Palestine Polytechnic University

College of Engineering and Technology
Electrical and Computer Engineering Department
Biomedical Engineering

Graduation project

Designing a Portable Respiratory Rate Meter Using Strain Gage Sensor

Project Team

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By the guidance of my supervisor , and by the acceptance of all Members in the testing committee , this project delivered to department of electrical and computer engineering in the collage of engineering and technology , to be as a partial fulfillment of requirement of the department for the degree of B.Sc

Supervisor Signature

…………………………………

Testing Committee Signatures

.... …………………. ………………......

Chief of the department signature

……………………………..

الإهداء

إلى أمي و أبي و كل من ساهم في انجاز هذا العمل

Acknowledgments

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Abstract

This project was chosen according to the important to measure a respiratory rate, and use a simple and easy method to measure it, and to be a portable (use a 5v battery), it can be used for healthy persons and in hospital.

The project use a strain gauge sensor to measure the respiratory rate, the sensor will fixed on chest by the movements of the chest the resistance of strain gauge will change; the ΔR component (change in resistance) is translatable into a changing voltage signal this signal will give information about the respiratory rate For this purposes it will be used many circuits to have the final value.

ملخص

لقد تم اختيار هذا المشروع بناء على أهمية قياس معدل **النفس**, و استخدام طريقة سهلة و سريعة فى قياس معدل التنفس والجهاز هو محمول(يستخدم بطارية 5 **فولت**)ويمكن استخدامه من قبل الأشخاص الرياضيين و في المستشفيات. .

حيث يثبت المجس(strain gauge sensor) على الصدر و نتيجة لحركة الصدر في الشهيق و الزفير سيؤثر الضغط الناتج عن الحركتان في مقاومة المجس هذا التغير سيمر من خلال عدة دوائر كهربائية و يعطى إشارة نهائية يتم من خلالها قياس معدل التنفس . .

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Chapter One
Introduction

1.1 Introduction

Without adequate respiration activity, human life is under threat. A normal adult human has respiration rate 14-18 breaths per minute at rest. Oxygen, O_2 enters the blood, and carbon dioxide, CO_2 is excreted through the alveoli.

Respiratory failure is difficult to predict and can become life threatening in a few minutes. Thus a Several non- invasive methods and devices provide information about respiratory rate or depth, or gas exchange. Methods are categorized into: volume and tissue composition detection, air flow sensing, and blood gas concentration. The measuring of respiratory rate is very important because the respiratory rate is a predicator of potentially serious clinical events. This project aims to design a respiratory rate meter using a strain gauge sensor, by the movements of the chest the resistance of strain gauge will change; the ΔR component (change in resistance) is translatable into a changing voltage signal this signal will give information about the respiratory rate.

1.2 Project Objectives

The main objectives of the project are:

1- To design a non- invasive medical device that can be used for medical applications.

2- To use the movement of the chest to measure the respiratory rate.

3-To Use a strain gauge sensor to measure the respiratory rate via analyzing the mechanical movements of the chest during the breathing cycles.

4- To design a responsive and low cost method to measure the respiratory rate.

1.3 The Importance of the Project

The project is important, because it adds a new technique in order to measure the respiratory rate by using a strain Gauge sensor.

The planned device's importance comes from the following points:

1. Its safe.
2. Simple to use.
3. Non invasive technique.
4. Low cost.
5. Highly responsive
6. The patient does not require special preparations.
7. Portable.

1.4 Literature Review

There are many devices and sensors used to measure respiratory rate. A number of final year projects at Palestine Polytechnic University (PPU) addressed respiration measurements and some included information about respiratory rate. Examples such projects are:

1- A project done by Huda Abufarda, Fatima Battat , and Ayat Sha'aban . This project talks about pulmonary ventilation monitoring and diagnostic (PVMD). PVMD is a technique used for monitoring breathing cycles by attaching temperature sensor to the infant's airway. A mask is used that contains a temperature sensor, fixed on an infant's mouth and nose. The output is a measurement of respiratory rate and some physiological information .

2- A project done by Ali Amro and Moayyad Al khatib to design respiratory . Monitoring system using impedance plethysmography. The output was respiratory rate and some physiological information.

3- The third project was done by Mashhoure Tarayrah , Hadel Arar ,Sojoud Al-Rjoub was aimed to designing a spirometer using turbine sensor(DSUTS). The idea is when the patient performs specific breathing maneuvers the turbine will move and cut infrared sensor a counter will count the pluses and by using computer software it will change it to volume , peak expiratory flow (PEF) , functional residual capacity (FRC) then it can be stored for transfer analysis and testes .

4-The fourth project was done by Salah Daraghmah , Raed Sha’aban was amid to designing a portable monitor to detect a respiratory rate and ECG signal and temperature and heart rate they measure the respiratory rate by using a pressure sensor to measure a respiratory rate.

1.5 Time Plane

The time planning consists of two time estimation schedules; the first one demonstrates what is done in the first semester and the second demonstrates the scheduling time of the second semester.

