CHAPTER ONE

Introduction

1-1 General View:

The depolarization and repolarization of the atrial and ventricular chambers of the heart produce an electrical activity, and the rhythm of the heart in terms of beats per minute may easily estimated. Abnormal heart rhythms (arrhythmias) are caused by problems in the electrical system that regulates the steady, rhythmic beat of the heart. The heart beat may be too slow or too fast; it may remain steady or became chaotic which is represented by an ECG waveform of different leads combination.

This project consist of a simple design comprised of portable ECG system using a microcontroller and stored in Labtop that represent an ECG signal acquired from the patient which help us to diagnose the patient whether it is a life threatening or bothersome.

This system can be used by physicians and medical staff nevertheless the design of the portable system is user friendly so the patient himself can use it with the right guidance.

1-2 Problem Statement:

Generally the evolution in the diagnosis of pathologies in these days led to the development of diagnostic equipments thus they became high in cost and the knowledge to handle these equipments is limited especially in poor and developing countries.

1-3 Objectives:

The objectives of this project are to:

I. Designing and implementing a simplified ECG system using microcontroller and the Labview programming language on personal computer.
II. Reduce unbearable cost of caring in private nursing homes/hospitals.
III. Follow up the heart beat in automated way.

1-4 Methodology:

The methodology will be based on design of an electric circuit to send ECG signals to computer via Arduino UNO board. A Labview 2015 programming language will be used as a tool acquiring, processing and display ECG signals on PC.

1-5 The Thesis Layout:

The research consists of six chapters:

- Chapter one is an introduction.
- The previous studies are given in chapter two.
- The concept of designing and implementing of ECG signal using microcontroller in chapter three.
- Chapter four is about the proposed system.
- The result and discussion is found in chapter five.
- Finally chapter six contains the conclusion and references.

CHAPTER TWO

Literature Review

2.1 Naazneen M. G., Sumaya Fathima, Syeda Husna Mohammadi, Sarah Iram L. Indikar, Abdul Saleem, Mohamed Jebran had proposed Design and Implementation of ECG Monitoring and Heart Rate Measurement System

This paper describes the design of a simple 3-lead Electrocardiogram (ECG) monitoring and heart rate measurement system with LCD output.

The system takes the physical pulse input using Ag/Cl sticking electrodes stuck to the arms and right leg of the patient under observation. The model encompasses of instrumentation amplifier and filter circuits, which are used for signal conditioning of the pulse input from the patient’s body and displayed on CRO as the ECG waveform. Thus conditioned signal is also processed by the microcontroller AT89S52 to count the heart for duration of one minute and displays the information on LCD display.

Instrumentation amplifier (IA), using op-amp 741 with a gain of 1000 and power supply is +12V to -12V .The output of IA, is passed through the low pass filter with a cut off frequency of 150Hz. The amplifier consists of a simple non inverting amplifier ,The main goal of designing a non-inverting amplifier is to saturate the all ECG signals and convert them into square waveforms and these square pulses are used as an input to AT89S52 microcontroller its Gain 11. Microcontroller AT89S52 is being used in our project for counting of the pulses. It takes the conditioned square pulses from hardware system as an input and counts it for one minute, which is the required heart rate count. In the software part, the tested code for the problem of processing the pulse input and displaying the analysis result in the form of ECG waveform and heart rate count successfully burnt on the microcontroller .Cathode Ray Oscilloscope (CRO) is used to display the ECG. LCD is used to display the heart rate.

This paper presents the implementation of an ECG Monitoring and Heart Rate Measurement System involving low cost amplifier, filter components coupled with a sophisticated microcontroller and LCD screen [1].

2.2 Abdullah Alsadig M. Adama, Magdy Baker M. Amin had proposed Design and Implementation of Portable PC-Based ECG Machine

The goal of this project is to design and implement a PC- Based Patient Monitoring System. The system can acquires signals and displays ECG signal on the PC screen. Besides that, it also has a function to calculate the number of heart beats per minute based on ECG waveform obtained.

The first stage is the bio potential electrode, which converts the bio potential into electric signal. the Signal amplifying stage contains pre amplifier AD624, to make the biological signal good to measure and process, designed primarily for use with low level transducers, including load cells, strain gauges and pressure transducers. Filtering stage used to attenuate certain frequencies of a signal. Using two active RC filters, A high pass filter with cut-off frequency of 0.5Hz is placed between the pre-amplification and low pass filter, The purpose of this filter is to reduce DC offset form being amplified with the signal and amplifier saturation, A low pass filter was placed at the output of the high pass filter to attenuate high frequency noise above 130Hz. The main power supply of the proposed system designed to give output 12VDC,-12VDC to supply analog parts and 5VDC to supply digital parts. The Atmega32L microcontroller is used as the processing unit to convert signal to digital value and send signal in PC throw serial within any second. The ECG uses a serial communication format called RS-232. The software is divided between on-board software for the slave nodes that manages the analog-digital conversion and sending of the data, and PC software responsible for receiving the data and displaying the signal. A Graphical User Interface (GUI) designed by LABVIEW uses as display unit, and the proposed power supply unit was utilized two 5, +12,-12 volts by designed a low cost small adapter. Successful implementation of the hardware necessary to obtain an ECG signal with a right leg driver is evidenced in the overall results where a clean ECG signal is obtained and displayed on PC Provider by LabVIEW. This project involves the Interaction with biological signals, which in general, would involve an actual human connection for data acquisition.

In order to test appropriately, there was need for some simulated bio-signals to analyze the system and determine functionality quickly and efficiently, ECG simulator is a system that has been designed to give a signal similar to the signal of heart. Noise was reduced through implementation of a ground plane. Filtering technique attenuated unwanted noise to highlight the electrocardiogram signal. the main objective has been achieved as a satisfactory level [2].

2.3 Joyanta Kumar Roy, Bansari Deb, Dip Chakraborty Satyajit Mahanta and Nairit Banik had proposed The Wearable Eletronic Rescue System for Home Alone Elderly- Labview & Arduino Evaluation

In the present work our attempt is to develop low cost wearable electronic system which can detect sudden fall and abnormal heart condition of elderly and send information to care giver or doctor through mobile SMS. We are working on the biomedical embedded system which basically acquires ECG (electrocardiogram) signal as well as body vibration signals from the human body], where the system is wearable to all. In any case of abnormality either in both or in any of the two signals, the system sends a text message alert to his family member's mobile, nearby hospital, police station and family doctor's cell phone using GSM module, The whole system has been divided into three essential parts such as – (i) ECG signal acquisition and analysis, (ii) body vibration signal, text message handling process.

i. ECG signal acquisition and analysis

we have used three disposable Ag-AgCl button type surface electrodes attached to right arm, left arm and right leg and are connected to the AD 620-B instrumentation amplifier with own designed circuit board through three individual ECG cables, Arduino (microcontroller) is used to interface to computer on which LabVIEW software is running to acquire ECG and Vibration signal ,The digitized ECG with noise fed to USB port of computer under LabVIEW platform having Advance Signal Processing Toolkit (ASPT) and Biomedical Toolkit.

We have used wavelet transform approach using ASPT which provides WA Detrend VI, will remove the low frequency trend of a signal such as base line wandering. After the elimination of all noises, processed ECG data are used for features extraction using biomedical toolkit, in the analysis part, if the ECG parameters go beyond the threshold or normal, then the logic circuit displays abnormality and tends to send a text message.

ii. Text message handling process

In the algorithm of text message algorithm process, at first the serial communication settings are provided with suitable COM port and baud rate, and thereafter AT commands are applied to write a text message to a particular cell phone number. If the ECG signal or the vibration signal is or both are natural, then this device runs normally with its continuous signal acquisition process. However, when any of the signal goes beyond the natural limit (in terms of voltage), the GSM sends a text message, There are three parameters in the ECG analyzer, i.e. peak amplitude, valley amplitude and QRS complex or RMS peak. All of these have their individual threshold values with which the actual accumulated values (Extracted from signal) are being continuously compared. Next all of these three parameter's resultant output is in a logical OR connection in series, so that, if any of the parameter exceeds its own threshold, the net output will have a true logical value, i.e. 1, thereafter the GSM logic automatically turns to TRUE and the text message sending algorithm starts working.

The entire system is fabricated and studied with volunteers and found working satisfactorily. However we could not able to simulated severe heart abnormality during evaluation of the developed system [3].

2.4 Zarina Md Amin, Suryani Ilias, Zunuwanas Mohamad had proposed Electrocardiogram (ECG) Monitoring System using Bluetooth technology

This paper introduces a mobile system in which the heart's electrical activity is transmitted to the mobile via Bluetooth and released, processed, stored and visualized in real time. . Bluetooth enabled ECG monitoring system consists of three parts, the ECG sensors, signal processing circuit also PC and display interface. Bluetooth-enabled ECG Monitoring System Circuits, have ECG sensor built to detect, amplify and filter out the weak electrical signals obtained from the patient's body.

Three electrodes are used to detect the ECG signal. Signal obtained represent an Einthoven bipolar lead, the potential difference between LA and RA are within 1-3mV and ECG changes in signal frequency from 0.02 to 150 Hz. This low value of the ECG from the sensors (electrodes) requires amplification by an amplifier with a gain of 1000 in the ECG instrumentation block; a low pass filter is used in this system in order to reduce the continuous noise produce by the component. Final stage buffer and Isolation Barrier Module are applied to protect the circuit, The ECG signal is sent continuously to the Bluetooth by using an acquisition unit. A PIC 16F877 microcontroller is used to convert analog signal to digital signal where it will be programmed to perform the following functions: capture and digitize the ECG signal, establish the connection to a PC using a Bluetooth and send data, Data from the Bluetooth module will send to the USB dongle has been installed on the computer. Communication between Bluetooth module and USB dongle connected to using the assembly language and Bluetooth protocol in which digital signals can be processed through layers of wireless networking application. Finally, Visual Basic program displays the signal from the connection device.

Prototypes are reduced the configuration and cable. Bluetooth technology will communicate with the monitoring center and the data can be stored in computer thus pen and paper method can now be reduced in medical laboratory and also hospital environments, Data stored in file format, reducing the space, to improve, and to limit human error. Most importantly, less wire would mean less dangerous and less administrative implemented [4].

CHAPTER THREE

Theoretical Background

3.1 Anatomy and Physiology of the Heart:

The cardiovascular system is a complex closed hydraulic system, which performs the essential service of transportations of oxygen, carbon-dioxide, numerous chemical components and the blood cells. The heart is divided into right and lift parts. Each part has two chambers called atrium and ventricle. The heart has four valves:

i. THE TRICUSPID VALVE prevents backward flow of blood from right ventricle to right atrium.
ii. BICUSPID MITRAL prevents backward flow of blood from lift ventricle to atrium.
iii. PULMONARY VALVE prevents the blood to come back to the right ventricle.
iv. AORTIC VALVE prevents the return of blood back to the left ventricle from aorta.

The heart which drives the blood through the blood vessels of the circulatory system consists of four chambers muscular pump that beats about 72 times per minutes, sending blood through every part of the body. The pump acts as two synchronized but functionally isolated to stage pumps. The first stage of each pump (The Atrium) collects blood from the hydraulic system and pumps it into the second stage (The Ventricle).

The heart wall consists of three layers:

i. The PERICARDIUM which is the outer layer of the heart that keeps the outer surface moist and prevent friction.

ii. The MYOCARDIUM is the middle layer and the main muscle of the heart which is automatic in action, contracting and relaxing rhythmically throughout life.

iii. The ENDOCARDIUM is the inner layer that provides smooth lining for the blood to flow [5].

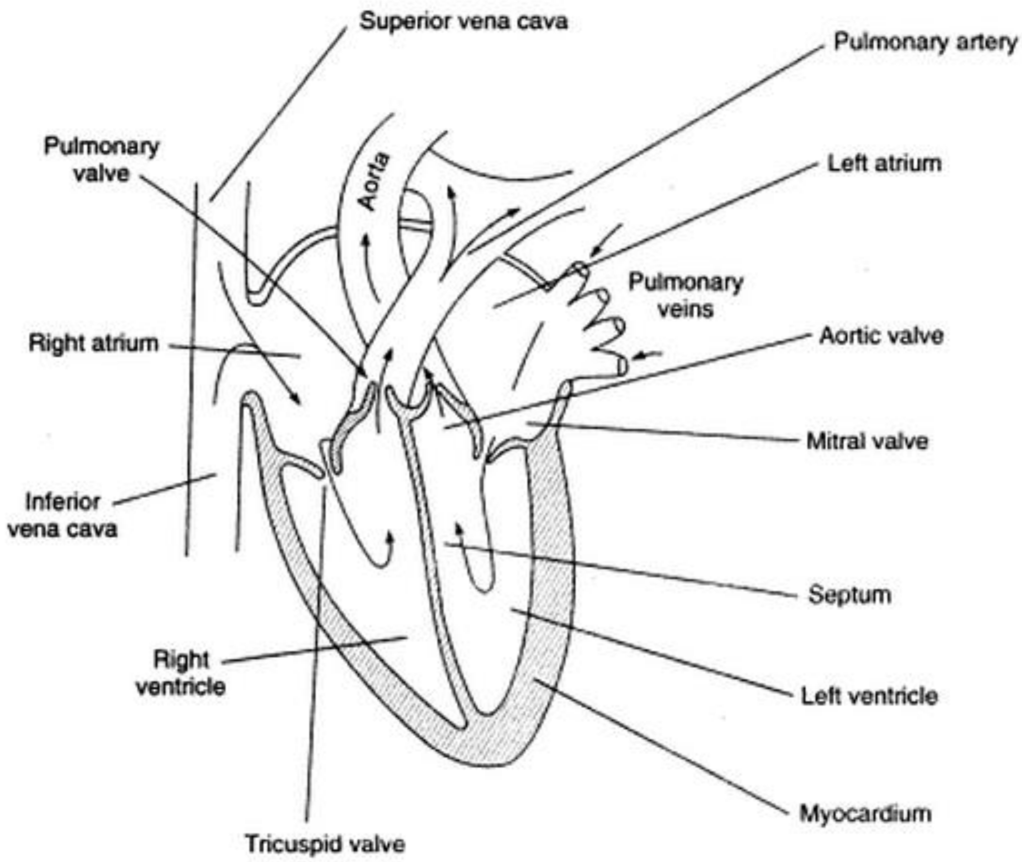

Figure 3.1 Anatomy of the Heart [5]

3.2 Electrocardiogram:

The Electrocardiogram is the recording of the electrical activity associated with the functioning of the heart.

