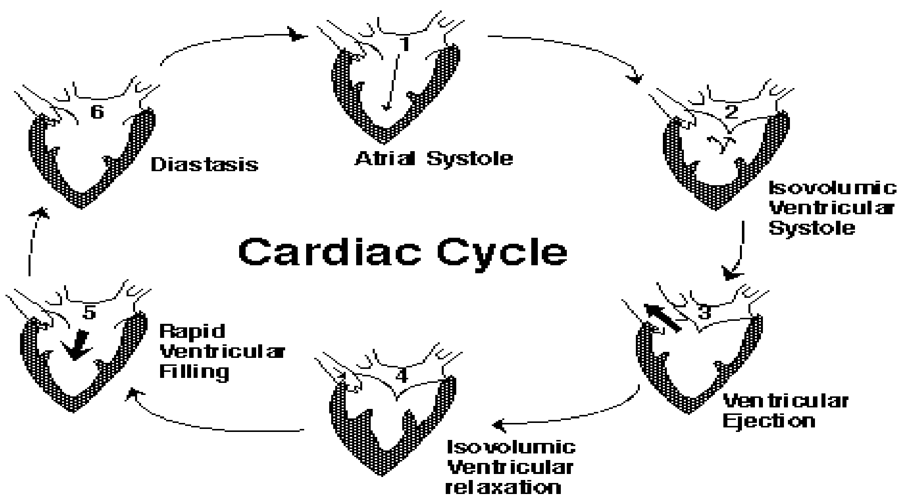


Fig. 3.3 Cardiac Cycle [13]

3.4 The Heartbeat

A heartbeat is a two-part pumping action that takes about a second. As blood collects in the upper chambers (the right and left atria), the heart's natural pacemaker (the SA node) sends out an electrical signal that causes the atria to contract. This contraction pushes blood through the tricuspid and mistral valves into the resting lower chambers (the right and left ventricles). This part of the two-part pumping phase (the longer of the two) is called the **diastole**.

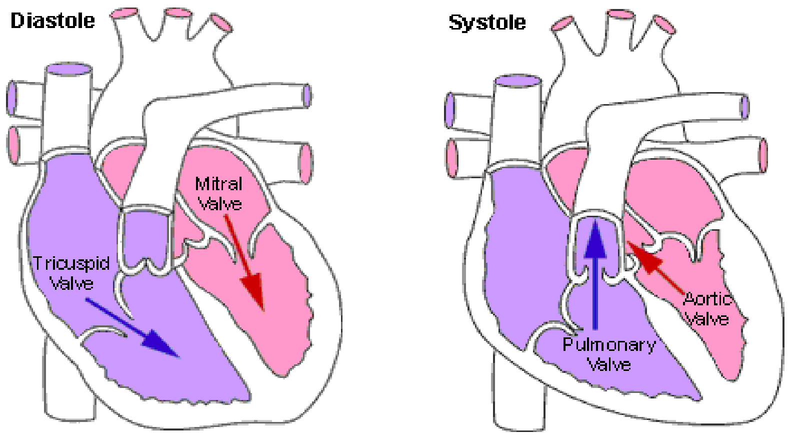


Fig. 3.4 Diastole [13]

The second part of the pumping phase begins when the ventricles are full of blood. The electrical signals from the SA node travel along a pathway of cells to the ventricles, causing them to contract. This is called systole. As the tricuspid and mitral valves shut tight to prevent a back flow of blood, the pulmonary and aortic valves are pushed open. While blood is pushed from the right ventricle into the lungs to pick up oxygen, oxygen-rich blood flows from the left ventricle to the heart and other parts of the body.

After blood moves into the pulmonary artery and the aorta, the ventricles relax, and the pulmonary and aortic valves close. The lower pressure in the ventricles causes the tricuspid and mitral valves to open, and the cycle begins again. This series of contractions is repeated over and over again, increasing during times of exertion and decreasing while you are at rest.

Your heart does not work alone, though. Your brain tracks the conditions around you-climate, stress, and your level of physical activity—and adjusts your cardiovascular system to meet those needs.

The human heart is a muscle designed to remain strong and reliable for a hundred years or longer. By reducing your risk factors for cardiovascular disease, you may help your heart stay healthy longer.

3.5 The Heart Valves

Four types of valves regulate blood flow through your heart:

- The tricuspid valve regulates blood flow between the right atrium and right ventricle.
- The pulmonary valve controls blood flow from the right ventricle into the pulmonary arteries, which carry blood to your lungs to pick up oxygen.
- The mitral valve lets oxygen-rich blood from your lungs pass from the left atrium into the left ventricle.
- The aortic valve opens the way for oxygen-rich blood to pass from the left ventricle into the aorta, your body's largest artery, where it is delivered to the rest of your body.

3.6 The Heart's Electrical System

The electrical system in your heart controls the speed of your heartbeat. The system includes a network of electrical pathways, similar to the electrical wiring in your home. The pathways carry electrical signals through your heart. The movement of the signals is what makes your heart beat.

When working properly, your heart's electrical system automatically responds to your body's changing need for oxygen. It speeds up your heart rate as you climb stairs, for example, and slows it down when you sleep. When your heart rate speeds up, it means your heart pumps faster and your body gets more oxygen-rich blood. Your heart's electrical system is also called the *cardiac conduction system.*

3.7 The Conduction System

Electrical impulses from your heart muscle (the myocardium) cause your heart to beat (contract). This electrical signal begins in the sinoatrial (SA) node, located at the top of the right atrium. The SA node is sometimes called the heart's "natural pacemaker." When an electrical impulse is released from this natural pacemaker, it causes the atria to contract. The signal then passes through the atrioventricular (AV) node. The AV node checks the signal and sends it through the muscle fibers of the ventricles, causing them to contract. The SA node sends electrical impulses at a certain rate, but your heart rate may still change depending on physical demands, stress, or hormonal factors as shown in figure 3.5.

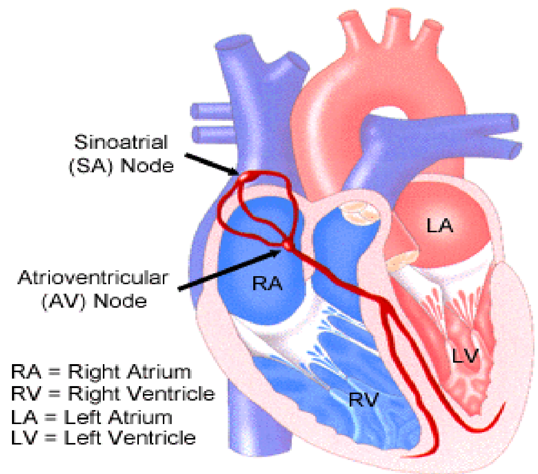


Fig. 3.5 Conductive system [14]

3.8 Amazing Heart Facts

Put your hand on your heart. Did you place your hand on the left side of your chest? Many people do, but the heart is actually located almost in the center of the chest, between the lungs. It's tipped slightly so that a part of it sticks out and taps against the left side of the chest, which is what makes it seem as though it is located.

Hold out your hand and make a fist. If you're a kid, your heart is about the same size as your fist, and if you're an adult, it's about the same size as two fists.

Your heart beats about 100,000 times in one day and about 35 million times in a year. During an average lifetime, the human heart will beat more than 2.5 billion times.

Give a tennis ball a good, hard squeeze. You're using about the same amount of force your heart uses to pump blood out to the body. Even at rest, the muscles of the heart work hard--twice as hard as the leg muscles of a person sprinting.

Feel your pulse by placing two fingers at pulse points on your neck or wrists. The pulse you feel is blood stopping and starting as it moves through your arteries. As a kid, your resting pulse might range from 90 to 120 beats per minute. As an adult, your pulse rate slows to an average of 72 beats per minute.

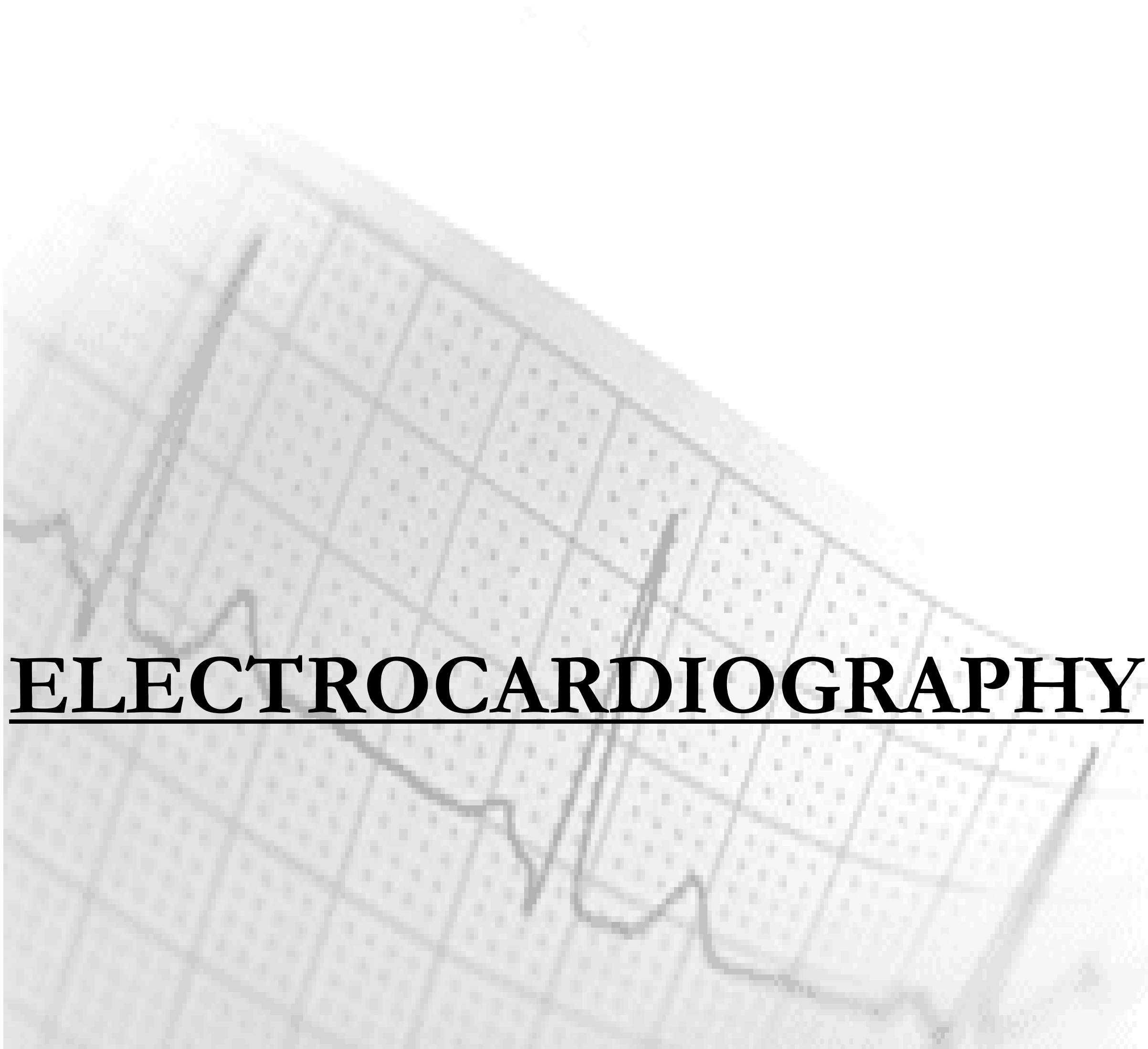
The aorta, the largest artery in the body, is almost the diameter of a garden hose. Capillaries, on the other hand, are so small that it takes ten of them to equal the thickness of a human hair.

Your body has about 5.6 liters (6 quarts) of blood. These 5.6 liters of blood circulates through the body three times every minute. In one day, the blood travels a total of 19,000 km (12,000 miles)--that's four times the distance across the US from coast to coast.

The heart pumps about 1 million barrels of blood during an average lifetime--that's enough to fill more than 3 super tankers.

If you listen to your heart you will hare Lub-DUB, lub-DUB, lub-DUB. These "lub" and "DUB" sounds are made by the heart valves as they open and close.

CHAPTER 4



ELECTROCARDIOGRAPHY

Introduction

The electrocardiogram is a noninvasive test is use to reflect underlying heart conditions by measuring the electrical activity of the heart.

4.1 The Electrocardiogram

Electrocardiography is related to the impulses that travel through the heart that determine the heart rate and rhythm. In the clinic, the ECG is one of the most commonly used diagnostic machines. The recording procedure by electrocardiograph is called electrocardiogram, also abbreviate ECG and EKG. By positioning leads (electrical sensing device) on the body is standardized locations, (electrodes are placed on chest arm or legs) information about my heart location condition can be learned by looking for characteristic patterns on the ECG. Physicians use this information to discover such things as heart rate, arrhythmias, myocardial infractions, atrial enlargements ventricular hypertrophies, and bundle branch blocks.

4.1.1 Method to take an ECG

Now a day ECG leads are attached to the body while the patient lies flat on a bed or table. Leads are attached to each extremity (4- total) and to 6 pre defined positions on the front of the chest. A small amount of gel is applied to the skin, which allows the electrical impulses of the heart to be more easily transmitted to ECG leads. The leads are attached small suction cups, Velcro straps, or by small adhesive patches attached loosely to the skin. The test takes about 5 minutes and its painless. In some time, men may require the shaving of a small amount of chest hair to obtain optimal contact between the leads and the skin.

4.1.2 Requirement of ECG

Electrocardiography is use:

- As part of a routine physical examination or screening evaluation
- As part of a cardiac exercise stress test
- As part of the evaluation of symptoms of chest pain, shortness of breath, dizziness or fainting, or palpitations

4.1.3 Conditions diagnosed with an ECG

This test will help the doctor to evaluate the patient's cardiac condition related to:

- Evidence of occurrence of a prior heart attack(myocardial infraction)
- Which part of heart was damaged
- If there are any irregular heartbeat or rhythm
- If there is a decrease supply of blood and oxygen to the heart

4.2 Recording of ECG

A pair of surface electrodes placed directly on the heart, records a repeating pattern of changes in electrical "action potential." As action potentials spread from the atria to the ventricles, the voltage measured between the two electrodes will vary in a way that provides a "pictures" of the electrical activity of the heart.

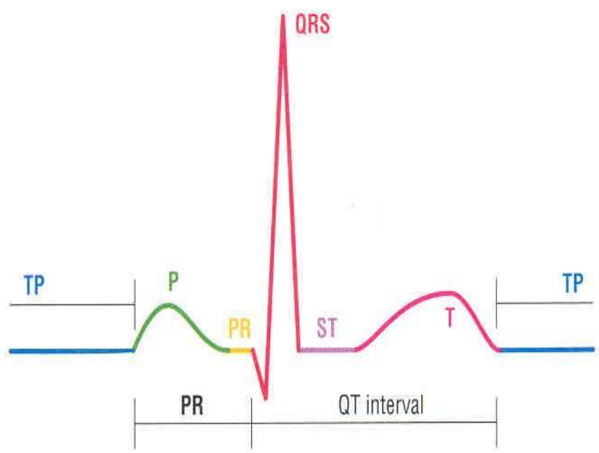


Fig. 4.1 Electrocardiography Wave [14]

The nature of this picture can be varied by changing the position of the changing electrodes; different positions provide different perspectives, enabling an observer to gain a more complete picture of the events. The body is the good conductor of the electricity because a tissue fluid contain a high concentration ions that move (creating a current) in response to potential differences, with any muscle, electrical activation of the heart is required for the mechanical activation (for the record, smooth muscle can be an exception to this). The electrical activation of the heart can be picked up (detected) using skin electrodes strategically placed on the body. As the heart undergoes depolarization and repolarization, the electrical currents spread throughout the body because the body acts as a Volume conductor. The electrical current, generated by the heart, are commonly measured by an array of electrodes placed on the body surface and the resulting tracing is called an electrocardiogram (ECG or EKG). Electrical measurements can also be made within the heart using special catheters; these are useful for specialized electrophysiological diagnostic procedures. The electrocardiogram indicates the conduction of electrical impulses through the heart, measures and record both the intensity of this electrical activity (in mille-volts), and the time intervals involved.

4.2.1 Lead Placement

By convention, electrodes are placed on each arm and leg, and six electrodes are placed at defined locations on the chest (varies in man and woman). These electrodes leads are connected to a device that measures potential differences between selected electrodes in order to produce the characteristic electrocardiographic tracings which can be plotted on thermal paper or displayed on the monitor. There are two basic types of electrocardiogram (ECG) leads:

- Bipolar
- Unipolar

Bipolar leads utilize a single positive and a single negative electrode between which electrical potential are measured. Unipolar leads (augmented leads and chest leads) have single positive recording electrodes to serve as a composite negative electrode.

4.2.1.1 Limb Leads (Bipolar)

Bipolar recording is represented by standard limb lead configurations depicted at the right. By convention, lead I have the positive electrode on the left arm, and the negative electrode on the right arm, and therefore measure the potential difference between the two arms. In this and the other two limb leads, an electrode on the right leg serves as a reference electrode for recording purposes. In the Lead II configuration, the positive electrode is on the left leg and negative electrode is on the right arm. Lead III has the positive electrode on the left leg and the negative electrode on the left arm. These three bipolar limb leads roughly form an equilateral triangle (with the heart at the center) that is called Einthoven's triangle in honor of Willem Einthoven who developed the electrocardiogram in 1901. Whether the limb leads are attached to the end of the limb (wrist and ankles) or at the origin of the limb (shoulder or upper thigh) makes no difference in the recording because the limb can simply be viewed as a long wire conductor originating from a point on the runk of the body.

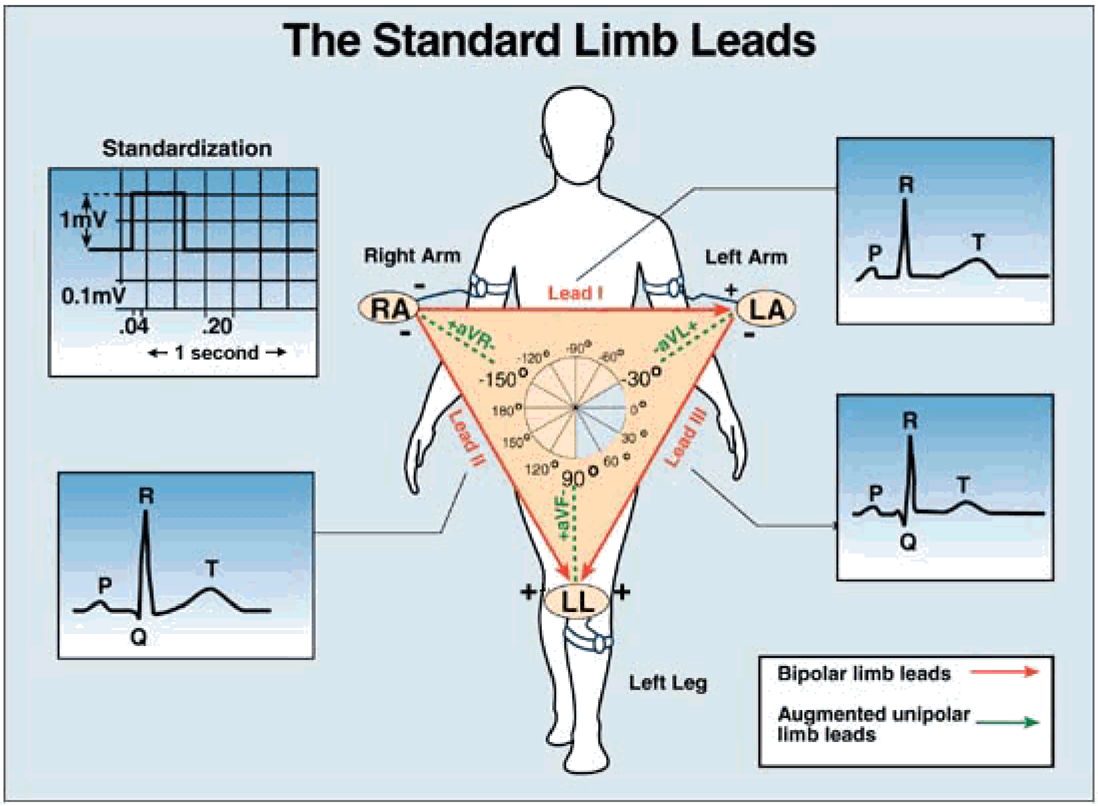


Fig. 4.2 Standard Limb Leads

Based upon universally accepted ECG rules, a wave a depolarization heading towards the left arm will give a positive deflection in lead I because the positive electrode is on the left arm. Maximal positive ECG deflection will occur in lead I when a wave of depolarization travels parallel to the axis between the right and left arms. If a wave of depolarization heads away from the left arm, the deflection will be negative. Also by these rules, a wave of repolarization moving away from the left arm will be seen as a positive deflection. Similar statements can be made for leads II and III where the positive electrode is located on the left leg. For example, a wave of depolarization traveling towards the left leg will give a positive deflection in both leads II and III because the positive electrodes for both leads is on the left leg. Similarly, a maximal positive deflection will be obtained in Lead II when the depolarization wave travels parallel to the axis between the left arm and left leg. If the three limbs of Einthoven's triangle (assumed to be equilateral) are broken apart, collapsed, and superimposed over the heart, then the positive electrode for lead I is said to be at zero degrees relative to the heart (along the horizontal axis) similarly, the positive electrode for lead II will be +60˚ relative to the heart, and the positive electrode for lead III will be 120˚ relative to the heart as shown to the right. This new construction of the electrical axis is called the axial reference system. With this system, a wave of depolarization traveling at + 60˚ will produce the greatest positive deflection in lead II. A wave of depolarization oriented +90˚ relative to the heart will produce equally positive deflections in both lead II and III.

LEAD	POSITIVE ELECTRODE	NEGATIVE ELECTRODE	GROUND ELECTRODE
I	Left Arm (LA)	Right Arm(RA)	Left Arm(LA)
I	Left leg(LL)	Right Arm(RA)	Left Arm(LA)
III	Left Leg(LL)	Left Arm(LA)	Right Arm(RA)

Table 4.1: Depolarization Wave

In this latter case, lead I will show no net deflection because the wave of depolarization is heading perpendicular to the 0˚, or lead I, axis

4.2.1.2 Augmented Limb leads (Unipolar)

In addition to the three bipolar limb leads described above, there are three augmented unipolar limb leads. These are termed unipolar leads because there is a single positive (+) electrode that is referenced against a combination of the other limb electrodes. The positive electrodes for these augmented leads are located on the left arm (aVL), the right arm (aVR), and the left leg (aVF). In practice, these are the same electrodes used for leads I, II and III. (The ECG machine does the actual switching and rearranging of the electrode Designations).

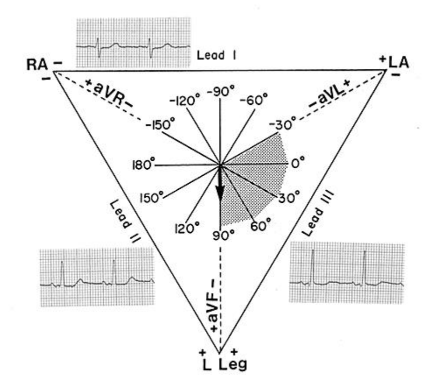


Fig. 4.3 Arrangement of Electrodes [14]

The three augmented leads are depicted using the axial reference system as shown to the right. The aVL lead is at -30˚ relative to the lead I axis; aVR is at -150˚ and aVF is at +90˚. It is very important to learn that which lead is associated with each axis. The three augmented unipolar leads, coupled with the three bipolar leads, constitute the six limb leads of the ECG. These leads record electrical activity along a single plane, termed a frontal plane relative to the heart. Using the axial reference system and these six leads, it is rather simple to define the direction of the electrical vector at any given instant in time. If a wave of depolarization is spreading from left to right along the 0˚ axis, then lead I will show the greatest positive amplitude. Likewise, if the direction of the electrical vector for depolarization is directed downwards (+90˚), then aVF will show the greatest positive deflection. If a wave of depolarization is moving from left to right at +150˚, then aVL will show the greatest negative deflection according to the rules for ECG interpretation.

4.2.1.3 Chest Leads (Unipolar)

The last ECG leads to consider are the pericardial, unipolar chest leads. These are six positive electrodes placed on the surface of the chest over the heart in order to record electrical activity in a plane perpendicular to the frontal plane (see figure).These six leads are named V1- V6. The rules of interpretation are the same as for the limb leads. For example, a wave of depolarization traveling towards a particular electrode on the chest surface will elicit a positive deflection. In summary, the twelve ECG leads provide different views of the same electrical activity within the heart. Therefore the waveform recorded will be different on each lead. To understand how cardiac electrical currents actually generate and ECG tracing and why the different lead display that electrical activity differently, it is necessary to understand volume conductor principles and vectors.

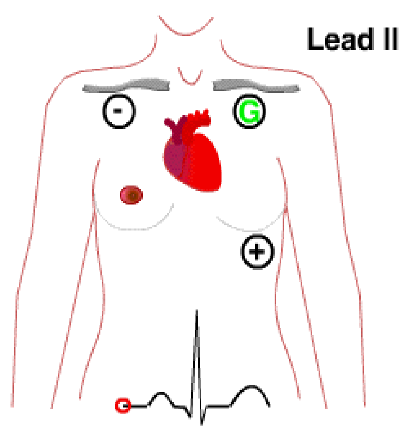


Fig. 4.4 Standard Limb Leads [15]

4.2.1.4 Einthoven's Bipolar or Standard limb leads- I, II, III

Recorded by electrodes at right arm (RA), left arm (LA), and left leg (LL), while right leg electrode to reduce disturbances. The electrodes measure differences between two points as shown in Table 4.2.

LEAD	**TWO POINTS**
I	LA-RA
I	LL-RA
III	LL-LA

Table 4.2 Depolarization Wave

Kirchhoff law – the total of potential in closed circle is zero. Einthoven reversed lead II, thus:
Lead I + (- lead II) + lead III = 0
II = I + III (Einthoven's law).

4.2.1.5 Goldberger's, Unipolar Augmented limb leads – aVR, aVL, aVF

It was introduced by Frank Wilson – 1933. He used Einthoven's leads but measured the potential changes between each limb with one central point at zero potential, thus called Unipolar leads. Wilson used 5,000 ohms resistance to overcome the skin resistance, thus they called non-augmented (VR, VL, VF). Goldberg canceled this resistance getting augmented lead by 50% thus
aVR = 3/2 aVR
Kirchhoff law: aVR + aVL + aVF = 0

4.2.1.6 Wilson's, Unipolar pericardial or chest leads –V1 to V6

This recorded as non-augmented with 5,000 ohms resistance to record potential of the frontal and lateral surface of the chest. ECG deflections may be affected by electrode location and distance from vector. Augmented and standard leads record potential at Frontal plane, while pericardial leads record potential at Horizontal (transverse) plane.