1.5.1 The First Time Planning

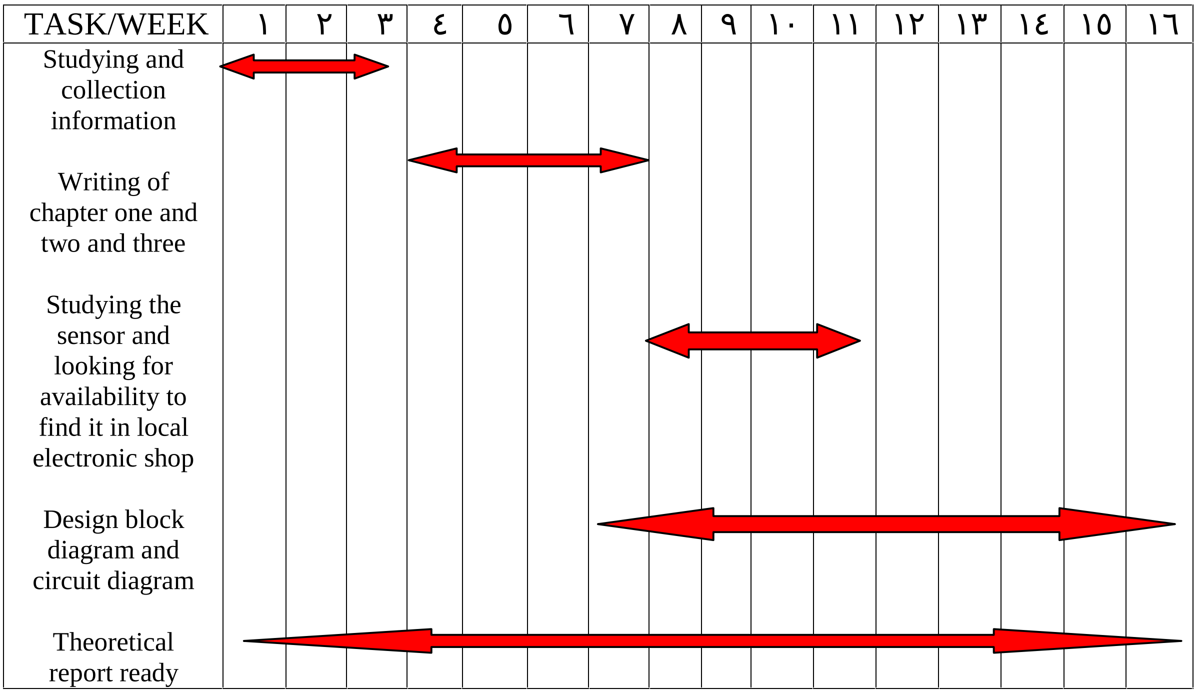


Figure 1.1 The First Time Planning

1.5.2 The Second Time Planning

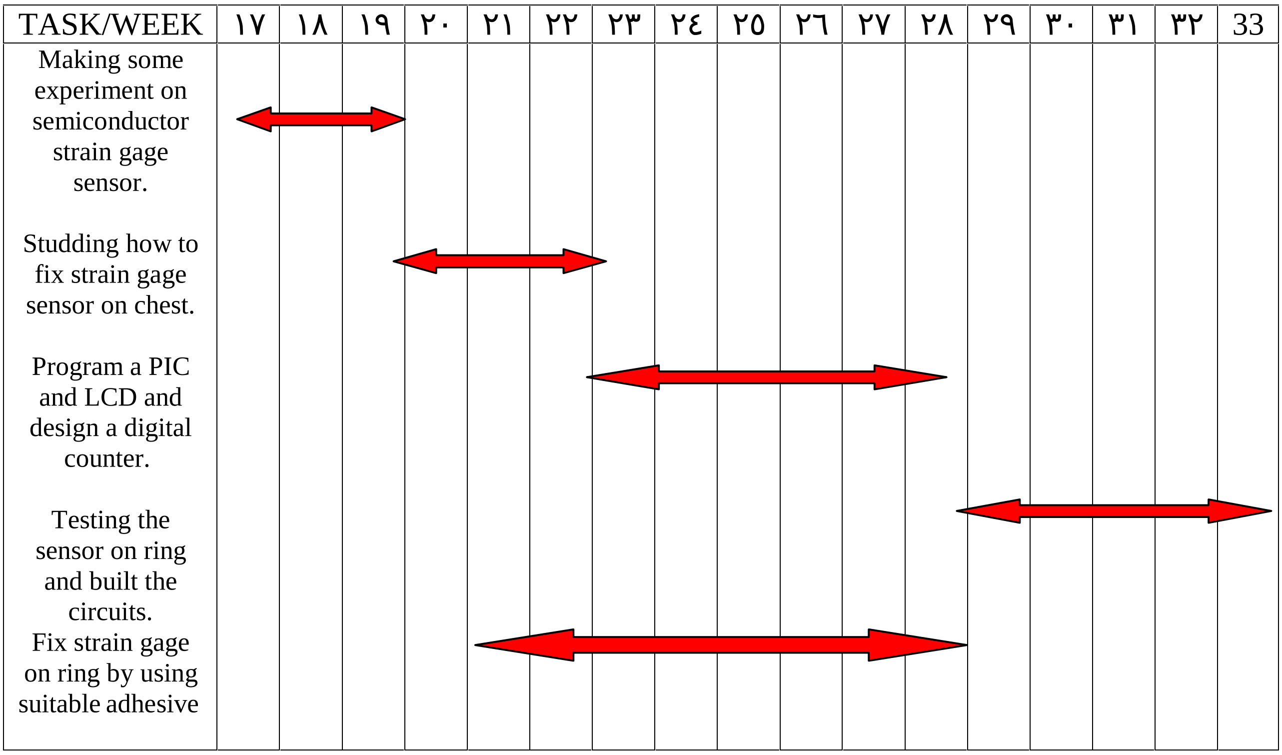


Figure 1.2 The second Time Planning

1.٦ The Cost of Equipments

Table (1.1): The Cost of Equipments

Equipment	Cost($)
Strain gauge sensor	50
Rubber band	4
LM741 and timer	5
4 Bit Binary Counters	3
Batteries	3
Resistors	3
Capacitors and switch	1
Seven segment display	5
Decoders	5
Regulators	5
Rings	3
Total Cost	**87**

1.7 Risk management

1.7.1 Hard risk

The most important hardware part in this project is the strain gage sensor. The Predicted risks are:

- The sensor was not available in the local markets.
- The sensor need to suitable adhesive and it was not available also.
- The available sensor was not for medical application**.**

1.7.2 Software risk

It was used a C language to program an LCD and count pulses by using a suitable microcontroller PIC. There may be some risks with the software such as:

Problems in learning the C language.

- Make a mistake during writing the program.

1.7.3 Group risk

- Group meeting difficulties

2

Chapter Two

Physiology of Respiration

Chapter Two
Physiology of Respiration

2.1 Introduction

The human cells use oxygen and produce carbon dioxide. The respiratory system brings the needed oxygen into the body and eliminates carbon dioxide from it. Oxygen and carbon dioxide diffuse between the Alveoli and pulmonary capillaries in the lungs, and between the systemic capillaries and cells throughout the body. The diffusion of these gases, moving in opposite directions, is called gas exchange.