ECG is a quasi-periodical, rhythmically repeating signal synchronized by the function of the heart, which acts as a generator of bioelectric events. This generated signal can be described by means of a simple electric dipole. The dipole generates a field vector, changing nearly periodically in time and space and its effects are measured on the surface. The waveforms thus recorded have been standardized in terms of amplitude and phase relationships and any deviation from this would reflect the presence of an abnormality. Therefore it is important to understand the electrical activity and the associated mechanical sequence performed by the heart in providing the driving force for the circulation of blood.

The heart has its own system for generating and conducting action potentials through a complex change of ionic concentration across the cell membrane. Located in the top right atrium near the entry of the vena cava, are a group of cells known as the Sino-Atrial node (SA node) that initiate the heart activity and act as the primary pace maker of the heart. The SA node is 25-30 mm in length and 2-5 mm thick. It generates impulses at the normal rate of the heart, about 72 beats per minute at rest. The body acts as a purely resistive medium, the potential field generated by the SA node extends to the other part of the heart. The wave propagates through the right and left atria at velocity of about 1 m/second. About 0.1 second is required for the excitation of the atria to be completed. The action potential contracts the atrial muscle and the impulse spread through the atrial wall about 0.04 second to the AV (Atrio-Ventricular) node. This node is located in the lower part of the wall between the two atria.

The AV node delays the spread of excitation for about 0.12 second, due to the presence of a fibrous barrier of non-excitable cells that effectively prevent its propagation from continuing beyond the limits of atria. Then special conduction system known as the bundle of HIS carries the action potential to the ventricles.

The atria and ventricles are thus functionally linked only by the AV node and the conduction system. The AV node delay ensures that the atria complete their contraction before there is any ventricular contraction. The impulse leaves the AV node via the bundle of HIS. The fibrous in this bundle known as purkinje fibres after a short distance split into two branches to initiate action potentials simultaneously in the two ventricles.

Conduction velocity in the purkinje is about 1.5 to 2.5 m/s. since the direction of the impulse propagation in the bundle of HIS is from the apex of the heart ventricular contraction begins at the apex and proceeds upward through the ventricle wall. This results in the contraction of the ventricles proceeding squeezing action which forces the blood out of the ventricles into the atrial system (Figure 3.2) [5].

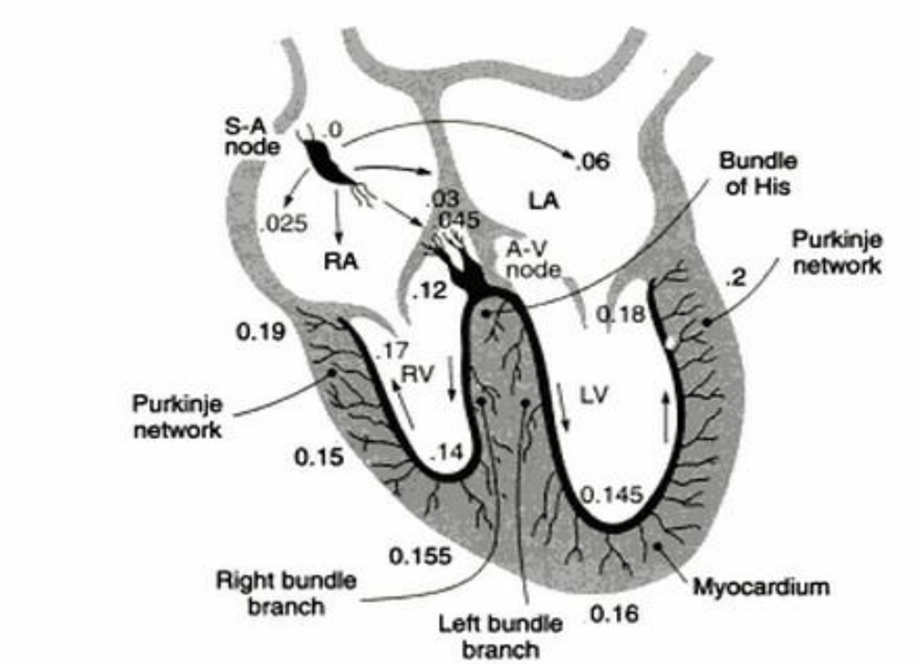

Figure 3.2 shows the time for action potential to propagate to various area of the heart [5].

The normal wave pattern of the electrocardiogram is shown in figure 3.3. The P R and P Q interval measured from the beginning of the P wave to the onset of the R or Q wave respectively marks the time which an impulse leaving the SA node takes to reach the ventricles. The PR interval normally lies between 0.12 to 0.2 second. The QRS interval, which represents the time taken by the heart impulse to travel first through the interventricular system and then through the free walls of the ventricles, normally varies from 0.05 to 0.1 second.

The T wave represents repolarization of both ventricles. The QT interval, therefore, is the period for one complete ventricular contraction. Ventricular diastole, starting from the end of the T wave extends to the beginning of the next Q wave. Typical amplitude of QRS is 1 mv for a normal human heart, when recorded in lead 1 position [5].

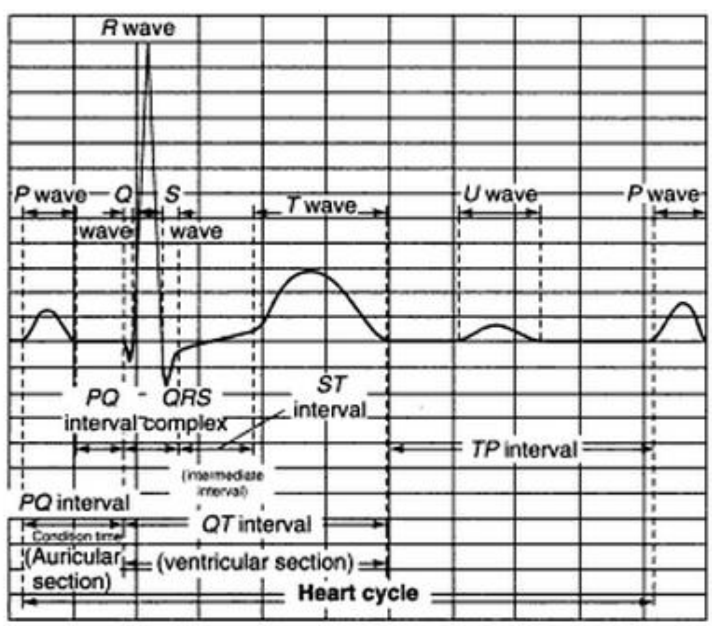

Figure 3.3 Normal ECG waveform recorded in the standard lead position [5].

3.3 The ECG Leads:

Two electrodes placed over different areas of the heart and connected to the galvanometer will pick up the electrical currents resulting from the potential difference between them.

BIPOLAR LEADS: in bipolar leads, ECG is recorded by using two electrodes such that the final trace corresponds to the difference of electrical potential existing between them. They are called standard leads and have been universally adopted. They are sometimes also referred to as Einthoven leads [5].

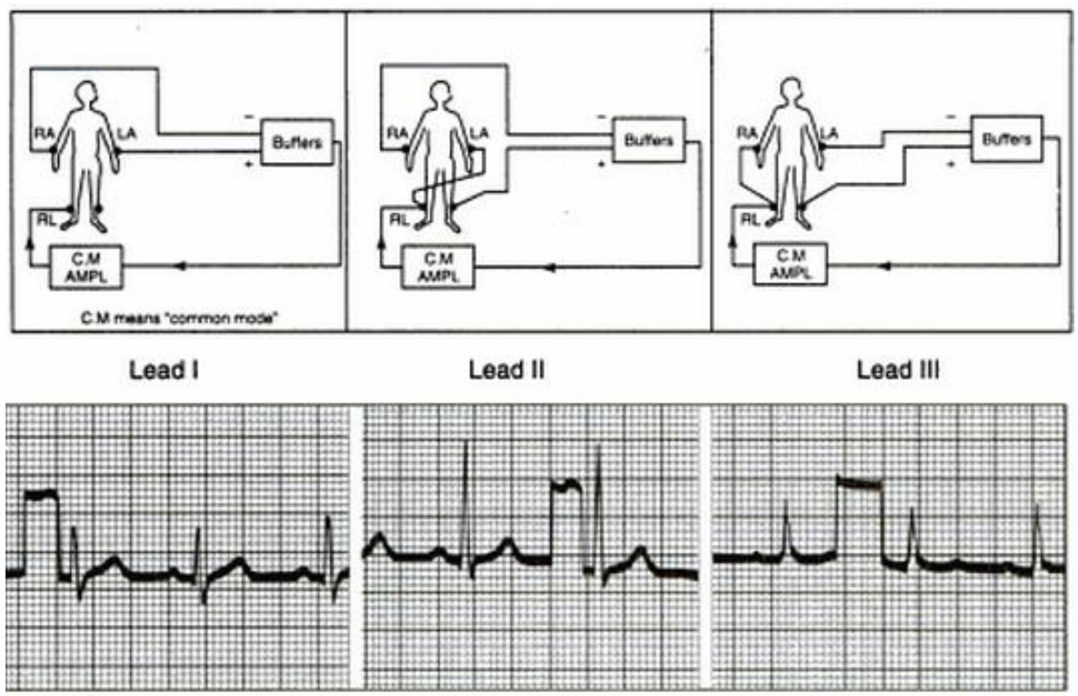

Figure 3.4 Types of leads connection with typical ECG waveforms (Bipolar Limbs Leads) [5].

In standard lead I, the electrodes are placed on the right and left arm (RA and LA). In lead II, the electrodes are placed on the right arm and the left leg and in lead III, they are placed on left arm and left leg. In all lead connections the difference of potential measured between two electrodes is always with reference to a third point on the body. The reference point is conventionally taken as the right leg. The records are, therefore, made by using three electrodes at a time, the right leg connection being always present.

In defining the bipolar leads, Einthoven postulated that at any given instant of the cardiac cycle, the electrical axis of the heart can be represented as a two dimensional vector. The ECG measured from any of the three basic limb leads is a time variant single dimensional component of the vector. He proposed that the electric field of the heart could be represented diagrammatically as a triangle, with the heart ideally located at the centre. The triangle, known as the "Einthoven Triangle", is shown in figure 3.5. The sides of the triangle represent the lines along which the three projections of the ECG vector are measured. It as shown that the instantaneous voltage measured from anyone of the three limb lead positions is approximately equal to the algebraic sum of the other two or that the vector sum of the projections on all three lines is equal to zero.

In all the bipolar lead positions, QRS of a normal heart is such that the R wave is positive and is greatest in lead II.

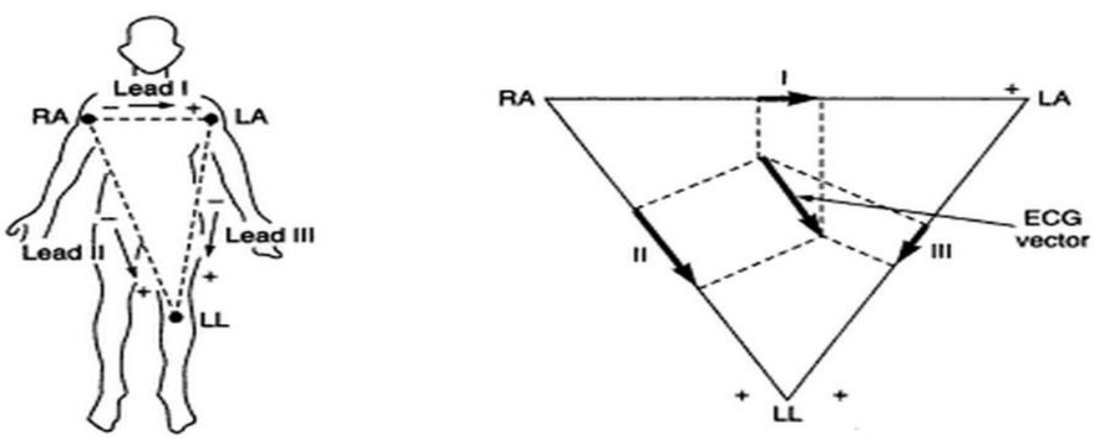

Figure 3.5 The Enithoven triangle [5].

UNIPOLAR LEADS (V leads): the standard leads record the difference in electrical potential between two points on the body produced by the heart's action. Quite often, this voltage will show smaller changes than either of the potentials and so better sensitivity can be obtained if the potential of a single electrode is recorded. Moreover, if the electrode is placed on the chest close to the heart, higher potentials can be detected than normally available at the limbs. This led to the development of unipolar leads introduced by Willson in 1894. In this arrangement the electrocardiogram is recorded between a single exploratory electrode and the central terminal which has a potential corresponding to the centre of the body. In practice, the reference electrode or central terminal is obtained by a combination of several electrodes tied together at one point [5].

Two types of unipolar limb leads are employed which are:

- *Limb leads* in unipolar limb leads (figure 3.6); two of the limb leads are tied together and recorded with respect to the third limb. In the lead identified as AVR, the right arm is a recorded with respect to a reference established by joining the left arm and left leg electrodes. In the AVL lead, the left arm is recorded with respect to the common junction of the right arm and left leg, in the AVF lead, the left leg is recorded with respect to the two arm electrodes tied together.

  They are also called augmented leads or 'averaging leads'. The resistances inserted between the electrodes-machine connections are known as 'averaging resistance'.

