REAL-TIME ECG ACQUISITION SYSTEM

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This report is submitted in partial fulfillment of the requirements for the award of Bachelor of Electronic Engineering (Computer Engineering) With Honours

Faculty of Electronic and Computer Engineering
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UNIVERSITI TEKNIKAL MALAYSIA MELAKA
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Tajuk Projek : REAL-TIME ECG ACQUISITION SYSTEM

Sesi Pengajian : 2007/2008

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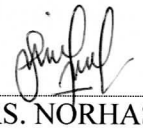
Signature	:	
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For my dearest parents and brother.

APPRECIATION

Alhamdulillah, thank you Allah for blessing me in completion of this Projek Sarjana Muda. I would like to express my gratitude to my family for their continuous support in my time of need. Also, a lot of thanks to lectures and staffs of UTEM for their guidance all the way and not forgetting fellow friends who helped me with this project directly or indirectly.

ABSTRACT

This project is titled real-time ECG acquisition system. An ECG is a test that records the activity of the heart over time. Each portion of the ECG waveform can hint whether the patient is in good health or else. ECG signal are usually very small (approximately 1mV) and therefore prone to interferences (in the form of noise which commonly produced the 50Hz power supply and by changing of skin electrode contact resistor). This project will focus on designing a system that will amplify and filter the ECG signals from six different sources and display them. To measure the ECG signal, an amplifier and a driven right leg circuit are used to reduce the 50Hz common noise. Then, it will go thorough the filter circuits where LPF will eliminate high frequency noise components and HPF will remove the base line drift. The system is consists of instrumentation amplifier IC AD620, precision amplifier OP97 and operational amplifier LM741.

ABSTRAK

Projek ini dinamakan sistem pemerolehan ECG masa nyata. ECG adalah ujian yang merekodkan aktiviti hati berselakan masa. Setiap bahagian daripada gelombang ECG mampu memberi petunjuk sama ada pesakit itu berada dalam kesihatan yang memuaskan atau tidak. Isyarat ECG biasanya adalah kecil (menghampiri 1 milivolt) dan oleh kerana itu ia terdedah kepada gangguan (di dalam bentuk hingar yang biasanya dihasilkan oleh bekalan kuasa frekuensi 50 Hz dan melalui penukaran rintangan sentuh elektrod kulit). Projek ini akan memfokuskan pada penciptaan sistem yang dapat menguatkan dan menapis isyarat ECG daripada enam sumber berlainan dan mempaparkannya. Untuk mengukur isyarat ECG ini, sebuah litar penguat dan litar pemacu kaki kanan akan digunakan untuk menghilangkan frekuensi hingar 50 Hz. Seterusnya, ia akan melalui litar penapis dimana litar penapis pototng-rendah akan menapis keluar frekuensi tinggi manakala litar penapis potong-tinggi akan menyahkan hanyutan garis teras. Sistem ini terdiri daripada litar-dalaman penguat AD620, litar jitu OP97 dan penguat beroperasi LM741.

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LIST OF SYMBOL / SHORTFORM / DEFINITION

ECG	-	Electrocardiogram
LPF	-	Low-pass Filter
HPF	-	High-pass filter
RA	-	Right Arm
LA	-	Left Arm
LL	-	Left Leg
RL	-	Right Leg
aVL	-	Augmented Vector Left
aVR	-	Augmented Vector Right
aVF	-	Augmented Vector Foot
PC	-	Personal Computer
ADC	-	Analog-to-Digital Converter
EEG	-	Electroencephalogram
EMG	-	Electromyogram

CHAPTER 1

INTRODUCTION

1.1 Introduction

Nowadays, ECG is becoming common to all people, even in the entertainment industry because it is associated to the heart attack syndrome and others. The electrocardiograph (ECG) is one of the medical equipment that can measure the heart rate of a person and transfer it into graphical representation in the form of ECG graph paper. However, it is not really efficient due to the fact that the result can be lost, damaged and cannot be saved for future usage between health care facility. The main purpose of this project is to design a system that can capture real-time ECG signals and transfer it to PC for monitoring.