During external respiration:

- Carbon dioxide diffuses form pulmonary capillaries into alveoli.
- Oxygen diffuses from alveoli into pulmonary Capillaries.

During internal respiration

- Oxygen diffuses from systemic capillaries into cells.
- Carbon Dioxide diffuses from cells into Systemic capillaries.

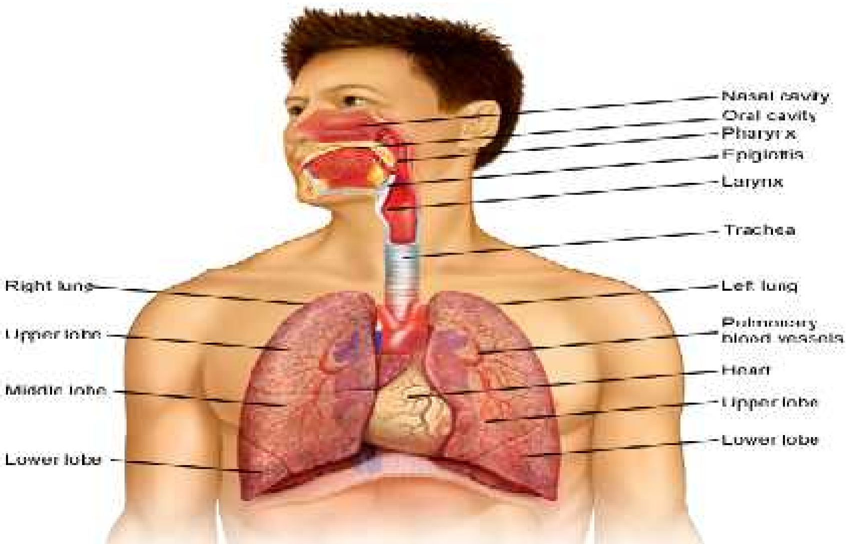
Gas effect exchange depends on:

- Available surface area, which varies in different tissues.
- Partial pressure gradients.
- The rate of blood flow [1].

The respiratory systems, it plays other important roles in the body. The respiratory system helps regulate the balance of acid and base in tissue, a process crucial for the normal functioning of cells. The respiratory system also houses the cells that detect smell. And keep the body temperature of body constant.

2.2 Respiratory System Structure

The organs of the respiratory system extend from the nose to the lungs and are divided into the upper and lower respiratory tracts. The upper respiratory tract consists of the nose and the pharynx, or throat. The lower respiratory tract includes the larynx; the trachea, bronchi (forms when the trachea splits into two main branches called bronchi), bronchioles (tiny branches of the bronchi) and the lungs (a pair of saclike, spongy organs). The nose, pharynx, larynx, trachea, bronchi, and bronchioles conduct air to and from the lungs. The lungs interact with the circulatory system to deliver oxygen and remove carbon dioxide[2] .



