بسم الله الرحمن الرحيم

**Palestine Polytechnic University**

**College of Engineering & Technology**
**Electrical & Computer Engineering Department**
**Biomedical Engineering**

**Graduation Project**

# Design Of Patient Monitor

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## Abstract

This patient monitor project has been chosen according to the urgent need that is the patient monitor is used for monitoring vital signs of the patient during surgical operations or in ICU units.

This device measures the vital signs inside the body, and those signs are considered one of the main signs in the human beings body, those vital signs are:

Respiration rate (RR), heart rate (HR), electrocardiograph (ECG), temperature(T).

The previously mentioned signs are important for diagnosing the patients case, for example: (ECG), indicates the hearts waveform, by which the number of heart beats can be realized. Using ECG signal, can determine whether the patient needs a DC-shock or not; the ECG signal mention to demonstrate electrical activity of the heart, which can give an idea about heart rhythm as in heart disorder and myocardial infarction.

(heart rate): after measuring this vital sign can detect tachycardia, bradycardia, and arrhythmia.

(temperature): by this vital sign used to evaluate internal body temperature, the normal temperature is (37 $C^o$), assistance in identifying an fever and hypothermia.

(respiration rate): by detect the (R.R) that indicates pneumonia and central nervous disease.

To detect these vital signs we used biomedical sensors for each vital sign: respiration rate by using pressure sensor by fixing the sensor on the mask; electrocardiograph (ECG) by using (Ag-AgCl) electrodes; temperature by using thermal (PTC) sensor.

All required devices (circuits) responsible for measuring various vital sign implemented each alone, then these circuits connected and assembled together in one device, which called: ***patient monitor***, and occurred results represented and shown, using a liquid crystal displays (LCDs) by interfacing them with (PICs) microcontrollers.

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# Chapter one

# Introduction

## 1.1 Introduction

Our final project is to design a patient monitor device that can measure a user's vital signs; these vital signs are electrocardiograph (ECG), heart rate (H.R), respiration rate (R.R), and skin temperature (T). The device is consisted of the following main parts: external hardware (ECG, heart rate, respiration rate, body temperature) circuits, battery, microcontrollers, and LCDs. The rechargeable battery supplies the circuits, the microcontrollers, and the LCDs with the required voltages to drive these parts. The microcontrollers are used to display the results on the LCDs; they used to display the ECG signal continuously, the heart rate on graphical LCD, the respiration rate for one minute on numerical LCD, and the skin temperature on numerical LCD. All of the components are put together in one package which allows a user to take it anywhere and perform a measurement whenever and wherever operator wants.

## 1.2 What's the importance of the project?

It is undeniable that nowadays people are more aware of the health conditions. One of the most widely used methods to test the health conditions of an individual is to measure his ECG, heart rate, respiration rate, and body temperature.

Our project is very important, because this patient monitor project has been chosen according to the urgent need in ambulances, that is; the patient monitor fastened and placed inside the ambulance car for monitoring vital signs of the patient during transportation toward the hospital. Many patients die through transportation them toward the hospital without knowing the medical reasons for death. These vital signs are very important to know these medical reasons. Furthermore some patients like they are suffering from pneumonia or the inflammatory stroke need a continuous monitoring.

This importance of this device comes from the following:

- It is safe.
- Non invasive technique.
- It is easy to use.

### 1.3Project objectives:

The main objectives of this project are:

- To study the physiology of heart, inspiration and expiration, and the body temperature.
- Designing patient monitor instrument.
- Programming microcontrollers to display the results on the LCDs.

### 1.4 Task Time Schedule :

| Task Number | Task | Time (Weeks) |
|---|---|---|
| 1 | Collection information about the system | 3 |
| 2 | Planning for the system | 4 |
| 3 | Collecting the requirements | 4 |
| 4 | Design the system | 10 |
| 5 | Documentation of the system | 16 |

**Table (1) :** Task Time Schedule

### 1.5 Distribution of Tasks Schedule:

| 16 | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Time(Weeks) | Task |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | | 1 | |
| | | | | | | | | | | | | | | | | 2 | |
| | | | | | | | | | | | | | | | | 3 | |
| | | | | | | | | | | | | | | | | 4 | |
| | | | | | | | | | | | | | | | | 5 | |

**Table(2):** Distribution of Tasks Schedule

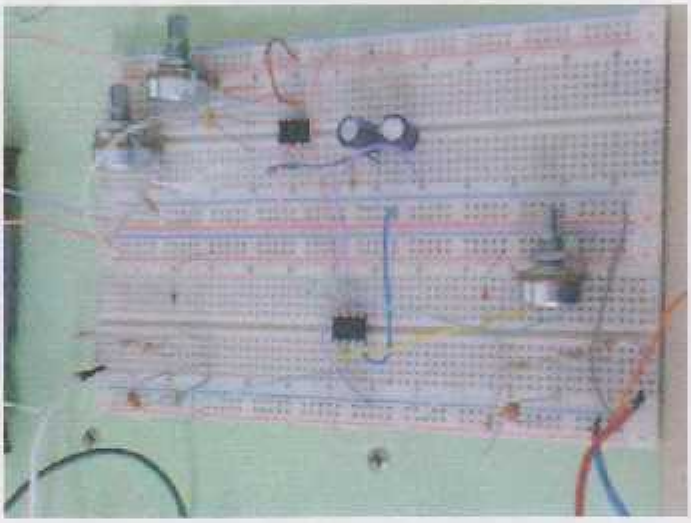
### 1.6 The Costs of Equipments:

| Equipment | Cost(NIS) |
|---|---|
| Pressure Sensor | 1200 |
| Numeric LCDS | 180 |
| PIC16f877 | 100 |
| PIC18f4550 | 400 |
| Graphical LCD | 350 |
| LM35 | 15 |
| Programmer | 450 |
| Ag-Agcl Electrodes | 400 |
| Batteries | 180 |
| Cover | 50 |
| Transformer | 150 |
| AD620 Amplifier | 60 |
| Resistors | 90 |
| Capacitors | 30 |
| Triac, Diac and Thyrestor | 20 |
| Heat Sinks | 10 |
| Amplifiers | 300 |
| **Total cost** | **3685** |

**Table(3):** The costs Of Equipments

### 1.7 Pictures of Project:

### 1.ECG Circuit:



ECG Circuit

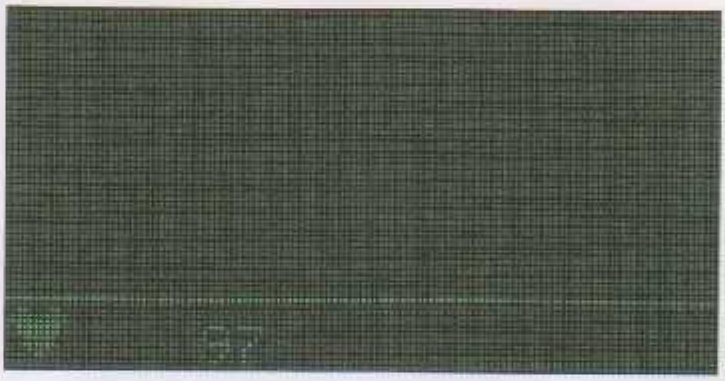
**2. ECG and Heart Rate Circuits :**

ECG and Heart Rate Circuits

**3. ECG Signal:**

ECG Signal

**4. Heart Rate Reading On LCD:**



Heart Rate Reading On LCD

**5.Respiration Rate Circuit:**

Respiration Rate Circuit

**6.Pressure Value at Inspiration:**

Pressure Value at Inspiration

**7.Pressure Value at Expiration:**

Pressure Value at Expiration

**8.Respiration Rate Pulses:**

Respiration Rate Pulses

# Chapter Two

## Physiological background

### 2.1 Human Heart

#### 2.1.1 Structure of the Human Heart

The human heart is primarily a shell. There are four cavities, or open spaces, inside the heart that fill with blood. Two of these cavities are called atria. The other two are called ventricles. The two atria form the curved top of the heart. The ventricles meet at the bottom of the heart to form a pointed base which points toward the left side of your chest. The left ventricle contracts most forcefully, so you can best feel your heart pumping on the left side of your chest.