4.2.1.7 Relation between bipolar and Unipolar

The voltage recorded by augmented Unipolar leads equal 87% of the bipolar leads. When measuring QRS axis using augmented and standard leads we gave to multiply the augmented by 100/87=1.15. When measuring the net deflection of the standard leads using the net deflection of the augmented leads we have to multiply by 87/100 = 0.87. The non-augmented lead's voltage is 58% of the standard lead's voltage. The standard leads are 100/58=1.72 of the non-augmented leads. Summary of the above:

II	I + III + VR + aVL + aVF
Augmented	3/2 non-augmented
Standard	1.15 augmented
Augmented	0.87 standard
aVR	-(I+II)/2*0.87
aVL	(I-III)/2*0.87
aVF	(II+III)/2*0.87
I	2/3(aVL-aVR)*1.15
II	2/3(aVF – aVR)*1.15
III	2/3(aVF – aVL)*1.15

Table 4.3 Relationship between Unipolar & Bipolar

4.2.2 Volume Conductor principles and ECG Rules of Interpretation

The electrocardiogram utilizes electrodes on the surface of the body to measure the electrical activity of the heart. It is possible to place electrodes on the body surface and measure cardiac potentials because the body acts as a conductor of the electrical currents generated by the heart.

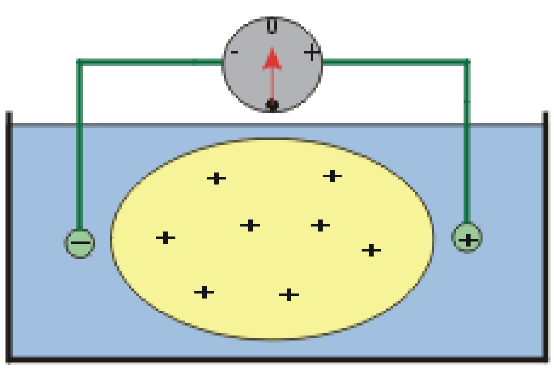


Fig.4.5 Volume Conductor Principle [15]

These cardiac currents, therefore, spread throughout the body and can be measured by electrodes placed on the skin. What do these electrodes actually measures? If a piece of living ventricular muscle were placed into a bath containing a conducting salt solution, and electrodes were placed in the bath on either side of the muscle, no potential difference would be recorded between the

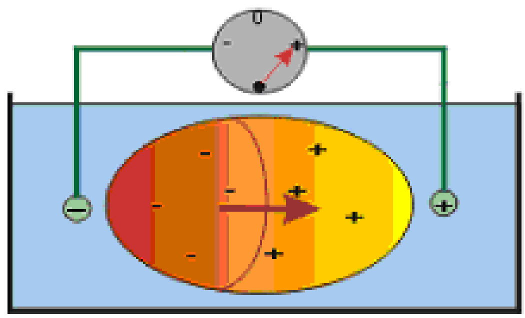


Fig.4.6 Charge Movements [15]

Two electrodes when the muscle was repolarized (i.e. at rest) (top panel of the figure at right). The reason for this is that the outside of the cells would be positive relative to the inside because the resting membrane potential would be about -90mv; therefore, there would be no currents flowing along the surface of the muscle. If the left side of the muscle were stimulated electrically to induce self propagating action potentials, a wave of depolarization would sweep across muscle from left to right (lower panel).

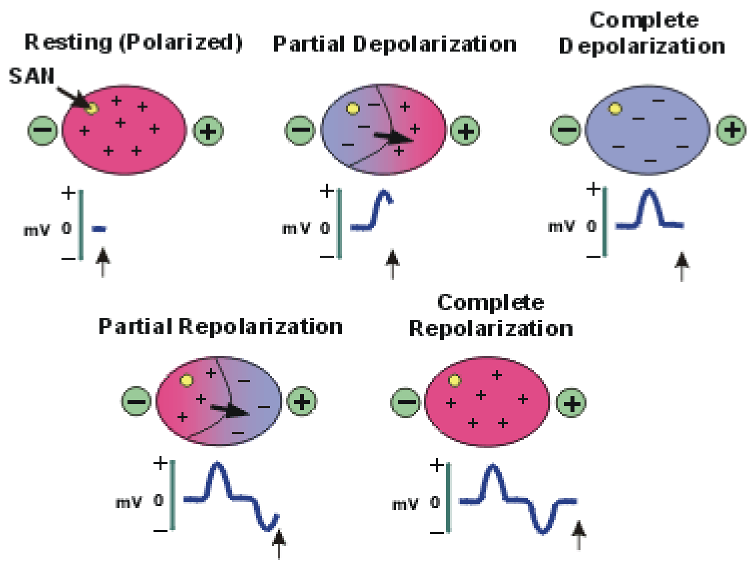


Fig.4.7 Depolarization [15]

Midway during this depolarization process, cell on the left (depolarized cells) would be negative on the outside relative to the inside, while non-depolarized cells on the right of the muscle would still be repolarized (positive on the outside). There would now exist a potential difference between the positive and negative electrodes. By convention, this wave of depolarization heading towards the positive electrode would be recorded as a positive voltage (upward direction in the recording). After the wave of depolarization sweeps across the entire muscle mass, all the cells on the outside would be negative, and once again, no potential difference would exist between the two electrodes. The entire process of depolarization and repolarization is depicted in the figure to the right which is representative of the electrical events that occur in the atria. In the resting, polarized state, no potential difference is measured between the positive and negative electrodes (i.e. isoelectric). When the SA node (SAN) fires, a wave of depolarization begins to spread across the atria, During this time, some of the muscle mass will temporarily remain positive on the outside (polarized) and some will be negative (depolarized) causing a potential difference between the electrodes, by convention, a positive voltage (upward deflection) will be recorded. Once the entire atria mass is depolarized (all cells negative on outside), there will no longer be a potential difference and the voltage will be isoelectric just as it was in the polarized state. When repolarization occurs, starting first with the SA nodal region then moving across the atria, there will once again be both positive and negative charges on the surface of the atria, but this time, the negative charges will be closest to the positive electrode. The wave of repolarization sweeping across the atria away from the negative electrode and towards the positive electrode will, by convention, cause a negative voltage (downward deflection) to occur. Finally, when all of the cells are repolarized, the voltage will once again be isoelectric until another wave of depolarization occurs.

When the atria (or ventricles) undergo Depolarization, the wave of depolarization that spreads across the muscle mass occurs in many different directions simultaneously. If a snapshot of electrical activity, could be taken at a given instant during the process of depolarization, many individual waves of depolarization represented by arrows could be observed (black arrow in figure). Each arrow represents a different individual vector representing depolarization. The mean electrical vector for all the individual vectors is also shown in the figure 5.8.

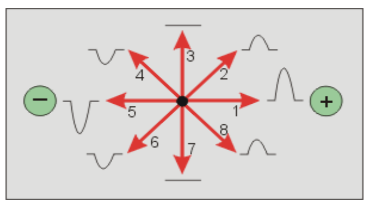


Fig.4.8 Heart Positions [16]

A similar process occurs within the ventricles with one major difference. Repolarization normally occurs in a direction opposite to depolarization. In other words, the last cells in the ventricle to depolarize are the first to repolarize. This results in a positive repolarization wave in the ventricles. Several important observations and rules emerge from these volume conductor considerations:

- A wave of depolarization traveling towards a positive electrode results in a positive deflection in the ECG trace.
- A wave of depolarization traveling away from a positive electrode results in a negative deflection.

- A wave of repolarization traveling towards a positive electrode results in a negative deflection.
- A wave of repolarization traveling away from a positive electrode results in a positive deflection.
- A wave of depolarization or repolarization traveling perpendicular to an electrode axis will result in a biphasic deflection of equal positive and negative voltages (i.e. no net deflection).
- The instantaneous amplitude of the measured potentials will depend upon the orientation of the positive electrode relative to the mean electrical vector.
- The voltage amplitude is directly related to the mass of the tissue undergoing depolarization or repolarization.

The first five rules are derived from the volume conductor model described above. The sixth rule takes into consideration that at any given point in time during depolarization in the atria or ventricles there are many separate waves of depolarization traveling in different directions to the positive electrode. The recording by the electrode will reflect the average, instantaneous direction and magnitude (i.e. mean electrical vector) for all of the individual depolarization waves. The seventh rule simply states that the amplitude of the wave recorded by the ECG will be directly related to the mass of the muscles undergoing depolarization or repolarization. For example, when the mass of a left ventricle increased hypertrophy, the amplitude of the QRS complex, which represents ventricular depolarization, is increased.

4.2.3 ECG Paper Measurement

ECG paper routinely moves through the machine at a constant speed of 25 mm/second, the horizontal axis represents time. Horizontal lines on standard ECG paper are ruled every mm, with darker lines every 5mm. Five large boxes of 5 mm each equal 25 mm, or 1 second of time.

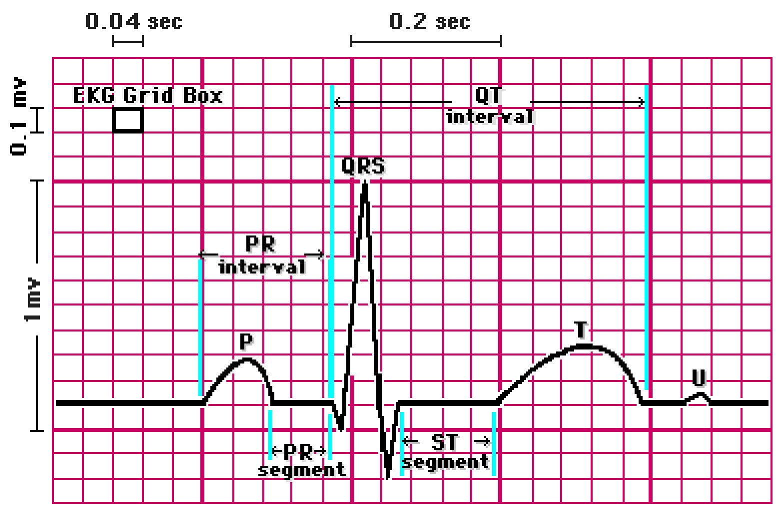


Fig.4.9 ECG signal with Graph [16]

Thus, a single large box 5 mm wide represents 0.20 second, and a single box 1 mm wide is 1/5 of that, or 0.04 second.

On the other hand, the ventricle axis on ECG paper represents voltage. Each ECG machine must be calibrated so that a 1 mv standardization signal produces a deflection of exactly 10 mm, and this should be checked and recorded before every ECG is taken. Thus, each small box of 1 mm in the vertical direction represents 0.10 mv, one large box represents 0.50 mv, and two large boxes represent 1 mv.

4.2.4 The ECG Waveforms

Each cardiac cycle produces three distinct ECG waves, designated P, QRS, and T. These waves are not action potentials; they represent changes in potential between two regions on the surface of the heart which are produced by the composite effects of action potentials in many myocardial cells. For example, the spread of depolarization through the atria causes a potential difference that is indicated by an upward deflection reaches a maximum value, because the potential difference between the depolarized and un-stimulated portions of the atria is at a maximum. When the entire mass of the atria is depolarized, the ECG returns to baseline because all regions of the atria is depolarized, the ECG returns to baseline because all regions of the atria have the same polarity. The spread of atrial depolarization thus creates the P wave. Conduction of the impulse into the ventricles similarly creates a potential difference that results in a sharp upward deflection of the ECG line, which that returns to the baseline as the entire mass of the ventricles becomes depolarized. The spread of the depolarization into the ventricles is thus represented by the QRS wave. During this time the atria repolarize, but this event is hidden by the greater depolarization occurring in the ventricles. Finally, repolarization of the ventricles produces the T wave.

Now let’s have a brief description of ECG’s P-wave, QRS wave and T wave in addition with PR interval and ST segment so that we can have a better understanding and visualization of these waves on the standard ECG graph paper discussed above.

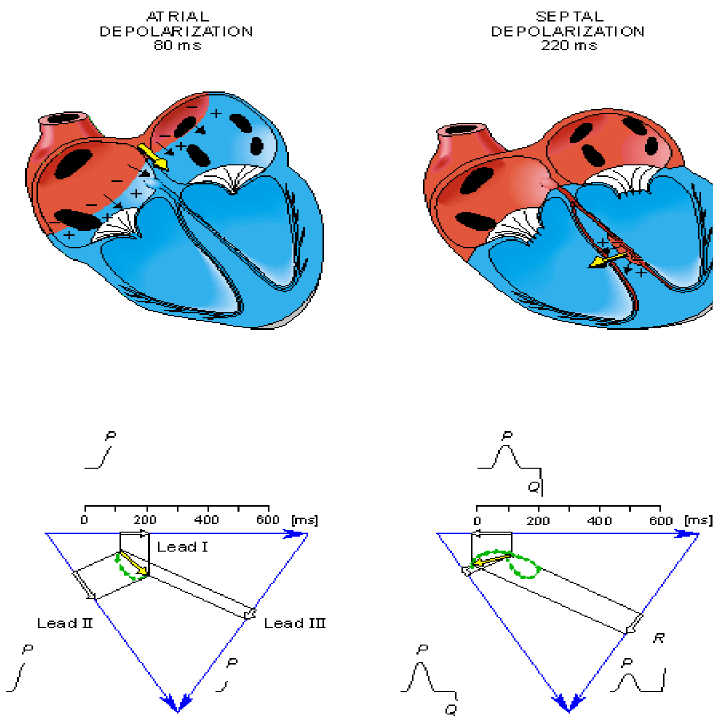


Fig.4.10 ECG signal [16]

4.2.4.1 P Wave

The P wave begins with the first upward deflection from the baseline and ends with return to the baseline. The normal P wave measures less than 0.11 second in width, or not quite three small boxes.

4.2.4.2 PR Interval

The PR interval is measured from the first upward deflection of the P wave to the first deflection of the QRS from the baseline, whether negative (Q) or positive (R). The normal PR interval varies slightly according to age and heart rate, but, for all practical purposes, it can be said to range from 0.12 to 0.20 second, or three to five small boxes.

4.2.4.3 QRS Interval

The QRS interval is measured from the first deflection of QRS from baseline, whether negative of positive, to the eventual return of QRS interval to the baseline. The QRS interval should be less than 0.10 second, or two and one-half small boxes.

4.2.4.4 ST Segment

The ST segment runs from the return of the QRS to the baseline until the first upward or downward deflection of the T wave. While the duration of the ST segment is not generally of clinical significance, it is an exceedingly important portion of the ECG because of shifts up or down from the baseline. These shifts may be associated with ischemic heart disease, pericarditis, or other conditions. Note that such shifts are generally measured at a point 0.08 second (80 msec), or two small boxes, after the end of the QRS complex.

4.2.4.5 T Wave

The T wave represents repolarization of ventricle products as shown in Figure5.9.

4.2.5 Standard ECG Waveform

Standard ECG Waveform uses the following configuration to take ECG from human body:

4.2.5.1 Lead I: LA-RA

Left foreleg (left arm) electrode (+) placed just below the point of the elbow on the back of the left forearm – right foreleg (right arm) electrode (-) placed just below the point of the elbow on the back of the right forearm.

4.2.5.2 Lead II: LL-LA

Left hind leg (left leg) electrode (+) placed on the loose skin at the left stifle in the region of the patella – left foreleg (left arm) electrode (-) placed just below the point of the elbow on the back of the left forearm.

4.2.5.3 Lead III: LL – RA

Left hind leg (left leg) electrode (+) placed on the loose skin at the left stifle in the region of the patella – right foreleg (right arm) electrode (-) placed just below the point of the elbow on the back of the right forearm.

4.2.5.4 aVR: RA – CT

Right foreleg (right arm) electrode (+) placed just below the point of the elbow on the back of the right forearm – the electrical center of the heart or central terminal x 3/2; left foreleg and left rear leg (-).

4.2.5.5 aVL: LA –CT

Left foreleg (left arm) electrode (+) placed just below the point of the elbow on the back of the left forearm – the electrical center of the heart or central terminal x 3/2; right foreleg and left rear leg (-).

4.2.5.6 aVF: LL-CT

Left hind leg (left leg) electrode (+) placed on the loose skin at the left stifle in the region of patella – the electrical center of the heart or central terminal x 3/2; right foreleg and left foreleg (-).

4.2.5.7 CV6LL: V1 – CT

V1 electrode (+) placed in the 6^{th} intercostals space on the left side of the thorax along a line parallel to the level of the point of the elbow – the electrical center of the heart (central terminal).

4.2.5.8 CV6LU: V2 – CT

V2 electrode (+) placed in the 6^{th} intercostals space on the left side of the thorax along a line parallel to the level of the point of the shoulder – the electrical center of the heart (central terminal).

4.2.5.9 V10: V3 – CT

V3 electrode (+) placed over the dorsal thoracic spine of T7 at the withers – electrical center of the heart. The dorsal spine of T7 is located on the line encircling the chest in the 6^{th} intercostals space (central terminal).

4.2.5.10 CV6RL: V4 – CT

V4 electrode (+) placed in the 6^{th} intercostals space on the right side of the thorax along a line parallel to the level of the point of the elbow – the electrical center of the heart (central terminal).

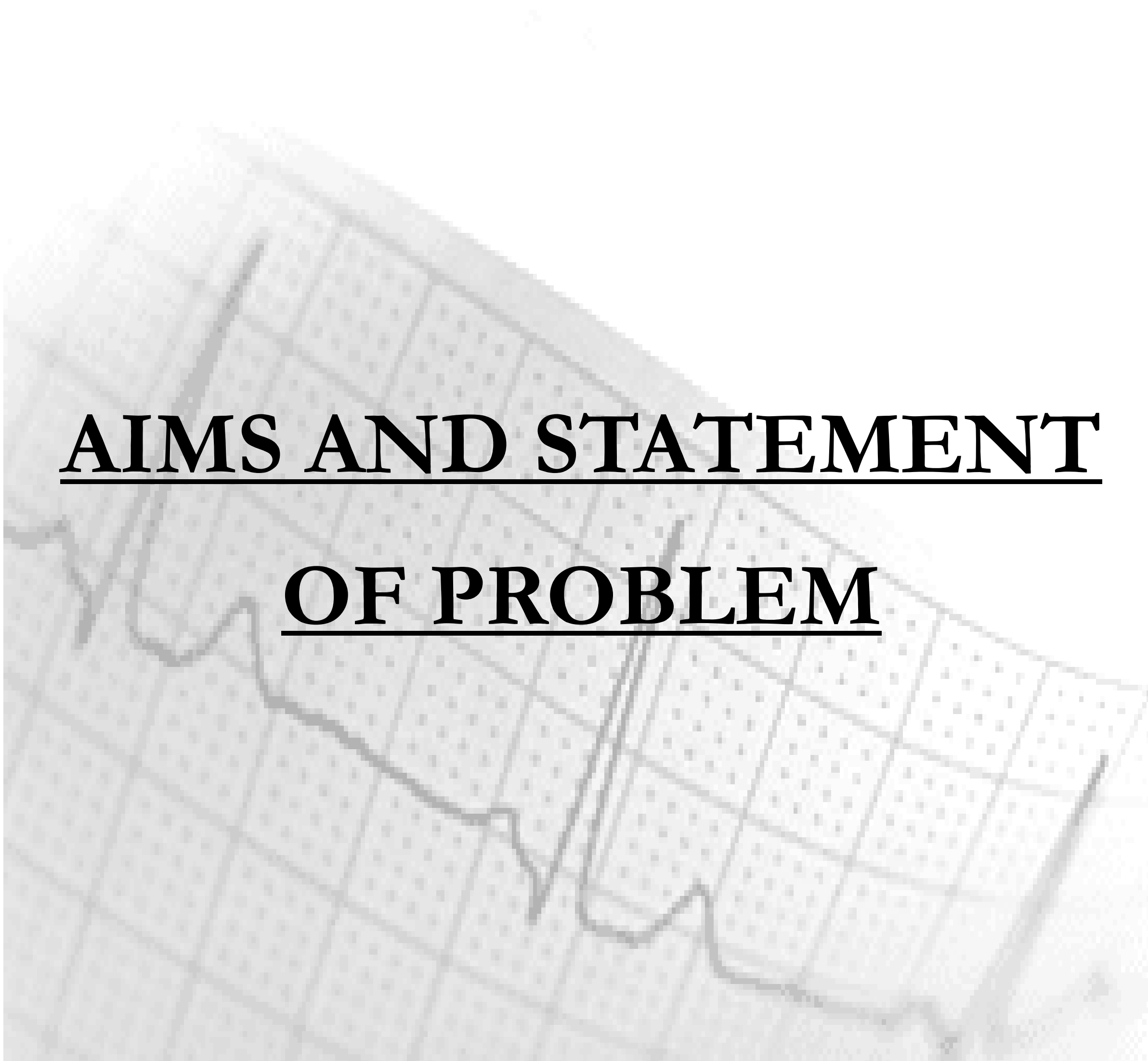
4.2.5.11 CV6RU: V5 – CT

V5 electrode (+) placed in the 6^{th} intercostals space on the right side of the thorax along a line parallel to the level of the point of the shoulder – the electrical center of the heart (central terminal).

4.2.5.12 Base – apex: LA – RA

Left foreleg (left arm) electrode (+) placed in 6^{th} intercostals space on left side of thorax along a line parallel to the level of point of elbow – right foreleg (right arm) electrode (+) placed on top of right scapular spine or over right jugular furrow.

CHAPTER 5



AIMS AND STATEMENT OF PROBLEM

Introduction

This chapter contains problem statement, problem solution, purpose and scope of the work, resources and method used in the project and activities of project.

5.1 Problem Statement

We have selected this project by analyzing the environment of Pakistan. We have visited different hospitals i.e. Government and Private. Private hospitals can afford the latest, advanced and expensive bio medical equipment but government hospitals are unable to do this. For example, we have visited Agha khan hospital, which is the most expansive private hospital of Pakistan. Agha khan hospital has purchased latest and expansive biomedical equipments like Cardiac monitor, electrocardiography machines … etc. on contrary side, when we have visited the civil hospital which is looking after by government of Pakistan. Civil hospital has not latest and expansive equipments they are using old and inaccurate biomedical equipments even in their ICUs.

For the above reason, we have decided to design such kind of project which can provide accurate reading and should be lower expansive than other accurate expansive equipments. So we have chosen this Heart Beat Analyzer project which is similar to Cardiac ECG monitor. In which doctor can analyze the ECG of any patient 24hrs with the heart rate analysis.

5.2 Aim and Objective of Solution

Our major purpose in the designing of this project is to reduce the cost of sensitive biomedical equipment without compromising on quality and accuracy. So we are interfacing a hardware device with the computer because computer prize decreases day by day with the increasing of efficiency. Our project contains two major components which are as follows,

- Hardware
- Software

5.3 Purpose and Scope of Work

The major purpose of this project is to reduce the cost of real time electrocardiography monitor so we have selected all those equipment which are cheap and provide osom accuracy because we are dealing with the human architecture one small mistake can destroy the human architecture. So we have decided to perform the limited work but should be accurate and efficient. We are just taking the input from the human body using one lead procedure then performing some hardware activities which amplify and reduce the noise from the ECG signal. On the other side, our software wait for the ECG signal on the parallel port then bring these signal for plotting purposes.

5.4 Resources and Methods

We have used different resources in this project that are,

- Websites
- Visits of different private and government hospitals.
- Doctors that provide better suggestion on this project
- Our colleagues and teachers were also helpful in this project

After some analysis we have decided to perform the software operations on Visual Basic and hardware operations on different ICs of Analog devices.

5.5 Project Activities

Every project consists of different designing aspects because everyone wants to make their project accurate and efficient. So we also did some project activities which made it successful.

5.5.1 Analysis

We have performed two major analyses in this project which can be detailed as,

- Language Analysis for Software development
- Integrated circuit analysis for Amplify and Filtering purposes.

Language Analysis is one of the most important analyses in this project because it is a real time system and requires proper attention on the incoming signal. We did this with the help of Visual Basic because it has less overhead as compare to other language.

Integrated Circuit Analysis has its own importance in this project because here we are dealing with milivolt signal. So we pay proper attention on it for the hardware purposes.

5.5.2 Design

We have considered only one ECG lead to fetch data and plot it on the graph. In the design phase we have designed Amplifier, Filters and Highly sensitive amplifiers. We have discussed this Design phase in implementation chapter.

5.5.3 Implementation

In implementation phase we have implemented all the theoretical concepts in hardware and software form. We have implemented filters and amplifier concepts on the hard board and object oriented concepts on software i.e. Visual Basic. Complete implementation of Hardware and software are discussed in Implementation chapter.

5.5.4 Testing

Testing is the major phase of this project in which we have tested all the components and parts of Heart Beat Analyzer. Complete testing with snapshots of tested results are explained in testing chapter.

CHAPTER 6

ANALYSIS AND DESIGN

Introduction to Analysis and Design

This chapter will discuss the feasibility study, design consideration, assumption & dependencies, general constraint, goals & guidelines, development methodology, architectural strategies, Object Oriented Analysis, Use Cases modeling, structural modeling, behavioral modeling, Object Oriented Design, class diagram, entity relationship diagram, and circuit design of the solution.

6.1 Feasibility Study

Feasibility Study is essential part of any project analysis and design. It is a detailed investigation and analysis of a proposed development project to determine whether it is viable technically and economically.

6.1.1 Purpose of a Feasibility Study

The feasibility study will defined the evaluation or analysis of the potential impact of our project. A feasibility study conducts to assist decision-makers in determining whether or not to implement proposed project. It also provides the relationship between risk management and the need and operation of the project. We have examined the risks face by our project and also consider the technical problems in development of project.

6.1.2 Technical Feasibility

The scope, limitation and opportunities have been studies thoroughly. To implement our project in Matlab was so easy and functionally compatible, but it consumes too much time in run time compilation. As our project is a run time system, So Matlab was not satisfying our requirements. Java and visual-C was not providing the facility to access parallel port and C/C++ was difficult to mange for run time graphics. Because of all above reasons we might be facing problems in implementation of the project. So we choose Visual Basic-6 that not only provides the facility to access parallel port but also gives opportunity to draw run time graphics. It also has functionality to access default printer.The expertise of project member was not enough to solve each and every problems faced during the implementation of project, but the support from supervisor, teachers and senior student gives help in trouble shooting the problems.

6.1.3 Economical Feasibility

The economical feasibility is the study of relationship between cost and benefit of the project. As for the project member concern it was difficult for us to complete our project with out support of university budget.

Heart Beat Analyzer will actually reduce the cost of about four Laces as compare to already existing projects in the market.

Heart Beat analyzer provides the soft copy of ECG wave that gives economically feasible solution to cost taken by concerning abroad doctors.

6.1.4 Organizational Feasibility

Since, the personnel at the hospitals are generally computer literal and Heart Beat Analyzer is very user friendly and power full system, so user would not faced enough problems to operate the system. The users just have to install the software of Heart Beat Analyzer at first time and all other works (i.e. taking, saving, printing, recalling already saved ECG) is not as such a big deals with the use of user manual.

6.2 SWOT Analysis

SWOT is the abbreviation of Strength, Weakness, Opportunities and Threat it is a method of evaluating the good and bad qualities of the system. The parts of SWOT analysis are discussed below.

6.2.1 Strengths

- The solution use already existing Computer system in the hospitals
- This solution has a standardized software version that can be changed according to the operating system.
- The solution has been developed after detailed surveys of hospital, So that it can fulfill the requirement of heart specialists.

6.2.2 Weaknesses

- The weaknesses of the project depend on the speed of computer systems.