Figure(2.1): Respiratory system structure[2]

2.3 The Mechanism of Respiration

The mechanics of respiration involve muscles that change the volume of thoracic cavity to generate inspiration and the expiration. The two sets of muscles are the diaphragm (the wall separating the abdomen from the thoracic (chest) cavity that moves up and down) and the intercostals muscles (muscles surrounding the thoracic cavity that rib cage in and out[3]. .

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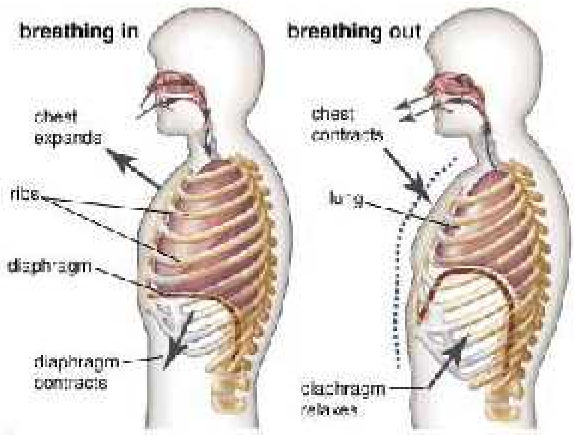

Figure (2.2): expiration and inspiration [4]

Inspiration results from contraction of the diaphragm (downward movement) and intercostals muscles (rib cage swing up and outward). The enlarged cavity housing the lungs undergoes a pressure reduction (-3 mm Hg) with respect to the pressure outside the body. Since the lungs are passive (no muscle tissue),they expand because of the positive external pressure , if external environmental pressure is 760 mm at sea level , the lung pressure is 757 mm Hg on inspiration. The closed nature of the thoracic chamber allows air to enter the lungs from one external opening [3].

Expiration results from the relaxation of the diaphragm (upward movement) and intercostals muscles (inward and downward). The elastic recoil of the lungs creates a higher than atmospheric intrapulmonic pressure (+3 mm Hg) that forces air out of the Lungs[3].

2.4 The lung Volumes

The lungs volume is the percentage of air lungs can hold at any period of time. The total lung capacity is maximum air volume can be contain.

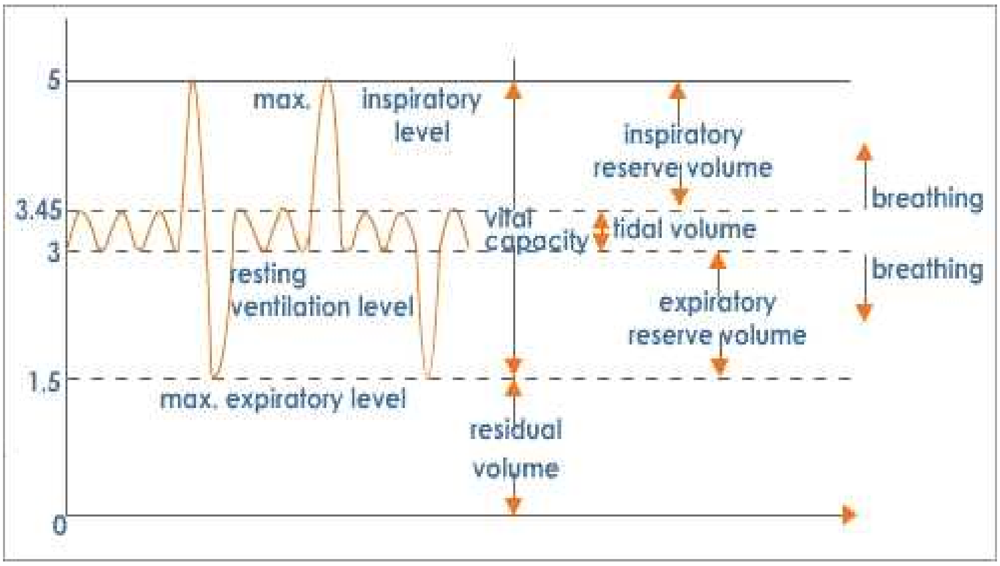

Figure (2.3): Spirogram [5]

The following term describe the various lung volumes:

. The tidal volume (TV) about 500 ml: is the amount of air inspired during normal relax breathing.

.The inspiration reserve volume (IRV) about3000 ml : is the additional air that can be forcibly inhaled after the inspiration of a normal tidal volume .

. The expiration reserve volume (EVR) about 1000 ml : is the additional air that can be forcibly exhale after the expiration of normal tidal volume

.. Residual volume (RV) about 1200 ml : is the volume of air still remaining in the lungs after the expiratory reserve volume is exhaled[6] .

Summing specific lung volumes produces the following lung capacities:

. The total lung capacity (TLC) about 7500 ml

TLC = TV + IRV + EVR +RV

. The vital capacity (VC) about 4500 ml : is the total amount or air that can be expired after fully inhaling .