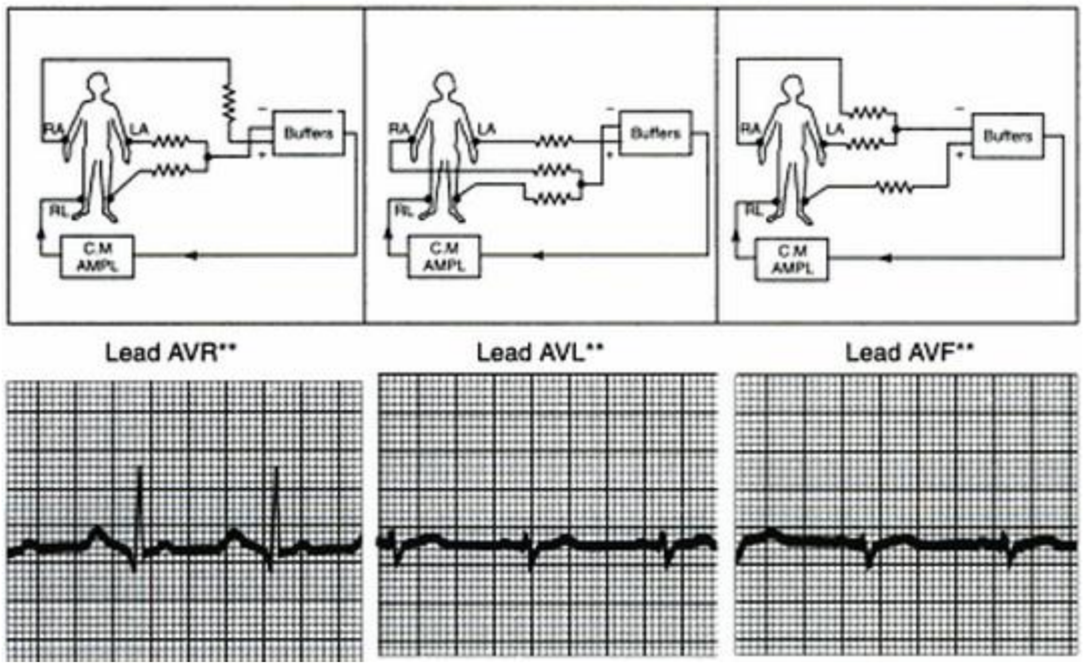

Figure 3.6 Types of lead connections with typical ECG waveforms (UNIPOLAR LIMB LEADS)[5].

- *Precordial leads* the second type of unipolar lead. It employs an exploring electrode to record the potential of the heart action on the chest at six different positions. These leads are designated by capital letter 'V' followed by a subscript numeral, which represents the position of the electrode on the pericardium. The positions of the chest leads are shown in figure 3.7 [5].

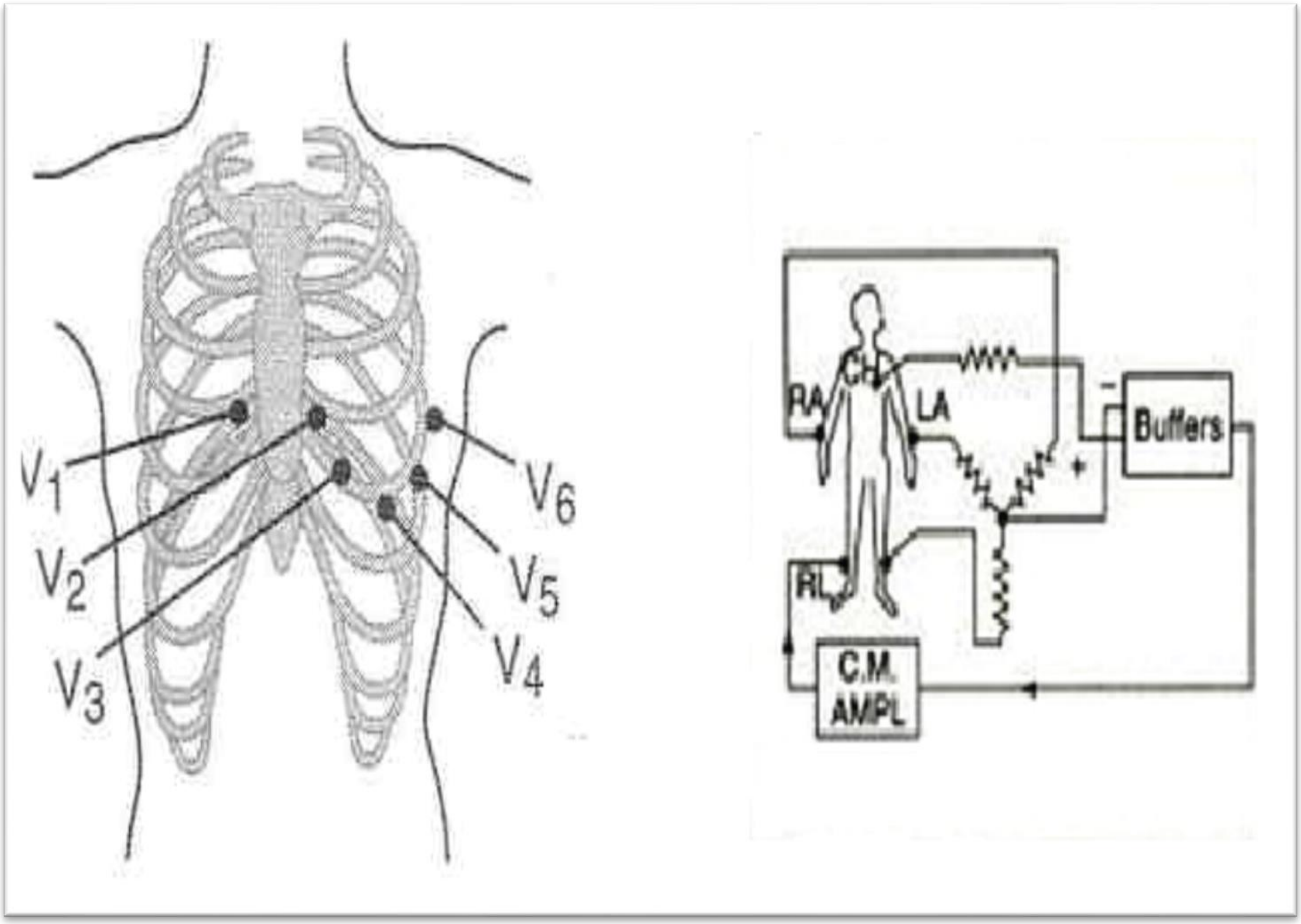

Figure 3.7 Unipolar Chest Leads (V1: fourth intercostal space, at right sternal margin, V2: fourth intercostal space at left sternal margin,V3: midway between V2 and V4,V4: fifth intercostal space, at mid-calvicular line,V5: same level as V4, on anterior axillary line,V6: same level as V4, on mid axillary line)[5]

3.4 ECG Signal:

3.4.1 ECG Waves:

I. P-WAVES: represent atrial depolarisation

II. QRS COMPLEX: represents depolarisation of the ventricles, The first downward deflection is the Q-wave, Any upward deflection is an R-wave, Downward deflections after an R-wave is called an S-wave, It should be between 0.06-0.10 seconds.

III. T-WAVE: represents ventricular re-polarisation.

3.4.2 ECG Segments:

I. PR Segement: starts at the end of the P-wave and finishes at the start of the Q wave, it represents the conduction time of the atrioventricular node, therefore it is useful in identifying pathology of the AV node (e.g. heart blocks), This is seen as a prolonged PR segment in 1st degree Heart block.

II. ST Segement: starts at the end of the S-wave & finishes at the start of the T-wave, it represents ventricular repolarisation, it should be level with the PR-segment and the T-P segment in healthy individuals, if it is elevated it suggests the individual is suffering a myocardial infarction, if it is depressed it suggests the presence of ischaemic myocardial tissue in the ventricles[6].

3.4.3 ECG Intervals:

I. PR-INTERVAL: starts at the beginning of the P-wave & ends at the start of the QRS complex, it represents the time taken for depolarisation to spread from SA node to the ventricular muscle. In healthy individuals it should be between 0.12-0.2 seconds.

II. RR-INTERVAL: starts at the peak of one R wave to the peak of the next R wave, it represents the time between two QRS complexes, useful in calculating heart rate.

III. QT-INTERVAL: starts at the beginning of the QRS complex and finishes at the end of the T-wave, it represents the time taken for the ventricles to depolarise and then repolarize [6].

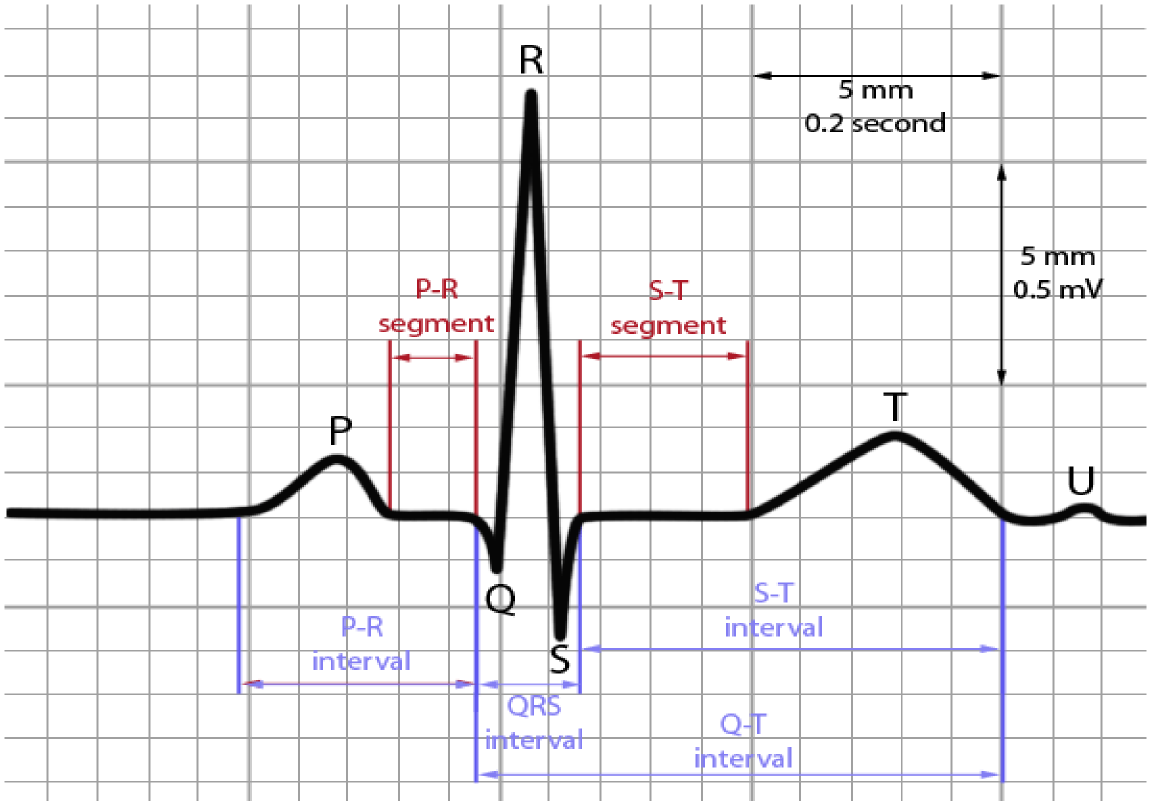

Figure 3.8 ECG segments and intervals [6].

CHAPTER FOUR

The Proposed System

4. 1 Introduction:

The hardware was design to acquire ECG signal which obtained from patient and saved in microcontroller then analysed and diagnosed by programming language (LabVIEW) then the signal displayed on PC.

4.1.1 Hardware components:

4.1.1.1 AD624 Instrumentation Amplifier:

4.1.1.1.1 Functional Block Diagram:

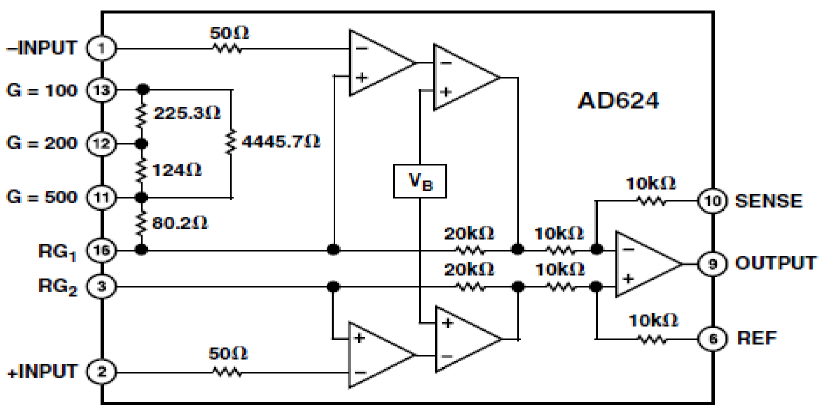

Figure 4.1 AD624 [11]

4.1.1.1.2 Features:

I. Low Noise: 0.2 V p-p 0.1 Hz to 10 Hz

II. Low Gain TC: 5 ppm max (G = 1)

III. Low Nonlinearity: 0.001% max (G = 1 to 200)

IV. High CMRR: 130 dB min (G = 500 to 1000)

V. Low Input Offset Voltage: 25 V, max

VI. Low Input Offset Voltage Drift: 0.25 V/C max

VII. Gain Bandwidth Product: 25 MHz

VIII. Pin Programmable Gains of 1, 100, 200, 500, 1000

IX. No External Components Required

X. Internally compensated.

4.1.1.1.3 Product Description:

The AD624 is a high precision, low noise, instrumentation amplifier designed primarily for use with low level transducers, including load cells, strain gauges and pressure transducers. An outstanding combination of low noise, high gain accuracy, low gain temperature coefficient and high linearity make the AD624 ideal for use in high resolution data acquisition systems. The AD624C has an input offset voltage drift of less than 0.25µV/°C, output offset voltage drift of less than 10µV/°C, CMRR above 80dB at unity gain (130dB at G = 500) and a maximum nonlinearity of 0.001% at G = 1. In addition to these outstanding dc specifications, the AD624 exhibits superior ac performance as well. A 25MHz gain bandwidth product, 5V/µs slew rate and 15µs settling time permit the use of the AD624 in high speed data acquisition applications. The AD624 does not need any external components for pretrimmed gains of 1, 100, 200, 500 and 1000. Additional gains such as 250 and 333 can be programmed within one percent accuracy with external jumpers. A single external resistor can also be used to set the 624's gain to any value in the range of 1 to 10,000 [11].