- Less amount of storage capacity for storing ECG waves.
- Lack of awareness of use of computer systems.
- Bad quality of input electrodes.
- Input DC-voltage is a big problem in the system. As no other feasible DC-voltage was available we use Batteries (DC power supply) that will weak with the passage of time.

6.2.3 Opportunities

- With this project, we have learnt different programming languages to analyze the best one for the given scenario.
- By the experience of working on this project we will be able to convert embedded system on computer based system through which cost can be reduced.
- With the experience of this project we will be able to analyze different IC for hardware designing.

6.2.4 Threat

- The major threat to our devised solution is the existence of other PC based ECG systems.
- If our project solution may be leaked, it is might be possible that they come up with the same idea and take the market share before our project could be introduced.
- One of the main constraints was time available for delivering the project.

6.3 Design Consideration

As Heart Beat Analyzer is a project that is design to facilitate heart patients, keeping in view of hospital environment (especially ICU environment) following considerations is address while designing the system.

- Generally this type of systems is use in ICUs where patients are in serious condition so those muscle movements are negligible.
- We add a notch filter that will filter noise added by air conditioners.
- This system is use to take ECG only of human beings.

6.4 Assumptions and Dependencies

The assumptions or dependencies regarding the software as well as the hardware and their usage are mentioned as follows:

6.4.1 Related Software and Hardware

Software solution of our proposed project is based on visual basic-6 technology, which bound it to plate form dependent.

As for hardware concern, it is designed to be as compatible and implementation specific as possible.

6.4.2 Interface / Protocol Requirement

For interoperability among the software and the hardware components, we have made our own protocol, customized according to our requirements. As part of this include the interface in between hardware and software.

6.4.3 Performance Requirement

For optimum performance and efficient run time ECG taking and/or recording, the solution should be able to take all samples available at parallel port. And hard ware should be able to samples ECG wave as accurate as possible.

6.5 Process Model

The software process model defined as a simplified description of a software process. As for the development of the solution is concerned we have taken formal system development as Process model, which encompasses the following trends:

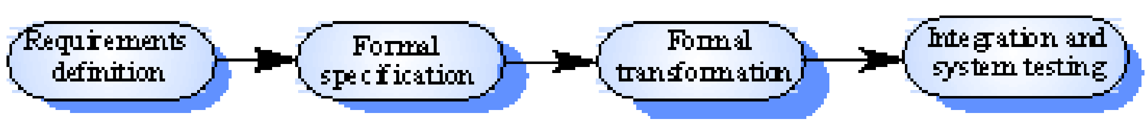


Fig.6.1 Formal system development model

We use this model because it provides safety and security in Critical systems before the system is put into actual operation.

6.6 Architectural Strategies

The strategies that provide insight into the key abstractions and mechanisms used in the system architecture are:

- Object Oriented Approach.
- Reaching equilibrium between speed and space tradeoff (in case of saving and plotting the ECG wave).

6.7 Object Oriented Analysis

Object Oriented Analysis of the proposed project i.e. Heart Beat Analyzer is done in detail as follows:

6.7.1 HBA Model Diagram

HBA model diagram shows the interconnectivity of all the software and hardware aspects. Different types of requests can be launched for example the doctor/technical assistant can view/print run time ECG wave, they can save ECG wave for future analysis, they can view/print already stored ECG wave at any time.

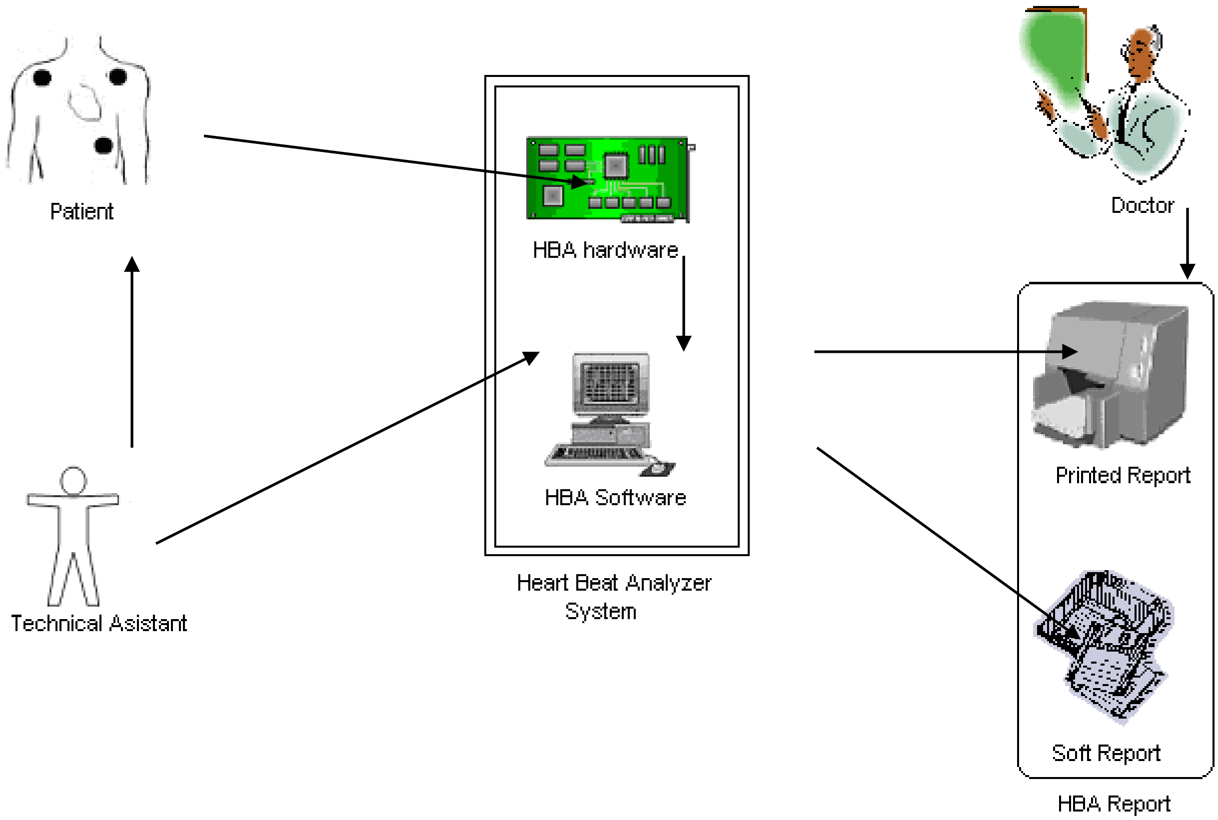


Fig.6.2 Heart Beat Analyzer Model Diagram

6.7.2 Use Case Modeling

The unified modeling language is now the most widely used graphical representation scheme for modeling the object oriented systems. It has indeed unified the variance popular notational schemes those who design systems use the language to model their systems.

Use case diagrams represent the interaction between the user and our system (i.e. all actions the user may perform on the system) when developers begin the project, they rarely start with as detailed a problem statement.

6.7.2.1 Analysis Use Case Model Diagram

Following is the use case diagram of our system in fig.6.2; if you look closely you might see and get a better feel of the whole scenario. And the job assigned to the hospital staff and their tasks and the way they are performed.

6.7.3 Data Flow Diagram

For both hardware and software complete flow of data is as below,

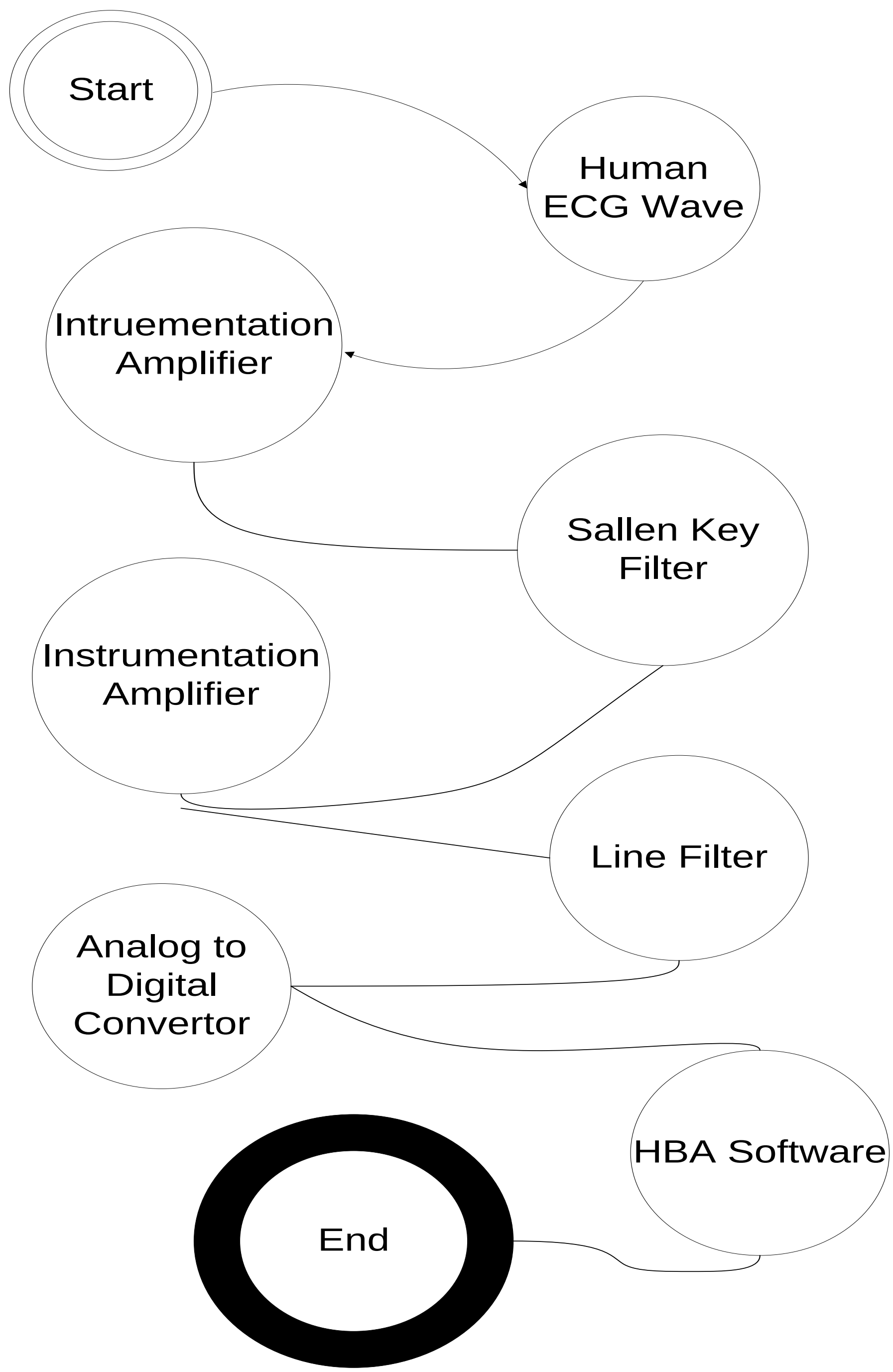


Fig.6.3 Data Flow Diagram of HBA

6.8 Object Oriented Design

Object-oriented design is a design strategy where system designers think in terms of “things” instead of operations or functions. The executing system is made up of interacting objects that maintain their own local state and provide operations on that state information. They hide information about the representation of the state and hence limit access to it.

An object oriented design process involves designing the object classes and the relationships between these classes. When the design is realized as an executing program, the required objects are created dynamically using the class definitions. Following is the object oriented design of our proposed solution.

6.8.1 Use Case Modeling

The UML provides the *use case diagram* to facilitate the process of requirements gathering. The use case diagram models the interactions between the system’s external clients and the *use cases* of the system. Each use case represents a different capability that the system provides the client.

Following is the description of use case design of our proposed solution

6.8.1.1 Design Use Case Model Diagram

The use case model diagram of our proposed solution is depicted in Figure which contains all the actors and use cases of the system.

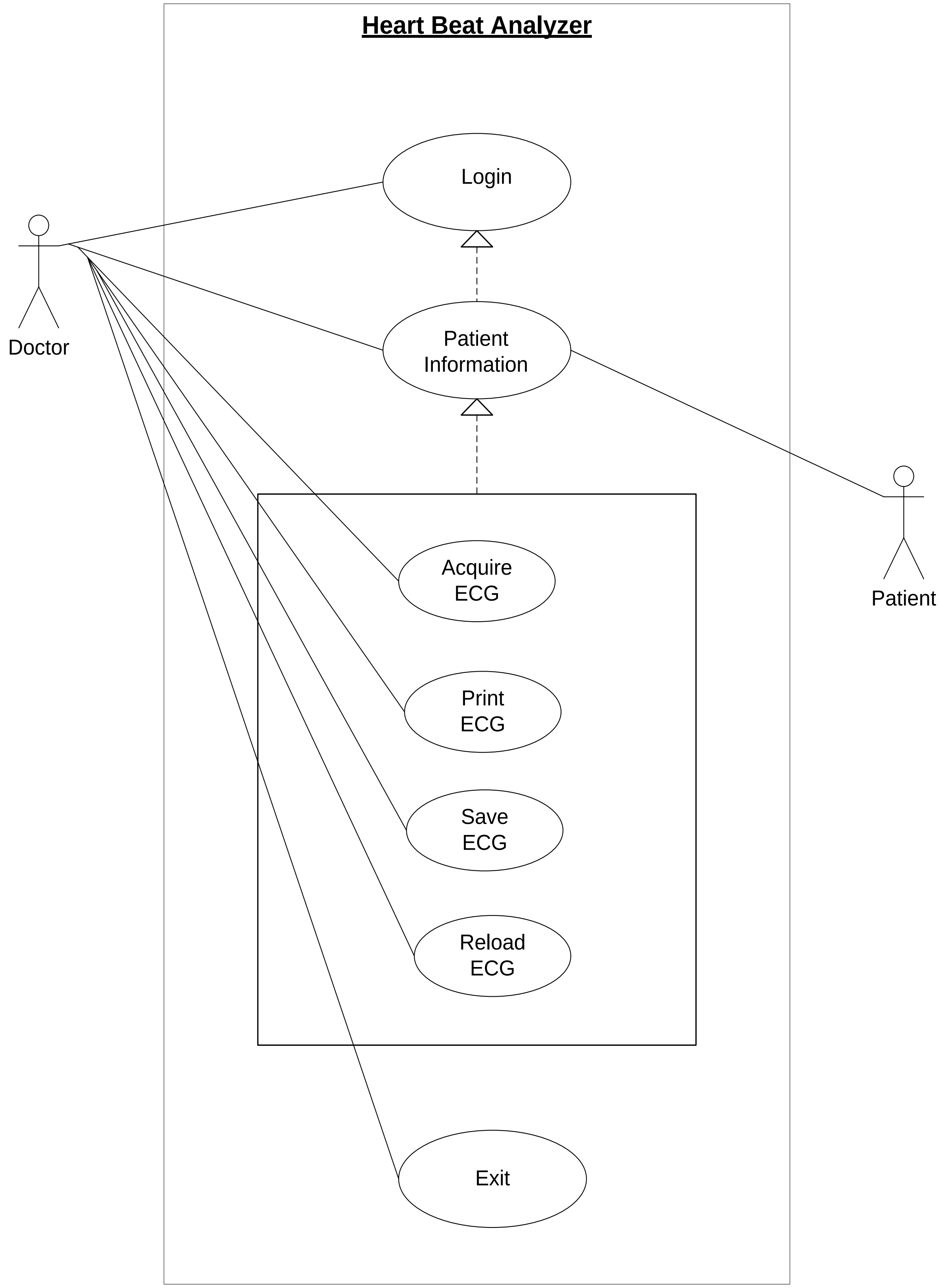


Fig.6.4 Use Case Diagram of HBA

6.8.2 Use Case Dependency diagram

We find out the various dependencies between the different components of the systems i.e. the effect of one component on the other. Foe example in our project the whole software is accessed by one component i.e. login. So it shows that all components of the software are dependent on the login window which is responsible for the user to login so in a way it is a gate to enter and explore the system. For further details see figure below.

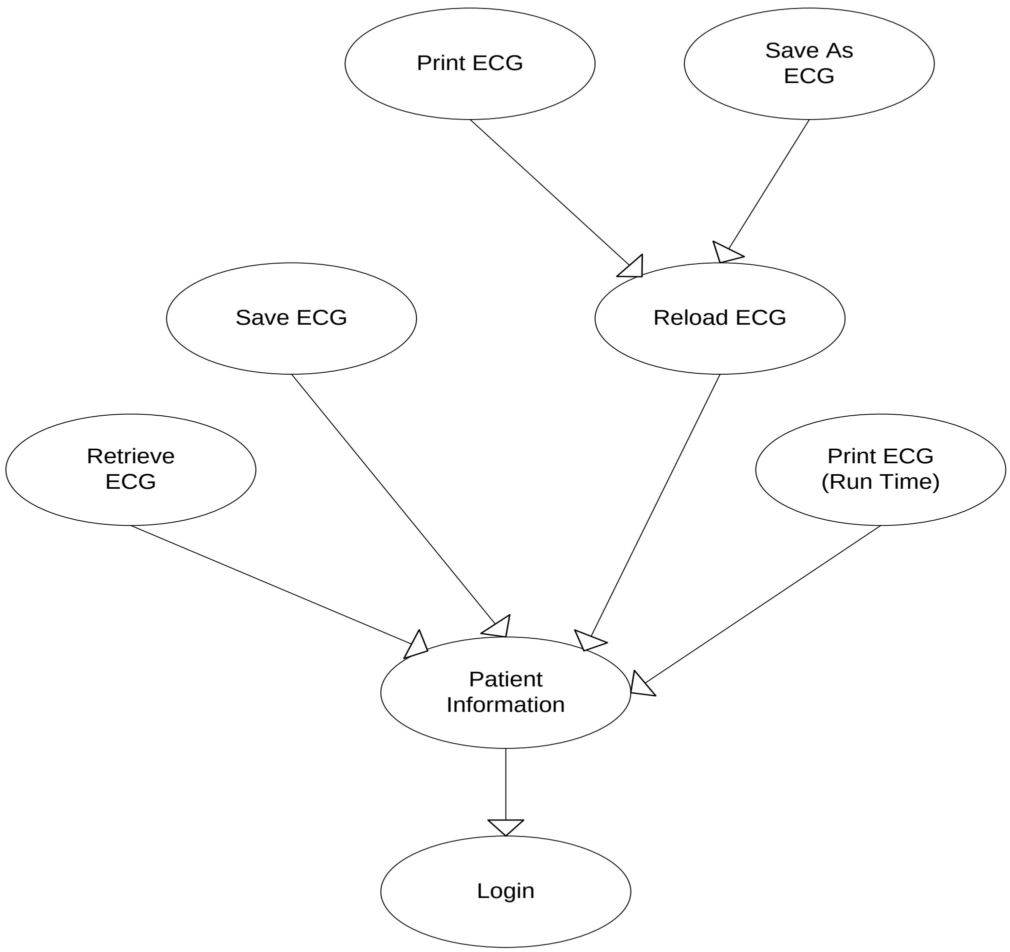


Fig. 6.5 Use Case Dependency Diagram 1

6.8.3 Design Class Diagram

The UML enables us to model the classes in our proposed solution and their relationships via the class diagram. Figure 12 shows the class diagram of proposed solution using UML. Each class is modeled as a rectangle. This rectangle can then be divided into three parts. The top part contains the name of the class, the middle part contains the class's attributes and the bottom part contains the class's operations.

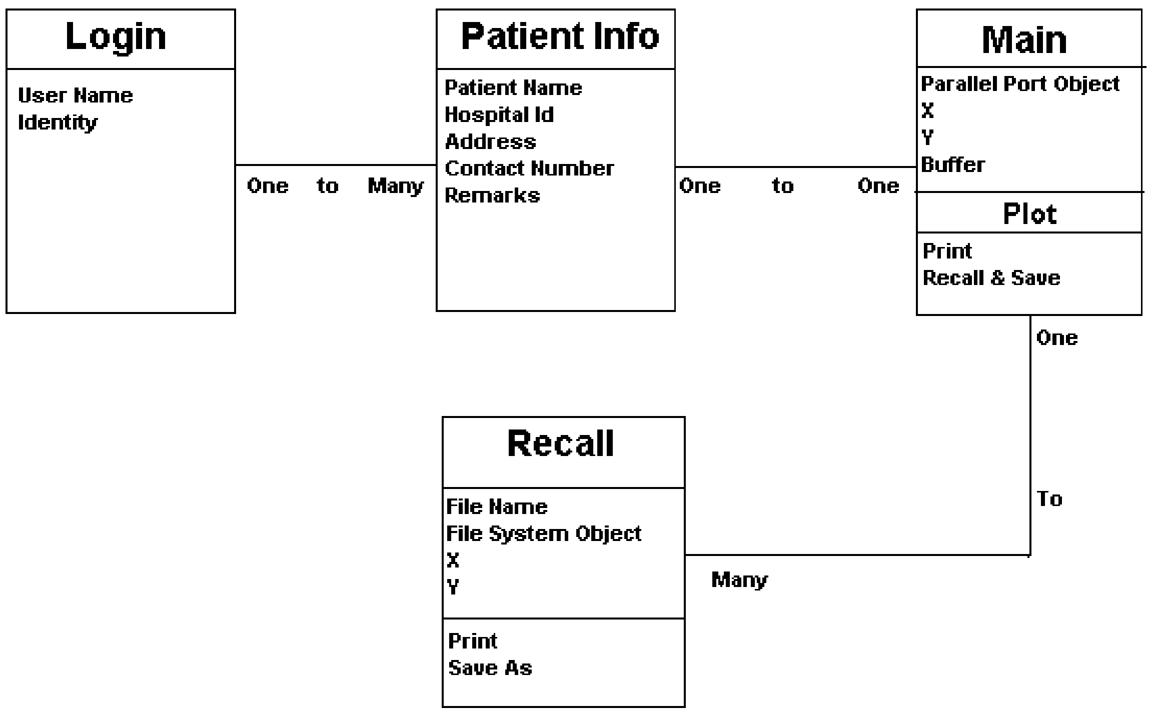


Fig.6.5 Class Diagram of HBA 1

CHAPTER 7

IMPLEMENTATION

Introduction

The purpose of this project is to design, built and test a low-cost digital real-time ECG Monitor. So we have decided to develop software on Visual Basic and used moderated cost hardware components that received ECG signal from the human body.

7.1 Hardware Development

The main reasoning behind hardware development was to keep the hardware cost to an absolute minimum. It was decided to use the AD624AD (Instrumentation Amplifier), because it's maximum gain is 1000. Another major component is 8-channel 8-bits Analogue-to-Digital converter that converts the analog signal that comes from AD624AD, into digital signal. In A-to-D at a time only channel will work, its selection is completely through Visual Basic.

7.1.1 Design Considerations

Accuracy, dependability, and precision are an absolute must if the device were to be used for diagnostic, or other medical purposes. Any small fluctuation in the waveform generated could carry critical diagnostic value, thus it is extremely important that the clinician can confidently and fully rely on the equipment. This means that the ECG must faithfully display the cardiac signal exactly as it exists in reality, such that any irregularity detected did in fact arise from an unhealthy cardiac cycle, *not* from the equipment that was used. Therefore, there were many special considerations that had to be taken into account when designing the ECG Monitor.

7.1.1.1 Noise

First and foremost in these considerations is the effect of *noise*. Noise interference in the signal detection process would be detrimental to the experiment, as the ECG signal is at such small amplitudes it could easily be masked by noise related fluctuations. Therefore in order to detect the signal accurately, there

must be strict limitations on the acceptable level of noise allowed, and every possible attempt must be made to minimize this level and reduce the effects of noise on the data acquisition process.

7.1.1.2 Signal Amplitude

Another consideration that strongly influenced the design of the ECG is the fact that the cardiac signal generated has very small peak amplitude. (As stated above, this is the very signal attribute that makes noise control so vital). Considerable amplification is necessary if there is any use to be made from the cardiac signal in terms of analysis and output. Also, the small size of the signal plays a very influential role in the approach to creating a system of visual output. Caution has to be taken to effectively differentiate between actual changes in the signal amplitude as opposed to a random variation in noise amplitude. In order to conversion from Analog to Digital we shout amplify the signal till 5 volts for better quality.

7.1.1.3 Low frequency

Because the signal that is generated from the cardiac muscle has such a low bandwidth, it is very important that the ECG have a good low frequency response. This is because any shifts in the frequency of the detected signal, especially the S-T portion of the waveform, carry critical diagnostic value.

7.1.2 Design Implementation

Figure 1.2, shows a simplified block diagram of the overall system. It is clear the electrodes are directly connected to the AD624AD. Then the output of AD624AD move into the Sallen key filter for filtering purposes and then it moves into the 50 Hz Notch filter for the reduction of line noise. Then it will move forward into another amplifier that amplifies the signal to 5volts using AD620. Afterward, 5volts amplified signal moved into Analog to digital converter for conversion purposes. That will move to parallel port of Computer System.