VC= TV +IRV+ ERV= approximately 80% TLC .

. The inspiration capacity (IC) about 3500 ml : is the maximum amount of air that can be inspired

IC = TV + IRV .

Note : these lung volume values for a healthy adult male[6] .

2.5 Regulation of Respiration

Respiration rate and depth are controlled by the nervous system and the chemical concentration of CO_2 in the blood .

Respiration results from involuntary neuronal activity modified by chemical influences. Voluntary control is also possible but is limited by internal body homeostasis. For example, voluntary deep breathing for a prolonged time may result in temporary unconsciousness to permit blood chemistry (pH level) to return to normal.

The respiratory centers in the brain are located within the medulla and Pons of the brain stem. Nerve cells from the brain send out streams of impulses that stimulate the diaphragm and intercostals muscles to contract and effect inspiration. pneumotaxic centers in the Pons receive impulses that rise to a maximum at inspiration peak from inspiratory centers in the medulla. Messages relayed to the expiratory centers (located dorsally to inspiratory centers in medulla) initiate expiration by sending out streams of pulses that inhibit inspiration. Muscles of inspiration relax, and expiration follows passively. This feedback system maintains rhythmic breathing rate and depth (TV)[3].

Respiratory activity is also affected by the chemistry and temperature of the blood passing through the brain. Changes in concentration of carbon dioxide in the blood changes the respiratory rate. The acid base balance of the blood (normally a pH of 7.4) arises from the following chemical reaction of carbon dioxide waste from cells with water in blood plasma.

$$CO_2 + H_2O \rightleftharpoons H^+ + HCO_3^-$$

If the concentration of carbon dioxide increase this will increase H^+ and HCO_3^- ions which will leading to simulation of brain respiratory center. This increase the depth and, eventually, rate of breathing. The CO_2 level in the blood drops as a result of ventilation, and brain respiratory centers decrease breathing rate. The constitutes a negative a negative feedback loop, and blood pH is maintained within normal limits (7.36 to 7.44). Stimulation and inhibition act through baroreceptors (stretch sensors in the lung), O2 chemoreceptor's (cells in the aorta), and respiratory centers (cells in brain) to ensure the balance of the partial pressure of O_2 and CO_2 in the blood [3].

2.6 Unbalance and Diseased States

Hyperventilation is alveolar ventilation in excess of metabolic needs for CO_2 removal. Partial pressure of CO_2 in blood falls below 40 mm Hg these results from voluntary or involuntary rapid or deep breathing, ridding the blood of excessive CO_2. Hypoventilation is alveolar ventilation inadequate for CO_2 removal. Partial pressure of CO_2 rises above 40 mm Hg .

Apnea is the cessation of breathing, usually temporary. This result from reduced stimulus to respiratory centers or brain center damage.

Dyspnea is labored breathing resulting from acidosis (low blood pH), pneumonia, and cardiac failure.

Polypnea (tachypnea) is accelerated breathing rate without increase in breathing depth , resulting from fever or hypoxia .

hypercapnia is decreased ventilation (excessively low partial pressure of CO_2 in the blood) resulting from central nervous system disorders , disease of nerves or respiratory muscles , metabolic disorders , or respiratory obstruction[3] .

2.7 Respiratory Rate

Respiratory rate is defined as the number of breaths per minute or ,more form all, the number of movements indicative of inspiration and expiration per unit time , in practice , the respiratory rate is usually determined by counting the number of times the chest rises and falls per minute[7] .

2.7.1 The Normal Respiratory Rates by Age

Newborns: average 44 breaths per minute.

Infant: 20-40 breaths per minute.

Preschool children: 20-30 breaths per minute.

Older children: 16-25 breathes per minute.

Adults: 12-20 breaths per minute.

Adults during strenuous exercise 35–45 breaths per minute.

Athletes' peak 60–70 breaths per minute [7].

2.8 Important of Measuring Respiratory Rate

There is substantial evidence that an abnormal respiratory rate is a predictor of potentially serious clinical events. Nurses and doctors need to be more aware of the importance of abnormal respiratory rate as a marker of serious illness such as cardiac arrest and admission to an intensive care unit (ICU) [8] .

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3

Chapter Three

Respiration System Measurements

Chapter Three
Respiration System Measurements

3.1 Introduction

The respiratory systems responsible for bringing oxygen into the body and for discharging waste carbon dioxide from the body. There are actually several different transducers used in respiratory measurements, although only a few different types of measurements are made. One class of instruments, known as pneumographs, is used to detect respiration, but these instruments do not deliver quantities data about the system. These devices are often paired with pneumotachometer (respiration rate meter) to perform monitoring jobs in intensive care unit. Instruments devised to quantitatively measure lung volumes are known As spirometers ; both mechanical and electronic models are available Blood gases and CO_2 expired at the end of a normal tidal volume are also considered to be respiratory measurements

3.2 Respiratory Transducers And Instruments

Respiratory instrument, like most other measurement instruments tend to be little more than extension of the Transducers used to acquire the data from the subject in some cases no than a simple dc amplifier is needed. It is, therefore, practically impossible to distinguish the transducers from the instruments .There are direct and indirect method of sensing alveolar ventilation, and breathing effort .