The left side of the heart houses one atrium and one ventricle. The right side of the heart houses the others. A wall, called the septum, separates the right and left sides of the heart. A valve connects each atrium to the ventricle below it. The mitral valve connects the left atrium with the left ventricle. The tricuspid valve connects the right atrium with the right ventricle.

The top of the heart connects to a few large blood vessels. The largest of these is the **aorta**, or main artery, which carries nutrient-rich blood away from the heart. Another important vessel is the **pulmonary artery** which connects the heart with the lungs as part of the pulmonary circulation system. The two largest **veins** that carry blood into the heart are the superior vena cava and the inferior vena cava. They are called "**vena cava**" because they are the "heart's veins." The superior is located near the top of the heart. The inferior is located beneath the superior.

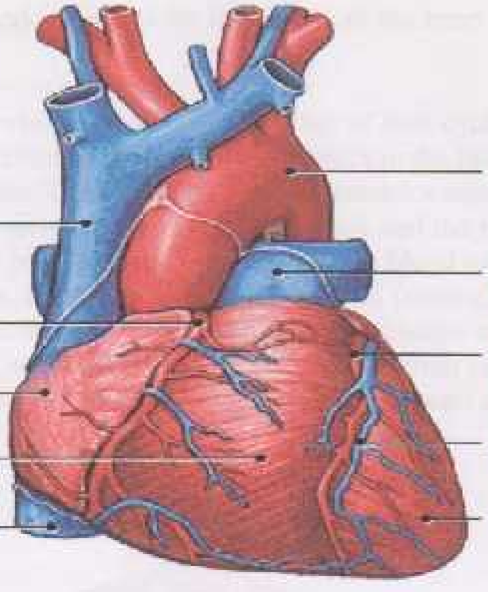



**Fig 2.1:** Structure of the heart,

http://www.milwaukeerenaissance.com, 5/10/2009

### 2.1.2 The circulation of Blood

The human circulatory system is really a two-part system whose purpose is to bring oxygen-bearing blood to all the tissues of the body. When the heart contracts it pushes the blood out into two major loops or cycles. In the systemic loop, the blood circulates into the body's systems, bringing oxygen to all its organs, structures and tissues and collecting carbon dioxide waste. In the pulmonary loop, the blood circulates to and from the lungs, to release the carbon dioxide and pick up new oxygen. The systemic cycle is controlled by the left side of the heart, the pulmonary cycle by the right side of the heart. Let's look at what happens during each cycle:

The systemic loop begins when the oxygen-rich blood coming from the lungs enters the upper left chamber of the heart, the left atrium. As the chamber fills, it presses open the mitral valve and the blood flows down into the left ventricle. When the ventricles contract during a heartbeat, the blood on the left side is forced into the aorta. This largest artery of the body is an inch wide. The blood leaving the aorta brings oxygen to all the body's cells through the network of ever smaller arteries and capillaries. The used blood from the body returns to the heart through the network of veins. All of the blood from the body is eventually collected into the two largest veins: the superior vena cava, which receives blood from the upper body, and the inferior vena cava, which receives blood from the lower body region. Both venal cave empty the blood into the right atrium of the heart.

From here the blood begins its journey through the pulmonary cycle. From the right atrium the blood descends into the right ventricle through the tricuspid valve. When the ventricle contracts, the blood is pushed into the pulmonary artery that branches into two main parts: one going to the left lung, one to the right lung. The fresh, oxygen-rich blood returns to the left atrium of the heart through the pulmonary veins.

Although the circulatory system is made up of two cycles, both happen at the same time. The contraction of the heart muscle starts in the two atria, which push the blood into the ventricles. Then the walls of the ventricles squeeze together and force the blood out into the arteries: the aorta to the body and the pulmonary artery to the lungs. Afterwards, the heart muscle relaxes, allowing blood to flow in from the veins and fill the atria again. In healthy people the normal (resting) heart rate is about 72 beats per minute, but it can go much higher during strenuous exercise. Scientists have estimated that it takes about 30 seconds for a given portion of the blood to complete the entire cycle: from lungs to heart to body, back to the heart and out to the lungs.

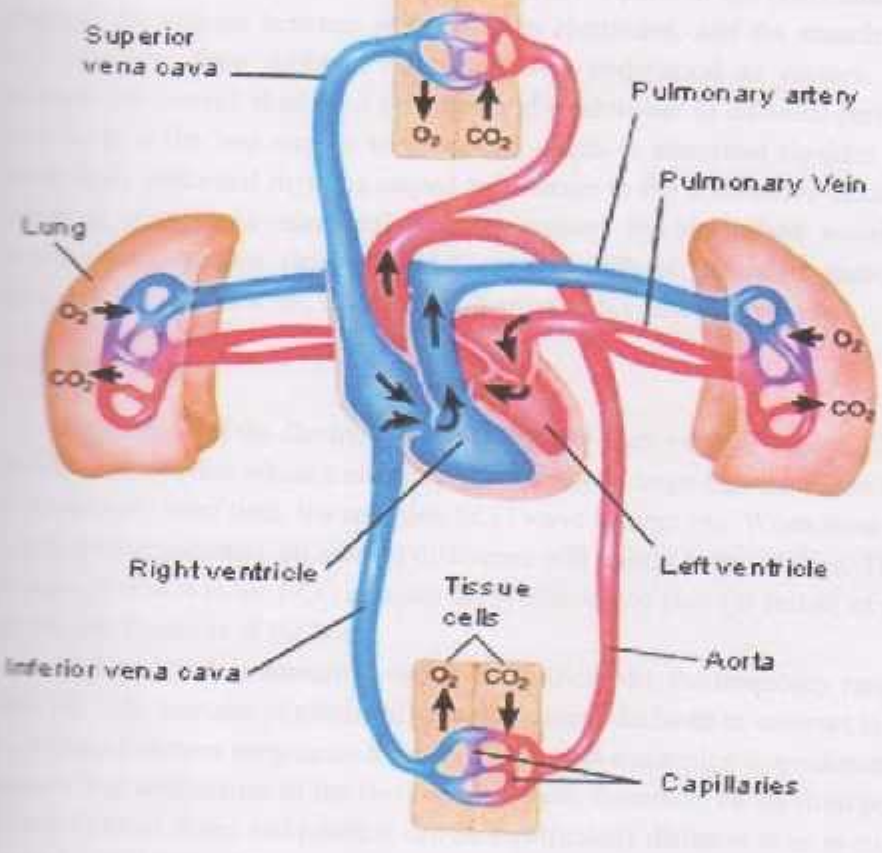



**Fig2.2:** circulatory system,

http://arditobook.pbworks.com/f/1179110236/Circul2.gif, 5/10/2009

## 2.2 The electrocardiograph (ECG)

### 2.2.1 What is the electrocardiography (ECG)?

Electrocardiography (ECG) is a transthoracic interpretation of the electrical activity of the heart over time captured and externally recorded by skin electrodes. It is a noninvasive recording produced by an electrocardiographic device. The etymology of the word is derived from *electro*, because it is related to electrical activity, *cardio*, Greek for heart, and graphs a Greek root meaning "to write"