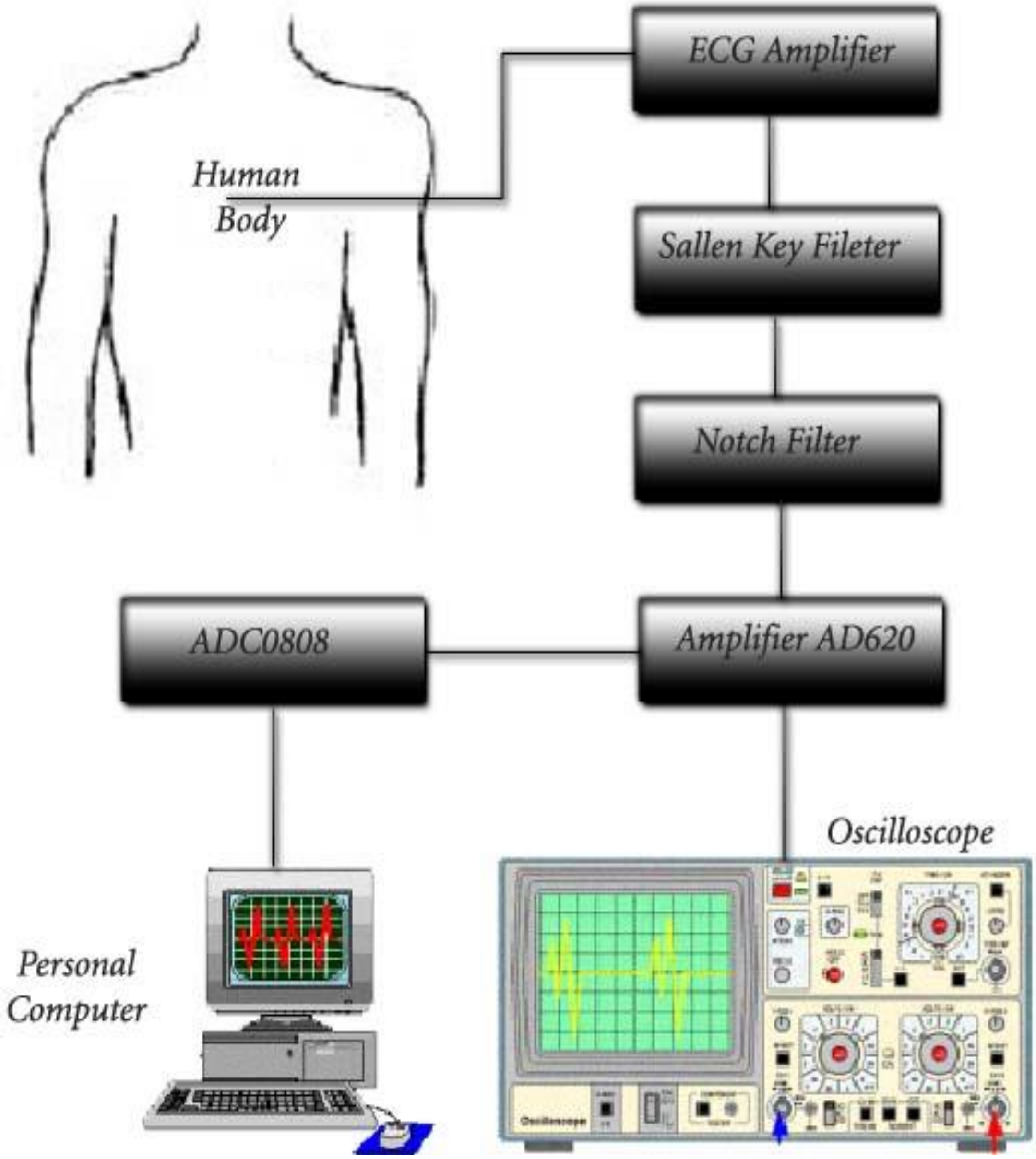


Fig.7.1 Complete Block Diagram of System

7.1.2.1 Interfacing Between Human and ECG Hardware (Electrodes)

The role of the electrodes is to act as bio-electric transducers at the interface between the Human body and the ECG Hardware. Inside the body, electricity exists in the form of ions. Thus, the purpose of the electrodes is to convert electricity from its ionic form in the body into an electric current in the wires. Ag-AgCl electrodes are the current standard for use in medical applications related to biophysical Instrumentation and measurements. The gel provides impedance matching at the interface between the electrode and the surface of the skin, which means that noise effects are reduced, increasing the signal-to noise ratio, allowing for a clear signal to be detected. They are non-Polarisable, meaning that the differences in potential that are measured do not depend on current variations in the wires. They are stable, easy to use, and inexpensive.

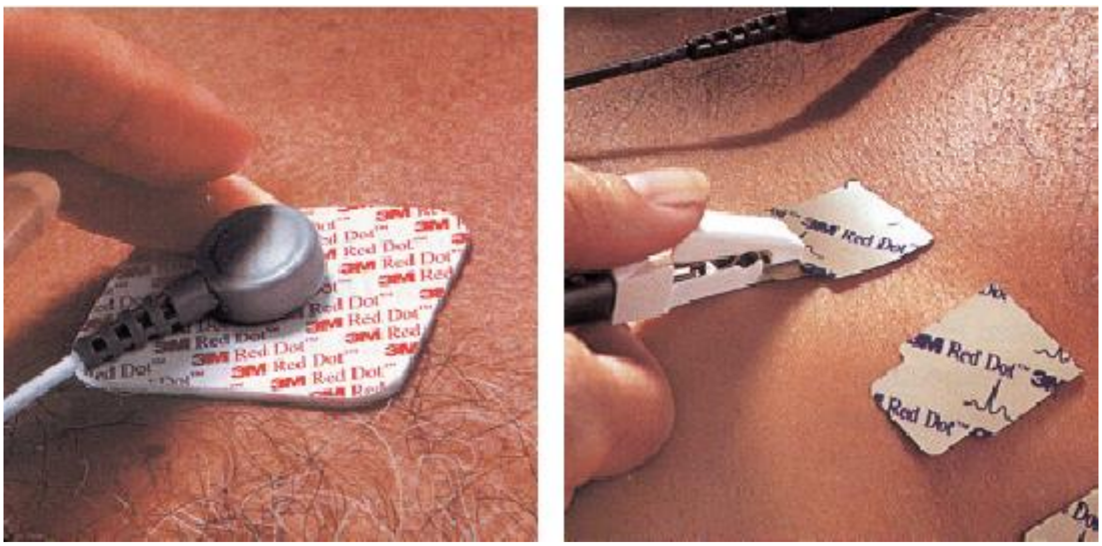


Fig. 7.2 Electrodes Position

7.1.2.2 Amplifier (AD624AD)

The first component of the hardware that directly receives the ECG signal from the human body is amplifier i.e. AD624AD (Analog Devices IC has 6 pins). AD624AD is a low noise amplifier that takes the input of 1mV – 2mV signal and can produce the output with 1000 gain or 1 – 2V signal. So here the major purpose of this amplifier to take the input of weak signal and produce the output with 1000 grain. Figure6.3 illustrates the better idea of interfacing.

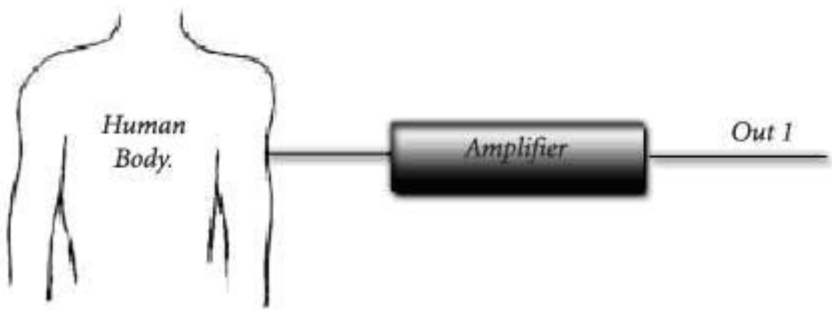


Fig. 7.3 Interface between Human and AD624

Figure 7.4 shows a simple ECG amplifier using the AD624AD instrumentation amplifier. A gain of 1,000 is selected by shorting certain pins together as shown. The two-stage RC filter weeds out frequencies higher than about 50 hertz. A 3 lead cable connects the circuit to the electrodes and two wires are required to connect the output to an ADC for sampling.

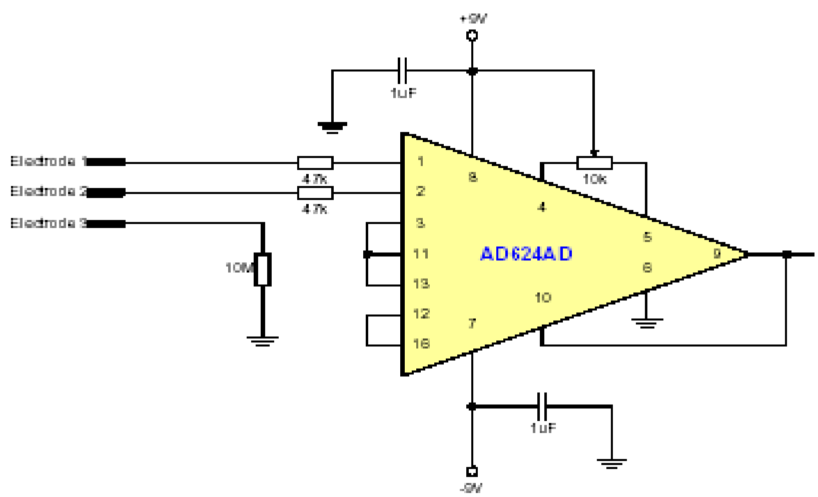


Fig. 7.4 Block Diagram of Analog Amplifier (AD6244D)

This amplifier produces the noisy signal so after this we are required to filter this signal using Sallen key filter. Means the output of AD624AD worked as an input of Sallen key filter. Datasheet and Notes of AD624AD can be found in Appendix B-1.

7.1.2.3 Sallen Key Filter

A two-stage RC network that forms a second order low-pass filter is shown below. This filter is limited because its Q is always less than 1/2. With R1=R2 and C1=C2, Q=1/3. Q approaches the maximum value of 1/2 when the impedance of the second RC stage is much larger than the first. Most filters require Qs larger than 1/2.

Larger Qs are attainable by using a positive feedback amplifier. If the positive feedback is controlled—localized to the cut-off frequency of the filter—almost any Q can be realized, limited mainly by the physical constraints of the power supply and component tolerances. Figure 2 shows a unity gain amplifier used in this manner. Capacitor C2, no longer connected to ground, provides a positive feedback path. In 1955, R. P. Sallen and E. L. Key described these filter circuits, and hence they are generally known as Sallen-Key filters.

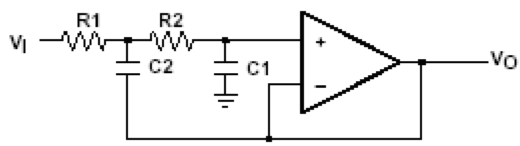


Fig.7.5 Unity gain Sallen Key Low pass filter [17]

The generalized Sallen key Filter is shown in following figure,

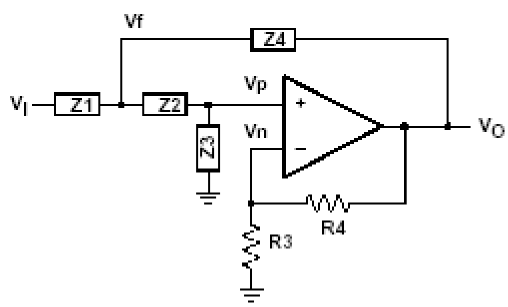


Fig.7.6 Generalized Sallen Key Low pass [17]

In our circuit, we are using Sallen key filter for two purposes which are,

- As a Buffer
- As a Non-Inverting amplifier

Sallen key filter is directly connected with the AD624AD (operational amplifier). Datasheet and Notes of UA741 can be found in Appendix B-4. Figure 6.7 illustrates the complete idea.

Fig.7.7 Sallen Key Low pass filter [17]

7.1.2.4 Notch Filter

Generally, a notch filter rejects a narrow frequency band and leaves the rest of the spectrum little changed. In our project, we are required to remove the line noise and make a sharp edge at Q and R peaks so we used notch filter. Notch filter is directly connected with the Sallen key filter as shown in the following figure,

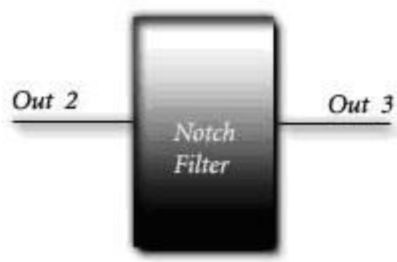


Fig.7.8 Notch filter [17]

The most common example is 60-Hz noise from power lines. Another is low-frequency ground roll. Such filters can easily be made using a slight variation on the all-pass filter. In the all-pass filter, the pole and zero have equal (logarithmic) relative distances from the unit circle. All we need to do is put the zero closer to the circle. Indeed, there is no reason why we should not put the zero right on the circle: then the frequency at which the zero is located is exactly canceled from the spectrum of input data.

Narrow-band filters and sharp cutoff filters should be used with caution. An ever-present penalty for using such filters is that they do not decay rapidly in time. Although this may not present problems in some applications, it will certainly do so in others. Obviously, if the data-collection duration is shorter than or comparable to the impulse response of the narrow-band filter, then the transient effects of starting up the experiment will not have time to die out. Likewise, the notch should not be too narrow in a 60-Hz rejection filter. Even a bandpass filter (an example of which, a Butterworth filter) has a certain decay rate in the time domain which may be too slow for some experiments.

A curious thing about narrow-band reject filters is that when we look at their impulse responses, we always see the frequency being rejected! For example, look at Figure2. The filter consists of a large spike (which contains all frequencies) and then a sinusoidal tail of polarity opposite to that of the frequency being rejected.

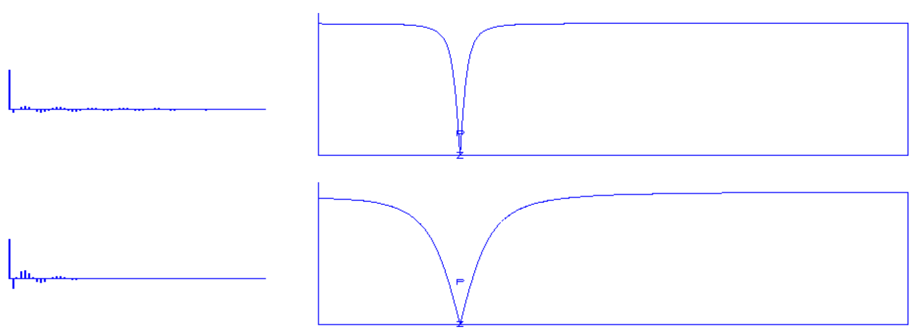


Fig.7.9 Notch Filter Response [17]

Figure 6.9 shows that a zero on the real frequency axis and a pole just above it give a notch filter; i.e., the zeroed frequency is rejected while other frequencies are little changed. Bottom:

the notch has been broadened by moving the pole further away from the zero. (This notch is at 60 Hz, assuming $\Delta t = .002$s.)

7.1.2.5 AD620 (Instrumentation Amplifier)

The major part of our project is to interface the hardware with the computer system. For this purpose we required to convert the noise free ECG signal into digital form. In order to convert it into digital form, we required to increase the strength of ECG signal till 3V – 5V because ADC0808 takes the input that has appropriate strength. But the output of notch filter is 1 – 2V, so here we require amplifying it with the appropriate gain. For this purpose we are using AD620 which amplify the 1- 2V signal into 3 – 5V.

The AD620 requires only a single external gain-setting resistor; Resistors R2 and R3 change the normal gain equation to

$$Gain = 1 + 49.4\ k/RG + (49.4\ k/2)/22\ k$$

To avoid output saturation, the usable gain is limited by the output swing and the maximum input voltage to the IA. With a + 5V power supply, the output swing of the AD620 is about + 3.8 V; and the maximum input is +5 mV plus a variable normal-mode

DC offset of up to + 300 mV, allowing a maximum gain of 12.45. Here, the gain is conservatively set to 8 (+1%), using RG = 8.45 k. Following is the pin diagram of AD620.

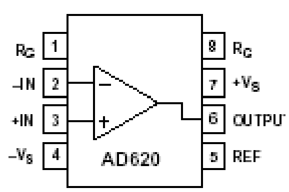


Fig.7.10 AD620 [17]

Now the output of Notch filter becomes the input of AD620 that performs amplification and promote this signal to the ADC0808. Datasheet and Notes of AD620 can be found in Appendix B-2. Complete illustration of this module is as follows,

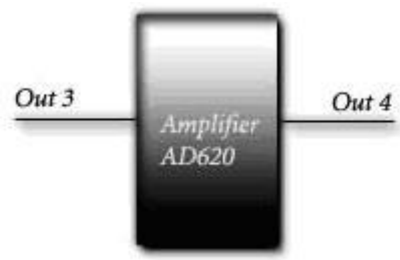


Fig.7.11 Interface between AD620 & ADC

7.1.2.6 Analog to Digital Conversion

ECG recordings made at rest have typically a length of 10 seconds. If digitized within accuracy limits 500 samples /sec and maximum 5µV/LSB, for each ECG lead per second 1,000 bytes of data is obtained with 16 bits/samples. This results in 3,000 bytes of data for a standard 3-leads in 10-second ECG (In this case, redundancy of limb leads which can be reconstructed from lead I and lead II has already been removed).Although less than medical imaging, electrocardiography thus results in large amounts of digital data compared to other medical data such as patient history, diagnostic codes and biomedical laboratory data. In this case we have used the ADC0808 for digitization purpose. ADC0808 get the input from three different AD620 for three different leads. Following figure illustrates the idea,

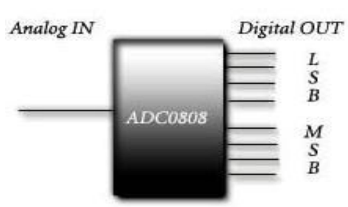


Fig.7.12 ADC with AD620

Normally analog-to-digital converter (ADC) needs interfacing through a microprocessor to convert analogue data into digital format. This requires hardware and necessary software, resulting in increased complexity and hence the total cost.

The circuit of A-to-D converter shown here is configured around ADC 0808. The ADC 0808 is an 8-bit A-to-D converter, having data lines D0-D7. It works on the principle of successive approximation. It has a total of eight analogue input channels, out of which any one can be selected using address lines A, B and C. For the controlling of these data lines, we have designed Visual Basic code that selects specific after the same period of time. Here, in this case, input channel IN0, IN1, IN2 (for three different ECG leads i.e. Lead-I, Lead-II & Lead-III) is selected by A, B and C address lines. Following is the Block diagram of ADC0808.

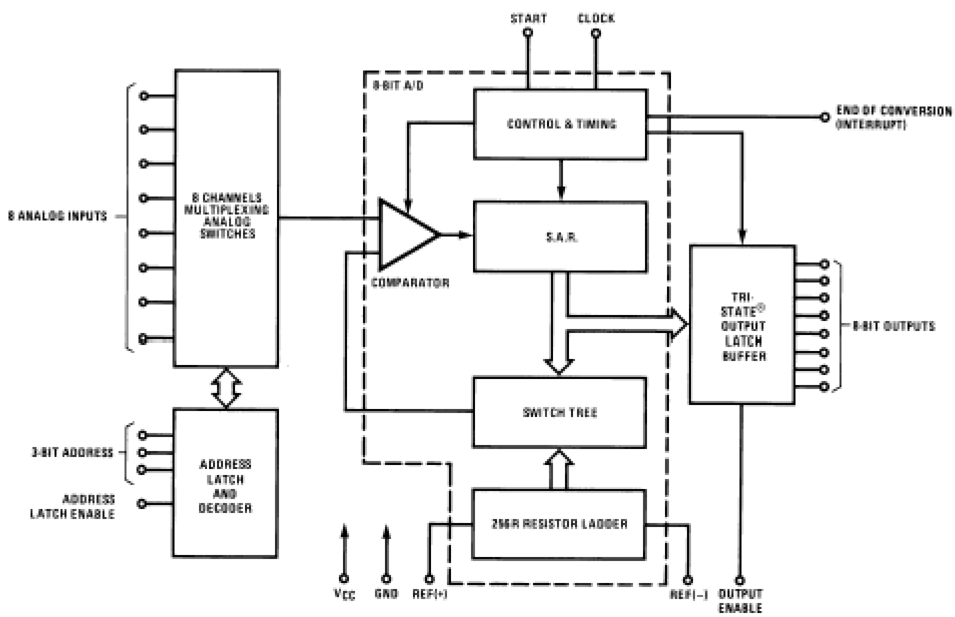


Fig.7.13 ADC0808 [18]

Usually the control signals EOC (end of conversion), SC (start conversion), ALE (address latch enable) and OE (output enable) are interfaced by means of a microprocessor. However, the circuit shown here is built to operate in its continuous mode without using any microprocessor. Therefore the input control signals ALE and OE, being active-high, are tied to Vcc (+5 volts). The input control signal SC, being active-low initiates' start of conversion at falling edge of the pulse, whereas the output signal EOC becomes high after completion of digitization. This EOC output is coupled to SC input, where falling edge of EOC output acts as SC input to direct the ADC to start the conversion.

As the conversion starts, EOC signal goes high. At next clock pulse EOC output again goes low, and hence SC is enabled to start the next conversion. Thus, it provides continuous 8-bit digital output corresponding to instantaneous value of analogue input. The maximum level of analogue input voltage should be appropriately scaled down below positive reference (+5V) level. Datasheet and Notes of ADC0808 can be found in Appendix B-3. Dual In line package representation of ADC0808 is as follows,

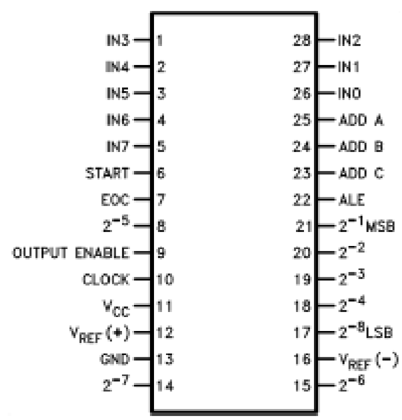


Fig.7.14 ADC0808 [18]

The ADC 0808 IC requires clock signal of typically 550 kHz, which can be easily derived from a stable multi vibrator. But here we require the clock of 1MHz that can easily convert the Analog signal into digital with data lose. In order to visualize the digital output, we have attached the parallel port with the computer system and have activated our Heart Beat Analyzer that bring the data from parallel port and display in the form of graph. After Analog to Digital conversion, we can move this data to the parallel port of personal computer. Following Figure illustrates the complete idea.

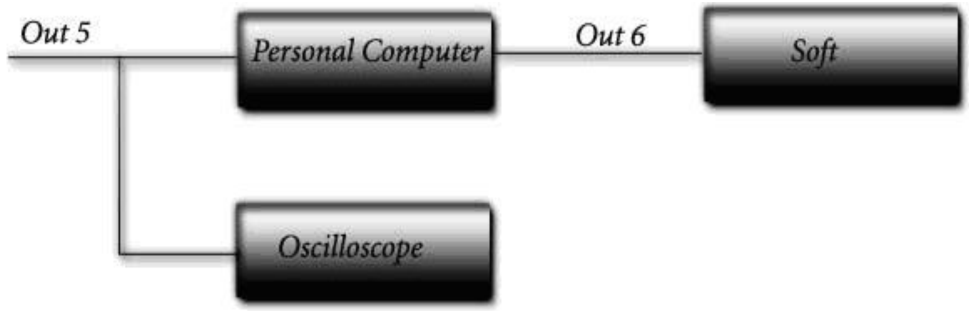


Fig.7.15 Output of ADC0808

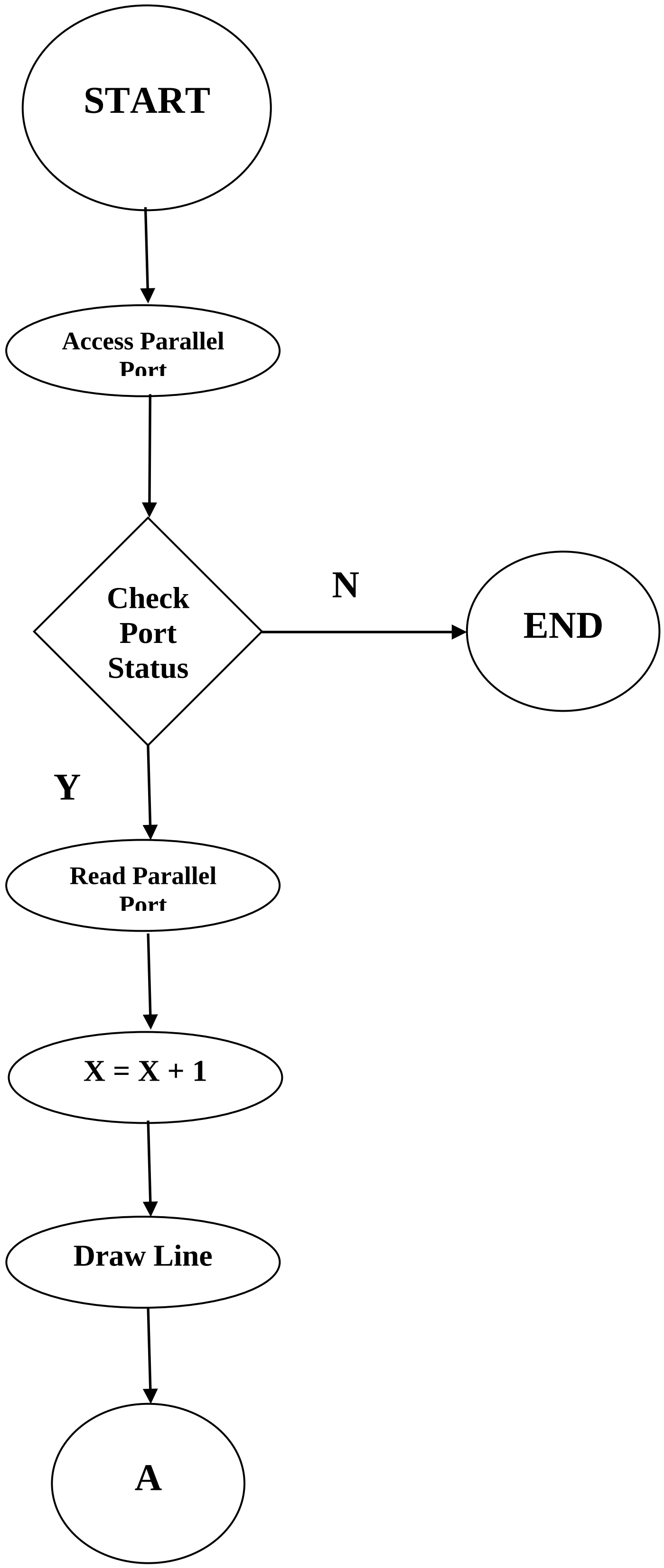
7.2 Software Development

The philosophy used during the development of the Visual Basic code was to keep it simple, straightforward, comprehensible, and to a minimum because if the code consume maximum resources then operating system can not provide the maximum resources. There are many small programs designed for testing the hardware and ideas, each program is labeled mark 1, 2, 3, etc… The end result is that the Visual Basic code is gradually built up step-by-step, instead of writing the entire program at once. This ensures that operational results are obtained, as testing procedures are carried out at each stage, while if the program was written all at once, there is little chance it will work and could prove difficult to debug. The high-level programming language C was chosen. There are many advantages for using C including: ease of programming, ease of modification, reusability of code, use of standard functions (e.g. printf, getc, putc, etc.), etc. But there is one drawback, C code is much less efficient, for example typically code produced by the C compiler (CCS) is at least twice as large as that programmed in Visual Basic.

7.2.1 Parallel Port Communication

This program is extremely simple; basically first it initializes Parallel Port (**378H**), with the help of predefined procedures and functions of a DLL i.e. WINIO.DLL, of Personal computer and receives "ECG signal from the hardware". By default, the incoming signal on the parallel port is binary so we are required to convert it into decimal form. In this routine we have also performed this conversion operation. If the parallel port is already occupied by another program then it will display the message

"Parallel Port was not initialized". Complete source code for 7.2.1 and notes of parallel port can be found in appendix A-1. The flow chart of this procedure is as follows,



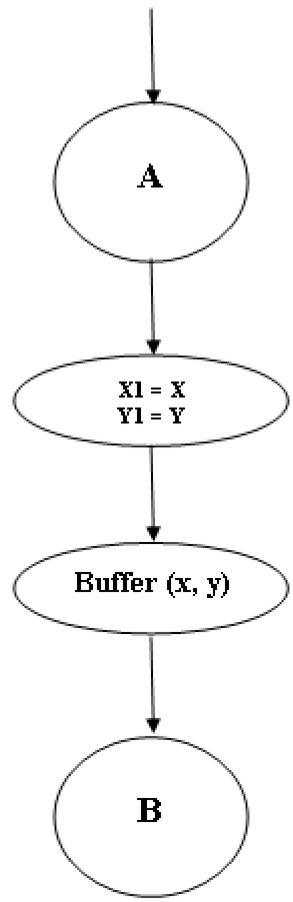


Fig 7.15 Parallel Port Communication

7.2.2 Plot the received signal

It is the next step of Mark1, in which we have received the ECG signal from parallel port and also converted into decimal form, in this step visual basic code plot the received decimal values with respect to time. Here, we used three different picture boxes that display the data from three different leads. Visual basic provides various methods to plot the received signal i.e. plot by line method, plot by pixel method etc. Here we are using plot by pixel method that plot the every received decimal value in the form of pixel using **SetPixel** method on the specified picture box. Received signal can be categorized into three different panels because incoming data generated from three different sources i.e. Lead-I, Lead-II and Lead-III. Lead-I data plot on graph-I (picturebox-I) similarly Lead-II plot on graph-II (picturebox-II) and same used for graph-III (picturebox-III). One question can raise here how can we plot the different Leads data by using single parallel port?? Answer of this simple question is that we have used the different addressing modes in ADC-0804 (Analog to Digital Converter) for selecting different channels using Visual basic. The flow chart of this procedure is also mentioned in the flow chart of parallel port communication and complete source code for 7.2.2 can be found in appendix A-1.