3.2.1 Direct Method

The method in which the sensor is coupled to the patient's airway, and measures the movement or other properties of the air transported into and out of the lungs. Various direct methods of sensing breathing effort, and ventilation have been in use in the pulmonary physiology, and pulmonary function laboratories for many years, these involve the measurements of volume flow and composition of inspired and expired gases [9].

3.2.1.1 Carbon Dioxide Sensor

Expired air has a higher percentage of carbon dioxide than inspired air, and this can be sensed by placing an open ended tube at the nose or mouth, so that it samples the air entering , and leaving the airway.

The sampled gas is transported along the tube to an instrument that contains a rapidly responding carbon dioxide sensor. This sensor detects the increased absorption of infrared radiation by carbon dioxide containing gas [9].

There is a delay in response of this instrument due to the time it takes the gas to be transported through the tube to the sensor; it is important to have rapid passage through the tube. This can present some problems since the tube must be thin flexible, and offers a relatively high resistance to the flow of gas.

3.2.1.2 Thermistor Meters

These ones use the resistance variation at temperature variation, due to the air flux near the sensor. The thermistor cooling due to the gas flux around it , cause its increase of resistance , which is immediately detected by suitable conditioning circuits it use to measure the respiratory flux , which enables to detect all other parameters of respiration activity[10]. .

3.2.1.3 Rotating – Vane Flow Meters

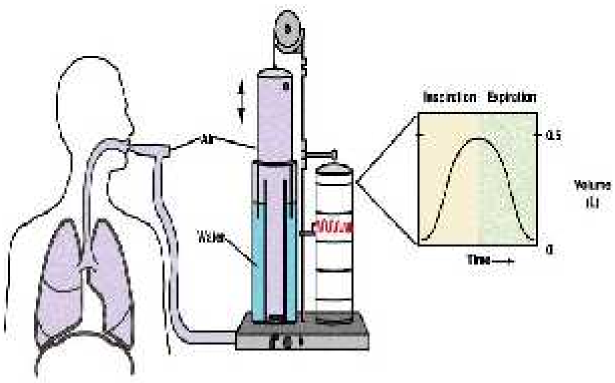
This type of sensor has a small turbine in air flow path. the rotation Of the turbine can be related to the volume flow gas Mechanical linkages have been used to display parameters of the flow (such as peak flow and integral over an expiration) on indicator dials on the instrument interruption of a light beam by the turbine has also been sensed and converted to voltages proportional to flow and or its integral, to be recorded photographically.

3.2.1.4 Differential Pressure Flow Meter

Convective flow occurs as result of a difference in pressure between two points. from the relationship between pressure difference and volume flow rated through a system , measurements of the difference in pressure yields an estimate of flow[10] .

3.2.1.4 Spirometer

Spirometer is instruments for measuring air entering and leaving the Lungs , used to asses pulmonary function. It is simply a device used for quantifying lung volumes and capacities by putting mouthpiece to the patient mouth as shown in the following figure.



Figure(3.1): Spirometer[10]

3.2.2 Indirect Methods

In this method, the sensor looks at variables related to air movement But not at the air movement itself. Indirect methods involve no contact with the air way, or the air being moved into or away from the lungs. Usually, indirect methods; are noninvasive, and can be mounted on near the body surface. There are a wide variety of indirect sensors of ventilation some of them as follow [9].

3.2.2.1 Impedance Pneumograph

An impedance penumograph is based on the fact that the ac Impedance across chest of a subject changes as respiration occurs. This technique is used in many respiration monitoring and apnea alarms. The impedance measurements are made by introducing an electrical current in the frequency rang of 20-100 KHz into the volume conductor and measuring the corresponding voltage. The ratio of voltage to current gives impedance Z. Usually the DC value is eliminated and the impedance variation is further examined. To eliminate the effect of the electrodes, separate electrode pairs for introducing the current and measuring the voltage are usually used; the outer electrode pair is used for introducing the current and the voltage is measured across an electrical electrode.

The output of the impedance pneumograph contains only rate data and the existence of respiration; hence its use in monitoring and apnea alarm devices [3]… .

3.2.2.2 Strain Gauge Displacement Sensors

Strain gauge measure small displacements or strain in an electrical Conductor, by measuring changes in its electrical resistance. A special type of strain gauge consisting of a compliant, thin walled, rubber capillary tube filled with mercury. This device can be placed on the chest or abdomen of an infant, breathing movements cause it to stretch and contract. By taping the end of such a strain gauge at different points on the chest or abdomen such that the gauge is slightly stretched, the changes in electrical resistance of the gauge can then be used to monitor infant breathing movements. [9]

3.3 Summery

After taking an idea about different types of respiratory instrumentations , it can be seen the differences on each type , here, the importance of my project appeared table 3.1 makes comparison between my project and other devices discussed in the previous sections .