Electrical impulses in the heart originate in the intercostals and travel through the intimate conducting system to the heart muscle. The impulses stimulate the myocardial muscle fibers to contract and thus induce systole. The electrical waves can be measured at electrodes placed at specific points on the skin. Electrodes on different sides of the heart measure the activity of different parts of the heart muscle. An ECG displays the voltage between pairs of these electrodes, and the muscle activity that they measure, from different directions, also understood as vectors. This display indicates the overall rhythm of the heart and weaknesses in different parts of the heart muscle. It is the best way to measure and diagnose abnormal rhythms of the heart, particularly abnormal rhythms caused by damage to the conductive tissue that carries electrical signals, or abnormal rhythms caused by electrolyte imbalances. In a myocardial infarction (MI), the ECG can identify if the heart muscle has been damaged in specific areas, though not all areas of the heart are covered.

### 2.2.2 ECG Signal

The spread of the electrical wave across the heart varies in speed. Simple physics dictates that where a change in potential of a large fraction of the heart occurs in a relatively brief time, the resulting ECG wave is large too. When most of the heart is at a similar potential, no voltage difference will appear at the surface. Thus, prominent waves in the ECG indicate the synchronized start (or finish) of activity in significant fractions of the heart.

These potentials amount to one or two mille-volts, the frequency range is (0.1-100) Hz. The impulse of electrical activity causing the heart to contract in a coordinated manner progresses through the heart in a complex three-dimensional pattern. The appearance of the electrocardiogram, therefore, varies from person to person as heart shape and position can be significantly different even in entirely normal individuals. Any person's pattern further alters with the location of the recording electrodes. Nevertheless, there are significant, consistently observed deflections and intervals in a typical electrocardiogram: the main 'peaks' are Interco as P, QRS, and T.

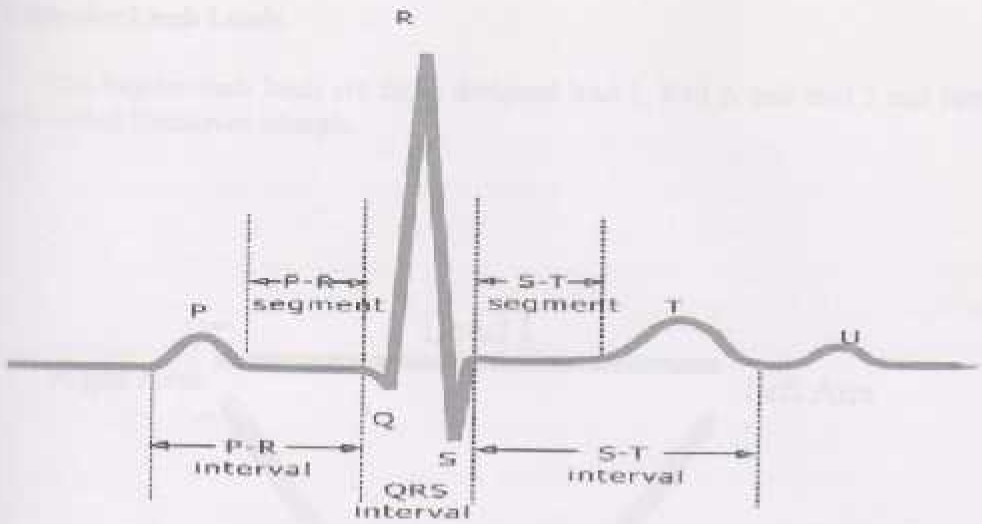



**Fig 2.3:** ECG signal.

http://zone.ni.com/cms/images/devzone/tut/2007-07-09_141618.jpg, 7/10/2009

The P-wave indicates the electrical activity associated with contraction of the cardiac atria, the heart's upper chambers.

The P-R interval is the delay between the beginning of activity in the atria and the ventricles (atria-ventricular conduction time). In adults, normal P-R intervals range between 120 and 200 milliseconds, occasionally being shorter in children and slightly longer in the aged. The P-R interval shortens at high heart rates (e.g. due to exercise or to fever) and increases at lower heart rates (e.g. during sleep).

The QRS complex indicates the onset of contraction of the ventricles. The shape of the QRS complex may be modified by a number of physiological factors (e.g. body position and breathing pattern). In normal adults, the duration of the QRS complex varies between 60 and 100 milliseconds; in children it tends to be shorter.

The Q-T interval is measured from the beginning of the QRS complex to the end of the T-wave and represents the time between activation of electrical activity in the ventricles and their return to the resting state. Like the P-R interval, the Q-T interval shortens at high heart rates and increases at lower rates.

The T-wave indicates when the electrical activity associated with the cells in the cardiac ventricle returns to the resting state after electrical activation. Thus, it signals the start of relaxation of the ventricle walls. It tends to be longer lasting than QRS because the onset of relaxation across the ventricle is less tightly synchronized than that of contraction.

2.2.3 Bipolar Limb Leads

The bipolar limb leads are those designed lead 1, lead 2, and lead 3 and form what is called Einthoven triangle.

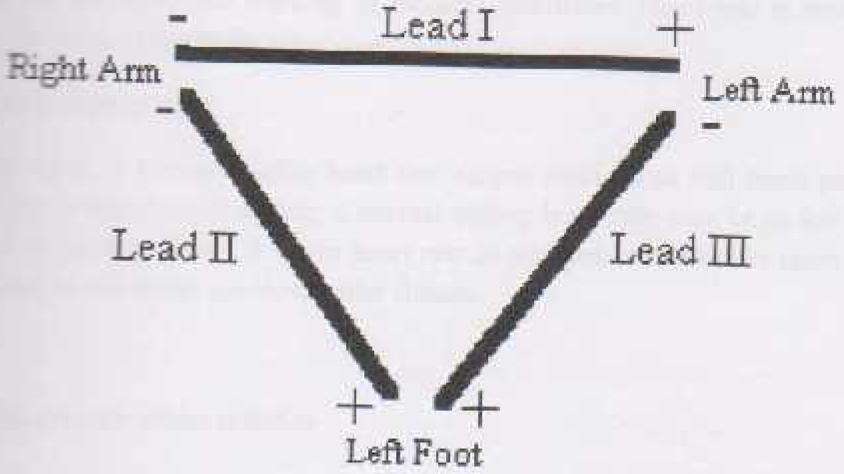



Fig 2.4: Einthoven triangle,

http://lanoswww.epfl.ch/personal/schimmin/uni/ecglex/einthov.gif, 7/10/2009

- Lead 1: LA is connected to the amplifier's non inverting input, while RA is connected to the inverting input.
- Lead 2: The LL electrode is connected to the amplifier's non inverting input, while the RA is connected to the inverting input.
- Lead 3: The LL electrode is connected to the non inverting input, while the RA is connected to the inverting input.