4.1.1.1.4 Product Highlights:

I. The AD624 offers outstanding noise performance. Input noise is typically less than 4nV/√Hz at 1 kHz.

II. The AD624 is a functionally complete instrumentation amplifier. Pin programmable gains of 1, 100, 200, 500 and 1000 are provided on the chip. Other gains are achieved through the use of a single external resistor.

III. The offset voltage, offset voltage drift, gain accuracy and gain temperature coefficients are guaranteed for all pretrimmed gains.

IV. The AD624 provides totally independent input and output offset nulling terminals for high precision applications. This minimizes the effect of offset voltage in gain ranging applications.

V. A sense terminal is provided to enable the user to minimize the errors induced through long leads. A reference terminal is also provided to permit level shifting at the output [11].

4.1.1.2 TL072 Low-Noise JFET-Input Operational Amplifier:

4.1.1.2.1 Features:

I. Low Power Consumption

II. Wide Common-Mode and Differential Voltage Ranges

III. Low Input Bias and Offset Currents

IV. Output Short-Circuit Protection

V. Low Total Harmonic Distortion . . . 0.003% Typ

VI. Low Noise V_n = 18 nV/√Hz Typ at f = 1 kHz

VII. High Input Impedance . . . JFET Input Stage

VIII. Internal Frequency Compensation

IX. Latch-Up-Free Operation

X. High Slew Rate . . . 13 V/μs Typ

XI. Common-Mode Input Voltage Range Includes VCC+

4.1.1.2.2 Description:

The JFET-input operational amplifiers in the TL07x series are similar to the TL08x series, with low input bias and offset currents and fast slew rate. The low harmonic distortion and low noise make the TL07x series ideally suited for high-fidelity and audio preamplifier applications. Each amplifier features JFET inputs (for high input impedance) coupled with bipolar output stages integrated on a single monolithic chip. The C-suffix devices are characterized for operation from 0°C to 70°C. The I-suffix devices are characterized for operation from −40°C to 85°C. The M-suffix devices are characterized for operation over the full military temperature range of −55°C to 125°C[12].

4.1.1.2.3 Schematic:

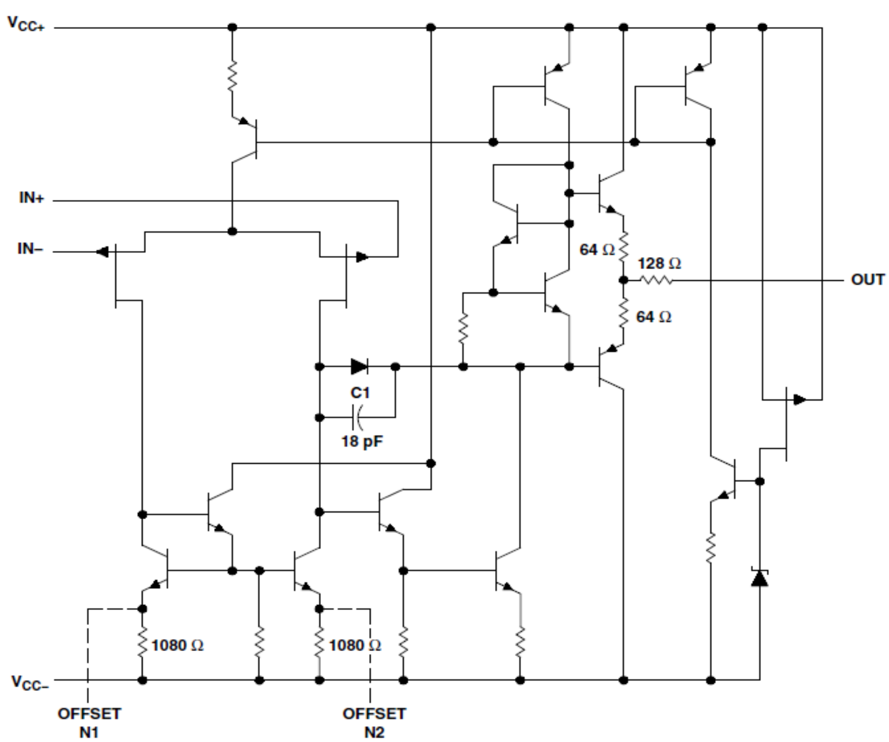

Figure 4.2 TL072 (each amplifier) [12]

Table 4.1 Component Count for TL072 [12]

Component Count*	
Component Type	**TL072**
Resistors	22
Transistors	28
JFET	4
Diodes	2
Capacitors	2
epi-FET	2

***Includes Bias and Trim Circuitry**

4.1.1.3 Arduino UNO Board:

Arduino/Genuino Uno is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; simply it connect to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started[9].

4.1.1.3.1 Features:

I. The ATmega328 on the Uno comes preprogrammed with a bootloader that allows you to upload new code to it without the use of an external hardware programmer. It communicates using the original STK500 protocol.

II. The Uno has a resettable polyfuse that protects your computer's USB ports from shorts and overcurrent. If more than 500 mA is applied to the USB port, the fuse will automatically break the connection until the short or overload is removed.

III. The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter.

IV. The Uno board can be powered via the USB connection or with an external power supply. The power source is selected automatically.

V. External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery.

4.1.1.3.2 Specifications:

Table 4.2 Arduino Uno Specification[10]

Microcontroller	ATmega328
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)
Analog Input Pins	6
DC Current per I/O Pin 4	40 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB of which 0.5 KB used by bootloader
SRAM	2 KB
EEPROM	1 KB
Clock Speed	16 MHz

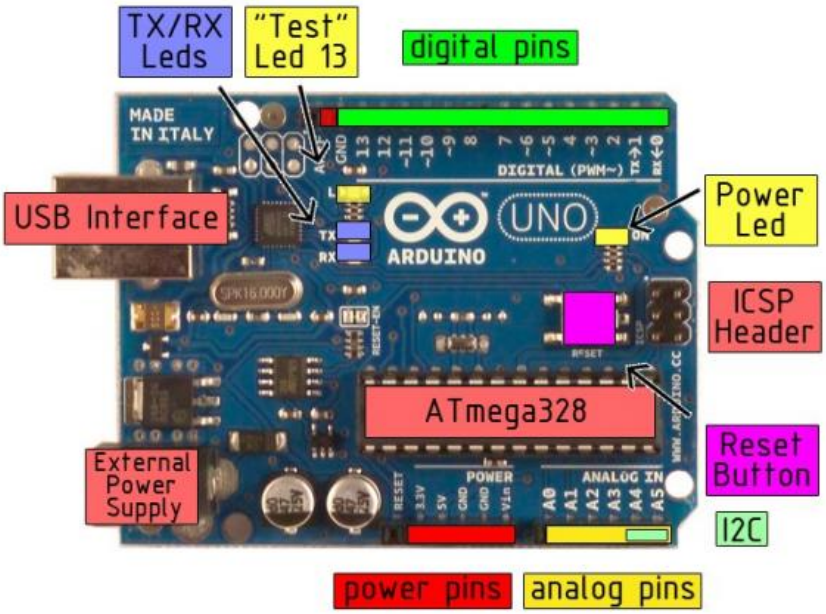

Figure 4.3 Arduino Board Parts[10]

4.1.1.3.3 ATmega328:

The ATmega328P is a low-power CMOS 8-bit microcontroller based on the AVR enhanced RISC architecture. By executing powerful instructions in a single clock cycle, the ATmega328P achieves throughputs approaching 1 MIPS per MHz allowing the system designed to optimize power consumption versus processing speed [7].

Table 4.3 ATmega328 Pin Description [7]

VCC	Digital supply voltage
GND	Ground
Port B (PB7:0)	Port B is an 8-bit bi-directional I/O port with

XTAL1/XTAL2/TOSC1/TOSC2	internal pull-up resistors (selected for each bit)
Port C (PC5:0)	Port C is a 7-bit bi-directional I/O port with internal pull-up resistors (selected for each bit)
PC6/RESET	If the RSTDISBL Fuse is programmed, PC6 is used as an I/O pin
Port D (PD7:0)	Port D is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit)
AVCC	AVCC is the supply voltage pin for the A/D Converter, PC3:0, and ADC7:6
AREF	AREF is the analog reference pin for the A/D Converter
ADC7:6 (TQFP and QFN/MLF Package Only)	In the TQFP and QFN/MLF package, ADC7:6 serve as analog inputs to the A/D converter.

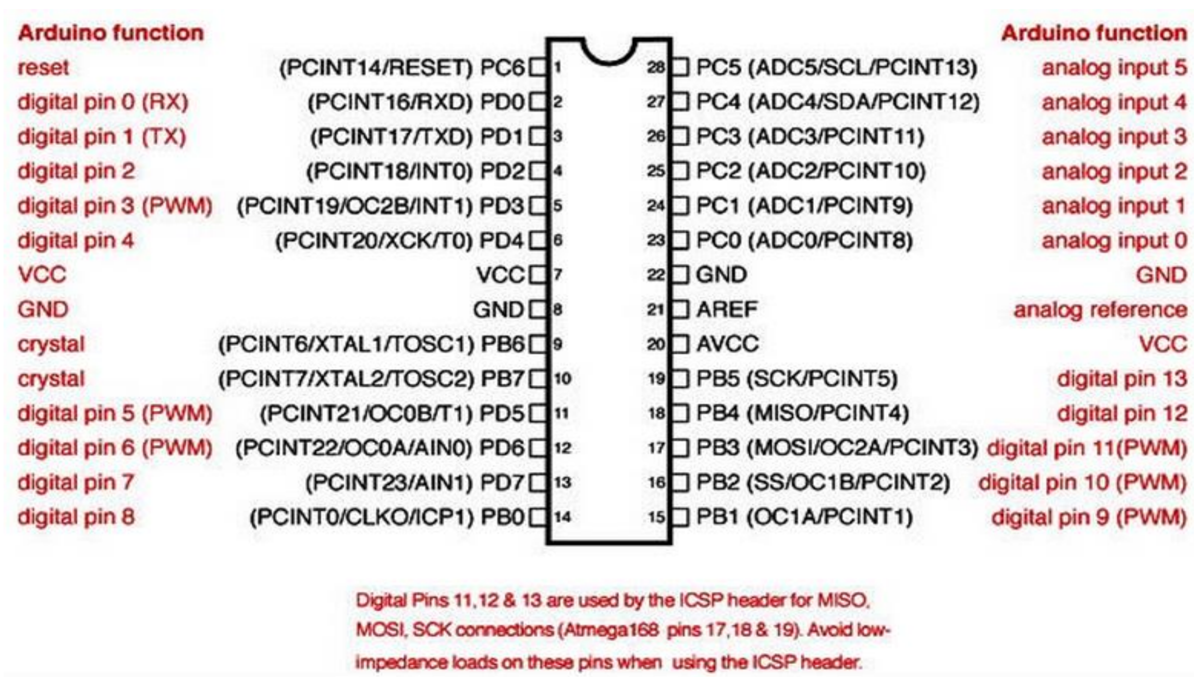

Figure 4.4 Atmega328 Pins Obverse Arduino Function [8]

4.1.1.4 SKINTACT Electrodes:

Figure 4.5SKINTACT FS-RG1 [13]

4.1.1.4.1 Features:

I. Secure Adhesion: The enhanced adhesion of SKINTACT FS-RG1 assures that the electrodes stick very securely ensuring good contact even when the patient is perspiring.

II. SKINTACT F-RG1 are all produced with standard adhesive to the same high quality as the FS range. Suitable for times when the enhanced adhesive is not required, particularly where the patient's skin is more sensitive.

III. Quick and Easy: A perforation in the middle can be used to tear the card apart giving you two strips of three or five.

IV. Superior Design: The label material overlaps the electrode and creates a lift tab which allows the clinical staff to handle the electrode easily even when wearing surgical gloves.

V. is a Low Cost Multipurpose ECG Electrodes.

4.1.1.4.2 Specifications:

Table 4.4 SKINTACT FS-RG1 Specifications[13]

Recommended Application	Monitoring
Electrode Shape	Rectangular, No Latex, No Pvc, Non-Sterile
Electrode Size- Max L/W [Cm]	4.1 / 3.2
Total Area [Cm^2]	Approximately 13.0
Shelf Life	36 Months Unopened Pouch
Characteristics	Disposable, Pre-Gelled,
Gel Area [Cm^2]	Approximately 2.0
Storing Conditions (Min. / Max.)	+5° C / +30° C
Adhesive Area [Cm^2]	Approximately 10.8

4.1.1.4.3 Materials:

Table 4.5 SKINTACT FS-RG1 Materials [14]

Metal	Stud Stainless Steel
Label	Pet-Foil
Backing Material	Stress-Adhesive-Pe-Foam
Adhesive Medical	Grade Acrylate

Sensor	Silver / Silverchloride (Ag/Agcl)
Gel	Aqua-Tac (Solid Adhesive Gel)
Release	Liner Siliconized Pet-Foil (Transparent)

4.1.2 Software:

4.1.2.1 LabVIEW programming language:

LabVIEW (laboratory virtual instrument engineering workbench) is a program development application, much like various commercial C/C++, FORTRAN or BASIC development system .National Instrument labVIEW is industry leading software tool for designing test, measurement and control systems. Since it was introduced in 1986, engineers and scientists worldwide who have relied on NI labVIEW graphical development for project throughout the product design cycle have gained improved quality, short time to market, and greater engineering and manufacturing efficiency by using the integrated labVIEW environment to interface with real world signals, analyse data for meaningful information and share result[15].

LabVIEW programs are called virtual instrument (VIs) because their appearance and operation imitate actual instruments. VI is applicable in many different types of application, starting from design to prototyping and deployment . A VI has three main parts:

I. The front panel looks like a front panel of a device. It is the user interface. Contains knobs, push bottoms, graphs, etc.

II. The block diagram (Executable code). It contains the actual source code but in block diagram format (Graphical Codes).
III. The icons and connectors. To use the VI as a sub VI the icons and connectors of the VI act as graphical parameter list for the VI. This allows for modular programming.

LABVIEW uses graphical programming language, called G programming; create programs allowing it to be in a "block diagram" form.

G programming is an easy to use graphical data flow programming language on which labVIEW is based which could be easier to use than conventional text based programming.

