ECG ACQUISITION WITH LABVIEW INTERFACE

ERNY SYAHIDA BT MD. SHAFII

KOLEJ UNIVERSITI TEKNIKAL KEBANGSAAN MALAYSIA

"This report attached here to entitled "ECG Acquisition with LABVIEW Interface" prepared by Erny Syahida bt Md. Shafii in partial fulfillment for the Bachelor Degree of Electronic Engineering (Industrial Electronic) is here by approved."

Signature : ______________________

Supervisor Name : Miss Izadora bt Mustaffa

Date : 9/5/08

ECG ACQUISITION WITH LABVIEW INTERFACE

ERNY SYAHIDA BT MD. SHAFII

This Report Is Submitted In Partial Fulfillment Of Requirements For
The Bachelor Degree Of Electronic Engineering (Industrial Electronic)

Faculty of Electronics and Computer Engineering
Kolej Universiti Teknikal Kebangsaan Malaysia

MAY 2006

"I hereby declare that the report is the result of my own, as clearly stated in the sources of references and sources is explained and stated."

Signature : ______________________

Name : Erny Syahida bt Md Shafii

Date : 9/5/06

I dedicate this to my beloved parents,
my family, and to all my friends,
Without whom, I am nothing...

ACKNOWLEDGEMENT

A special thank goes to my supervisor, Miss Izadora bt Mustaffa. Without her teachings, comments, and continued support my degree's work would not have been possible. I have learned so much about conducting research, electronic engineering, medical equipment and life in general. She has made my time at KUTKM as a graduate student both educational and entertaining.

Special thanks also go to my parents for the countless hours they spent giving advice, supported and encouraged me with their continuous love since the beginning, now and hopefully until the days to come.

Special thanks again go to my colleague, Mohd Fahmi Idzul for his contribution of ideas and sharing of parts and components to ensure the success of the project. Also special thanks to all my friends; Arni, Norliana, Noor Diana, Nooradillah and Airin who helped and encourage me when I most needed. Their friendship and accompanies led me through those difficult days.

I would like to extend a thank you to Mr. Azmi from Makmal Digit 1 and Mr. Firdaus from Makmal PSM for their assistance of my project.

Lastly, my special thanks to all people who in one way or another contribute to the success of this project.

Thanks a lot. Your sincere help will be remembered for the whole life.

ABSTRACT

The electrocardiogram (ECG) is a recording of the electrical activity of the heart which serves in diagnostic application. The ECG records the electrical activity that results when the heart muscle cells in the atria and ventricles contract. The ECG waveform is analyzed by the cardiologist in diagnosis various disease and condition associated with the heart. The purpose of this project is to develop an ECG amplifier using Instrumentation Amplifier (IA) which have the value gain of at least 1000 (Gain = 1000). The function of this IA is to amplify the bioelectric signal. The output of the circuit is displayed and recorded on a PC using LABVIEW interface card. Three electrodes are connected to the human body, one on the right arm, one on the left arm and other on the right leg as reference or ground to extract ECG signal from human body. The electrical signal appeared at the ECG input is typically less than 1mV and it is essential to amplify the signal amplitude at least 1000 times to have significant voltages for use with the display devices. Normally, the problem of amplification is the signal has a lot of noise interferences which appears at the input from ac power line, arrangement of component and others sources. These interferences have to be overcome. The output signal from ECG amplifier then is interfaced with LABVIEW software for the purpose of display and enabling for further signal processing.

ABSTRAK

Elektrokardiograf (EKG) adalah merakam aktiviti elektrik dalam jantung yang mana bertujuan untuk diagnosis atau mengesan penyakit. EKG merekod aktiviti elektrik jantung ketika sel otot jantung (atrial dan ventrical) mengalami pengecutan. Bentuk gelombang ECG dianalisa oleh ahli kardiologi dalam mengenalpasti pelbagai jenis penyakit dan kondisi yang dihasilkan oleh jantung. Projek ini bertujuan untuk membina penguat ECG yang menggunakan penguat instrumentasi yang mana mesti mempunyai gandaan sekurang-kurangnya 1000 (Gandaan = 1000). Penguat instrumentasi ini berfungsi untuk menguatkan isyarat bioelektrik. Hasil keluaran daripada litar ini akan dipaparkan dan direkodkan pada PC menggunakan antaramuka LABVIEW. Tiga elektrod akan disambungkan kebadan manusia iaitu di bahagian lengan tangan, lengan kiri dan kaki kiri iaitu sebagai rujukan kebumi bagi memisahkan isyarat ECG dari badan manusia. Isyarat yang dihasilkan oleh badan biasanya kurang dari 1mV dan ia mesti digandakan sekurang-kurangnya 1000 kali untuk voltan masukan yang digunakan oleh perkakasan. Biasanya, masalah penggandaan isyarat ini mempunyai banyak hingar dan gangguan berpunca dari talian kuasa, sambungan antara komponen dan sebagainya. Keluaran isyarat daripada penguat ECG akan diantaramuka kepada program LABVIEW untuk tujuan paparan dan membenarkan ke proses isyarat seterusnya.

CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

ECG	-	Electrocardiogram
SA	-	Sinoatrial
AV	-	Attrioventricular
RMP	-	Resting Membrane Potential
Hz	-	Hertz
dB	-	Desibel
μA	-	Micro Ampere
V	-	Volt
mV	-	Mili Volt
nF	-	Nano Farad

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

A recording of the electrical activity of the heart which serves in diagnostic application is called the electrocardiogram (ECG). In 1893, Willem Einthoven introduces the term of electrocardiogram at the meeting of the Dutch Medical Society and in 1924; he got the Nobel Prize for his life's work in developing the ECG. All the information on the condition and performance of the heart can be gain from the ECG recording. The ECG recording can be made by applying electrodes to various parts of the body. Normally for the standard recording, the electrodes can be applied at four points and the chest wall. In this project, only three electrodes are used to capture the signal which is on the right arm, left arm and the right leg as references. Standardizing electrocardiogram makes it possible to compare them as taken from person to person and from time to time from the same person.

1.2 ECG GENESIS

According Ned T Geneesk [1] to Willem Einthoven was born on May 21, 1860, in Semarang on the island of Java, in the former Dutch East Indies (now Indonesia). His father was Jacob Einthoven, born and educated in Groningen, The Netherlands, an army medical offcer in the Indies, who later became a parish doctor in Semarang.

In the first phase of his research career Einthoven probed into various subjects in the fields of vision and respiration but later he restricted himself almost entirely to electrical phenomena in physiology, in particular those related to the heart. In Einthoven's electrocardiographic model the cardiac source is a two-dimensional dipole in a fixed location within a volume conductor that is either infinite or homogeneous or a homogeneous sphere with the dipole source at its center. Einthoven first recognized that because the limbs are generally long and thin, no significant electrocardiographic currents from the torso would be expected to enter them. Accordingly, Einthoven realized that the potential at the wrist was the same as at the upper arm, while that at the ankle was the same as at the upper thigh. Einthoven consequently assumed that the functional position of the measurement sites of the right and left arm and the left leg corresponded to points on the torso which, in turn, bore a geometric relationship approximating the apices of an equilateral triangle.

He further assumed that the heart generator could be approximated as a single dipole whose position is fixed, but whose magnitude and orientation could vary. The location of the heart dipole relative to the leads was chosen, for simplicity, to be at the center of the equilateral triangle. The signals were obtained from the two arms and left leg (modern Lead I). To enhance conduction, hands and foot were bathed in saline solution with the tubs wired to the input of the electrocardiograph. Noticing a recurring pattern of movement, Einthoven named the prominent waves alphabetically, P, Q, R, S, and T: the P-Wave, representing the impulse across the atria to the A/V Node; the QRS representing the impulse as it travels across the ventricles; the T-Wave, representing the repolarization of the ventricles. The four deflections prior to the correction formula were labelled ABCD and the 5 derived deflections were labelled PQRST. The choice of P is a mathematical convention by using letters from the second half of the alphabet. N has other meanings in mathematics and O is used for the origin of the Cartesian coordinates. In fact Einthoven used O till X to mark the timeline on his diagrams. P is simply the next letter.

A lot of work had been undertaken to reveal the true electrical waveform of the ECG by eliminating the damping effect of the moving parts in the amplifiers and using correction formulae. At the diagram in Einthoven's 1895 paper, how close it is to the string galvanometer recordings and the electrocardiograms today. The image of the PQRST diagram may have been striking enough to have been adopted by the researchers as a true representation of the underlying form. It would have then been logical to continue the same naming convention when the more advanced string galvanometer started creating electrocardiograms a few years later.