## 2.3 Heart Rate

### 2.3.1 What is the heart rate?

Heart rate is the number of heart beats per unit time, usually per minute. The heart rate is based on the number of contractions of the ventricles (the lower chambers of the heart). It can vary with as the body's need for oxygen changes, such as during exercise or sleep. The measurement of heart rate is used by medical professionals to assist in the diagnosis and tracking of medical conditions. Heart rate is measured by finding the pulse of the body.

### 2.3.2 Normal heart rate

For an adult, a normal resting heart rate ranges from 60 to 100 beats per minute (BPM). For a well-trained athlete, a normal resting heart rate may be as low as 40 to 60 BPM. In healthy adults, a lower heart rate at rest generally implies more efficient heart function and better cardiovascular fitness.

### 2.3.2 Heart rate abnormalities

Tachycardia: is a resting heart rate more than 100 beats per minute. This number can vary as smaller people and children have faster heart rates than average adults.

Bradycardia: is defined as a heart rate less than 60 beats per minute although it is seldom symptomatic until below (50 Bpm) when a human is at total rest.

Arrhythmia: Arrhythmias are abnormalities of the heart rate and rhythm (sometimes felt as palpitations). They can be divided into two broad categories: fast and slow heart rates. Some cause few or minimal symptoms. Others produce more serious symptoms of lightheadedness, dizziness and fainting.

The table below shows estimated target heart rates for different ages. Look for the age category closest to yours, then read across to find your target heart rate.

| Age | Target HR Zone 50–85 % | Average Maximum Heart Rate 100 % |
|---|---|---|
| 20 years | 100–170 beats per minute | 200 beats per minute |
| 25 years | 98–166 beats per minute | 195 beats per minute |
| 30 years | 95–162 beats per minute | 190 beats per minute |
| 35 years | 93–157 beats per minute | 185 beats per minute |
| 40 years | 90–153 beats per minute | 180 beats per minute |
| 45 years | 88–149 beats per minute | 175 beats per minute |
| 50 years | 85–145 beats per minute | 170 beats per minute |
| 55 years | 83–140 beats per minute | 165 beats per minute |
| 60 years | 80–136 beats per minute | 160 beats per minute |
| 65 years | 78–132 beats per minute | 155 beats per minute |
| 70 years | 75–128 beats per minute | 150 beats per minute |

**Table (4):** Estimated target heart rates for different ages,

http://www.americanheart.org/presenter.jhtml?identifier=4736, 8/10/2009

maximum heart rate is about 220 minus your age. The table above is averages, so use them as general guidelines.

## 2.3 Body Temperature

### 2.3.1 What is body temperature?

Body temperature is a measure of the body's ability to generate and get rid of heat. The body is very good at keeping its temperature within a narrow, safe range in spite of large variations in temperatures outside the body.

When you are too hot, the blood vessels in your skin expand (dilate) to carry the excess heat to your skin's surface. You may begin to sweat, and as the sweat evaporates, it helps cool your body. When you are too cold, your blood vessels narrow (contract) so that blood flow to your skin is reduced to conserve body heat. You may start shivering, which is an involuntary, rapid contraction of the muscles. This extra muscle activity helps generate more heat. Under normal conditions, this keeps your body temperature within a narrow, safe range.

### 2.3.2 Where is body temperature measured?

Your body temperature can be measured in many locations on your body. The skin surface, mouth, ear, armpit, and rectum are the most commonly used places. Temperature can also be measured on your forehead. In our project, we will measure the temperature from the skin surface.

### 2.3.3 What is normal body temperature?

Most people think of a "normal" body temperature as an oral temperature of 37°C. This is an average of normal body temperatures. Your temperature may actually be 1°F (0.6°C) or more above or below 37°C. Also, your normal body temperature changes by as much as 0.6°C (1°F) throughout the day, depending on how active you are and the time of day. Body temperature is very sensitive to hormone levels and may be higher or lower when a woman is ovulating or having her menstrual period.

A rectal or ear (tympanic membrane) temperature reading is 0.5 to 1°F (0.3 to 0.6°C) higher than an oral temperature reading. A temperature taken in the armpit is 0.5 to 1°F (0.3 to 0.6°C) lower than an oral temperature reading.

### 2.3.4 High or low body temperature diseases

#### 2.3.4.1 What is a fever?

Fever is one of the most common diseases in cases of high body temperature. In most adults, an oral temperature above 37.8°C (100°F) or a rectal or ear temperature above 38.3°C (101°F) is considered a fever. A child has a fever when his or her rectal temperature is 38°C (100.4°F) or higher.

### 2.3.4.2 Can a low body temperature be dangerous?

An abnormally low body temperature (hypothermia) can be serious, even life-threatening. Low body temperature may occur from cold exposure, shock, alcohol or drug use, or certain metabolic disorders, such as diabetes or hypothyroidism. A low body temperature may also be present with an infection, particularly in newborns, older adults, or people who are frail. An overwhelming infection, such as sepsis, may also cause an abnormally low body temperature.

## 2.4 Human Respiratory System

### 2.4.1 What is the respiratory system?

The respiratory system is made up of the organs in your body that help you to breathe. The goal of breathing is to deliver oxygen to the body and to take away carbon dioxide.

### 2.4.2 Body Parts of the Respiratory System

- Nostrils
- Nasopharynx
- Oral Pharynx
- Glottis
- Trachea
- The right and left Bronchi
- Bronchioles, each of which terminates in a cluster of Alveoli

### 2.4.3 The pathway of inhaled air

- Air enters the nostrils
- passes through the nasopharynx,
- the oral pharynx
- through the glottis
- into the trachea
- into the right and left bronchi, which branches and rebranches into bronchioles, each of which terminates in a cluster of alveoli

Only in the alveoli does actual gas exchange takes place. There are some 300 million alveoli in two adult lungs. These provide a surface area of some 160 $m^2$.