7.2.3 Patient Record

It is a procedure in which we are storing and displaying the patient information i.e. Name, Age, Disease, Hospital ID, Contact number (in case of emergency), Name of Caring person & his/her contact number, etc. It is necessary form that should be filled by Nurse or ward Boy. Without filling this form no one can move to further. The snapshot of this form is as follows.

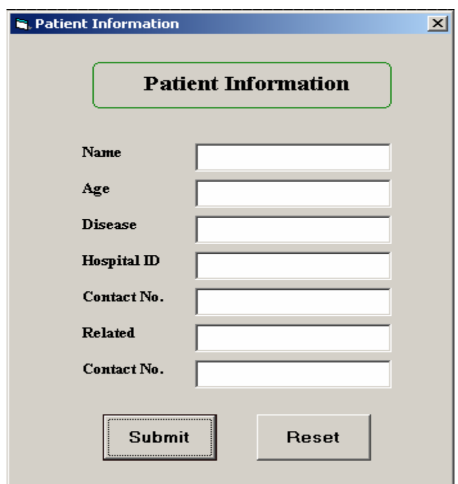


Fig. 7.16 Patient Information Form

7.2.4 Heart Rate Calculation

There is only one calculation in this project that is Heat Rate Calculation. Heart rate can be defined as "*The number of beats per minute. Normal resting heart rates are variable with age, sex, size and overall cardiovascular condition. Heart rate can be determined by taking the pulse. Normal heart rate for an average sized adult is in the range of 60-85 beats/minute*". Heart rate calculation depends on the number of R-Peaks in one minute. As we know R is the bigger peak in an ECG signal that has large amplitude. So, its calculation is very simple. We have already stored ECG signal (decimal values) in a two dimension array. For heart rate we are comparing every value of two dimension array with each other and obtaining the largest value i.e. is the amplitude of R-Peak. Continuing this process till one minute then counts the number of largest values. These number of largest values is basically is the heart rate. Complete source code for 7.2.4 can be found in appendix A-2.

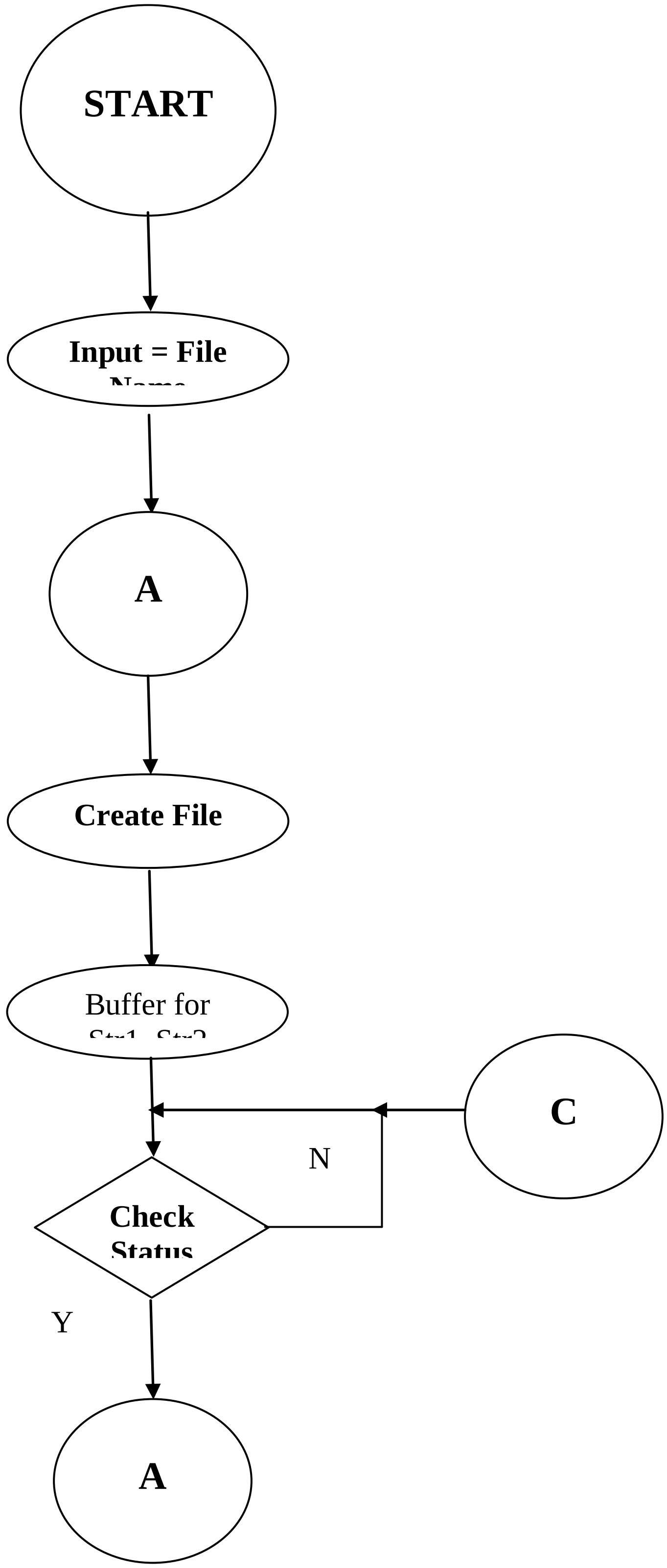
7.2.5 ECG saving procedure

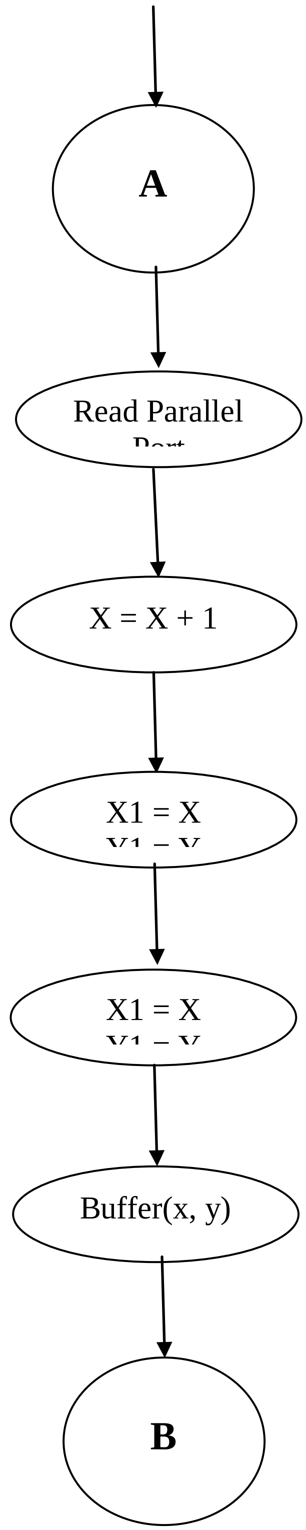
In normal ECG machines, ECG storing facility is not present because they just provide the printing of real time ECG signal on the ECG paper and monitoring of ECG signal for 24 hrs without storing. Our project is unique in these kinds of equipments because the major feature of our project is the storing of ECG for unlimited time (depends on the situation and Hardware configuration). We are storing the ECG signal (Decimal Values) on the text file by using Visual basic's predefined filing procedures. The ECG storing procedure consists of following steps,

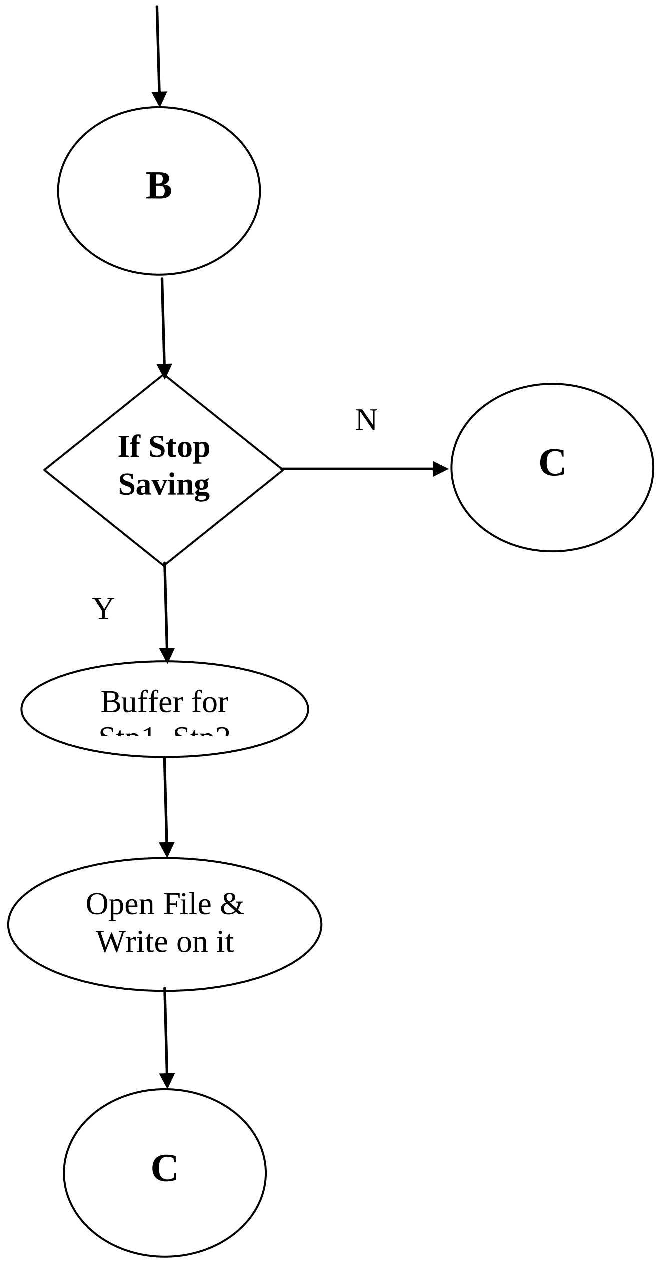
Get the text file name from the user if the file is already present then it will display the Rename frame for renaming purposes. After the successful completion of first step, visual basic code starts storing the ECG Signal (decimal values) in a two dimension array.

Continue the above step until the user press “Stop” button but when user press “Stop” button then filing procedure initializes and start writing these decimal values of two dimension array in that text file whose name is entered by the user in first step.

The flow chart of this procedure is as follows and complete source code for 7.2.5 can be found in appendix A-3.


START
Input = File
A
Create File
Buffer for
C
N
Check
Status
Y
A


A
Read Parallel
X = X + 1
X1 = X
X1 = X
Buffer(x, y)
B


B
If Stop
Saving
N
C
Y
Buffer for
Open File &
Write on it
C

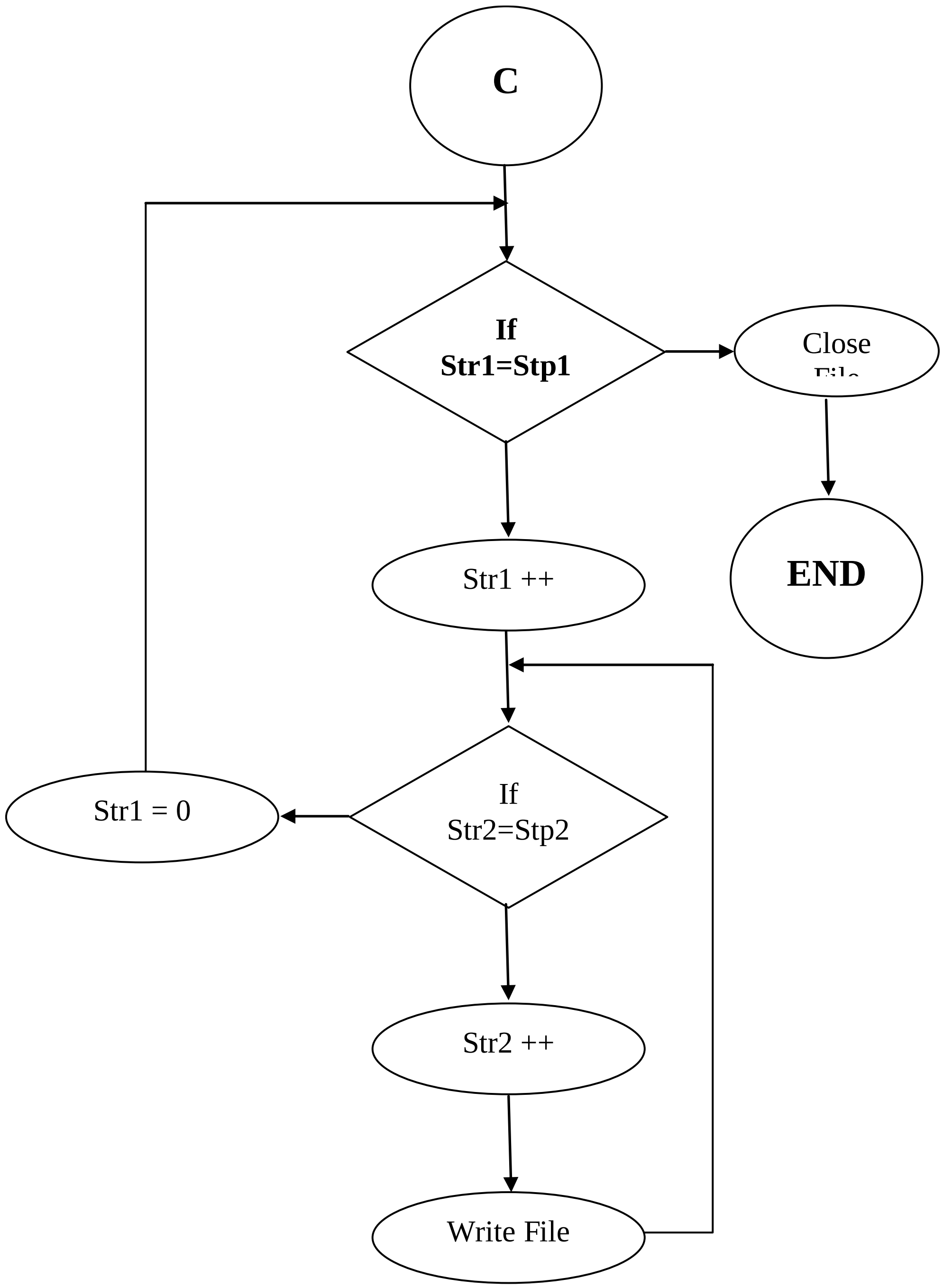


Fig 7.16 Saving Procedure

7.2.6 Loading of Stored ECG

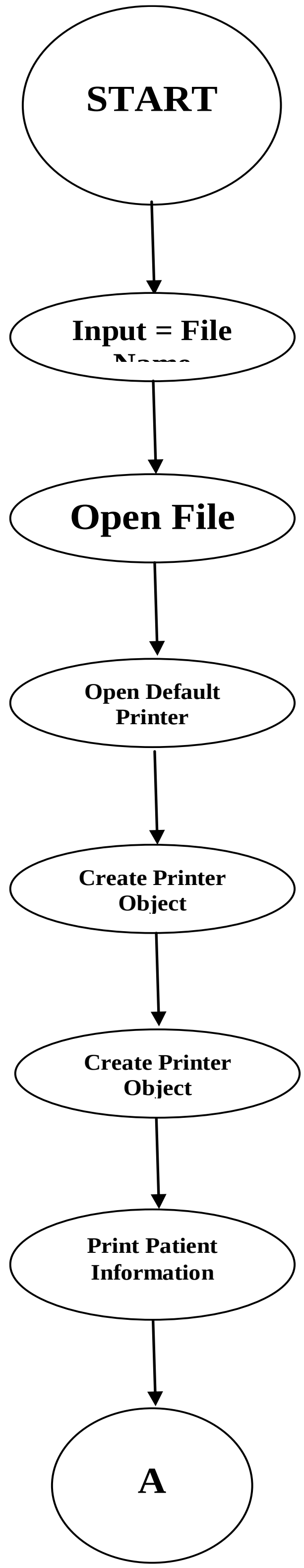
The major objective of this procedure is to load the ECG signal (decimal values) from the text file and display it (graph form). This procedure used the predefined filing libraries of visual basic. In this procedure, user just selects "open" option from the main menu bar and then selects the file that is required to open. Then this procedure starts getting the decimal values from the selected file and displays it on the graph in the form of pixels. This graph contained two axis namely X-axis (time) and Y-axis (decimal values/ amplitude of ECG signal).

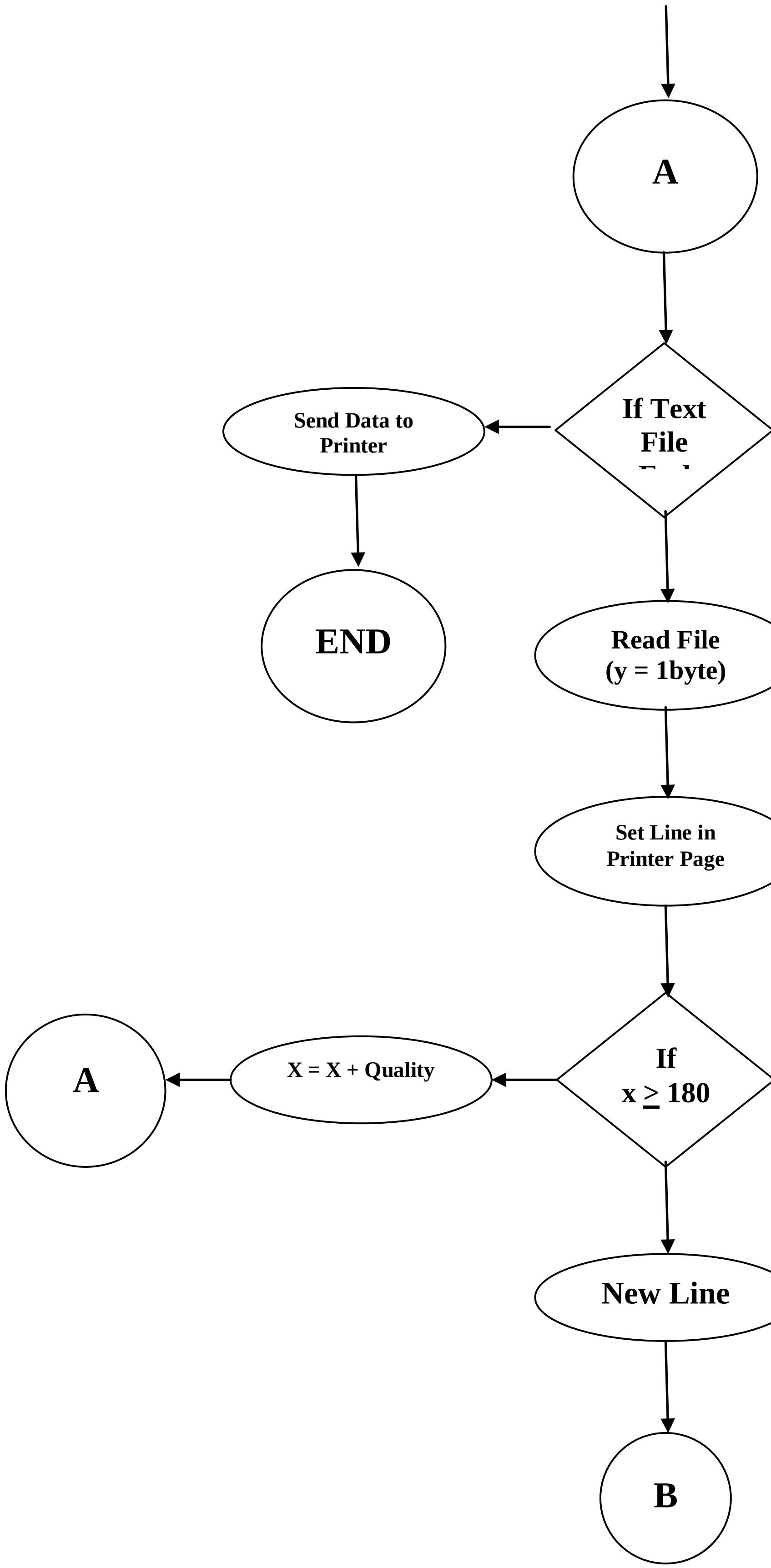
The flow chart of this procedure is as follows and complete source code for 7.2.6 can be found in appendix A-4.

7.2.7 Printing of Stored ECG

Aim of this procedure is to print the Stored ECG of patient. This procedure follows the following step to perform print operation,

- Get the file name from the user
- Then read the file for the confirmation purposes
- Select the default printer from the Operating system's Printer menu
- Create the Default Printer's object
- The send the patient information of selected file to the printer object and perform printing.
- Then start getting data from selected file. If file contain 0 bytes then end otherwise move forward
- Read data byte by byte and first store the value of single byte in string **y**.
- Then perform setting of line on printer page
- initialize the two variables with printer's page i.e. x & y for corresponding x and y axis
- If the value of **x** is equal or greater than 1800 (for maximum value of x-axis) then change the line on printer page
- similarly, if the value of y is equal or greater than 4800 then move to next printer page


START
Input = File Name
Open File
Open Default Printer
Create Printer Object
Create Printer Object
Print Patient Information
A


A
If Text
File
Send Data to
Printer
END
Read File
(y = 1byte)
Set Line in
Printer Page
If
x ≥ 180
X = X + Quality
A
New Line
B

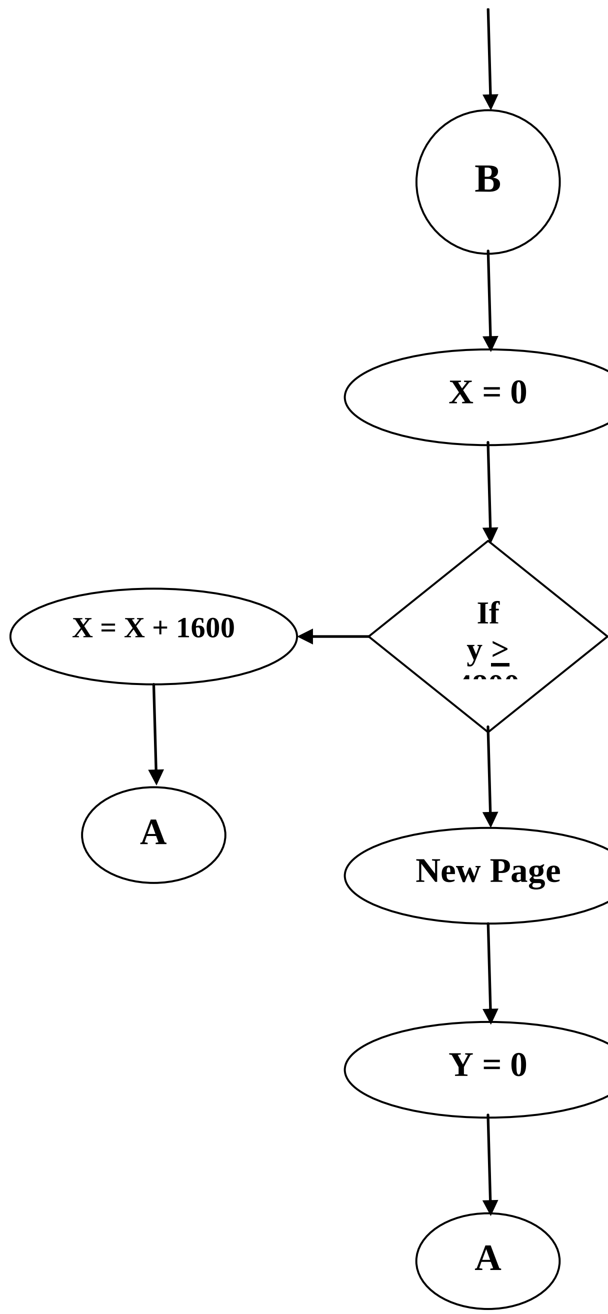


Fig 7.17 Printing Of ECG

By using these simple steps we are printing the saved ECG using Visual Basic code. The flow chart of this procedure is as follows and complete source code for 7.2.7 can be found in appendix A-5.

7.2.8 Software Overview

In software overview we have explained the different views of Heart Beat Analyzer. Following are the snapshots of Heart Beat Analyzer.

7.2.8.1 Main Screen & Patient Information Form

After running the ECG.exe file, Main screen of Heart Beat Analyzer's software will appear and automatically maximized. Main screen consists of following information.

- Heart Status
- Intervals
- Patient History
- Remarks about patient

On front of the main screen, a patient information form will appear first. It is necessary to fill this form that contains patient information, before viewing the Electrocardiography. Snapshot of main screen with patient information form is as follows.