An ECG (electrocardiogram) is a test that measures the electrical activity of the heart. The heart is a muscular organ that beats in rhythm to pump the blood through the body. The signals that make the heart's muscle fibers contract come from the sinoatrial node, which is the natural pacemaker of the heart.

In an ECG test, the electrical impulses made while the heart is beating are recorded and usually shown on a piece of paper. This is known as an electrocardiogram, and records any problems with the heart's rhythm, and the conduction of the heart beat through the heart which may be affected by underlying heart disease.

ECG signals are usually small, approximately 1mV and therefore, it is prone to corruption by various noises; power line interference, electrode contact noise, motion artifacts. Also, it is necessary to design a good filter system that can filter out the noises from the ECG signal in order to get better result. Therefore, measuring an ECG signal is not an easy task to achieve.

The ECG signals are captured by the electrode sensors, and then it is amplified by the instrumentation amplifier and precision amplifier. The gain achieved by cascading the amplifiers must be equal or greater than 1000 in order to achieve the desired signal output. However, the noises may still interfere with the signal. Therefore, it is necessary to design a band-pass filter (BPF) circuit where the low-pass circuit (LPF) will eliminate the high-frequency noises and the high-pass circuit (HPF) will eliminate the direct current (DC) noise components. An operational amplifier will be used to invert the common noise voltage and drive it back to the right leg of the patient which is considered the ground, in order to cancel the interference.

1.2 Objectives

The objectives for this project are:

a) To amplify and filter the ECG signals.
b) To filter the ECG signal obtained from the amplifier.
c) To send the signal to ADC for microcomputing memory & signal display

1.3 Scope of work

a) Focusing on the hardware part of the project only, for capturing ECG signals.
b) The biopotential electrodes focusing only on standard (I, II and III) and augmented limb (AVR, AVL and AVF) leads & not on the precordial leads (chest leads).
c) Filtering the signal obtained from the amplifier.
d) Parallel circuits for simultaneous recordings.
e) Outputs send to ADC.

1.4 Problem statements

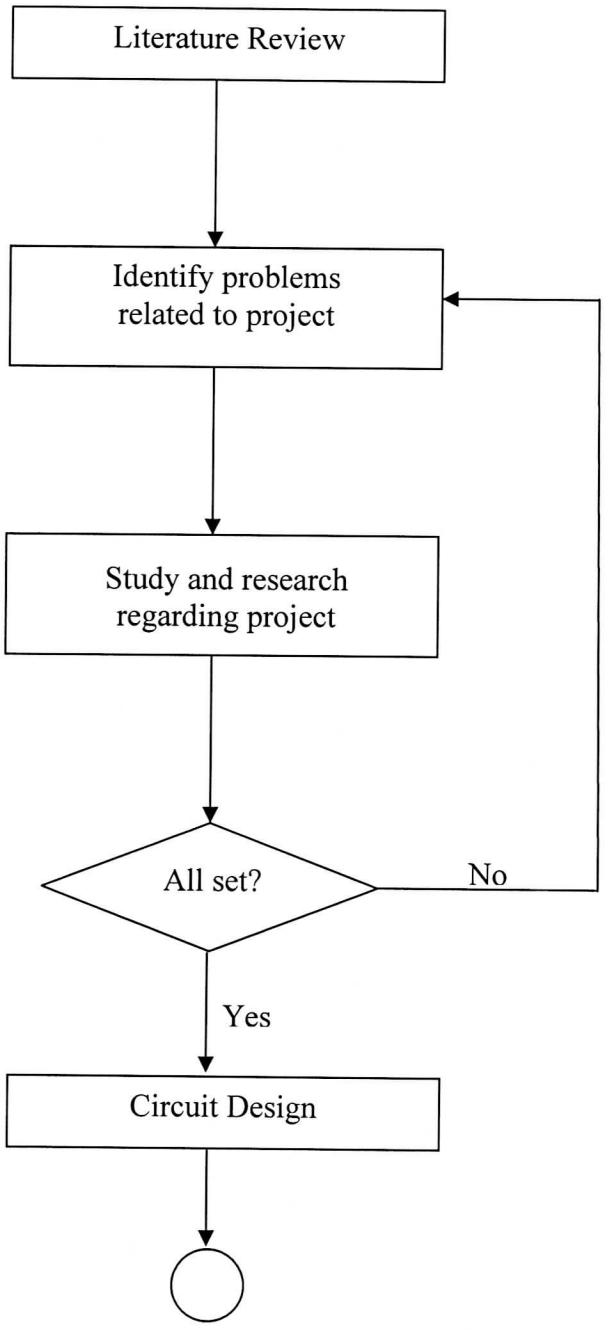
ECG signal are small (approximately 1mV) and therefore, prone to interference in the form of noises that came from the surrounding environment. Even the equipments in the laboratory may provide noises that will interfere with the signal capturing. Also, since the signal is so small (1mV), it is hard to view it as it is. Therefore, it is important to design a filter that will eliminate the noises from the signal and amplifier circuits that will boost up the signal to a viewable output.