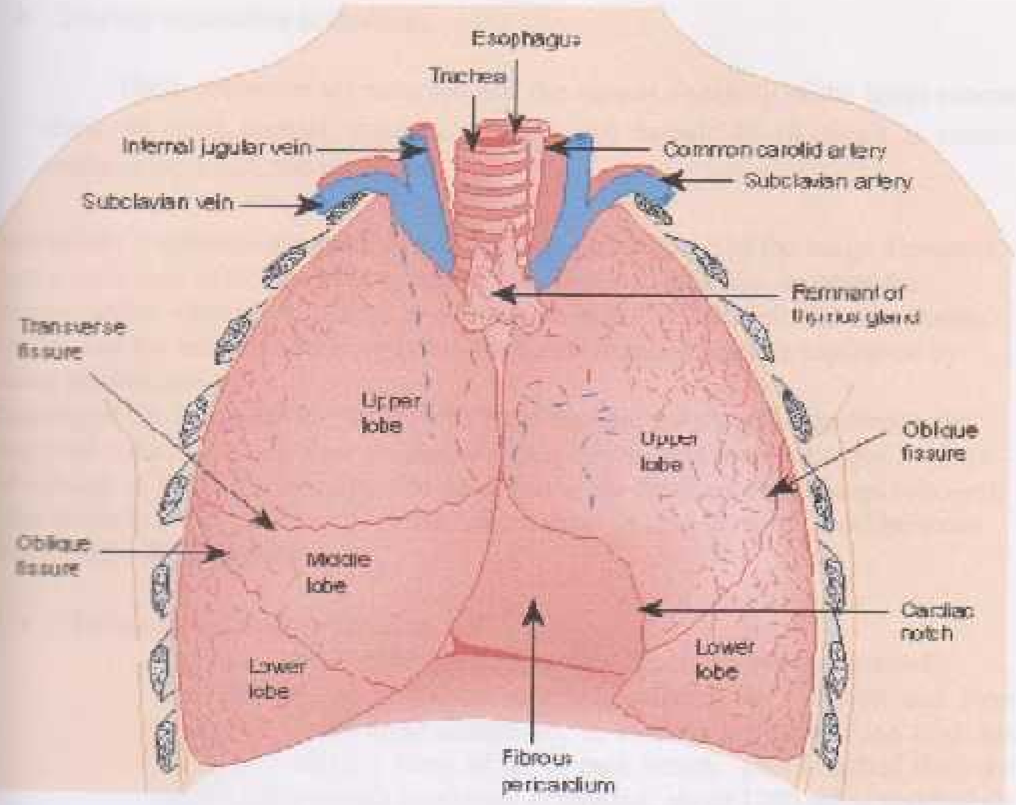


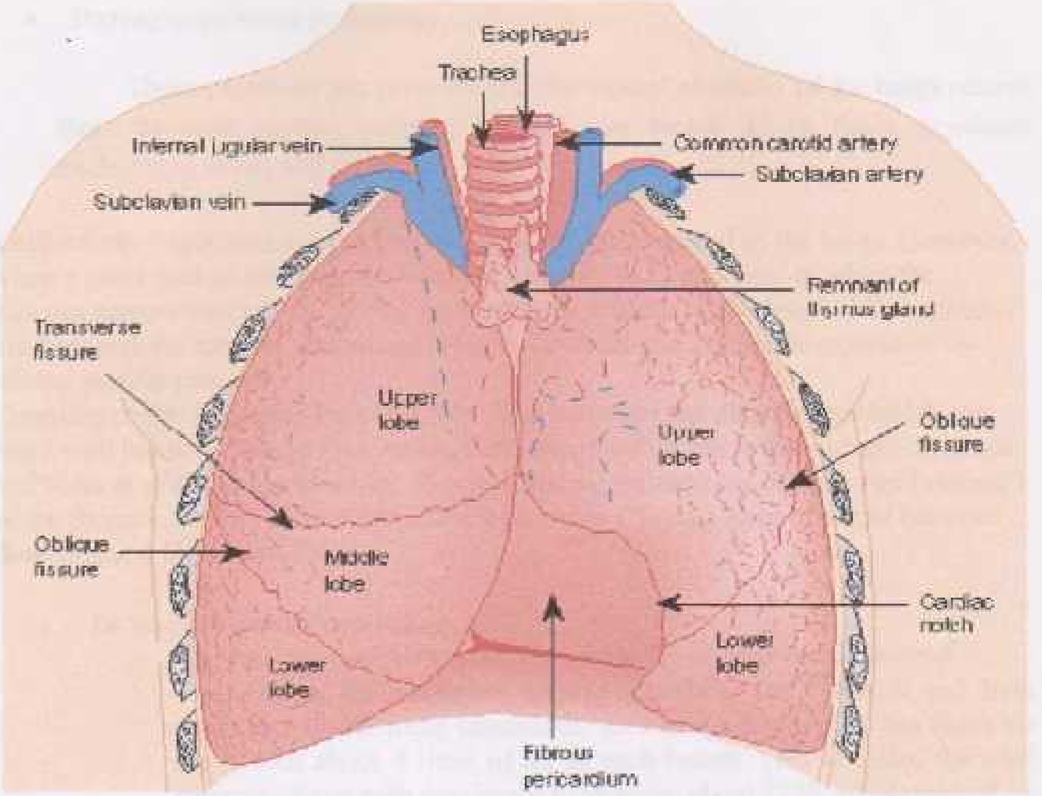

**Fig2.5:** Body Parts of the Respiratory System,

http://www.differencebetween.net, 10/10/2009

### 2.4.4 Inspiration (inhaling) and Expiration (exhaling)

- **During inspiration (inhaling),**
  - The external intercostals muscles contract, lifting the ribs up and out.
  - The diaphragm contracts, drawing it down.

**Inspiration:** Inspiration is the active part of the breathing process, which is initiated by the respiratory control centre in medulla oblongata (Brain stem). Activation medulla causes a contraction of the diaphragm and intercostals muscles leading to an expansion of thoracic cavity and a decrease in the pleural space pressure. The diaphragm is a dome-shaped structure that separates the thoracic and abdominal cavities and is the most important muscle of inspiration. When it contracts, it moves downward and because it is attached to the lower ribs it also rotates the ribs toward the horizontal plane, and thereby further expands the chest cavity. In normal quite breathing the diaphragm moves downward about 1 cm but on forced inspiration/expiration total movement could be up to 10cm. When it is paralysed it moves to the opposite direction (upwards) with inspiration, paradoxical Movement. The external intercostals muscles connect adjacent ribs. When they contract the ribs are pulled upward and forward causing further increase in the volume of the thoracic cavity. As a result fresh air flows along the branching airways into the alveoli until the alveolar pressure equals to the pressure at the airway opening.

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- **During expiration (exhaling),**

These processes are reversed and the natural elasticity of the lungs returns them to their normal volume. At rest, we breath 15-18 times a minute exchanging about 500 ml of air.

**Expiration:** Expiration is a passive event due to elastic recoil of the lungs. However, when a great deal of air has to be removed quickly, as in exercise, or when the airways narrow excessively during expiration, as in asthma, the internal intercostals muscles and the anterior abdominal muscles contract and accelerate expiration by raising pleural pressure.
Coupling of the lungs and the chest wall: The lungs are not directly attached to the chest wall but they change their volume and shape according to the changes in shape and volume of the thoracic cavity. Pleura covering the surfaces of the lungs (visceral) or the thoracic cavity (parietal) together with a thin (20 μm) layer of liquid between them create a liquid coupling.

- **In more vigorous expiration,**
  - The internal intercostals muscles draw the ribs down and inward
  - The wall of the abdomen contracts pushing the stomach and liver upward. Under these conditions, an average adult male can flush his lungs with about 4 liters of air at each breath. This is called the vital capacity. Even with maximum expiration, about 1200 ml of residual air remain.