The labVIEW platform provide specific tools and models to solve specific applications ranging from designing signal processing algorithms to making voltage measurements, and can target any number of platforms from the desktop to embedded devices.

With version 9, labVIEW scales from design and development on PCs to several embedded targets from ruggedized toaster size prototypes to embedded systems on chips.

LabVIEW has many applications in bio-signal processing like ECG, EEG and MRI, because it provides a robust and efficient environment for resolving signal processing problems.

LabVIEW is commonly used for data acquisition, instrument control and industrial automation on a variety of platform including Microsoft Windows, Mac OS and Linux.

A VI within another VI is called a sub VI. The icon and connector panel of a VI work like a graphical parameter list so that other VIs can pass data to it as a sub VI. With these features labVIEW promotes and adheres to the concept of modular programming, the application can be divided into a series of tags, which can be divided again until a complicated application becomes a series of simple sub tasks. The project can be built to accomplish each sub task and then combine those VI for another block diagram to accomplish a larger task. Finally, the top-level VI contains a collection of sub VI that represents application functions. Because it can be execute each sub VI by itself, apart from the rest of the application, debugging is much easier. Furthermore, many low-sub VIs often perform tasks common to several application; so that the development of a specialized set of sub VIs suited to other application construct. [15] .

4.1.2.2 Proteus:

Proteus 7.0 is a Virtual System Modelling (VSM) that combines circuit simulation, animated components and microprocessor models to co-simulate the complete microcontroller based designs. This is the perfect tool for engineers to test their microcontroller designs before constructing a physical prototype in real time. This program allows users to interact with the design using on-screen indicators and/or LED and LCD displays and, if attached to the PC, switches and buttons[16]. One of the main components of Proteus 7.0 is the Circuit Simulation -- a product that uses a SPICE3f5 analogue simulator kernel combined with an event-driven digital simulator that allow users to utilize any SPICE model by any manufacturer. Proteus VSM comes with extensive debugging features, including breakpoints, single stepping and variable display for a neat design prior to hardware prototyping.

In summary, Proteus 7.0 is a program used to simulate the interaction between software running on a microcontroller and any analog or digital electronic device connected to it [16].

4.2 Proposed System:

4.2.1 Hardware:

The signal from the electrodes inducted in the instrumentation amplifier AD624 with gain equal to 1000 that was obtained by connecting pin 11 and 13 with pin 3 in the first stage, the second stage the signal was filtered by band pass filter using TL072;

$$F_C = \frac{1}{2\pi RC}$$

2nd order high pass cut off frequency from R= 30kΩ and C= 10uF is equal to 0.5 Hz,

2nd order low pass cut off frequency from R= 12kΩ and C= 100nF is equal to 130 Hz.

After that by using TL072 again in the third stage as an inverting amplifier with gain equal to 1 for one amplifier with R_f = 1kΩ and R_{in} = 1kΩ;

$$G = -\frac{Rf}{Rin}$$

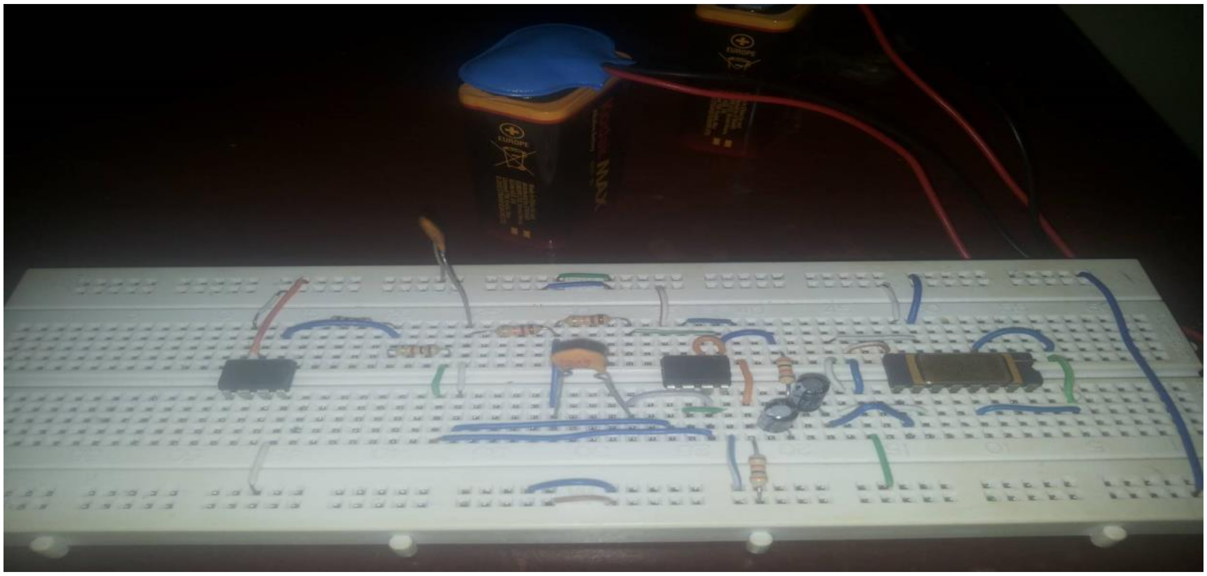

Figure 4.6 hardware

4.2.1.1 Arduino UNO Program:

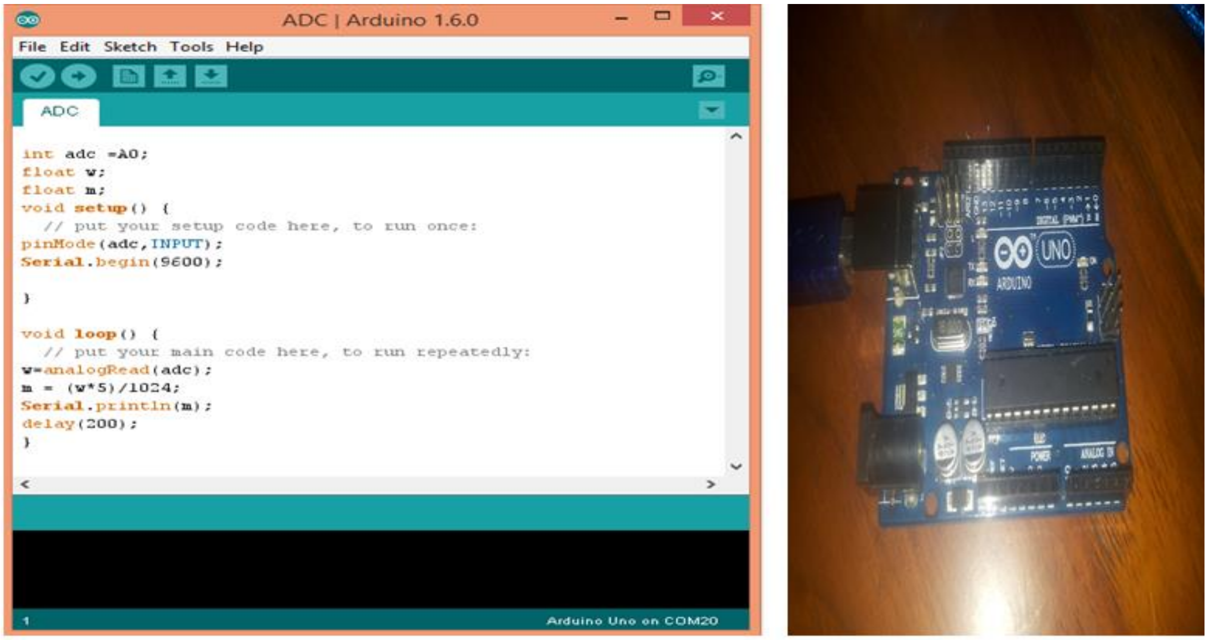

Figure 4.7 Arduino UNO Program

4.2.2 Software:

4.2.2.1 Proteus simulation:

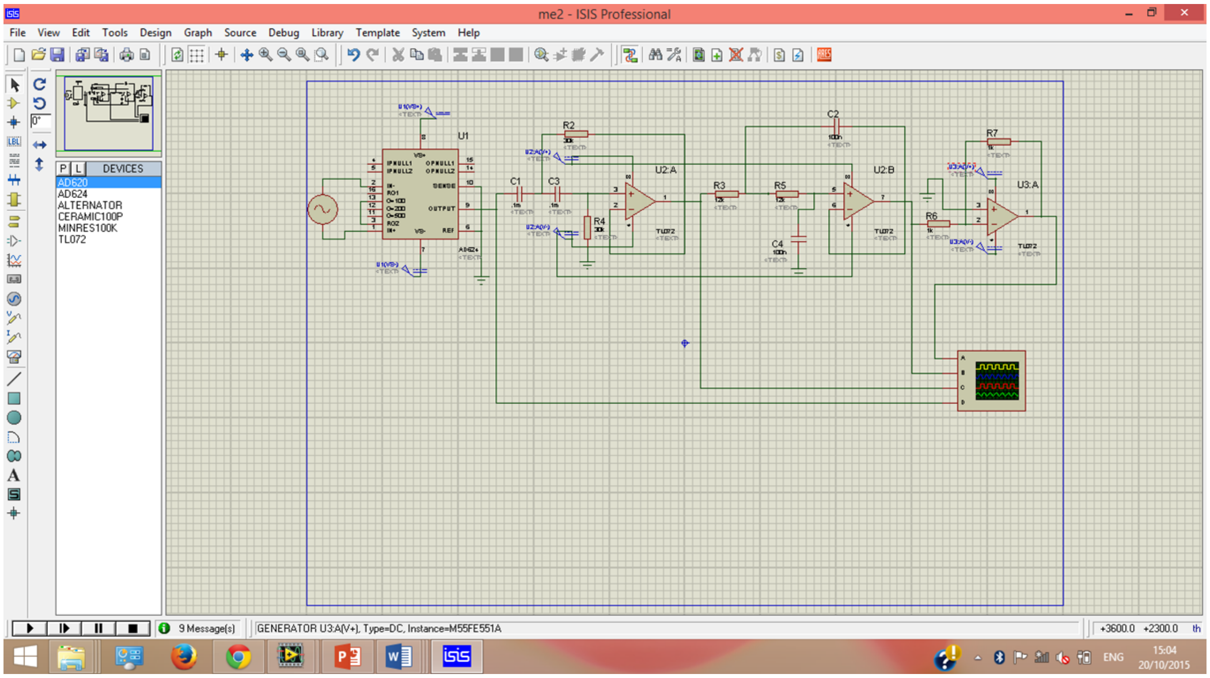

Figure 4.8 Proteus Simulation

4.2.2.2 LabVIEW Program:

I. VISA configure serial port.

II. VISA read: reads the specified number of bytes from the device interference specified by VISA resource name.

III. Fractional and exponential string to number.

IV. Array storing the element of ECG signal.

V. VISA close: close the device session by VISA resource name.

VI. Write to spread sheet file: convert 1D array of strings, signed integers or double precision numbers to text string.

VII. Number of cases.

VIII. While loop.

IX. Stop condition.

Case 1:

Calculate the number of elements that less than zero, then viewed in array 1.

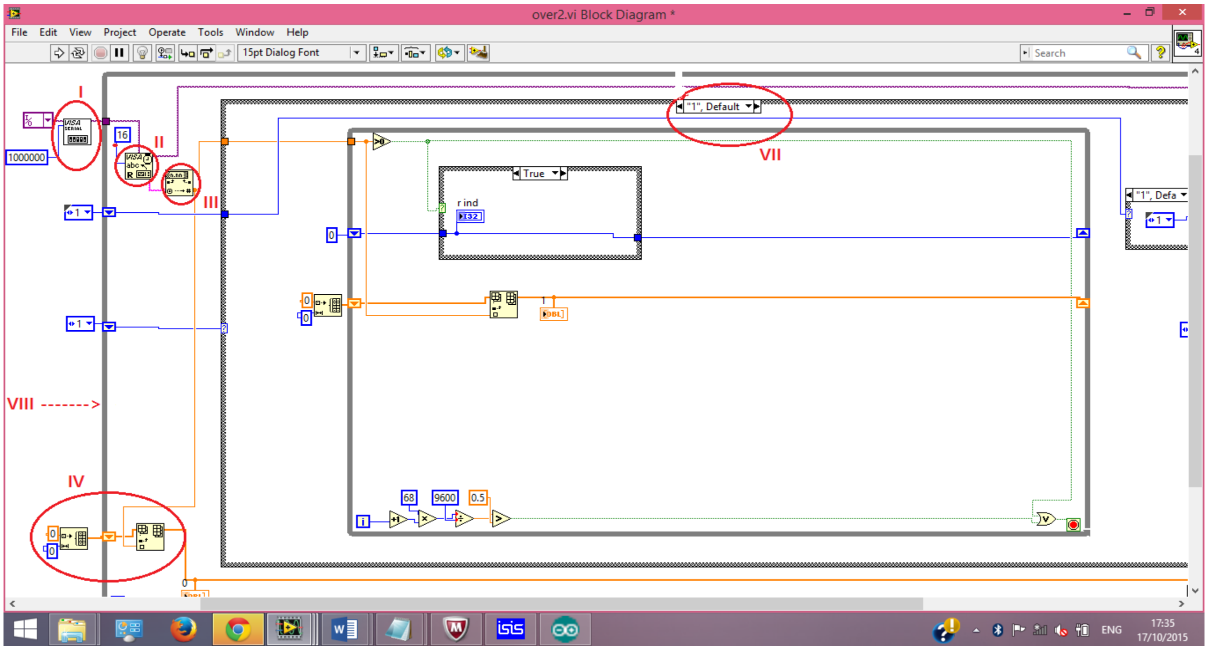

Figure 4.9 Case 1(a) (I, II, III, IV, VII, VIII)