1.5 Project methodology

Below are the procedures that will be utilized in order to complete this project:

1. Literature review
   - study and research about ECG
2. Identify related problems regarding ECG and this project.
3. Study of circuit diagram.
4. Circuit simulation
   - simulation will be done using Multisim and Proteus 6 Professional
5. Circuit construction
   - circuit will be tested on breadboard and then transferred to PCB board
6. Circuit testing
7. Circuit finalization
8. Full report writing
9. Final product.

The following page contains the flowchart of this project.



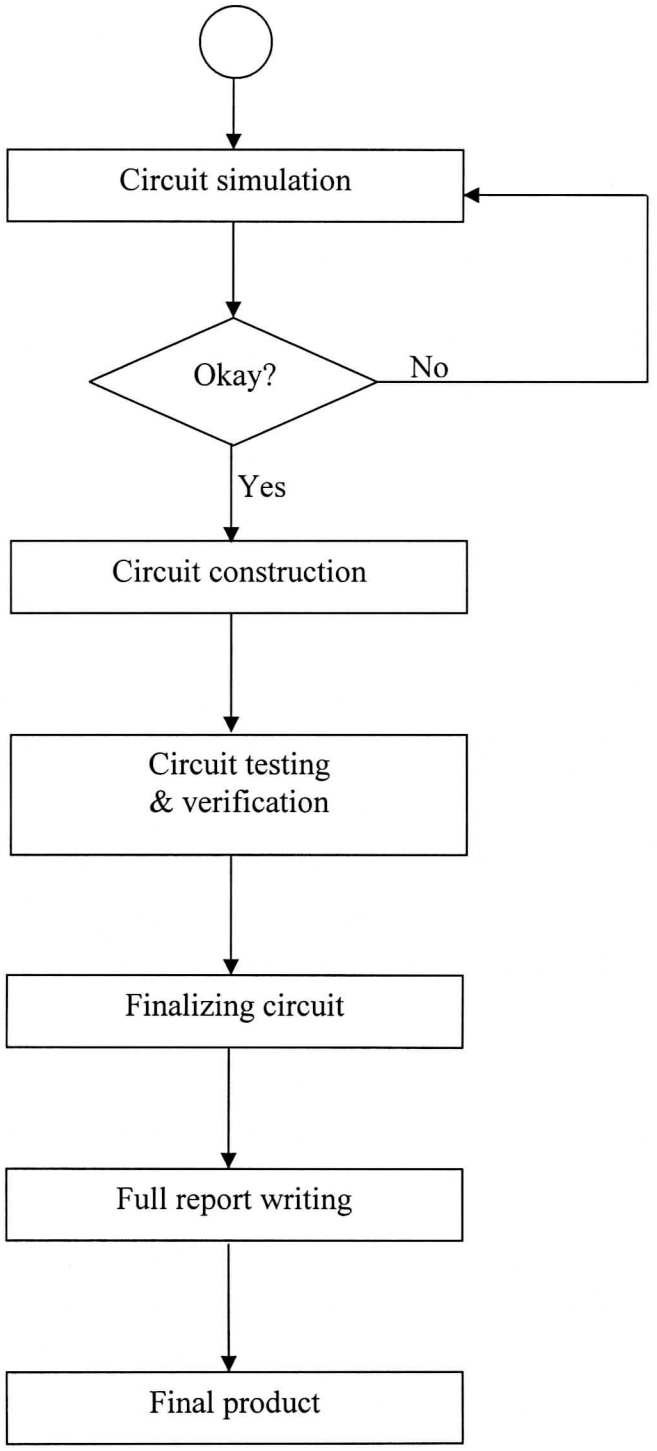


Figure 1.1 Flowchart of the work of this project

CHAPTER 2

LITERATURE REVIEW

2.1 ECG

An electrocardiogram is,derived from the Greek language consisting of the words electro-cardio(heart)-gram(write) (ECG or EKG, abbreviated from the German language of *Elektrokardiogramm*) is a graphic produced by an electrocardiograph, which records the electrical activity of the heart over time. Analysis of the various waves and normal vectors of depolarization and repolarization yields important diagnostic information.

The electrocardiogram does not directly assess the contractility of the heart. However, it can give a rough indication of increased or decreased contractility. This activity was directly recorded and visualized using a Lippmann capillary electrometer by the British physiologist John Burdon Sanderson. The first to systematically approach the heart from an electrical point-of-view was Augustus Waller, working in St Mary's Hospital in Paddington, London. His electrocardiograph machine consisted of a Lippmann capillary electrometer fixed to a projector.