# Chapter Three

## Patient Monitor Design

### 3.1 ECG design

The ECG circuit in Fig. 3.1

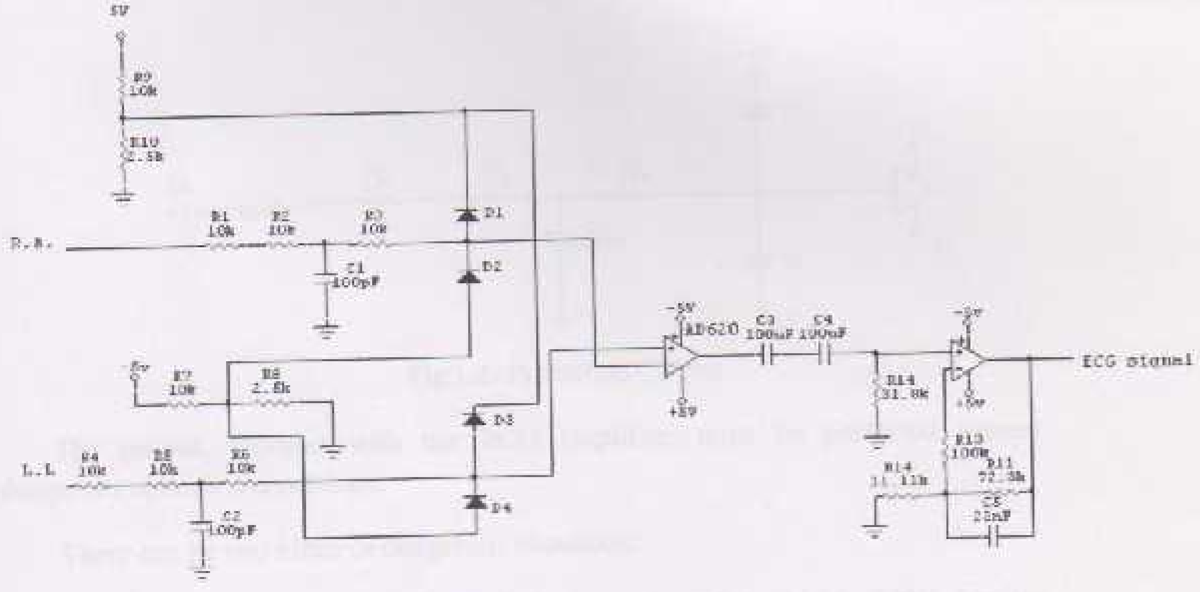


**Fig3.1:** ECG circuit

- **ECG Surface Electrodes:**

In our ECG device, the surface electrodes placed on three extremities are used to catch very weak and time-varying potentials. The electrodes used in our design are Ag-AgCl electrodes. Three electrodes will be attached to the following sites: the right arm, the left arm, and the right leg to display the lead 2 signal.

- **Protection circuit:**

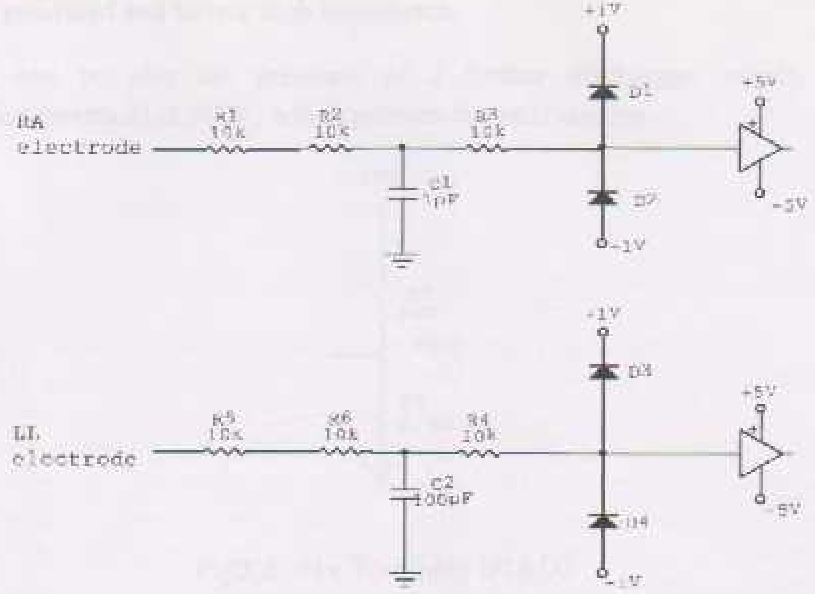


**Fig3.2:** Protection Circuit

The patient, together with the ECG amplifier, must be protected against dangerous operation conditions.

There can be two kinds of dangerous situations:

- The patient can accidentally touch the power supply at 110 to 220V. besides the risks for the patients, this situation can cause breakage in the electronic components of the ECG amplifier.
- If the an electronic defibrillator is used while detecting the ECG, high voltage signals enter the amplifiers across the electrodes. The amplifier must usually be protected against voltage transistors up to 5000V.

The Fig. 3.2 shows different kinds of components used to protect the ECG amplifier.

First of all a series of resistors across the inputs of each electrode limits the current entering the amplifier and reduce the voltage. The first resistors must be dimensioned to stand high voltages and dissipate high power.

The amplifier is further protected for voltages lower than 100V reaching the inputs protecting the next components of the amplification chain.

According to the polarity of the discharge, the diode D1 conducts when the voltage is higher of 1V or the diode D2 when the voltage is lower 1V. The normal operation of the amplifier is not affected by these components in normal conditions.

The diodes, in fact, for voltages ranging between -1V and +1V,result as inversely polarized and have a high impedance.

There can be also the presence of a further discharger, usually with intervention threshold at 500V, which protects the next circuits.

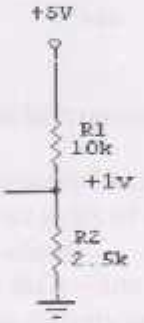


**Fig3.3:** +1v To supply D1&D3

The diodes D1&D3 supplied with +1v according to the following equation:

$V_{D1\&D3}$ = 5V*R10/(R9+R10) = +1V, where R9=10kΩ, so

R10= 10KΩ/4 = 2.5KΩ.

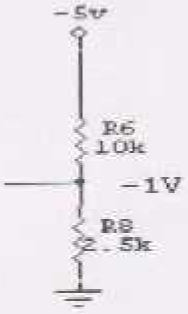


**Fig3.4:** -1v To supply D2&D4

The diodes D2&D4 supplied with -1v according to the following equation:

$V_{D1\&D3}$ = -5V*R8/(R6+R8) = -1V, where R6=10kΩ, so

R8= 10KΩ/4 = 2.5KΩ.

- **AD620:**

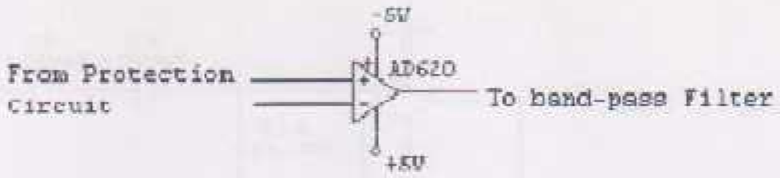


**Fig3.5:** AD620 Instrumentation amplifier

The AD620 is a low cost, high accuracy instrumentation amplifier that requires only one external resistor to set gains of 1 to 1000. We set gain of 100, so we set the gain resistor $R_G$ to 0.5KΩ, where:

gain = $1+(49.4k\Omega/R_G) = 1+(49.4k\Omega/0.5k\Omega) = 100$.

In this amplifier, the two inputs are directly connected to the two non-inverting inputs of the two operational amplifiers. Consequently, the input impedance of these amplifiers is always very high. The output of the preamplifier amplifier is double-ended as the input. Then, it must be connected to a differential amplifier as the one of the next figure to produce a single-ended output. The typical use are the biomedical ones those of electronic instrumentation, in the amplification of signals coming from sensors and transducers.

AD620 has very important characteristics such as:

- very high input impedance.
- very high CMRR.
- Low output impedance.