1.3 CHALLENGES IN ECG ACQUISITION

ECG signal is a very small signal and it is difficult to capture. The noise will be interfered and distort the signal. In this project, the notch filter is used to filter the noise.

According to the Alexander & Sadiku [7], any noise from 50Hz power line present the input signal will be attenuated by 80dB. This mean that the 50Hz noise at the output will be 10000 times smaller than at the input. The notch filter rejects just 50Hz. It passes frequencies below and above the 50Hz centre.

But while tried to reduce the 50Hz noise, the entire small signal also been rejected include the ECG signal.

1.4 PROJECT OBJECTIVES

The purpose of this project is to develop a functional ECG amplifier using Instrumentation Amplifier (IA) which have the value gain of at least 1000 (Gain = 1000). This device is just to amplify the small signal from human body and try to reduce unwanted signal such as noise interference as much as possible. This particular ECG bio-electric amplifier is designed and developed to interface with LABVIEW. The following below are sub objectives in this project.

1) To develop an amplifier circuit with a minimum gain of 1000 has to be constructed to acquire the signal

2) To ensure an ECG signal will be display on a personal computer (PC) using LABVIEW interface

3) To reduce a signal that affected by 50 Hz power noise and surrounding noise filteration

4) To study the protection either for the patient or the circuit itself

1.5 PROJECT SCOPE

This project has several scopes. It almost concentrates and specific in hardware design only. It also covered on designing an amplifier circuit that have the protection in both circuit and patient. At the same time, it studied study about the ECG waveform characteristic and its importance. The last scope was selecting and designing the best type of filter circuit to reduce a noise signal especially in recognizing which is the acquire signal from human body.

1.6 CONCLUSION

This chapter describe about the project and the genesis of the ECG. Instead of that, this chapter is an introduction to the main purpose and function of the ECG. It also covered about the challenges in capturing the ECG signal. The major problem in this project was the signal was very small and it difficult to capture the signal. The interference of noise also affects the signal to be captured. The other chapter will discuss the way to reduce the noise.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter deals with the heart and all its components. It states the biological principle behind the human cardiovascular system, the anatomy of the heart, electrophysiology of the heart, and bioelectricity. This chapter also will explain about the ECG waveform and the significance of ECG.

2.2 HEART

According to the Carr & Brown [2], the human heart is located in the upper middle portion of the chest *(thorax)*. Although many people believe that the heart is clearly on the left side of the body, it is actually a little more centered, with the lower tip pointed toward the left hip. About one-third of the heart lies to the right of the midline of the body; the rest lies to the left. The size and weight of the heart vary from one individual to another. In most people the heart is approximately the size of their clenched fist, and the average weight of the heart is on the order of 300 grams (g).

The heart is a muscle encased in a sac called the *pericardium.* This double layer of tissue helps the heart stay in position and protects it from harm. The pericardium creates a lubricating fluid on its inside surface so that the friction between it and the heart wall is reduced, allowing the heart to beat freely within the walls of the sac. A cutaway view of the human heart is shown in Figure 2.1. Besides two layers of pericardium (described before), there is an *epicardium* and a *myocardium,* the main muscle tissue of the heart. The thick myocardium accounts for approximately 75 percent of the heart wall thickness.

The heart contains four chambers, which are used to form two separate pumps. Each pump consists of an upper chamber *(atrium)* and a lower chamber *(ventricle).* The high pressure output side of each pump is the ventricle, so the myocardium thickness in the ventricular region is considerably greater than it is in the atrial region. There are four valves in the human heart. The valve between the right atrium and the right ventricle is known as the *tricuspid valve.* It gets its name from the fact that it is formed of three cusp-shaped flaps of tissue arranged so that they will shut off and block passage of blood in the reverse direction (from ventricles back to the atrium). These valves are attached at their bases to a fibrous strand of tissue ringing the opening between upper and lower chambers, and at their ends to objects called *chordae tendinae.* These structures are attached to the muscle tissue in the ventricle and keep the tricuspid valve closed as the right ventricular pressure builds up to force blood out of the heart into the pulmonary artery. The valve between the right ventricle and the pulmonary artery also has a name reminiscent of its shape: *semilunar* (half moon) valve. It also consists of three flaps, but it lacks the chordae tendinae of the tricuspid valve. It prevents reverse flow (regurgitation) of blood from the pulmonary artery to the right ventricle.