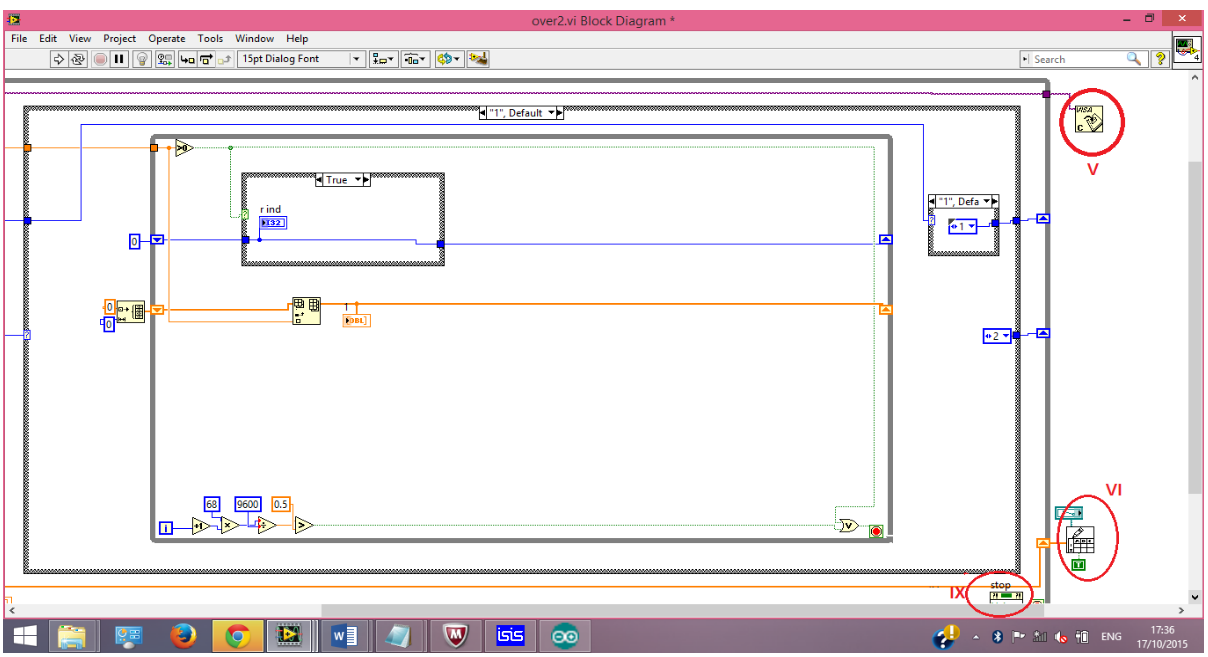

Figure 4.10 Case 1 (b) (V, VI, IX)

Case 2:

Calculate the number of elements that greater than zero, which representing P wave, then view in array 2, after that determine P amplitude and calculate P duration.

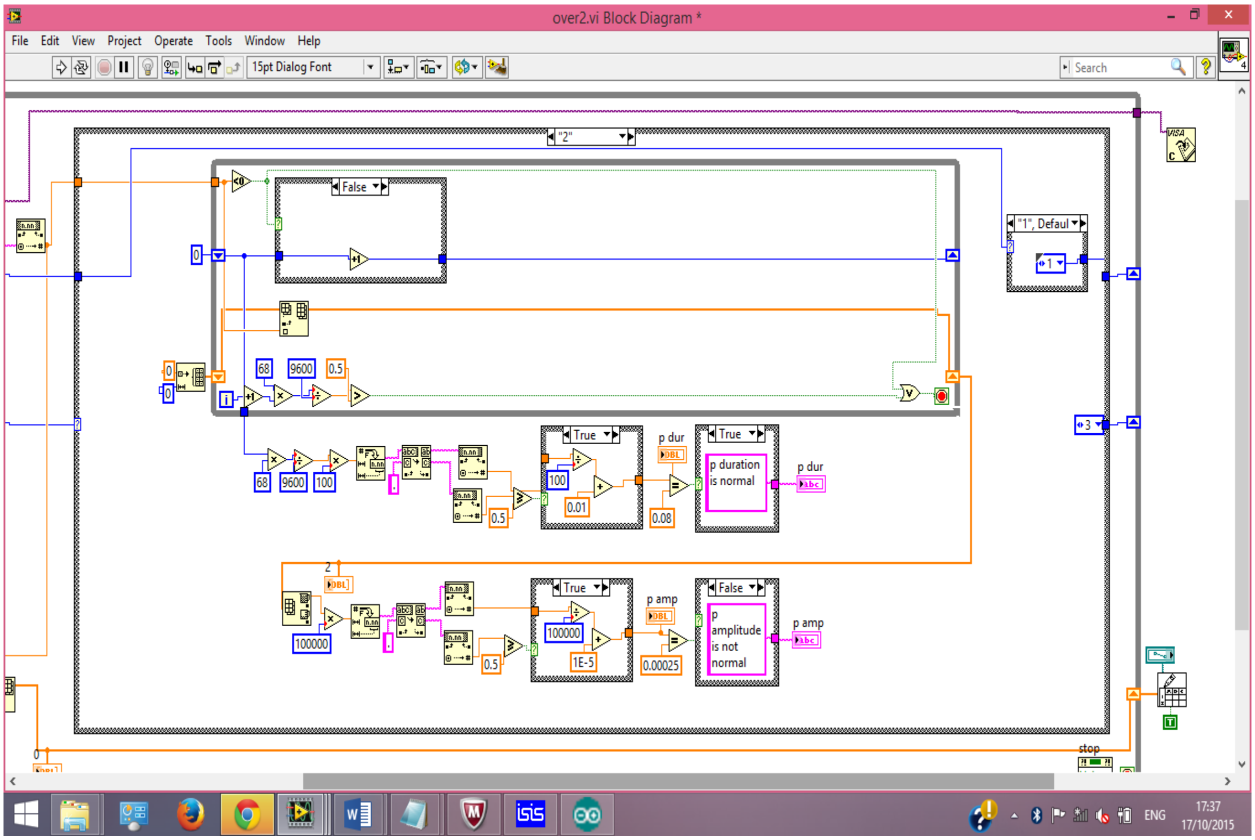

Figure 4.11 Case 2

Case 3:

Calculate the number of elements that less than zero, which representing PR interval, then view in array3 after that determine Q amplitude.

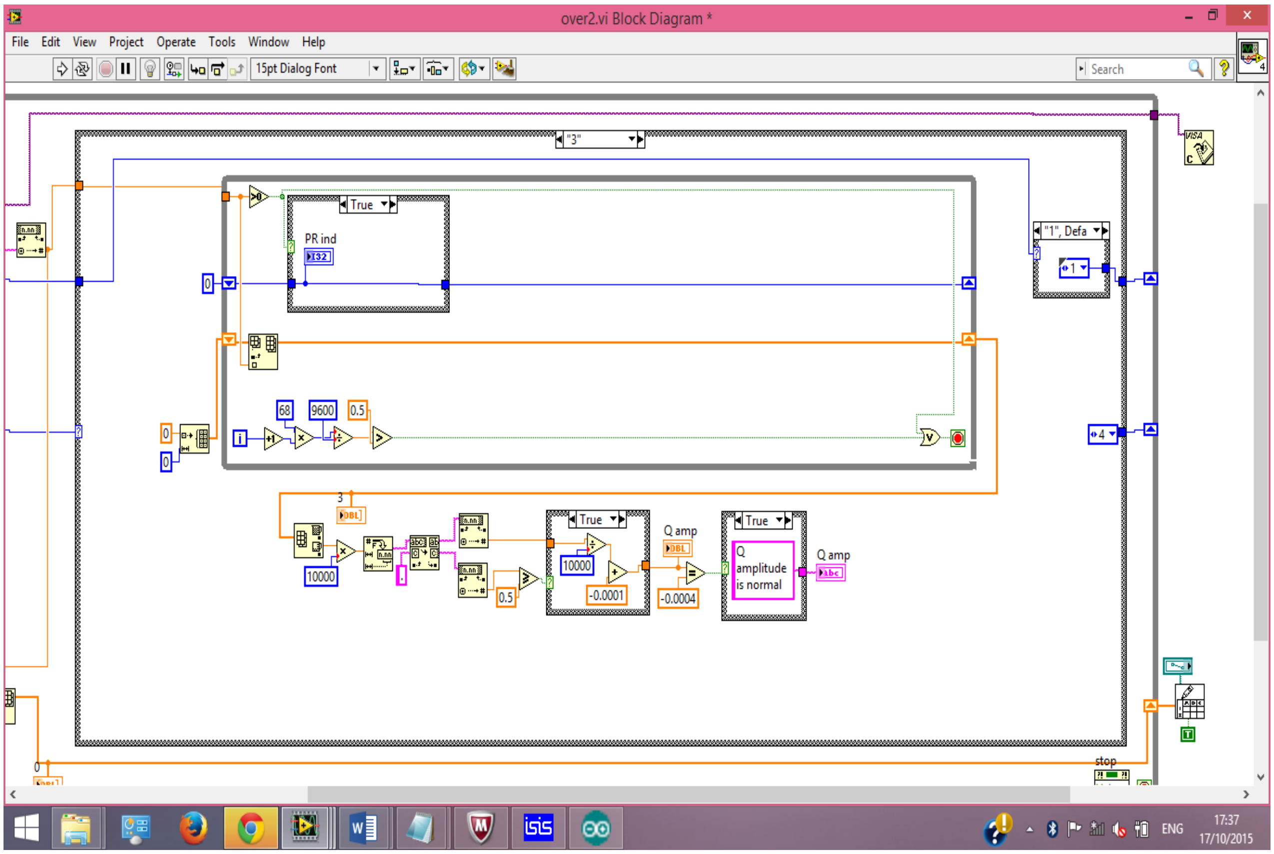

Figure 4.12 Case 3

Case 4:

Calculate the number of elements that greater than zero, which representing QRS interval, then view in array4 after that determine QRS amplitude.

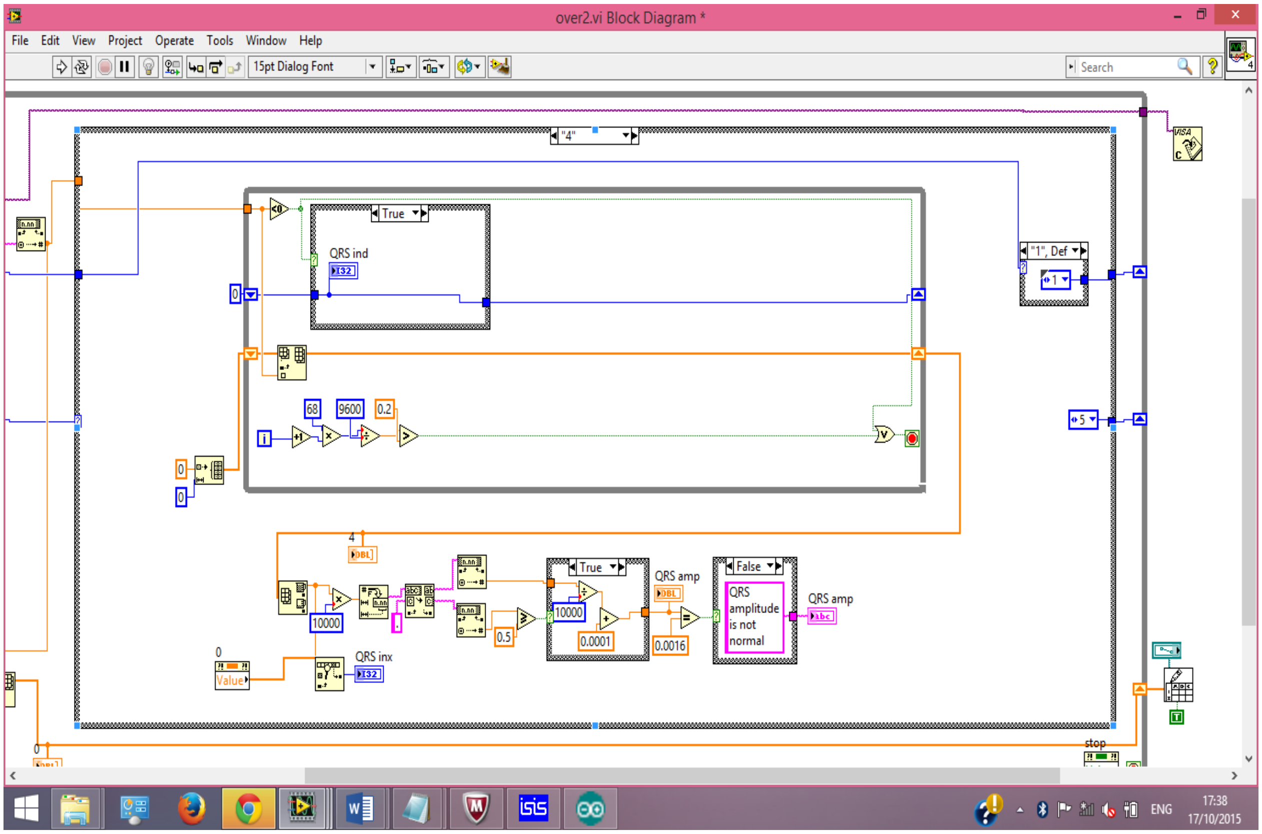

Figure 4.13 Case 4

Case 5:

Calculate the number of elements that less than zero, which representing ST interval, then view in array5 after that calculate f duration which include PR, QRS and ST intervals.