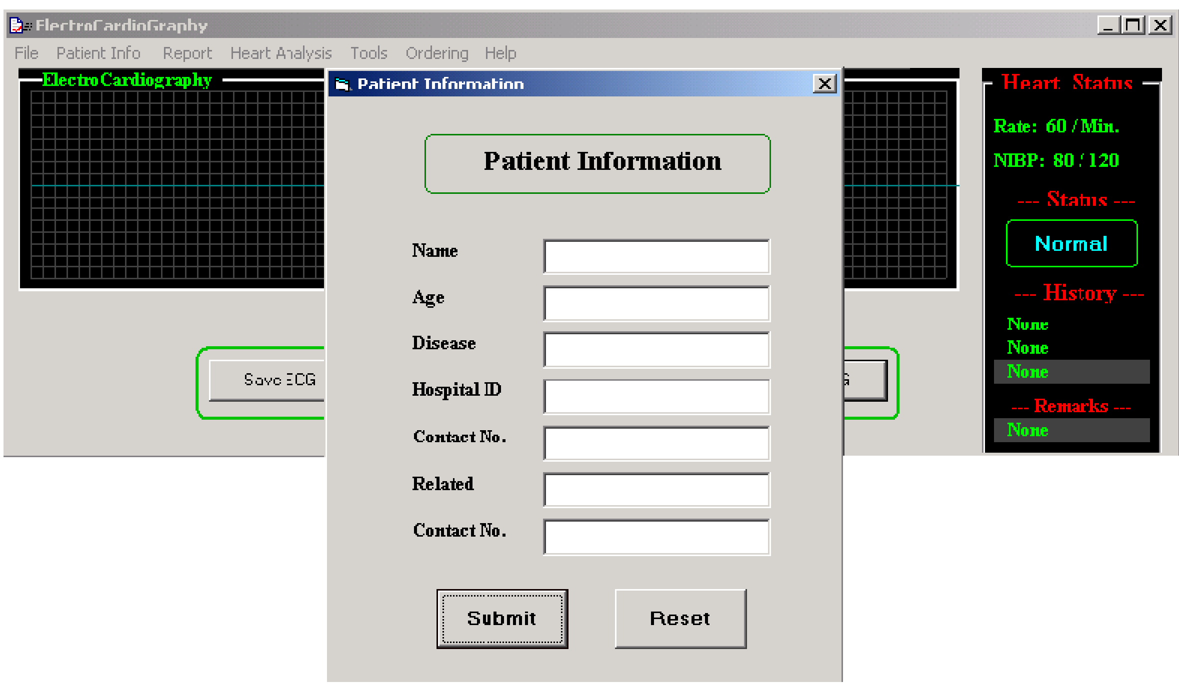


Fig. 7.17 Main Screen

After filling the patient information form, when the users press "Submit" button then the Patient information will move onto the left portion of main screen. Following snapshot illustrates the complete idea about this,

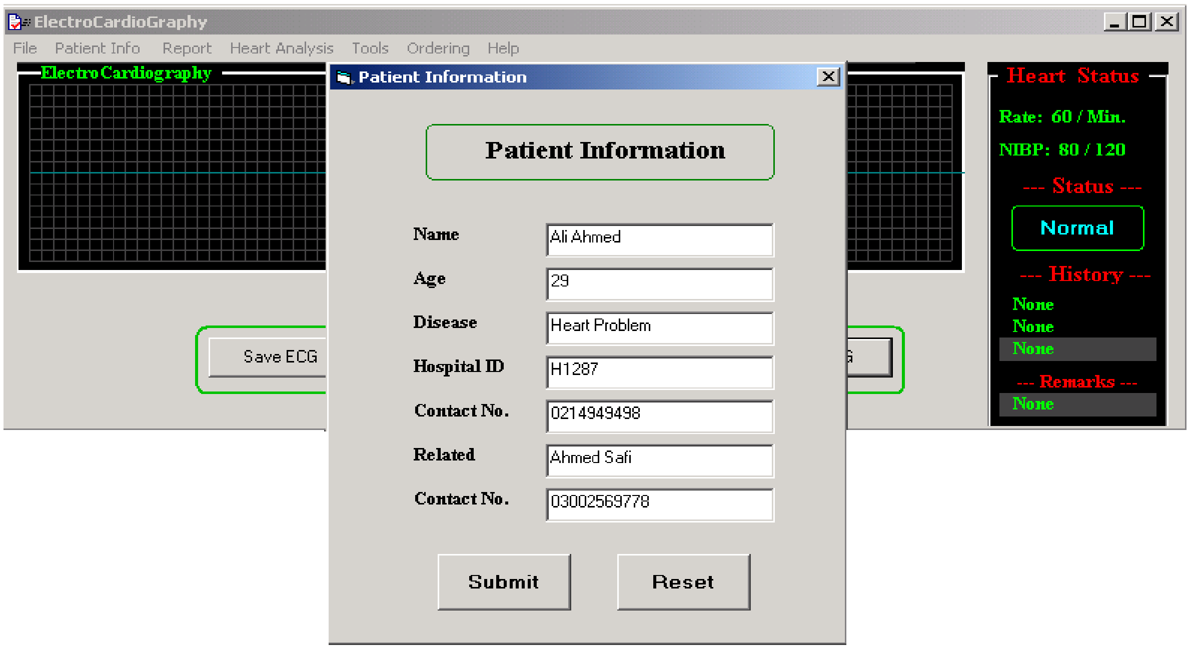


Fig. 7.18 Patient Information Box

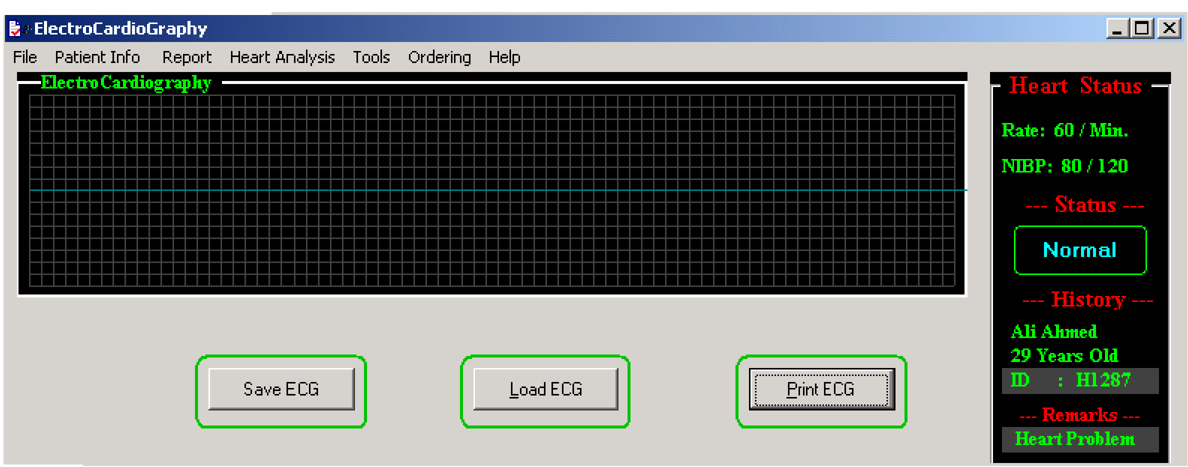


Fig. 7.19 after Filling Patient Information Box

7.2.8.2 Main Screen Buttons

Main screen also consists of three buttons which are,

- Plot ECG
- Save ECG
- Load ECG
- Print ECG

7.2.8.2.1 Plot ECG

In this option we are plotting the stored ECG on graph by using line method.

7.2.8.2.2 Save ECG

When the user press Save ECG button then ECG saving procedure starts, without taking any information about the patient or else other because it's a critical time at which staff require saving the ECG urgently so we didn't place any kind of input box here. Following snapshot illustrates the complete idea,

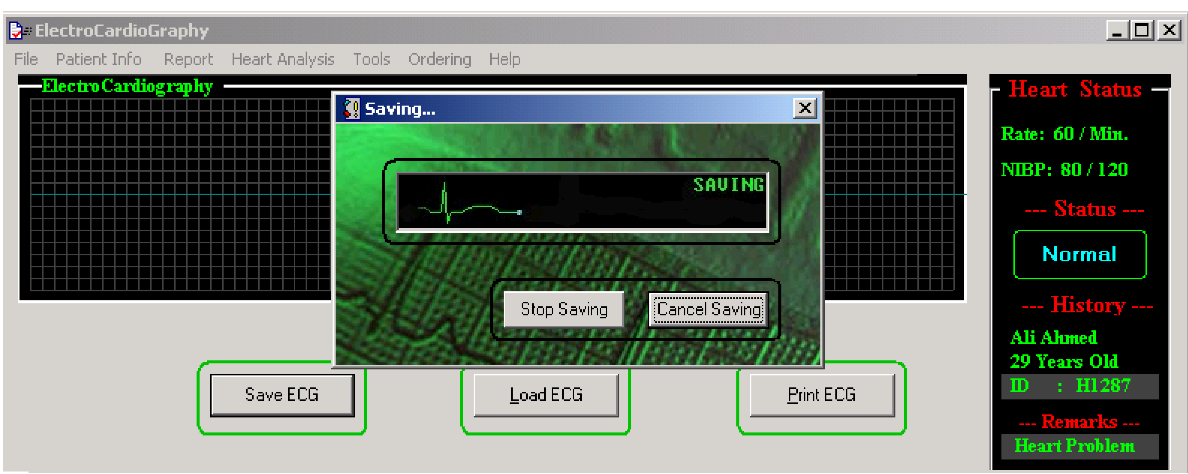


Fig. 7.20 ECG Saving

In the above figure the small green box shows the ECG saving process. This frame will appear when the user press Save ECG button. This small frame also consists of two buttons i.e. Stop saving and Cancel saving. If user press Stop saving then it will take the name of file and saved it. Following figure illustrates the idea,

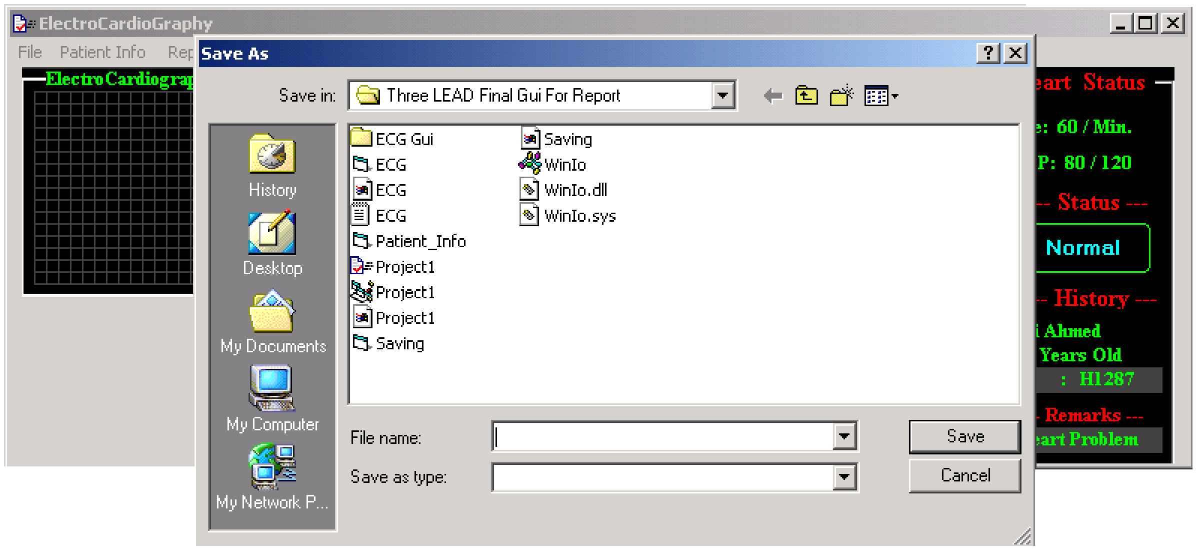


Fig. 7.21 ECG Saving when Stop

But if the user wants to exit or cancel the saving procedure then he/she can easily do this by selecting Cancel Saving button. When user press Cancel saving button then it will take the confirmation by showing a same small dialog box whose illustration is as follows,

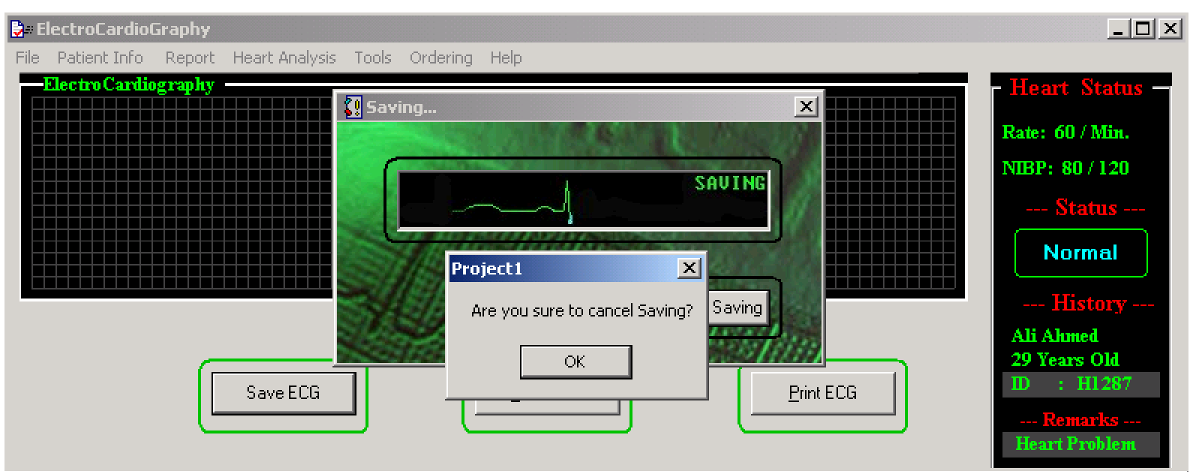


Fig. 7.22 ECG Saving when Cancel

7.2.8.2.3 Load ECG

If the user wants to view the saved ECG then he/she can do this by selecting the load ECG button. When user press Load ECG button then the open dialog box will appear and user can select the saved ECG file and press OK button then the saved ECG graph will appear on the frame other than main frame. Following snapshot illustrates the idea,

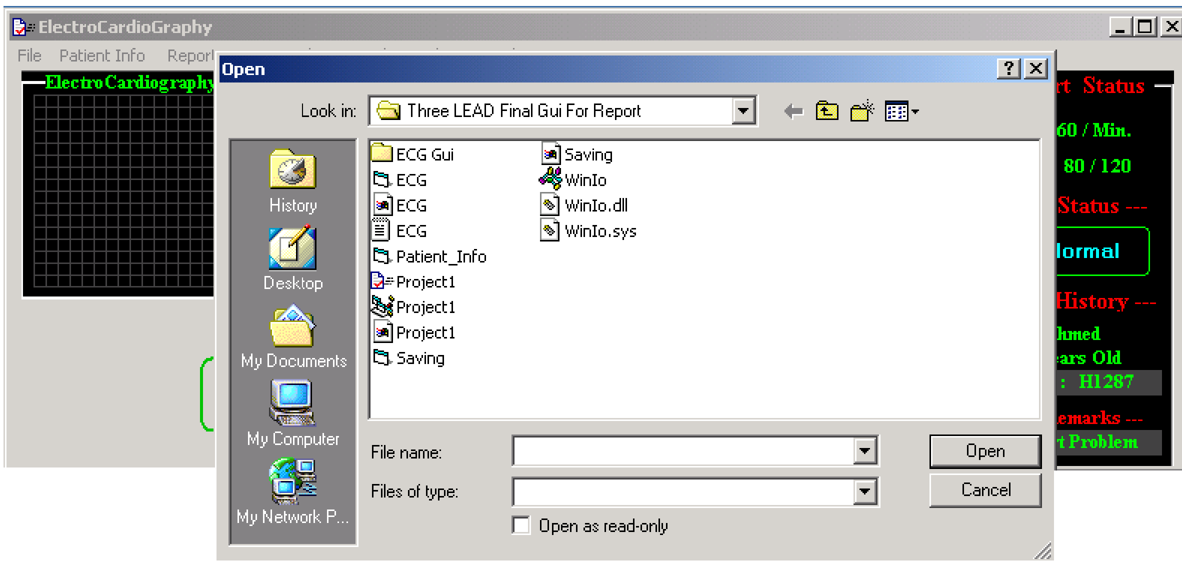


Fig. 7.23 Load ECG

7.2.8.2.4 Print ECG

When the user wants to print the ECG on the ECG paper then he/she can do this by selecting Print ECG button. When user press print ECG button then an open dialog box will appear and the user require to select the Saved file (that he/she wants to print) then simply press Print button for printing purposes. Following figure illustrates the complete idea about printing button.

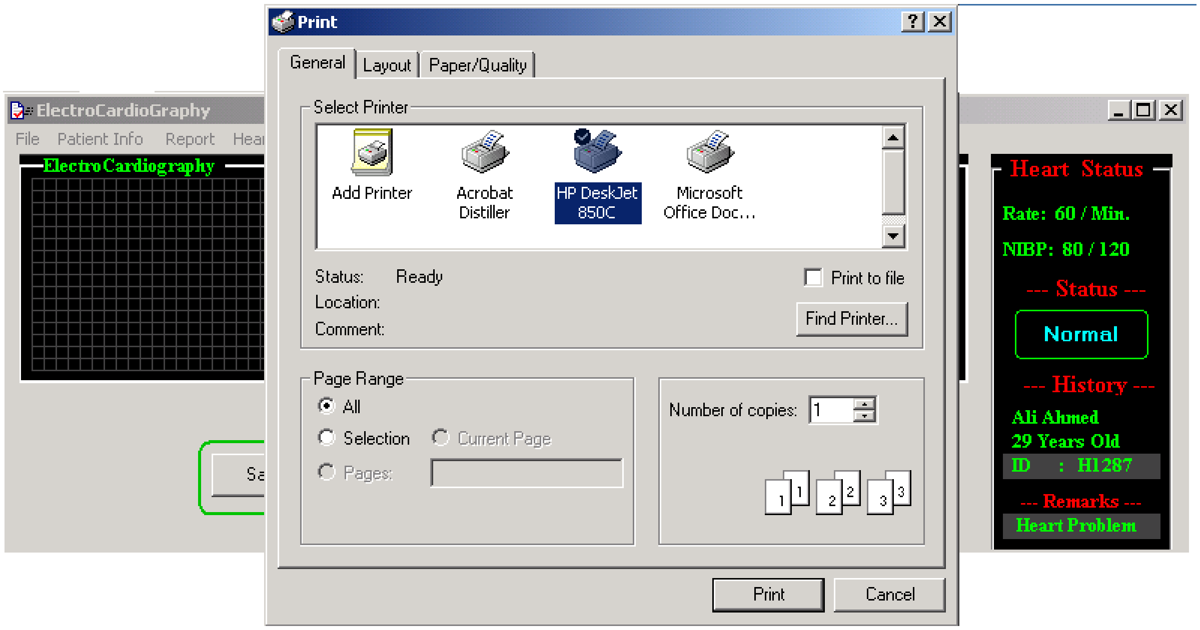


Fig. 7.24 Print ECG

7.2.8.3 Menu

HBA 's software contains different Drop down menus:

- Standard drop down menu
- patient information

7.2.8.3.1 Standard Drop down Menu

HBA's software contains a standard drop down menu i.e. **File**. This standard drop down menu consists of the following options:

Open	(Ctrl + o)	To open the Saved ECG
Save	(Ctrl + S)	To append the saved ECG of one lead
Save As	(F12)	To save ECG of one lead in new file
Save All	(F11)	To save ECG of All three leads in new file

Snapshot of Standard drop down menu is as follows,

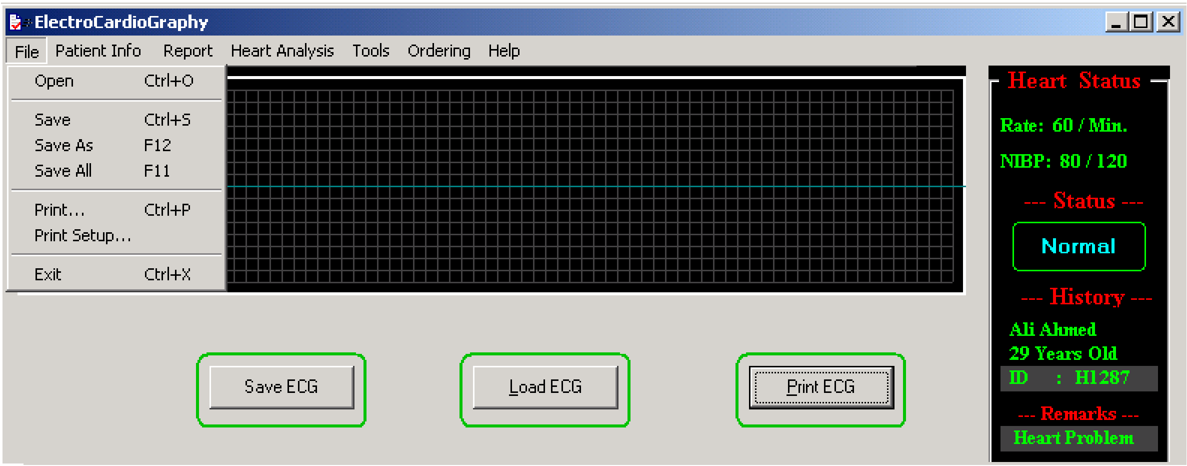


Fig. 7.25 File Menu

7.2.8.3.2 Patient Information

It is another drop down menu, in which doctor or other related person can edit the patient information by using the (name here) patient information form. This drop down menu also contains following options,

- Time & Date Patient Entering Time & Date
- Remarks Doctor Remarks about patient

Snapshot of Patient Information drop down menu is as follows,

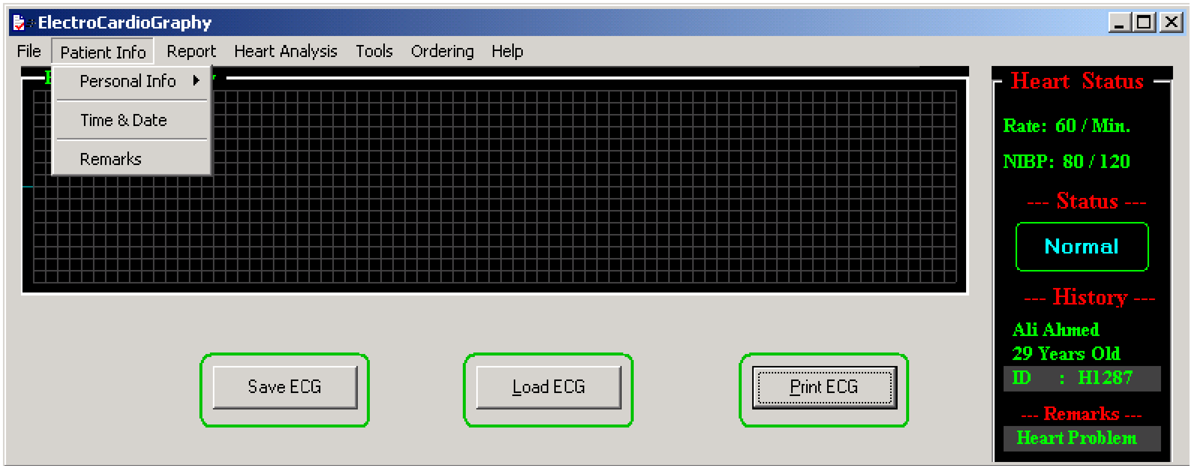


Fig. 7.26 Personal Info Menu

7.2.8.3.3 Report Menu

Report menu contains all the report related options which are as follows,

- View Report
- Edit Report
- Print Report

Report deploys the complete idea about patient to the doctor. In which, some important information are provided such that

- Patient Information
- Remarks from Doctor
- Electrocardiography of Patient for one 10 seconds
- Heart Rate of patient

In the Report Edit option, doctor or other related person can edit the above four options of the report but they can never change the ECG signal by altering the ECG values. Snapshot of Report Drop down menu is as follows,

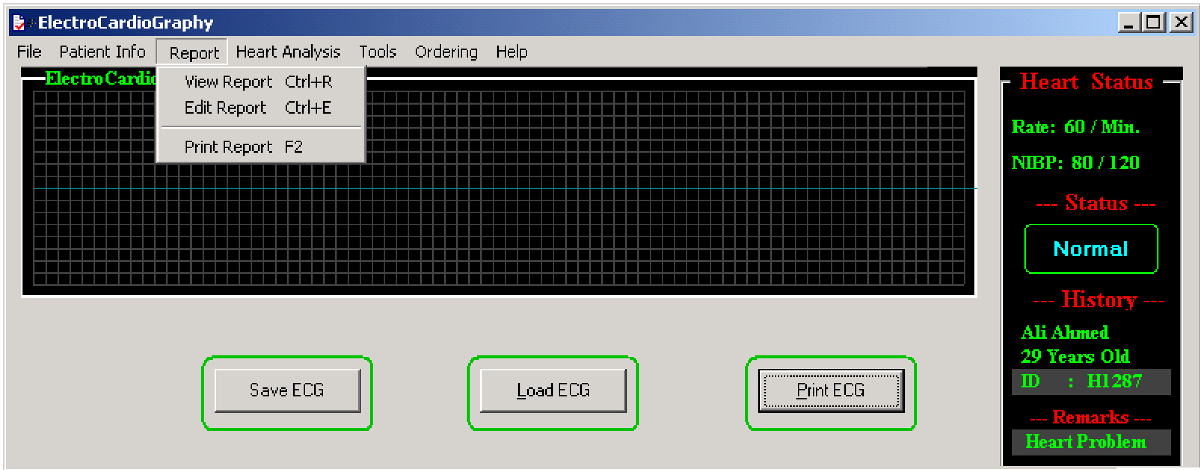


Fig. 7.27 Report Menu

7.2.8.3.4 Heart Analysis

It is the third drop down menu which provides the important information about the patient's heart to the Doctor. Like,

- Heart Rate (Ctrl + H) Patient's Heart Rate per minute
- NIBP (Ctrl + N) Patient's NIBP per 120
- Intervals
- PR-Peak PR-Peak value of specific ECG Signal
- QRSD-Peak QRSD-Peak value of specific ECG Signal
- QT-Peak QT-Peak value of specific ECG Signal
- QTC-Peak QTC-Peak value of specific ECG Signal

By using these data, Doctor can make better decision about the patient. With the help this data, doctor can analyze the heart problem of the patient. Snapshot of Heart Analysis Drop down menu is as follows,

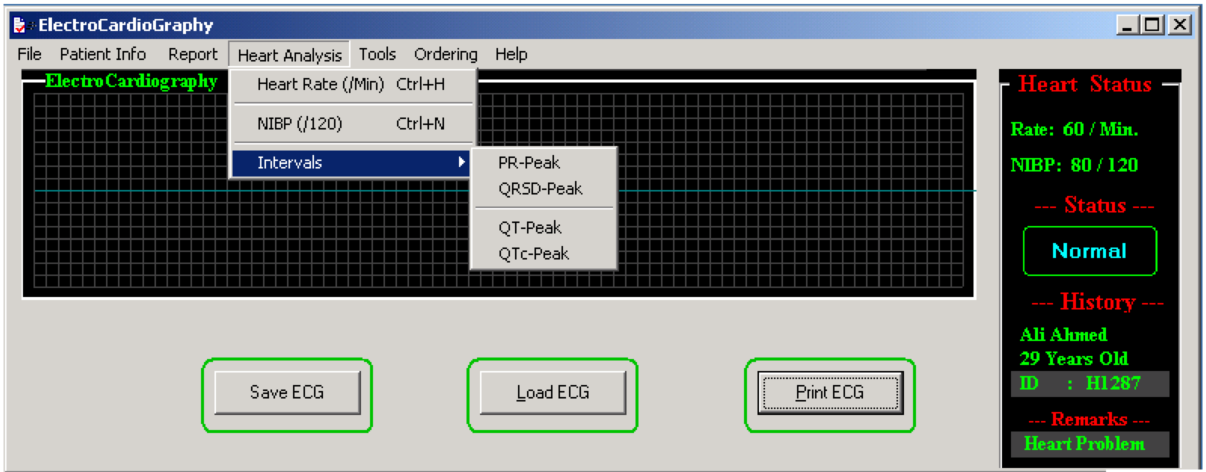


Fig. 7.28 Heart Analysis Menu

7.2.8.3.5 Tools and Ordering Drop Down menu

These tools are just for the sake of software updating purposes on the internet. The Tools drop down menu contains the following options,