- **Band-Pass Filter :**

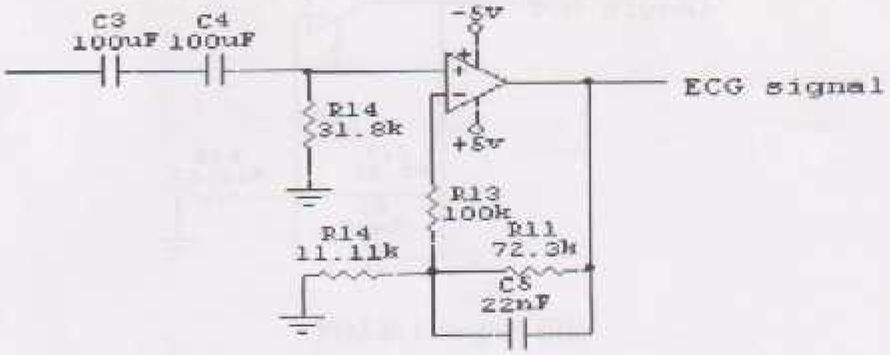


**Fig3.6:** Band-pass filter

A band-pass filter is a circuit that passes frequencies within a certain range and rejects frequencies outside that range. The figure below illustrates using one op.amp. second order filer. The 2[nd] order pass band is (0.1HZ-100HZ). The total gain of signal in ECG circuit is 1000. Because AD620 amplifier amplifies the signal by 100 times, this filter must has a voltage gain of 10, where:

The gain of band-pass filter =1+ R13/R14 = 10. So,

R14= R13/( the gain of band-pass filter - 1) = 100k /(10 – 1 ) = 100k / 9 = 11.11k

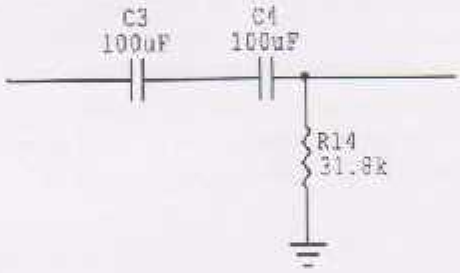


**Fig3.7:** High-pass filter

2[nd] order high pass cutoff frequency = 1/2 π (Ceq*R13) = 0.1Hz , where Ceq=100uF//100uF = 50 uF , so

R14=1/2 π *(0.1*50uF) =31.8kΩ

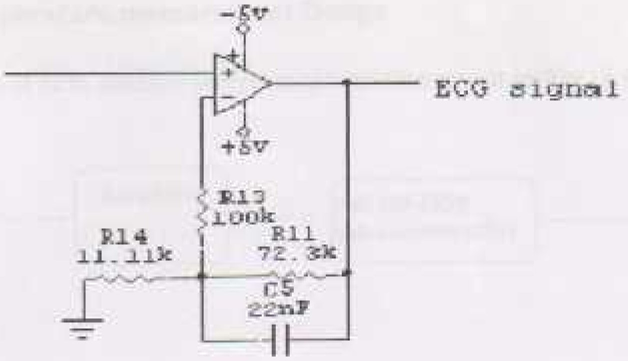


**Fig3.8:** Low-pass filter

$2^{nd}$ order low pass cutoff frequency $= 1/2\,\pi(C5*R11) = 100Hz$

, so $R_{11} = 1/2\,\pi(100*22nF) = 72.3k\Omega$

### 3.2 Heart rate measurement

Heart rate calculated by calculating R-waves displayed in ECG signal. So, heart rate displayed on graphical LCD that displayed ECG signal by programming (assembly language).

### 3.3 Skin temperature measurement Design

The block diagram of skin surface temperature measurement in Fig. 3.9


**Fig3.9:** Block diagram of body temperature measurement

- **LM35 Sensor:**

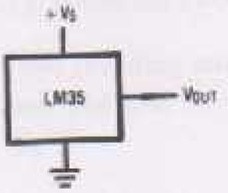


**Fig3.10:** LM35 Sensor

We used LM35 thermal sensor in skin temperature measurement. The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. The LM35's low output impedance, linear output, and precise inherent calibration make interfacing to readout or control circuitry especially easy. It is Linear + 10.0 mV/°C scale factor. So, at normal body temperature (37°C), the output voltage of this sensor is 370mV.

- **Amplifier :**

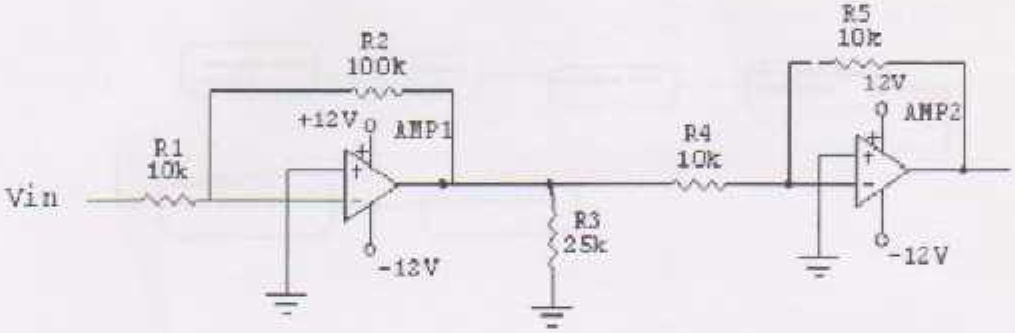


**Fig3.11:** Amplifier Circuit

This amplifier circuit consists of two inverting amplifiers used to amplify the signal that came from LM35 by 10 times. The first inverting amplifier AMP1 invert the signal and amplifies it by 10 times So,

the voltage gain of the first amplifier AMP1 = -R2/R1= -100K/10K= -10.

The second inverting amplifier AMP2 invert the signal again to keep the signal Vin that come from LM35 sensor output positive. So,

the voltage gain of the second amplifier AMP2=-R5/R4= -1. Then,

the total voltage gain of this amplifier circuit = -10*-1 = 10.

### 3.4 Respiration rate measurement Design

The block diagram of respiration rate measurement in Fig. 3.15

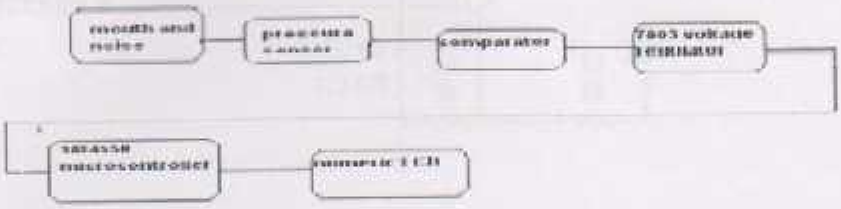


**Fig3.12:** Block diagram of respiration rate measurement

- **ZSE30/ISE30 Pressure sensor:**

**Fig3.13:** ZSE30/ISE30 Pressure sensor

A ZSE30/ISE30 is a pressure sensor gives +12v and -12v pulsed signal . This sensor is placed on the mouth and noise mask of patient. We calibrated the pressure range from 0KPa to 0.5 KPa to give +12v and -12v pulsed signal. At this range, the sensor is very sensitive to any change of pressure value, where at this range or over, the sensor gives an output of +12v and -12v pulsed signal.