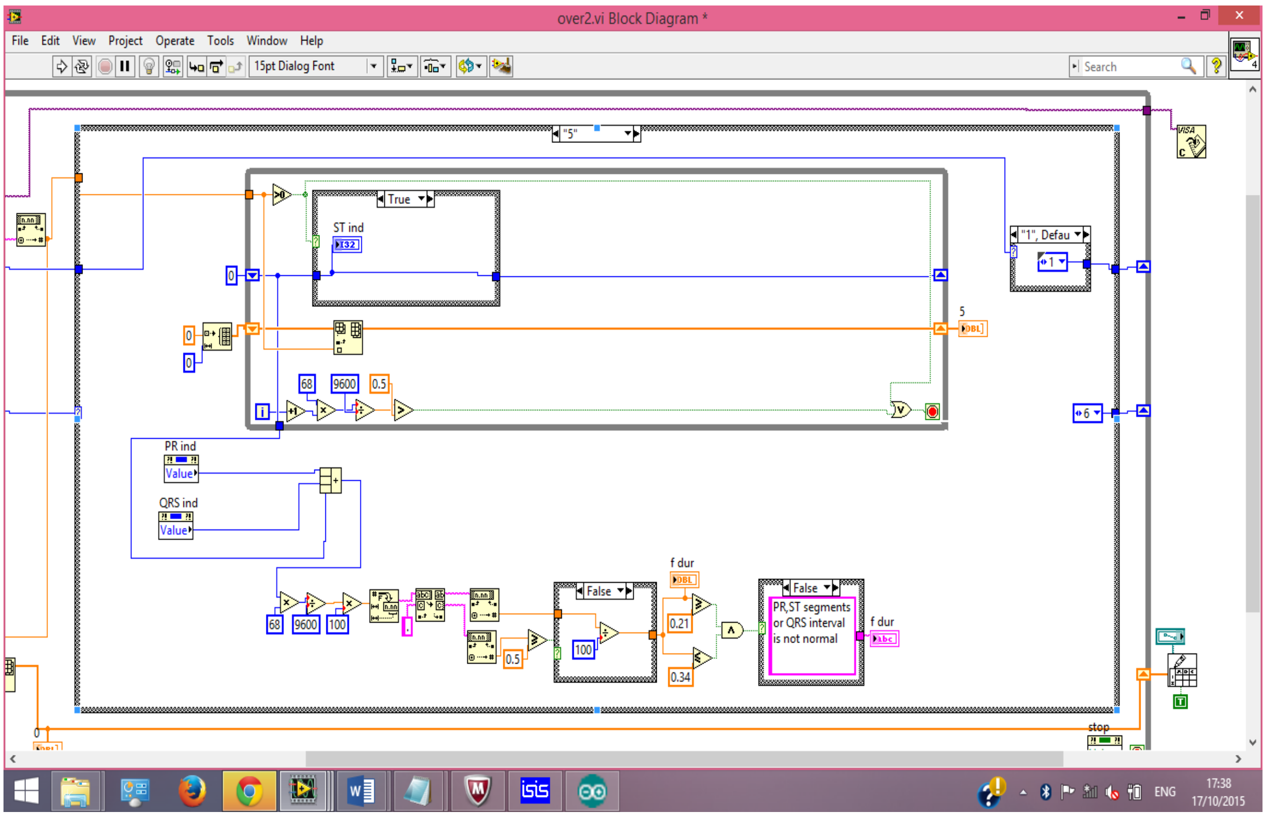

Figure 4.14 Case 5

Case 6:

Calculate the number of elements that greater than zero, which representing T wave, then view in array6 after that determine T amplitude and calculate T duration.

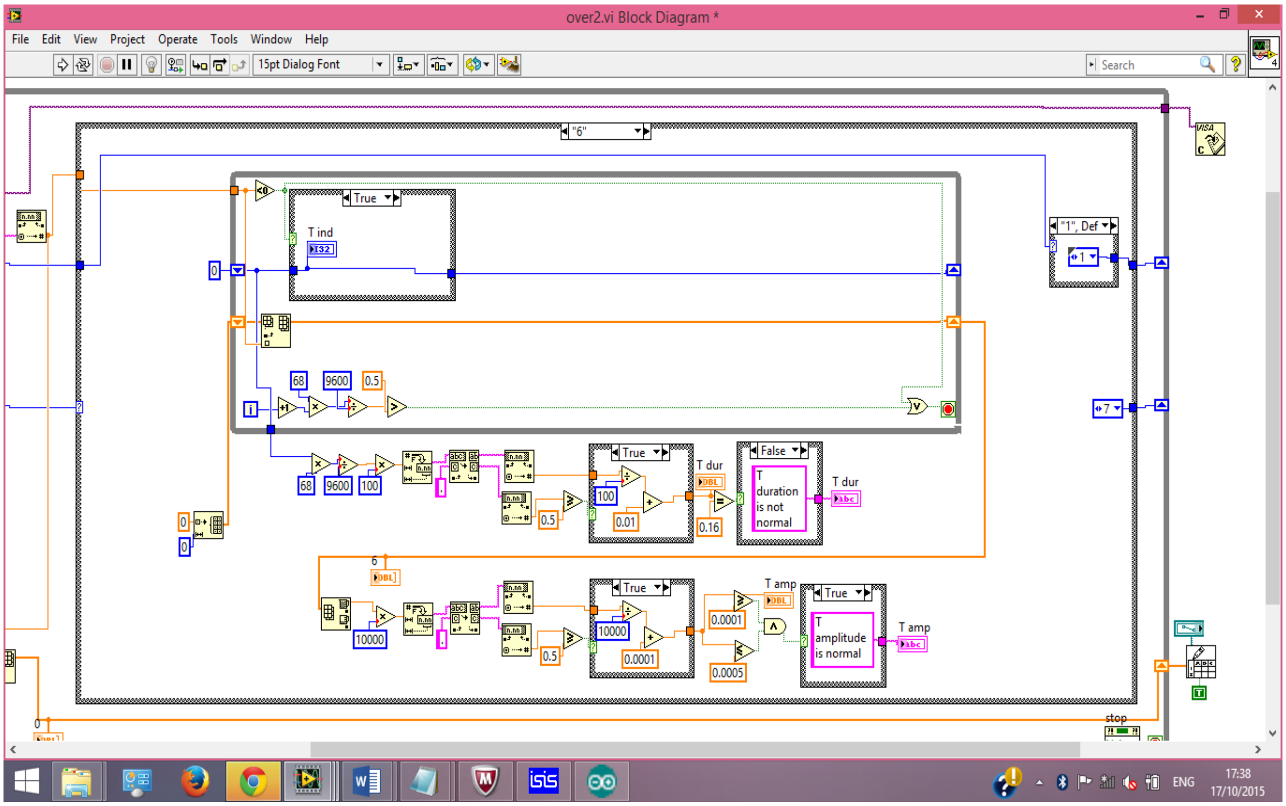

Figure 4.15 Case 6

Case 7:

use For viewing P amplitude, P duration, QRS amplitude, f duration, T amplitude, T duration and QRS index.

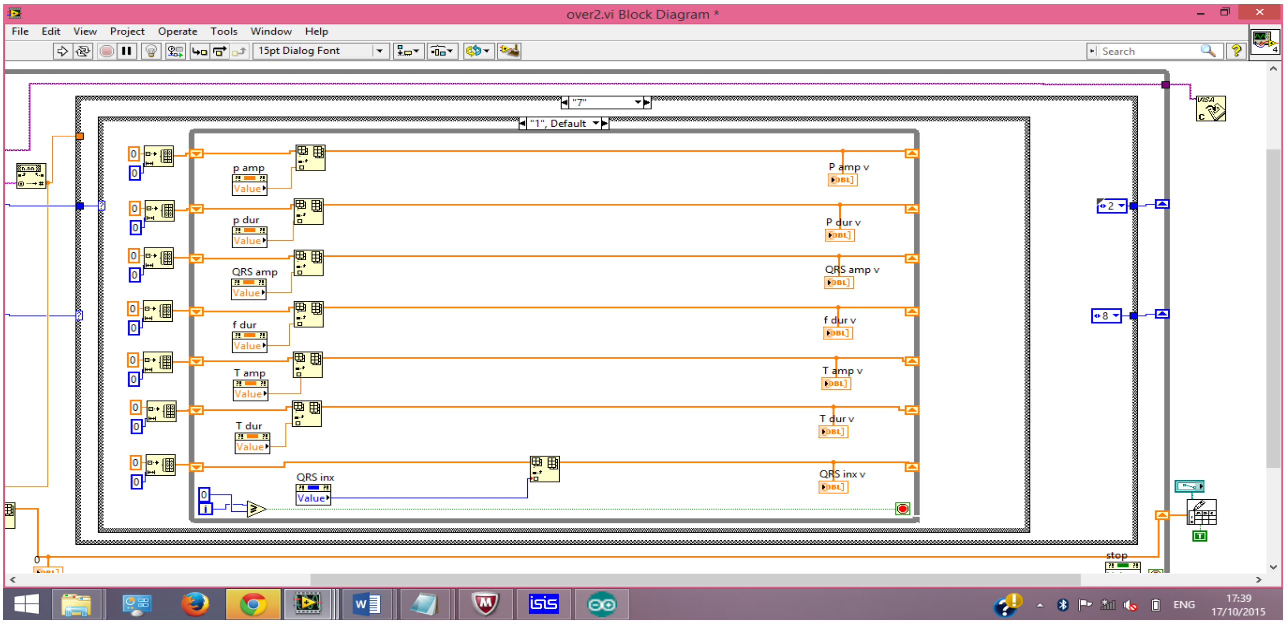

Figure 4.16 Case 7 (a)

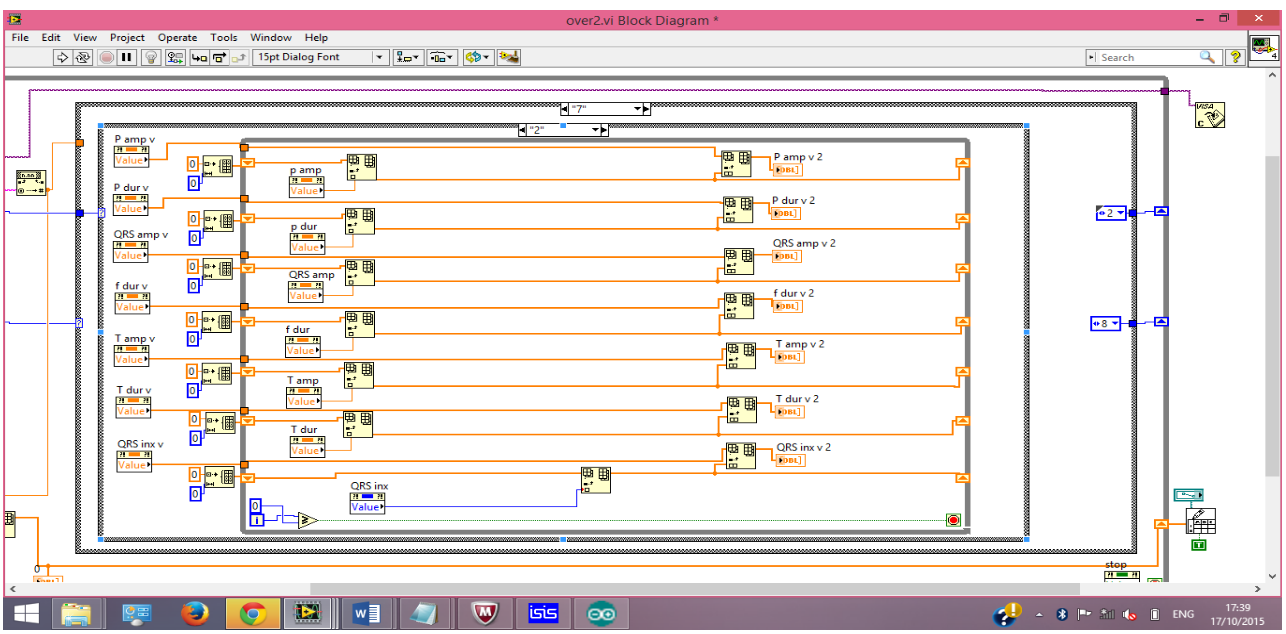

Figure 4.17 Case 7 (b)

Case 8:

Use For determine if heart rate is normal or abnormal.

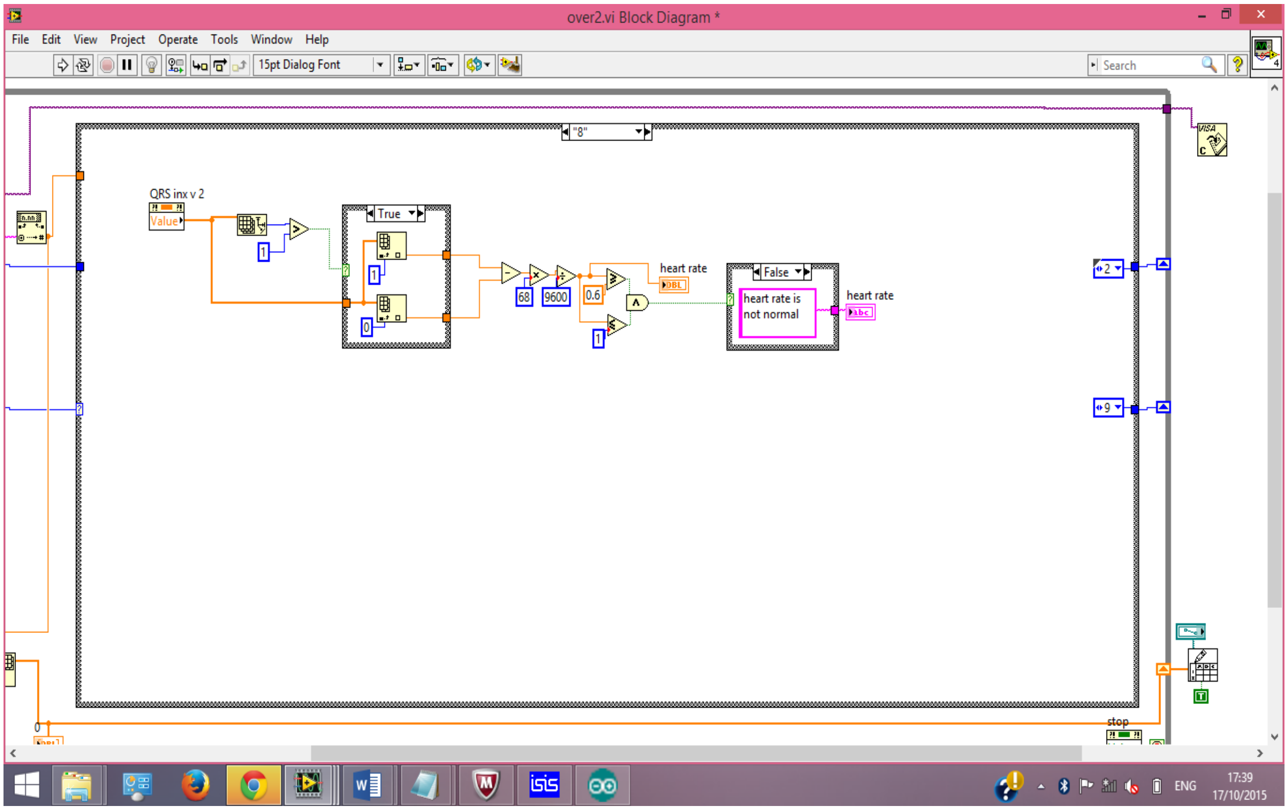

Figure 4.18 Case 8

Case 9:

Use for determine the condition for stop the while loop.