The breakthrough came when Willem Einthoven, working in Leiden, The Netherlands, used the string galvanometer invented by him in 1901, which was much more sensitive than the capillary electrometer that Waller used. Einthoven assigned the letters P, Q, R, S and T to the various deflections, and described the electrocardiographic features of a number of cardiovascular disorders. In 1924, he was awarded the Nobel Prize in Medicine for his discovery. Though the basic principles of that era are still in use today, there have been many advances in electrocardiography over the years. The instrumentation, for example, has evolved from a cumbersome laboratory apparatus to compact electronic systems that often include computerized interpretation of the electrocardiogram.

Year	Name	Achievement
1856	Kollicker and Mueller	Discovered the electrical activity of the heart when a frog sciatic nerve/gastrocenemius preparation fell onto an isolated frog heart and both muscles contracted synchronously.
1901	Willem Einthoven	- Invented the string galvanometer. - Einthoven's triangle - Awarded the Nobel Prize in Medicine for his discovery in 1924.

Table 2.1 Short History of ECG achievement

2.2 The Origin of Biopotentials

[5] Biopotentials arise from cells, and more generally from organs. They hold rich physiological and clinical information. For example, action potentials give information on fundamental ion channel biophysics and molecular aspects of any pathology. Biopotentials from the organs of the body are of clinical diagnostic significance.

Examples:

a) Action potentials from heart:
   i. Neuronal action potential (history of Squid axon and Hodgkin-Huxley work)
   ii. Patch clamp technique and single channel recording (Sakman-Neher)
   iii. Water channel work of Peter Agre (JHU)

b) Biopotentials from the organ/body:
   i. Electrocardiogram (ECG) from heart - used in heart attack, pacemakers
   ii. Electroencephalogram (EEG) from brain - used in epilepsy, brain trauma
   iii. Electromyogram (EMG) from muscle - used in muscle diseases, prosthesis