- Check for Updates
- Update web page
- Grade software
- Available Commands

When the user press the update web page then our personal website will open and show only that page which has currently update. In Grade software option, user can perform the evaluation of Heart Beat Analyzer software either good or moderate or bad. In the available command option, user can view all the shortcuts of the Heart Beat analyzer's Software like,

Available Shortcuts are as follows:

- Open Alt + O
- Patient Info Alt + P
- Report Alt + _R

- Language Alt + L
- Tools Alt + T
- Ordering Alt + O
- Help Alt + H

Illustration of Tools Drop down menu and Ordering Down menu are as follows,

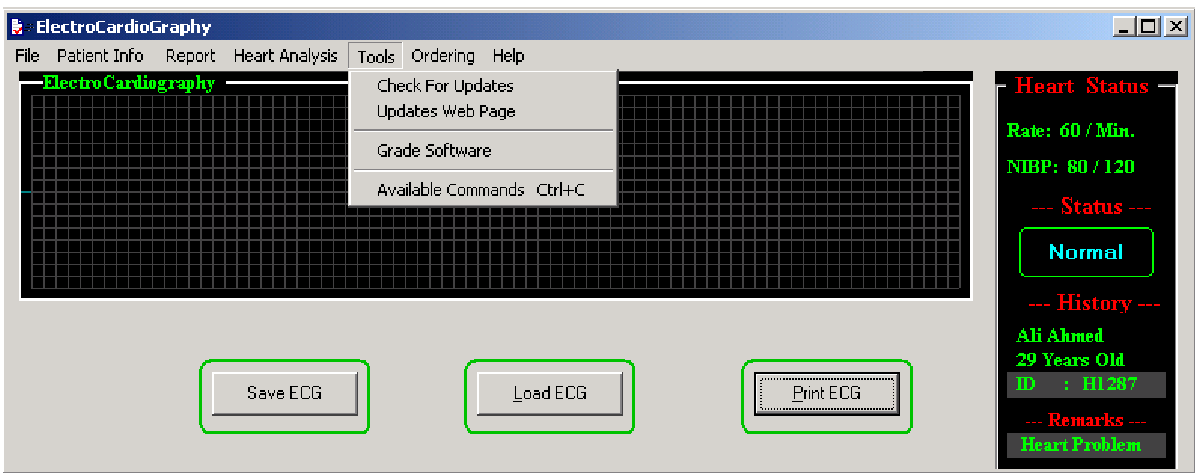


Fig. 7.30 Tools Menu

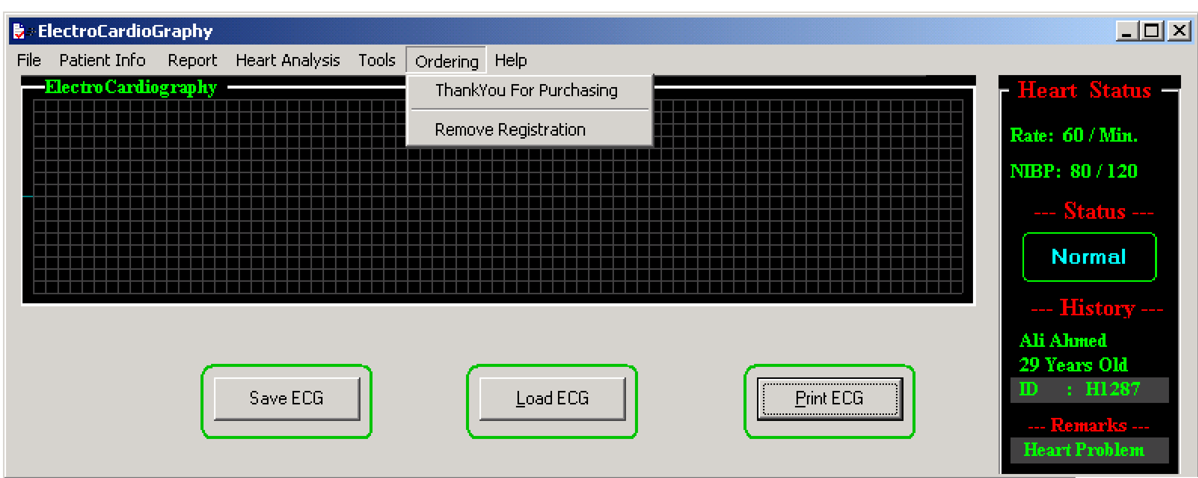


Fig. 7.31 Ordering Menu

7.2.8.3.6 Help Menu

This menu helps the user to use this Complete Heart Beat Analyzer Project This menu provides the basic help to the user like,

- How to paste the Gel on the body?? With specified position
- How to paste electrodes on the body?? With specified position
- How to make interface between hardware and body??
- Describes the nature of electrodes either +Ve, -Ve, & Gnd.
- How to use the Heart Beat Analyzer software??
- How to Save the ECG of patient in new or old file??
- How to Print the Stored ECG??
- How to view the peaks of ECG signal?? … etc

Help menu also provide the connectivity between the user and the vendor by selecting technical help menu. In help menu, users can also submit their feedback on the website by filling a form. If the Heart Beat Analyzer's software provides bogus readings and analysis then user can repair it by selecting Detect and Repair Option from the help tool bar. From the Help menu user can also view the Readme File and the name of those persons who have designed this project. Our Software also provides the facility of Shortcuts means user can view the Help by simply strike on F1. Complete illustration about the Help Menu is as follows,

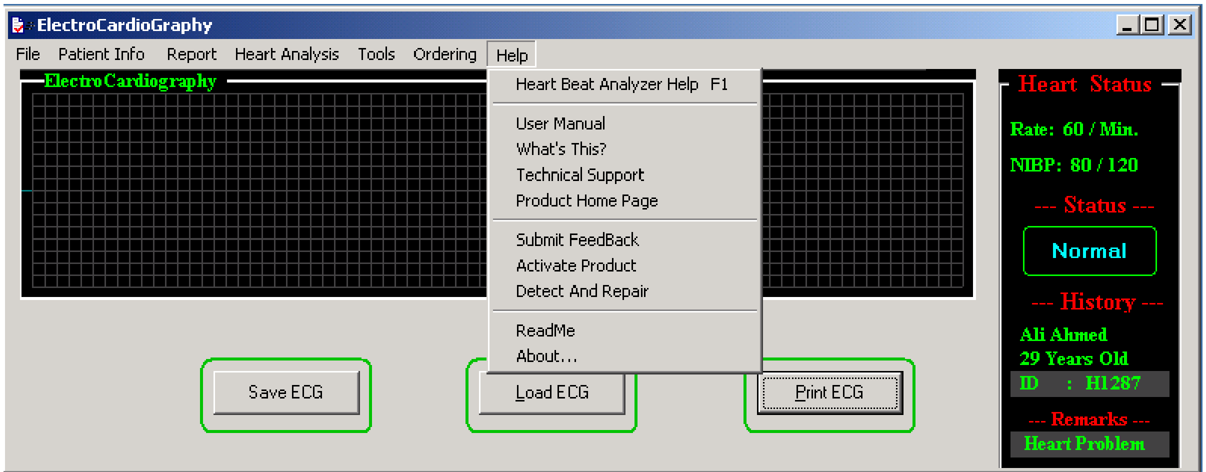


Fig. 7.32 Help Menu

CHAPTER 8

TESTING RESULTS

Introduction to Testing

Photograph of the circuit is shown in figure; the circuit was constructed on strip board.

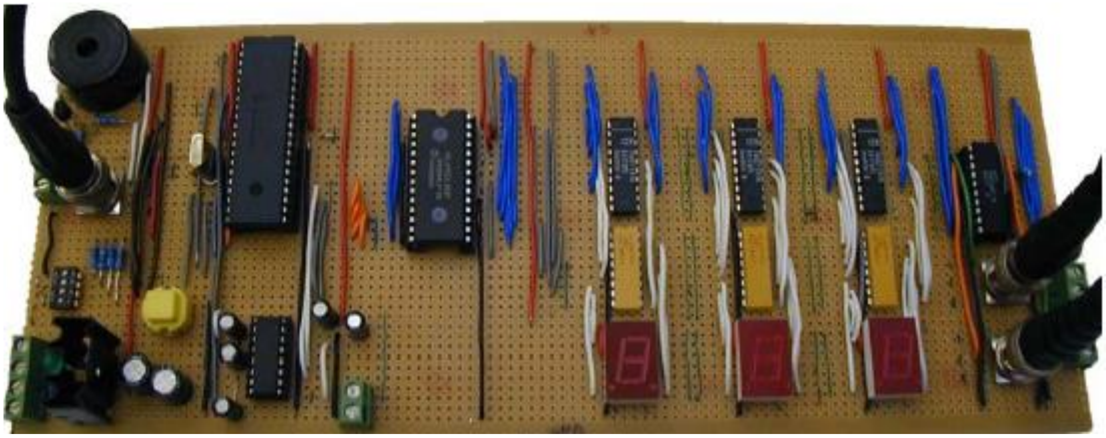


Fig. 8.1 Strip Board

Photograph of the test setup is shown in figure b, equipment used included: Digital dual trace oscilloscope, DC power supplies (batteries plus Goodwill’s equipment), signal generator, Personal computer running Rims Demo.

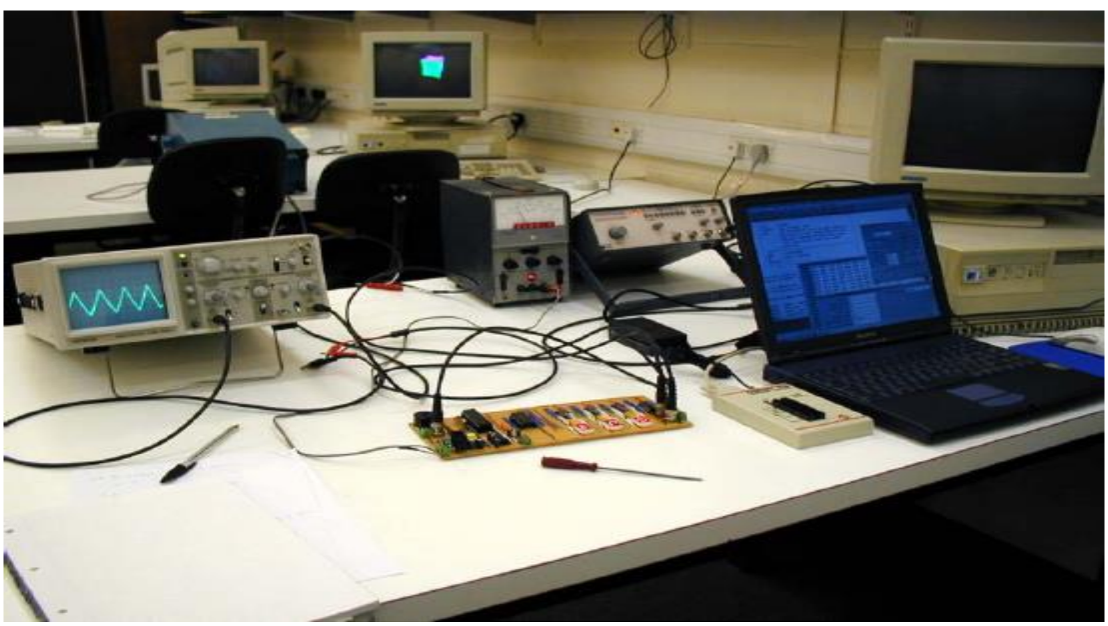


Fig. 8.2 Photograph of Test Setup

8.1 Lead, Electrode & Gel Test

Our major concentration is always on the input due to its weak strength. In our project, input getters are electrode and the matter that increases the conduction in between electrodes & human body is Gel. Leads used to pass these weak strength signals into the hardware if the leads produced more noise than signal then the whole circuit will become failing to produce appropriate output. We have performed the test of all these important components with the help of three different procedures which are as follows,

8.1.1 Leads Test

Given the millivolt input signal at one end of lead and received the same output at the other end of lead.

8.1.2 Electrodes Test

Attached the electrodes with the human body on the specified Position and test the output using multimeter.

8.2 Test Parallel Port Communications

We have tested the parallel port communication between the parallel port personal computer and External hardware. We test it with the help of predefined parallel port procedures of Visual basic and Rims Microprocessor board. We designed a code in visual basic that bring the data from parallel port of computer and then display it in the graph form. In this scenario, Rim's Microprocessor board used as an external hardware that provides the digital sine wave on the parallel port of personal computer and our designed visual basic program fetch this sine wave and display it on the graph. Complete source code for this test can be found in appendix 9. Following figure illustrates the idea of this test.

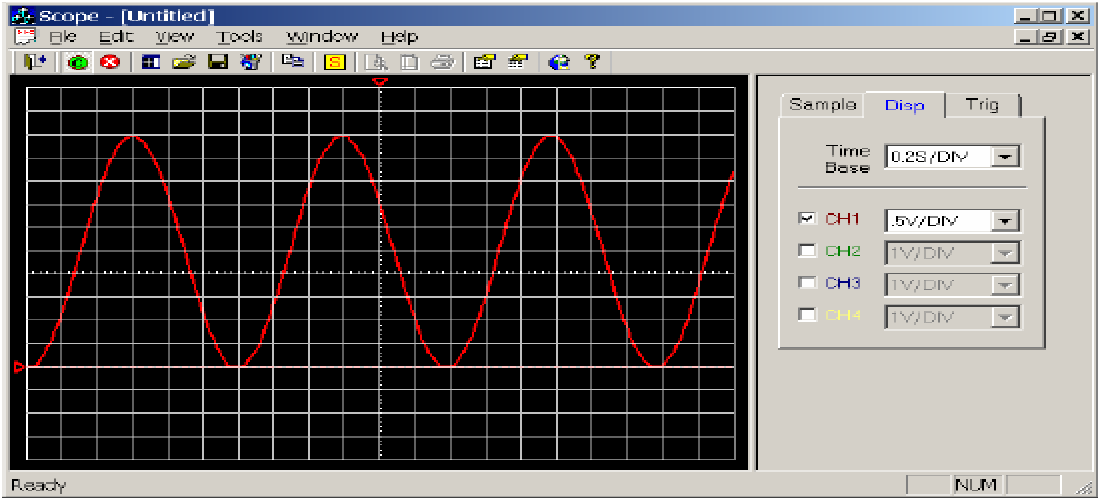


Fig. 8.3 Sine Wave

8.3 Amplification Test of AD624AD

The major component of our hardware is AD624AD which works as an amplifier. We have tested this IC implementation and Gain of this IC by providing different resistances using potentiometer. First we provide milivolt signal to this instrumentation amplifier using function generator then receive the output in volts using Digital dual trace oscilloscope. Following figure illustrates the idea of this test.

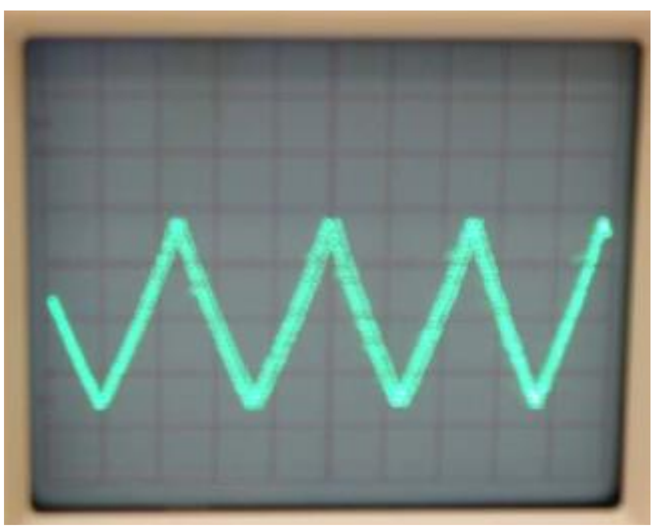


Fig. 8.4 Output of AD624AD

8.4 Amplification Test of AD620

Another important component of our hardware is AD620 which also acts as an instrumentation amplifier. We have tested this IC with the help of same procedure as we followed up in AD624AD (instrumentation amplifier). But the only difference is input signal we have given the input to AD624AD in milivolt but here we provided it in volts (1 – 2V) and received the output in greater volts (5 – 6v). Following figure illustrates the idea of this test.

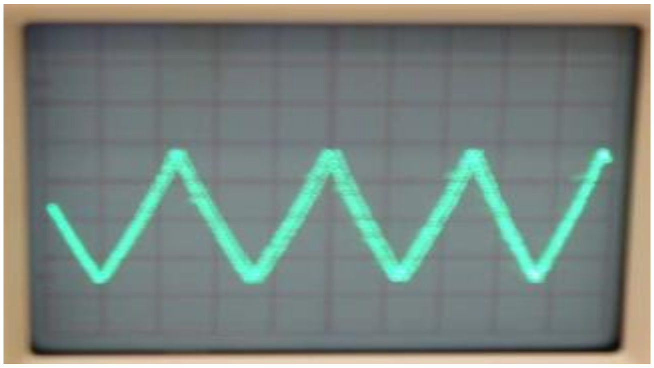


Fig. 8.5 Output of AD620

8.5 Analog to Digital conversion Test

The major objective of our project is to interface the own designed hardware with the personal computer. But personal computer works on RGB signal and our hardware output is analog. In order to interface both of them we required to convert this analog signal into digital form so we used here ADC0808. We have performed the test of ADC0808 by taking input in analog form using function generator and received the output in digital form using parallel port of personal computer.

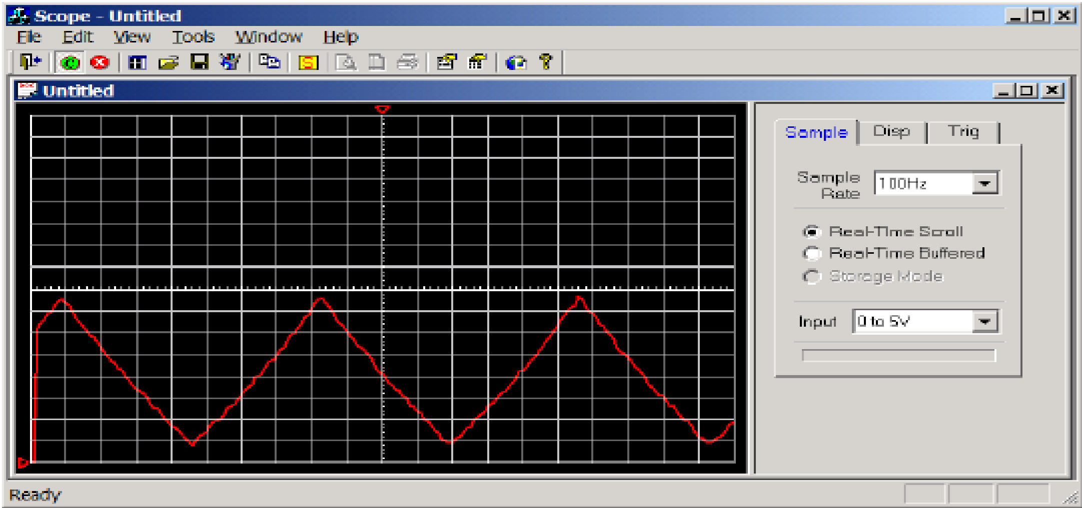


Fig. 8.6 Output of ADC0808 on personal computer

8.6 Printer Test

Printing occupies the major position in our project because doctor will analyze the ECG signal on page. So we have designed a code in Visual Basic that print's the received signal of parallel port using any default printer of operating system. We have performed the test of default printer using visual basic code and print the stored sine wave.

CHAPTER 9

CONCLUSION

Conclusion

The purpose of this project was to design, construct and test a simple low-cost computer based ECG monitoring system. Clearly this objective has been achieved successfully, as it has been proven under testing that the design works, although further development is required as there are limitations and flaws in the current design.

Clearly the heart's strong pumping action is driven by powerful waves of electrical activity, which are detected by attaching electrodes to the skin. It is clear that these electrical signals are extremely small and must be amplified considerably (about 1000 times) to be of any use. Evidently an ECG monitor displays these electrical signals graphically just like an oscilloscope displays voltage variations; except that the trace on an ECG monitors scrolls across the screen. The concept of an ECG is not novel one; the attraction of this project lay in the challenge to build a simple, compact, operational medical device at a low cost. It is clear that the electrocardiogram (ECG) is a simple, non-invasive technique for detecting abnormalities and diagnosing heart defects, merely by noting the presence of irregularities in the PQRST waveform. Clearly other applications are very effective in areas of sports medicine, or sports therapy, in tracking the heartbeat through various levels of physical activity to assist the patient in attaining a desired, optimum heart rate.

The CRT display (Cathode Ray Tube) is one of the common display types in use today (TVs, monitors, oscilloscopes, etc...), clearly this technology is coming to the end of its life as new compact low power technologies like TFT and LCD are becoming more widely used. The main disadvantage of the CRT (besides it high power consumption) is the way it draws the image, the spot is moved across the screen at 50 Hz, even at 50 Hz some people will still see the display flickering badly (modern computer monitors have a refresh rate of over 100Hz), and most people experience problems when an CRT display is within their peripheral vision, causing headaches, dizziness, and eye strain when exposed for long periods of time. The use of a TFT or LCD display instead of a CRT display is clearly a better option, as the screen does not flicker, the reason why it does not flicker is because the screen is split up into pixels, each pixel can be modified independently of each other, hence only the changes made to the display are refreshed. The transport medium was chosen to transmit the ECG to a PC in real-time is Parallel port connector, the main reasons why it was chosen is because it is more faster than the serial port, reliable and every PC has at least one parallel port. The main advantage of Parallel port is that it is faster when compared to other mediums (e.g. Serial, USB 12Mbps).

Obviously accuracy, dependability, and precision are an absolute must for the ECG monitor as the device is to be used for diagnostic, and other medical purposes. Clearly any small fluctuation in the waveform generated could carry critical diagnostic value. It is obvious that noise is the main design consideration, as the ECG is extremely small and can easily be masked by noise related fluctuations. The ECG amplifier must amplify the ECG single (1000 times) and not the noise, hence the need for an expensive “instrumentation amplifier” i.e. AD624AD with a high CMRR. This explains why the ECG amplifier is the single most expensive module within the ECG amplifier.

The ADC0808 was chosen; this is one of most powerful analog to digital converter chip. Clearly this chip was chosen because it has eight channels with three address lines.

The hardware was first proven to work under testing (many small simple test programs), before work began on the main program. Evidently this technique was a success as it allowed for the visual basic code to be gradually built up step-by-step, instead of writing the entire program at once. There would have been little chance of the main program working if the entire program was written at once, without the hardware being tested. Clearly this is the case as many problems occurred during development (most of which were hardware based), hence if it was not for the simple test programs, these small problems would have been extremely difficult to track down and may have lead to failure of the project.

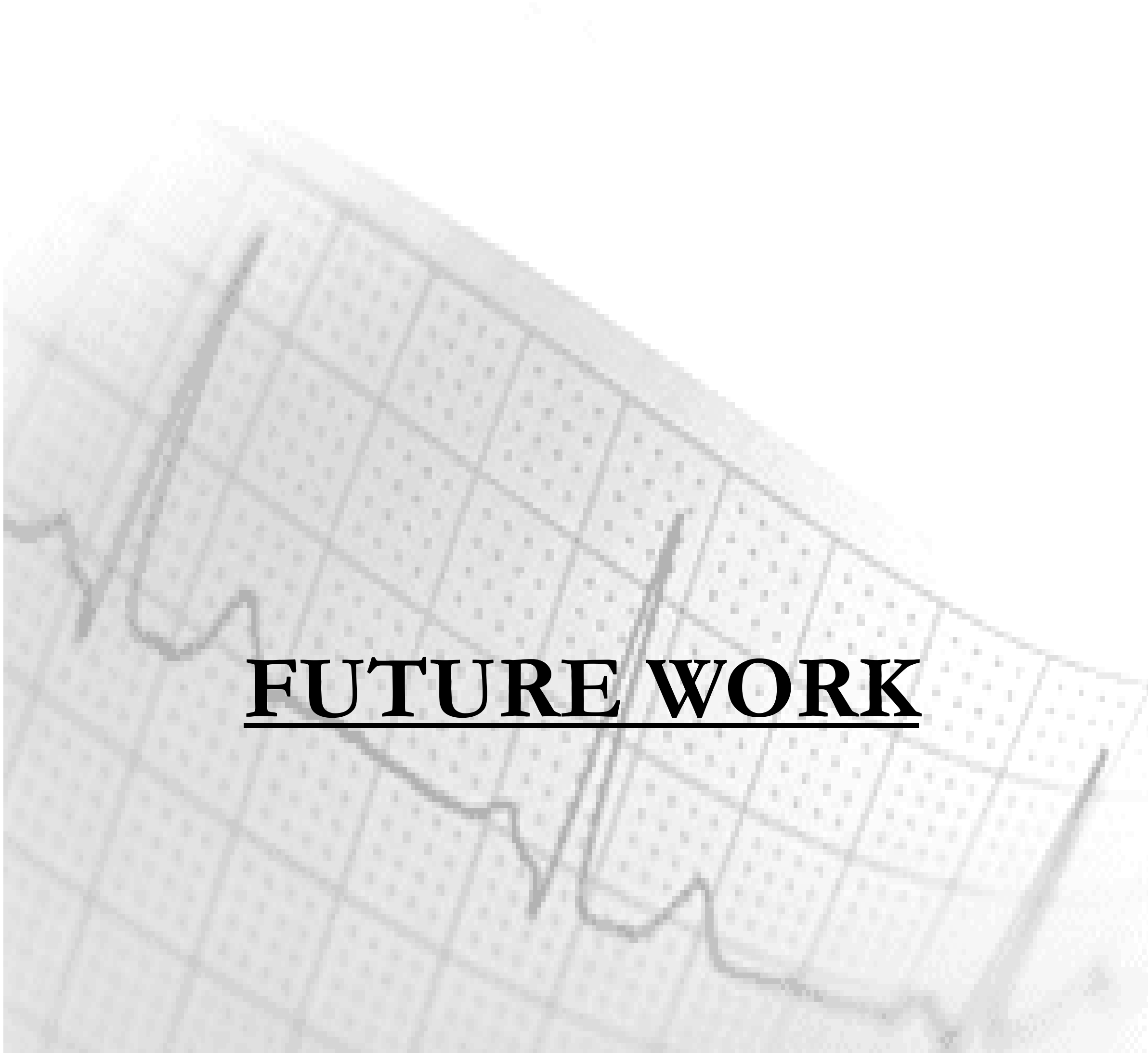
A triangle waveform was generated from a signal generator to test the system as the analogue ECG amplifier was not implemented. Test results show that the X and Y outputs of the system successfully controlled the position of the spot on a Monitor display, which was moving fast enough so that the waveform did not flicker. We are also controlling the Flickerness of monitor with the help of refreshing rate of Visual basic code. It was also noted that the ECG signal (triangle wave in this case) scrolled across the screen as designed. Clearly there was a problem; the CRT display was showing a slight double image, which appeared to improve as the signal moved across the screen. Evidently this problem is not any fault of the design of the ECG monitor, but the oscilloscope used to represent a Monitor display as it had trouble drawing the waveform on the return journey. Obviously the solution to this problem is to purchase a more expensive oscilloscope (**our university have provided**

this king of oscilloscope to us) or to rewrite the software so that the waveform is only drawn on the forward journey then ‘fly back’ (move the spot off the screen and quickly move it back) to the start position and redraw again (easier to achieve than drawing both directions, but reduced refresh rate, hence increased flicker). But recall that originally there was a problem, the Monitor display was badly distorted and it was assumed that it was taking to long to calculate the bpm, the program was optimized and this solved the problem; hence it was assumed that this was indeed the reason of the distorted display (with147Hz refresh rate).