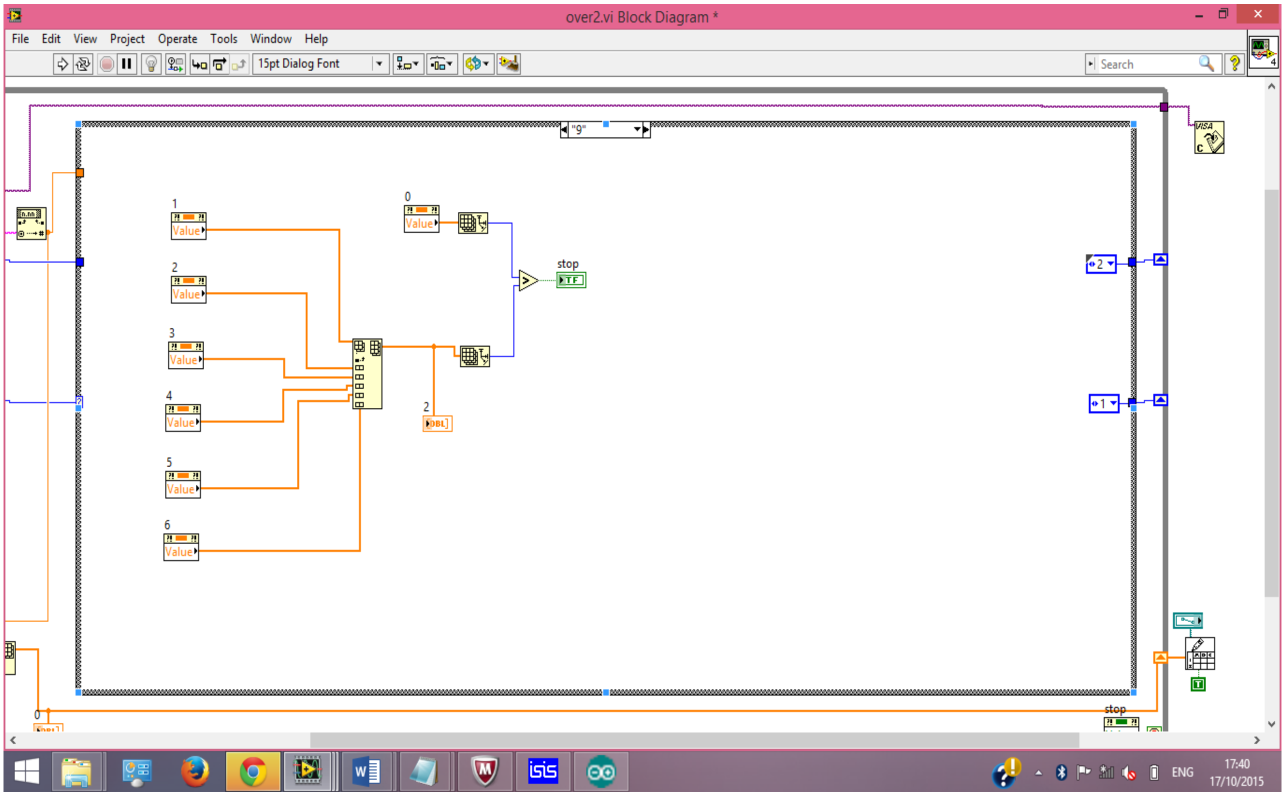

Figure 4.19 Case 9

CHAPTER FIVE

Results and Discussion

5.1 Results:

This project involves the Interaction with biological signals, which in general, would involve an actual human connection for data acquisition.

Successful implementation of the hardware necessary to obtain an ECG signal is evidenced in the overall results where ECG signal is obtained and displayed on analog and digital oscilloscope.

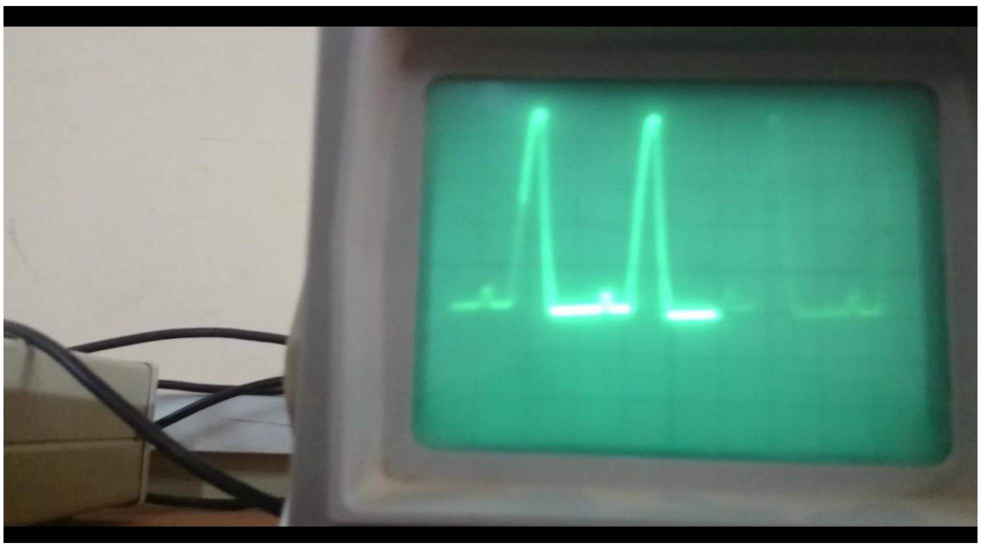

Figure 5.1 ECG signal displayed on analog oscilloscope

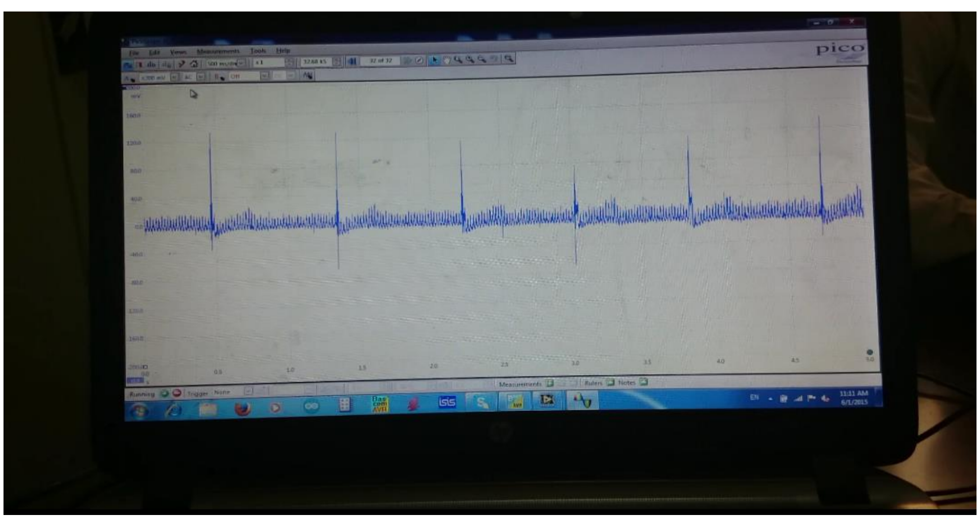

Figure 5.2 ECG signal displayed on digital oscilloscope

The front panel or the user panel displayed the ECG signal and its diagnose which include determining if the amplitude (P, Q, QRS, T), duration (P, f, T) and the heart rate are normal or not.

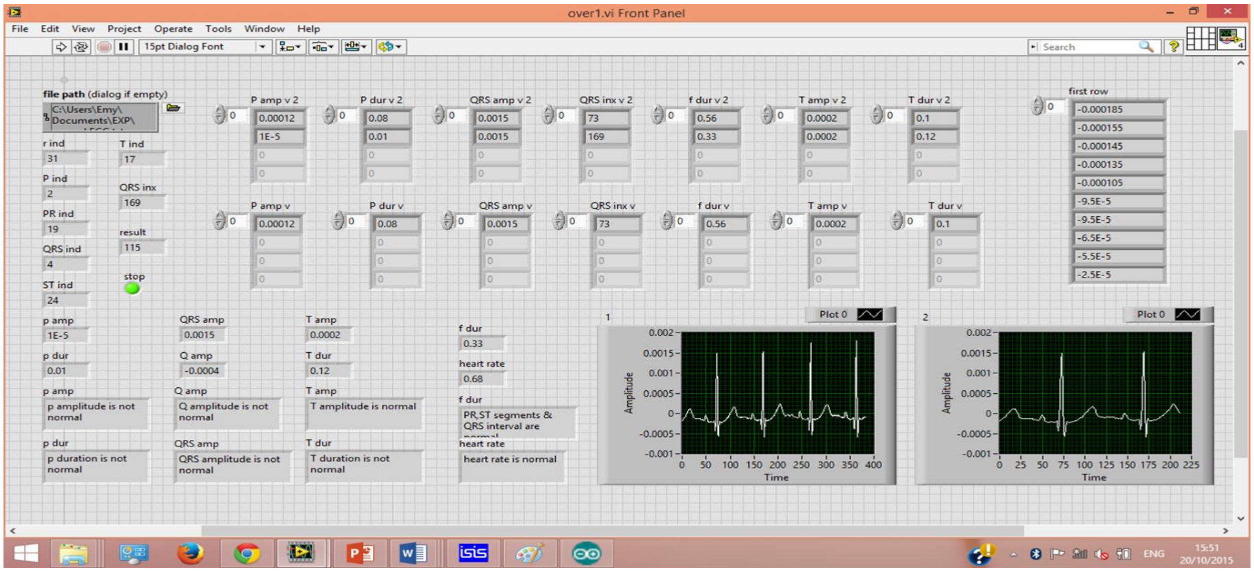

Figure 5.3 LabVIEW Results (a)

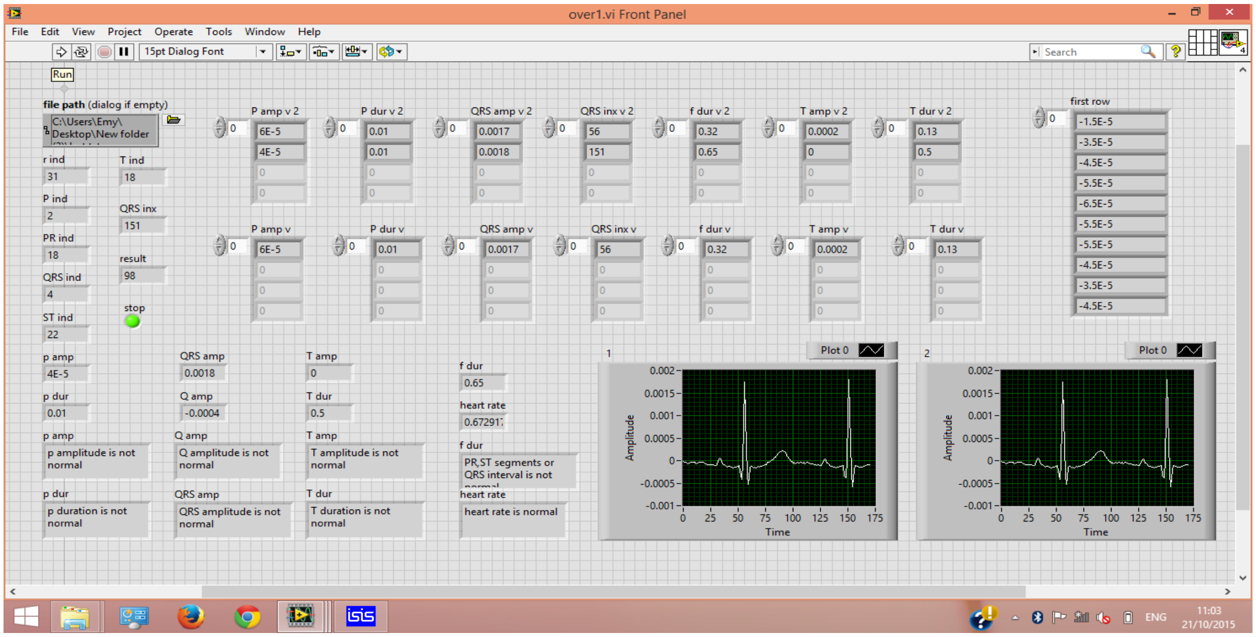

Figure 5.4 LabVIEW (b)

5.2 Discussion:

The first circuit we tried to acquire the signal using AD620 instrumentation amplifier but the signal we received was indistinguishable and unsettled so we replaced it with AD624 then we obtained a clearer signal due to its high CMRR.

The hardware obtained an ECG signal which is not stable thus it couldn’t be diagnosed and displayed in the labVIEW.

LabVIEW displayed and diagnosed a prerecorded ECG signal but for a more detailed diagnosis we need more cases structure for intervals.

CHAPTER SIX

Conclusion and Recommendations

6.1 Conclusion:

On the whole the upturn in technology these days particularly in medical equipment followed by the dilemma of proficiency inadequacy in dealing with it and rising cost specially in developing countries, so this project implement a simplified ECG diagnostic device with a bearable cost ; fulfilled by using Ag/AgCl electrode to picking up the signal then processing it with filters and amplifiers afterward the signal is displayed in labVIEW by connecting Arduino UNO to the serial port on the PC thus in labVIEW the obtained signal is then compared to a normal one then determined if normal or not.

6.2 Recommendations:

The recommendations of this project are:

I. Using 12 leads based ECG instead of 3 leads.

II. Using mobile phones as a telemedicine system for transmission real time ECG.

III. Using Bluetooth technology.

IV. To use more intervals (PR-ST-QT) in LabVIEW for more accurate results.

V. To use more features like power spectrum to diagnose the symptoms of the most heart diseases.

VI. To use PCB layout.

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