Blood returning to the heart from the lungs must pass through the left atrium and the mitral valve (also known as a *bicuspid valve* after its shape) to the left ventricle. This valve is formed of two flaps of cusp-shaped pieces of tissue. The last valve is the *aortic valve.* It is shaped similar to the pulmonary valve and functions to prevent regurgitation of blood from the aorta back to the left ventricle. The heart serves as a pump because of its ability to contract under an electrical stimulus.

When an electrical triggering signal is received, the heart will contract, starting in the atria, which undergo a shallow, ripple like contracting motion. A fraction of a second later the ventricles also begin to contract, from the bottom up, in a motion that resembles wringing out a dishrag or sponge. The ventricular contraction is known as *systole.* The ventricular relaxation is known as *diastole.* The heart in a resting adult pumps approximately three to five liters of blood per minute (3-5 1/min)

$$CO = \textit{heart rate}\ (\text{BPM})\ X\ \textit{stroke volume}\ (\text{liters per beat})$$

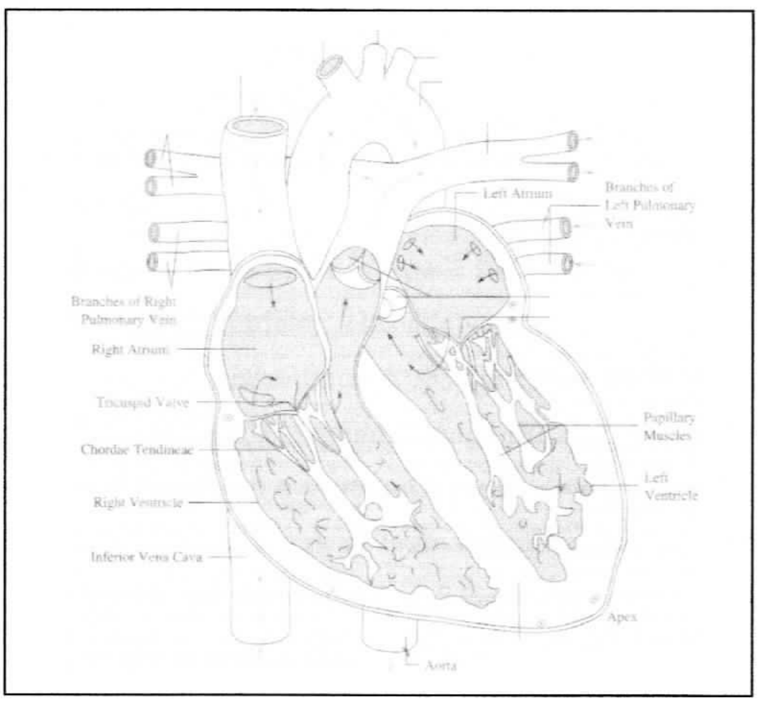

Figure 2.1: Cross-sectional view of the human heart.

[Source: Crouch & McClintic, 1976]

2.3 ANATOMY AND PHYSIOLOGY OF THE HEART

2.3.1 Electrical Conduction System of the Heart

The conduction system of the heart (Figure 2.1) consists of structures called the sinoatrial (SA) node, bundle of His, attrioventricular (AV) node, tissue called the bundle branches, and additional structures call Purkinji fibers. The sinoatrial node or SA node is commonly called the pacemaker of the heart because it possesses the fastest inherent rate of automaticity. This is the part of the heart that initiates the wrist medical impulse. It is a specialized area located near the superior vena cava and right atrial junction [2].

Normally it generates impulses at 60 to 100 times per minute. These impulses travel across the atria via the internodal pathways to the atrial ventricular node or AV node. These intranodal atrial pathways conduct the impulse from the SA node to the right atrial musculature to the atrial ventricular node. Specialized areas, Bockman's bundle, conduct impulses from the SA node to the left atrium. Located on the floor of the interatrial septum is the atrioventricular (AV) node [2].

The small junctional fibers of the AV node slow the velocity of the impulse from the atria before it goes to the ventricles. This allows time for both ventricles to fill prior to ventricular systole. It then passes through the bundle of his at the AV junction and continues down the intraventricular septum through the right and left bundle branches and out to the Punkinje fibers and a ventricular muscle wall. These fibers transmit the impulse into the subendocardial layers of both ventricles; provides for depolarization from the endocardium to the epicardium, followed by ventricular contraction and ejection of blood out of the ventricles [2].

The bundle of his arises from the AV node and conducts impulses to the bundle branch system. This system is composed of the left bundle branch and the right bundle