It was discovered that the voltage level of the waveform was incorrect for example the input triangle wave to the ADC had a peak-peak voltage of 4V, but the **Rim’s Demo program** had a peak-to-peak voltage of 1V (hence scope displayed image at reduced resolution). So we have converted the analog signal into the digital form using ADC0808 and directly display the received digital signal our own designed software with quality 0.002.

Clearly a dedicated ECG application is required for the PC, this application should be able to display the ECG signal in real-time, scream real-time data to disk. So that a doctor can view the stored ECG single. The stop button successfully stopped the ECG display and the printing button simply prints the recorded ECG.

CHAPTER 10



FUTURE WORK

Future Work

Electrocardiography is a very wide field in Computer's technology because in this era, everything is switched or interfaced with computer. The main reason behind this advancement is the rapidly growing of computer related fields. Day by day latest, fast, & new equipments are emerging with very effective and appropriate manner.

According to our knowledge, in the history of Bahria university Karachi campus no one adopt and designed the biomedical related project. We are the first which adopt and tried to do this project. We have many ideas to enhance this Heart Beat Analyzer project with different advancement manner but due to the lack of time we are unable to do this.

In this project, we have achieved the following objectives,

- Received the ECG signal from human body using Electrodes, Leads.
- Transfer this signal to the instrumentation amplifier (gain = 1000) and produce the reasonable strength of signal.
- Filter the noise from the incoming signal with the help of Sallen key filter.
- In order to convert it into digital form, we are required to amplify the signal so we did this using another instrumentation amplifier.
- Then convert the analog signal into digital form using ADC.
- Designed a software which received and plot the ECG signal on graph
- Our software also performed the following functions,
- Saving of ECG signal.
- Loading of ECG signal from file
- Printing of ECG signal using operating system's default printer

We are encouraging the next generation of our Bahria University which can do the advancement in this project. We have the following ideas which they can do in future and enhance our project, Designed the 12 Leads ECG projects that are more accurate and efficient than 3 Leads ECG Project.

We have interfaced the ECG hardware with the personal computer using wired medium they can enhanced the same technique using wireless medium. This is most the most beneficial technique because

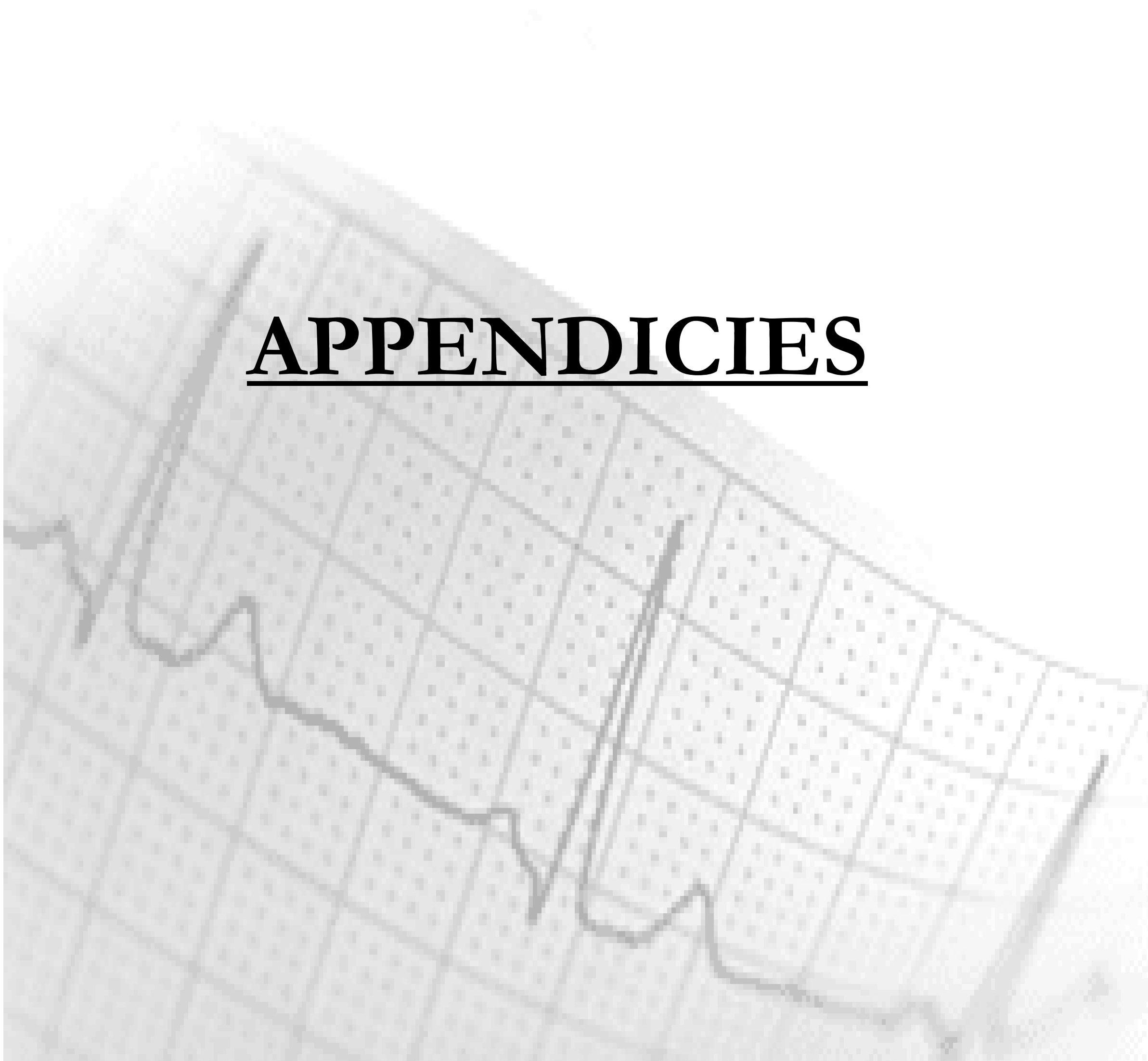
"Doctor can easily monitor the patient from his/her room if the data move wirelessly from patient place to the doctor's room"

There are different ways to enhance this project:

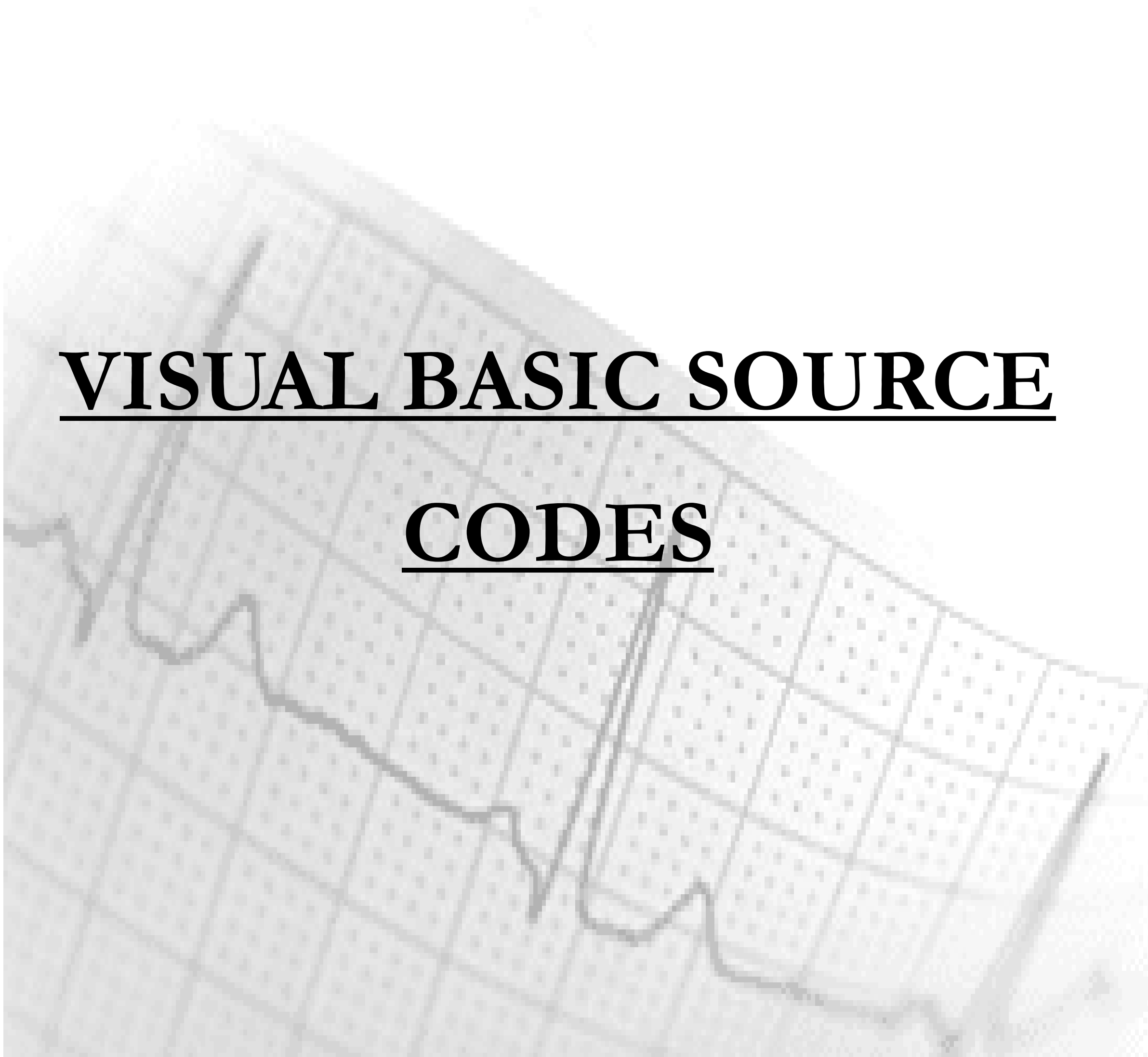
- If the patient live in different country as that of doctor then how the doctor can view the real time ECG of the patient?? Yes we can do this using deployment of the same project on the internet.
- To integrate all the nodes of ECG machines and make it centralized using different networking techniques, in such a way that doctor can easily view the ECG of all the patients at a time and on single monitor.

As we already mentioned, ECG is a very wide field in computer systems so there are many ideas that can be implement other than above. We hope that the next generation of Bahria university adopt this project and make it more accurate better than us using different advance techniques. In this universe, there is nothing important than the human beings. We should have to take the appropriate steps in the development different projects that safe the human's life.

APPENDICIES



APPENDIX – A



VISUAL BASIC SOURCE CODES

Visual Basic Source Codes

A-1 Parallel Port Communication & Plotting of Received Signal

```
Private Sub ECG_Load()

""" Declaration of Variables """
Dim color As Long
Dim x2 As Double
Dim X As Double
Dim Y As Double
Dim x1 As Double
Dim y1 As Double
Dim ReadText As Integer
Dim PortAddr As Integer
Dim PortVal As Long
Dim status As Integer

"Dim Fsys As New FileSystemObject

Dim p As Double
p = 0
a = 0
c = 0 """check this Value
b = 0

    """ Initialze the Parallel Port
If InitializeWinIo = False Then
MsgBox "Parallel Port was not initialized", vbOKOnly + vbCritical, "VB Test Parallel Port"

Else
```

```
    ''Call ReadCmd_Click
End If

'' Backbuffer in case the form is redrawn

Buffer = CreateCompatibleBitmap(DrawArea.hdc, 301, 301)
Buffhdc = CreateCompatibleDC(DrawArea.hdc)

''' BackBuffer in case the form is redrawn for DrawArea1 ''
Buffer = CreateCompatibleBitmap(DrawArea1.hdc, 301, 301)
Buffhdc = CreateCompatibleDC(DrawArea1.hdc)

''' BackBuffer in case the form is redrawn for DrawArea2 ''
Buffer = CreateCompatibleBitmap(DrawArea2.hdc, 301, 301)
Buffhdc = CreateCompatibleDC(DrawArea2.hdc)

''To Buffer Data in Buffhdc '''
SelectObject Buffhdc, Buffer
Me.Show

''' Declaration of DrawArea Color ''''
DrawArea.BackColor = RGB(0, 0, 0)
DrawArea1.BackColor = RGB(0, 0, 0)
DrawArea2.BackColor = RGB(0, 0, 0)
'cmdClear_Click
ch = False

'''' To Control the Speed and Quality(Distance Between Two Pixels)
Quality = 0.9

  '''''' Parallel Port Initialization ''''''''''''''''''''''''''''''
```

```
PortAddr = Val("&H" + "378")
status = GetPortVal(PortAddr, PortVal, 1)
Pat_Info.Show

While (status)

 """""""" To Get Data From Parallel Port """
color = RGB(0, 128, 128) "250 * Rnd, 250 * Rnd, 255 * Rnd)
x1 = 0
y1 = 0
c = 0

c = c + 1
x2 = x2 + Quality
PortAddr = Val("&H" + "378")
status = GetPortVal(PortAddr, PortVal, 1)
values(c) = PortVal And &HFF
Y = PortVal And &HFF
X = x2 / 2
checkLoop(c) = Y
Y = (Y) + 80
SetPixel DrawArea.hdc, x2 + 8, Y, color
SetPixel Buffhdc, x2, Y, color

""" For DrawArea1 and DrawArea2
SetPixel DrawArea1.hdc, x2 + 8, Y, color
SetPixel Buffhdc, x2, Y, color

SetPixel DrawArea2.hdc, x2 + 8, Y, color
SetPixel Buffhdc, x2, Y, color
```

```
x1 = X / 2
y1 = Y
DoEvents

""" Refreshing Rate of the Sinusoidal Wave """
If x2 >= 150000 Then
x2 = 0
DrawArea.Cls
DrawArea1.Cls
DrawArea2.Cls
End If
Wend
c = 0
x2 = 0

    """" After Insertion, Shutdown the Parallel Port
Call ShutdownWinIo
End Sub
```

A-2 ECG Saving Procedure

```
Private Sub Save_Click()

Dim Fsys As New FileSystemObject
Dim wrstr As String
Dim i As Integer
i = 0

If ch = True Then
    ch = False
        If (i = 0) Then
            Set TStream = Fsys.OpenTextFile(fname, ForAppending)
            stp1 = a
            stp2 = b

            ''''''''temporary checking
            MsgBox (CStr(str1) + "-" + CStr(str2) + " to " + CStr(stp1) + "-" + CStr(stp2))

        End If

            While (str2 <= stp2)
            While (str1 <= stp1)

            wrstr = CStr(checkLoop(str1, str2))
            If (Len(wrstr) < 3) Then
               TStream.Write (wrstr)
               wrstr = wrstr + " "
               str1 = str1 + 1
            Else
                TStream.Write (wrstr)
                str1 = str1 + 1
```

```
            End If
               Wend
            str2 = str2 + 1
            Wend
Else
   MsgBox ("No Saving")
End If
GoTo Ending
 '''''' To Close Parallel Port
   Call ShutdownWinIo
Ending: End Sub
```

A-3 Loading of Stored ECG Procedure

```
Private Sub Load_Click()
Dim rd As Integer
Dim x2 As Integer
Dim x As Integer
Dim x1 As Integer
Dim y As Integer
Dim y1 As Integer
Dim y2 As Integer
Dim TStream As TextStream
CommonDialog1.ShowOpen
fname = CommonDialog1.FileName
'MsgBox (fname)

If (fname = "") Then
   MsgBox ("File name not mention")
Else

If (Fsys.FileExists(fname)) Then
   On Error GoTo Ending
   Set TStream = Fsys.OpenTextFile(fname, ForReading)
   Do While TStream.AtEndOfStream = False
      rd = Val(TStream.Read(2))
      x = x2 / 2
      y = rd 'values(c)
      y = (y) + 120
      SetPixel DrawArea.hdc, x2, y, color
      SetPixel Buffhdc, x2, y, color
      x1 = x / 2
      y1 = y
      DoEvents
```

```
    Loop
Else
    MsgBox ("File Not Exists")
End If
End If
Ending:
End Sub
```

A-4 Printing of Stored ECG Procedure

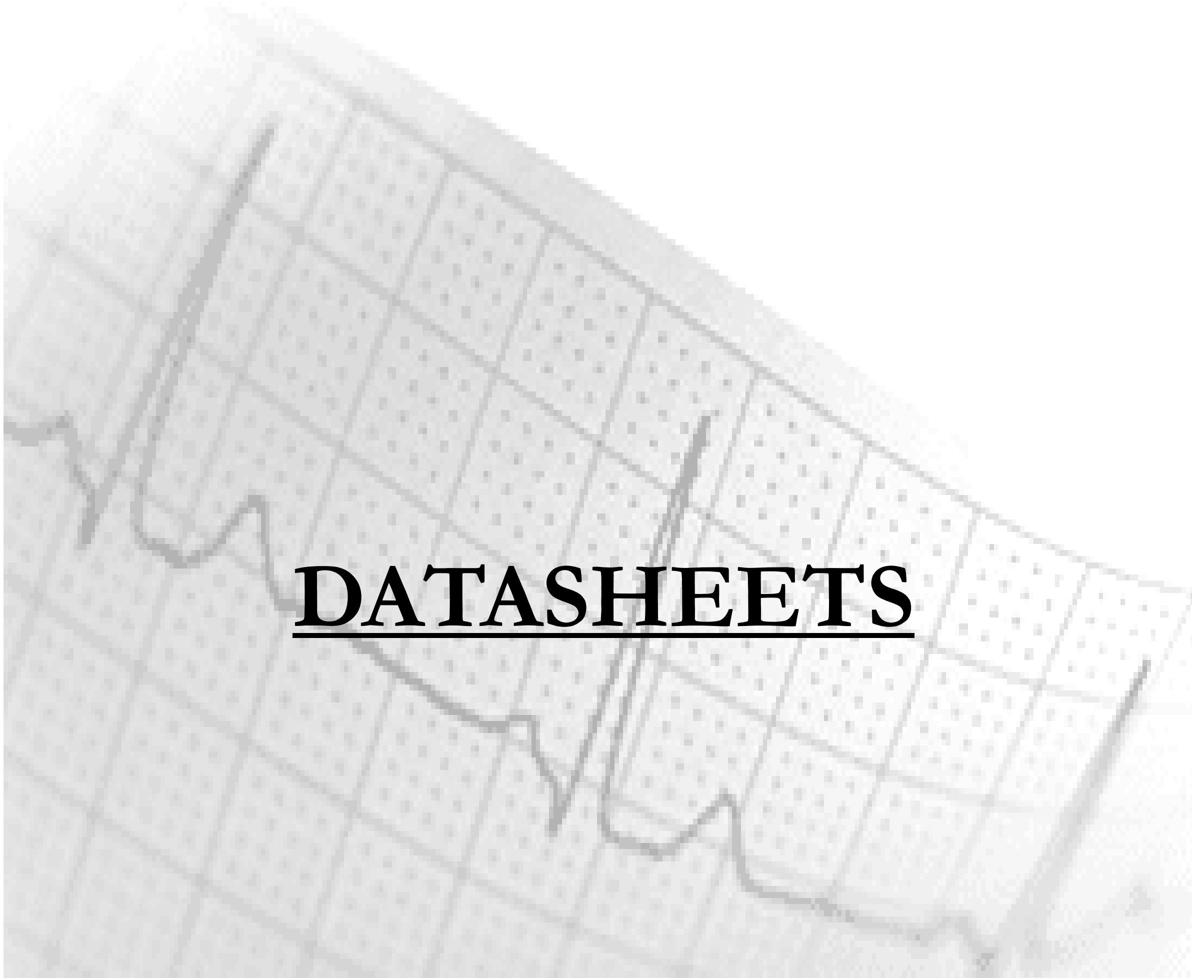
```
Private Sub open_Click()
Dim rd As Integer
Dim x2 As Integer
Dim x As Integer
Dim x1 As Integer
Dim y As Integer
Dim y1 As Integer
Dim y2 As Integer
Dim TStream As TextStream
CommonDialog1.ShowOpen
fname = CommonDialog1.FileName
'MsgBox (fname)

If (fname = "") Then
   MsgBox ("File name not mention")
Else

If (Fsys.FileExists(fname)) Then
   On Error GoTo Ending
   Set TStream = Fsys.OpenTextFile(fname, ForReading)
   Do While TStream.AtEndOfStream = False
      rd = Val(TStream.Read(2))
      x = x2 / 2
      y = rd 'values(c)
      y = (y) + 120
      SetPixel DrawArea.hdc, x2, y, color
      SetPixel Buffhdc, x2, y, color
      x1 = x / 2
      y1 = y
      DoEvents
```

```
    Loop
Else
    MsgBox ("File Not Exists")
End If
End If
Ending:
End Sub
```

APPENDIX - B



DATASHEETS

Datasheets of Components

B-1 AD624AD

B-2 AD620

B-3 ADC0808

B-4 UA741

APPENDIX - C

USER MANUAL

User Manual

In order to operate the Heart Beat Analyzer, User should have to follow the following steps,

SOFTWARE SETTINGS

Step # 1

Run the Heart Beat Analyzer.exe from operating system Environment.

Step # 2

Fill the Patient Information form and press Submit button

HARDWARE SETTINGS

Step # 1

Connect the parallel port connecting wire with personal computer and Heart Beat Analyzer's Hardware.

Step # 2

Press the Blue switch button from Heart Beat Analyzer's Hardware in order to turn it on.

Step # 3

Place the Leads on the specified positions means Lead-I (Green Lead) on right shoulder, Lead-II (Yellow Lead) on left shoulder and Lead-III (Black Lead) on stomach.

Step # 4

Then connect the other terminals of all the three leads with the Heart Beat Analyzer's Hardware on the specified connectors means Yellow lead on Yellow connector similarly other.

EXTRA SETTINGS

Store ECG

In order to store ECG, simply press CTRL + S then mentioned the name of file and stored it.

Print ECG

In order to Print ECG, simply press CTRL + P then locate the file that is required to print and press print button.

Load ECG

In order to load the ECG, simply press CTRL + L and then locate the file that is required to load.

With the help of above setting user can easily see his/her ECG with the following facilities,

Saving of ECG

Loading of Stored ECG

Printing of ECG

APPENDIX - D

MEETINGS

Bahria University (Karachi Campus),
Department of Computer Science and Engineering,
13 National Stadium Road,
Karachi

BI-WEEKLY FINAL YEAR PROJECT LOG

Title of Project: **Heart Beat Analyzer**

Name of Supervisor: **Syed Aley Imran Rizvi**

Group Members: 1. **Tahir Bashir**

2. **M. Farooq Shibli**

3. **Tasneem Aslam**

4. ____

MEETING No. **9**:

Topic:

Date: **November 2, 2005**

Time: **3:30 – 4:30 PM**

Supervisor's Initials: ____

MEETING No. **10**:

Topic:

Date: **November 9, 2005**

Time: **3:30 – 4:30 PM**

Supervisor's Initials: ____

Form Submitted on: ____

Submitted by: Name____________________ Signature: ________________________

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13 National Stadium Road,
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Supervisor's Initials: ____________________

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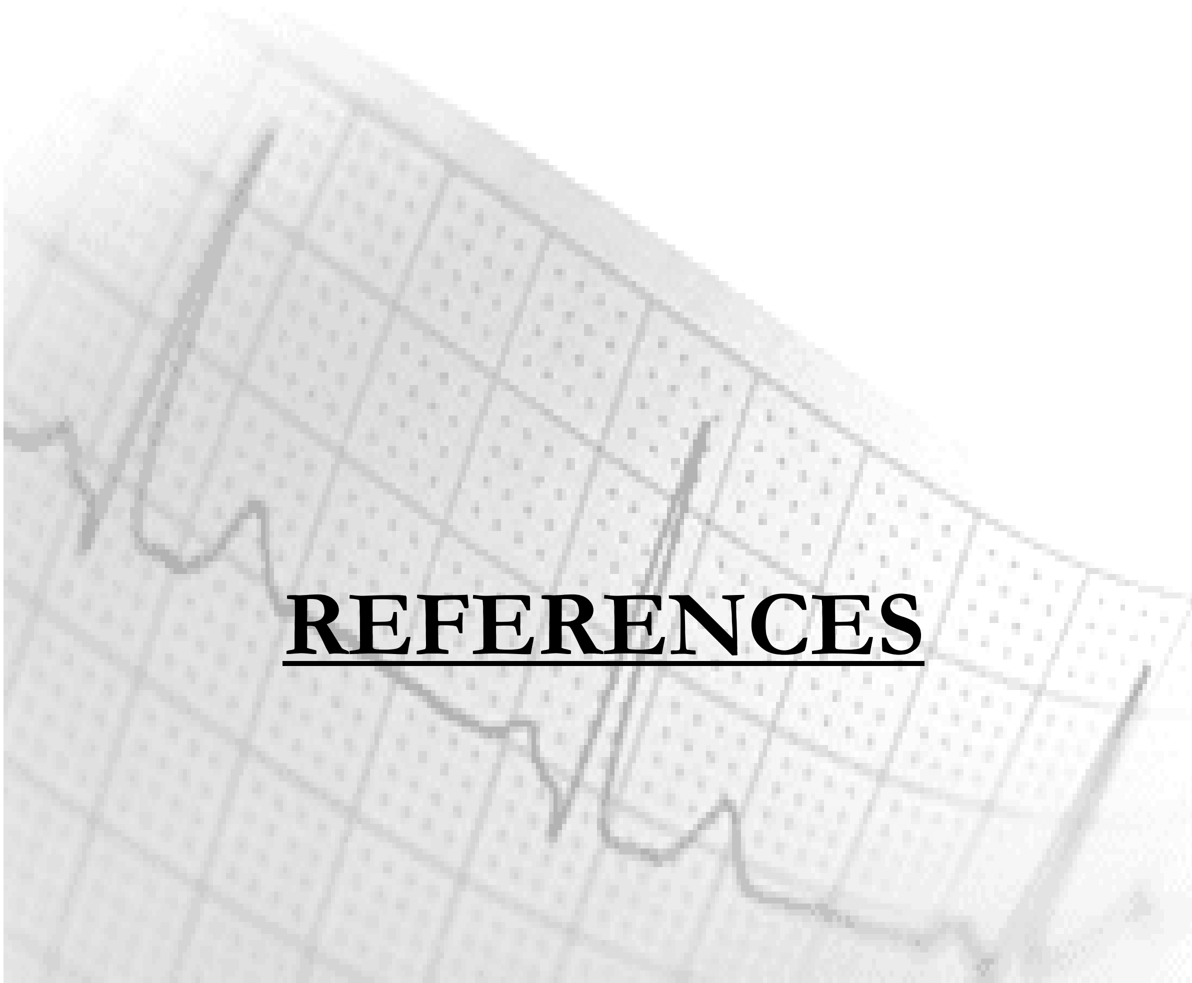
Submitted by: Name____________________ Signature: ____________________

APPENDIX - E



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