- **Comparator:**

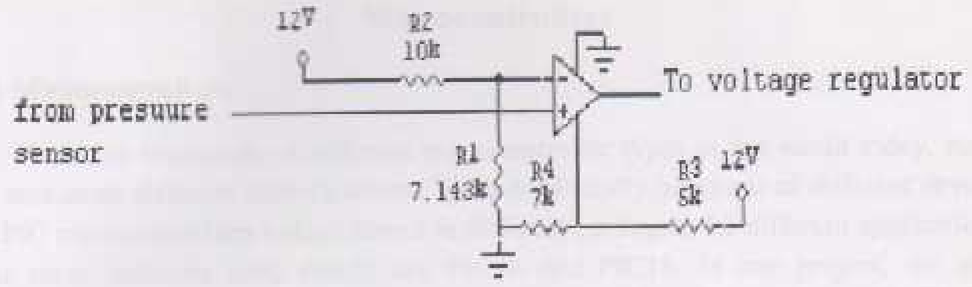


**Fig3.14:** Comparator Circuit

This circuit gives pulsed signal of +7v and 0v. To give this signal we supplied the comparator with 0v at –Vcc and +7v at +vcc. The positive input connected with signal that come from pressure signal. The negative input supplied with +5v.

According to Figure3.17:

+Vcc= 12*R7/(5k+7k)= 12*7k/(5k+7k)= +7v.

The negative input voltage = 12*R1/(R1+R2)=12*7.143k/(7.413k+10k)=+ 5v.

When the positive input of the comparator is +12v, the output voltage is +7v. When the positive input is -12v, the output voltage is 0v.

- **7805 Voltage regulator:**

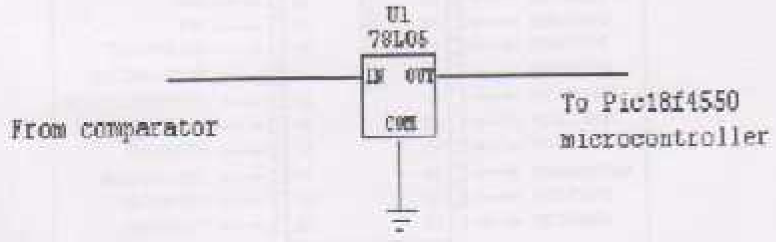


**Fig3.15:** 7805 Voltage Regulator

This voltage regulator gives an output voltage of +5v when the input voltage of it equal or higher than +5v. So, this voltage regulator gives pulsed signal of +5v and 0v. When the input voltage is +7v, the output voltage of this regulator is +5v. When the input voltage is 0v, the output voltage is 0v.

# Chapter Four

## Microcontrollers

### 4.1 Microcontrollers

There are thousands of different microcontroller types in the world today, made by numerous different manufacturers. There are literally hundreds of different devices of PIC microcontrollers today offered in different packages, for different applications. The most common used family are PIC16 and PIC18. In our project, we used PIC16F877 and PIC18F4550 microcontrollers which can be easily interfaced with LCDs and programmed using specific software (assembly language and c language). We used PIC16f877 microcontrollers to program it by assembly program to display ECG signal and heart rate value on graphical LCD (ITM-12864CSTL). We used two PIC18F4550 microcontrollers to program them by a c language to display the respiration rate and temperature values on numeric LCDS(L2021).

### 4.2 PIC16F877 microcontroller

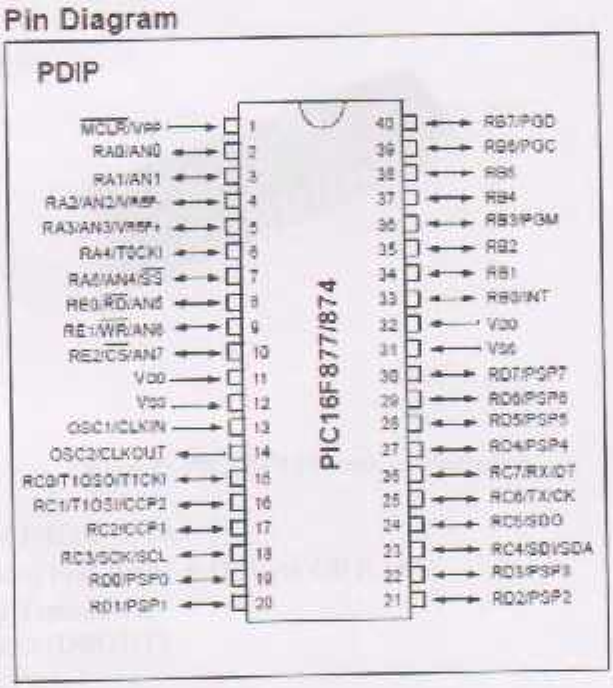


Fig4.2: PIC16F877 microcontroller Pins

Features of PIC16F877:

- High performance RISC CPU.
- Only 35 single word instructions to learn
- All single cycle instructions except for program branches which are two cycle.
- Operating speed: DC - 20 MHz clock input
  DC - 200 ns instruction cycle
- Up to 8K x 14 words of FLASH Program Memory.
  Up to 368 x 8 bytes of Data Memory (RAM).
  Up to 256 x 8 bytes of EEPROM Data Memory.
- Pinout compatible to the PIC16C73B/74B/76/77.
- Interrupt capability (up to 14 sources).
- Eight level deep hardware stack.

**4.3 PIC18F4550 microcontroller**

**Fig4.3:** PIC18F4550 microcontroller

Features of PIC18F4550:

- 1K byte Dual Port RAM + 1K byte GP RAM
- Full Speed Transceiver
- 16 Endpoints (IN/OUT)
- Streaming Port
- Internal Pull Up resistors (D+/D-)
- 48 MHz performance (12 MIPS)
- Pin-to-pin compatible with PIC16C7X5


**Fig4.4: PIC18F4550 Microcontroller Pins**

# Chapter Five

## Testing and Implementation

### 5.1 Results:

#### 5.1.1 ECG and Heart Rate Results:

We implemented the ECG circuit and tested it. The lead2 ECG signal displayed on oscilloscope was accurate and without noises. But when we displayed it on the graphical LCD, the signal was not the same as on oscilloscope. Some problems in programming the LCD caused these problems. The heart rate reading displayed on the LCD and was accurate such that every R-wave was calculated.

#### 5.1.2 Temperature Results

We implemented the temperature system and tested it. We performed three tests on three persons. The results were 37°C, 36.5°C, and 36.7°C. The results take some time to be steady because thermal sensor takes some time to give its final output result. So, we considered that the results are reasonable.

#### 5.1.3 Respiration Rate Results :

We implemented the respiration system and tested it. We performed three tests on three persons. The results were 14, 15, and 17 in one minute. So, we considered that the results are reasonable.

### 5.2 Conclusion :

- Patient monitor is a device that can measure and monitor many parameters, like ECG, heart rate, respiration rate, and temperature.
- We can choose the parameters which we want to measure or monitor in this device.
- We can design simple Patient monitor or complex patient monitor according to parameters and equipments.

### 5.3 Suggestions :

- Adding the blood pressure to be measurable in this device.
- Adding the Spo2 to be measurable in this device.
- Solving the problem of programming the graphical LCD to display the ECG properly.

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[19] www.datasheetcatalog.com

## Appendix

### Datasheets

http://www.datasheetcatalog.org/datasheets/228/390068_DS.pdf

http://www.datasheetcatalog.org/datasheet/nationalsemiconductor/DS005516.Pdf

http://www.datasheetcatalog.org/datasheet/stmicroelectronics/2161.pdf

http://www.datasheetcatalog.org/datasheet/microchip/39617a.pdf

http://www.datasheetcatalog.org/datasheet/analogdevices/105505445AD620_e.pdf

http://www.datasheetcatalog.org/datasheets2/14/1476762_1.pdf

http://www.datasheetcatalog.org/datasheet/microchip/33023a.pdf