Table(3.1) : Comparison Between Impedance Pneumograph , PVMD , Strain Guage Sensors, DSUTS

Impedance Pneumograph	**PVMD**	**Strain gauge Sensor**	**DSUTS**
Indirect measuring and noninvasive .	Direct measuring and noninvasive.	Indirect measuring and noninvasive.	Direct measuring and noninvasive
Work by attaching sensor on the chest uses the fact that the impedance across the chest of a subject changes as respiration occur.	Work by attaching temperature sensor (thermistor) on the patient mouth .	Work by attaching Sensor on the chest by changing the volume of the chest the resistance of the sensor will change	Work by attaching the turbine sensor On the patient mouth
Electronic device	Electronic device	Electronic device	Electronic device
Good accuracy	Good accuracy	Good accuracy	Good accuracy
Monitoring device	Monitoring device	Measuring device	Monitoring device

4

Chapter Four

Strain Gauge Sensor

Chapter Four

Strain Gauge Sensor

4.1 Introduction

Strain is the amount of deformation of a body due to an applied force (stress).More specifically, strain (ε) is defined as the fractional change in length .Strain can be positive (tensile) or negative (compressive). Although dimensionless, strain is sometimes expressed in units such as in./in. or mm/mm. In practice, the magnitude measured strain is very small. Therefore, strain is often expressed as microstrain (με) which is ε e x 10^{-6} [12].

Stress (σ) is refers to force applied to body per unit area on a given plane within a body. While there are several methods of measuring strain, the most common is with a strain gauge. This sensor was Designed to convert mechanical motion into an electrical voltage. In this project it will be used a strain gauge sensor electronic signal to measure (respiratory rate) by using the fact that the resistance of strain gauge will change by the stress of the movement of the chest on the sensor.

4.2 Strain Gauge Sensor

The strain gage sensor is a resistive device whose operation is very closely tied to R=ρ L/A equation. The strain gage is used primarily for the detection of stress and strain although it can readily be adapted to sense other measurements well .[11]

$$R = \rho L/A \qquad \ldots\ldots 4.1$$ [11]

R= Resistance(Ω)

ρ = Resistivity (Ω-m)

A= Area (m^2)

4.2.1 Strain Gauge Factor

The gage factor for any strain gage compares that gage's output, expressed as a ratio of resistance change to the gage's original resistance, to its input, expressed as a strain[13]. .

Gage factor (GF) = (ΔR/R)/ ε………………4.2[11]

ΔR= Change in resistance due to stress (Ω)

R=Original resistance of strain gage sensor (Ω)

ε = strain (in/in)

4.2.2 Kinds of Strain Gauge Sensors

Usually, there are two kinds of strain gauge: bounded strain gauge and unbounded The most common strain gauges are of the bonded type, where the gauge consist of metal foil, cut into a grid structure by a photoetching process, and mounted on aresin film base. The film backing is then attached to the structure to be measured With a suitable adhesive. The gauge should be positioned so that its active axis is along the strain along ،direction of the measured strain: the change in resistance, due to a given the passive axis is very small compared with that produced by the same strain along the active axis. a typical strain gauge has:

-Gauge factor 2.0 to 2.2

-Unstrained resistance 120 ± 1 Ω

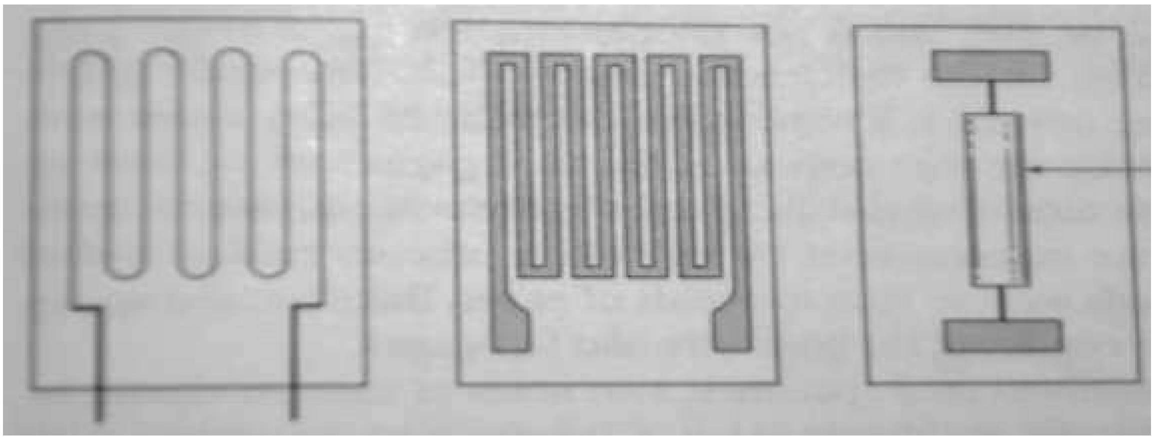
-Linearity within ±0.3%

-Maximum tensile strain +2 × 10−2

-Maximum compressive strain −1 × 10−2

-Maximum operating temperature 150 °C

The change in resistance at maximum tensile strain is ΔR =+4.8 Ω, and ΔR =−2.4 Ω at maximum compressive strain. A maximum gauge current between 15 and 100mA, depending on area, is specified in order to avoid self-heating effects[14] . In semiconductor gauges the piezoresistive. The most common material is silicon doped with small amounts of p-type or n-type material. Gauge factors of between +100 and +175 are common for p-type silicon, and between −100 and −140 for n-type silicon. A negative gauge factor means a decrease in resistance for a tensile strain. Thus semiconductor gauge have the advantage of greater sensitivity to strain than metal ones, but have the disadvantage of greater sensitivity to temperature changes. Typically a rise in ambient temperature from 0 to 40 °C causes a fall in gauge factor from 135 to 120. Also the temperature coefficient of resistance is larger, so that the resistance of a typical unstrained gauge will increase from 120 Ω at 20 °C to125[12].



(a) (b) (c)

Figure (4.1): Three Types of Resistance Strain Gauges. (a) Wire Gauge (b) Foil Gauge; (c) semiconductor Gauge [13]

Unbounded strain gauges consisting of fine metal wire stretched over pillars are used in some applications.

Another strain gauge type is mercury strain gauge in this instrument, a very thin elastic tube filled with mercury is stretched across the patients chest. The tube is typically of 0.5 mm inside diameter and 2 mm outside diameter. Most are about 3c. long The ends of tube are typically plugged with amalgamated copper, silver[3].

4.2.3 Application Of Strain Gauge

Pressure Sensors

A strain gauge can be used in the manufacturing of pressure sensors or a pressure transducer. A pressure sensor is used in measuring the amount of pressure in substances, such as liquids or gasses. The strain gauge circuit that is used for pressure strain sensors is made out of foil, a thick film, a metal film, silicon and polysilicon.

Gauges can be used in combinations of four. This is known as a full bridge. Pressure sensors are also used to observe the different qualities of liquids and gases. Some of the qualities that can be observed are the altitude, the flow and the depth of the object.

Piezoresistors

Another application for the strain gauge is for piezoresistors. This is. used to measure small amounts of strain of an object. Semiconductor strain gauges are used in this type of measurement. This is ideal for measuring small amounts of strain as semiconductor strain gauges are sensitive to temperature changes. This device is also more expensive than the standard foil gauge.

Biological Measurements

Strain measurement is also used in the medical field. Strain gauges are used in measuring the swelling of tissue or the blood flow of a person. In this case, a mercury in rubber strain gauge is used. This strain gauge is made up of liquid mercury that is placed inside a rubber tubing. The gauge is then applied on the swelling area of the body and the strain is measured by observing the Applied to rubber tube . it also was used a strain gauge sensor in a pulse meter a strain gauge is applied to detect the minute change in arterial volume. The sensor is placed over the superficial radial artery at wrist. The artery will respond to different transmural pressure and its wall properties may be assessed .

Civil Engineering

In Civil Engineering, strain gauges are used in measuring movements of different structures. The strain gauges for this field are installed on buildings and observed over time in order to know the movement of the structure. A theory is then made on the movement of the structure according to the strain gauge. There are different strain gauges that are used in Civil Engineering. One of them is the Rosette Strain Gauge. The Rosette Strain Gauge is made up of two or more grids that measure the surface of a structure. A strain amplifier is also used in Civil Engineering[14].

These are some of the applications for using a strain gauge. There are more uses for a strain gauge and there are also different machines and devices that are used in measuring displacement of an object.

4.2.4 Strain Gauge Measurement

To measure the strain requires accurate measurement of very small changes in resistance. strain gauges are almost always used in a bridge configuration with a voltage or current excitation source.

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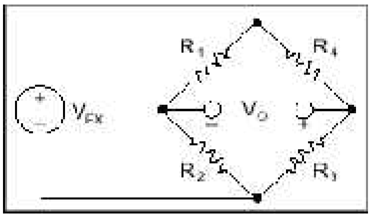


Figure(4.2) Full wave Wheatstone Bridge[15]

The output voltage of the bridge, V_O, is equal to:

$$Vo= ((R3/ (R3+R4))-(R2/ (R1+R2))).V_{EX} \ldots\ldots\ldots\ldots\ldots..4.3$$ [15]

From this equation, it is apparent that when $R_1/R_2 = R_4/R_3$, the voltage output V_O is zero. Under these conditions, the bridge is said to be balanced. Any change in resistance in any arm of the bridge results in a nonzero output voltage. Therefore, if you replace R_4 with an active strain gage, any changes in the strain gauge resistance will unbalance the bridge and produce a nonzero output voltage. If the nominal resistance of the strain gauge is designated as R_G, then the strain-induced change in resistance(DR) can be expressed as $DR = R_G \cdot GF \cdot e$, from the previously dned Gauge Factor equation[15].

5

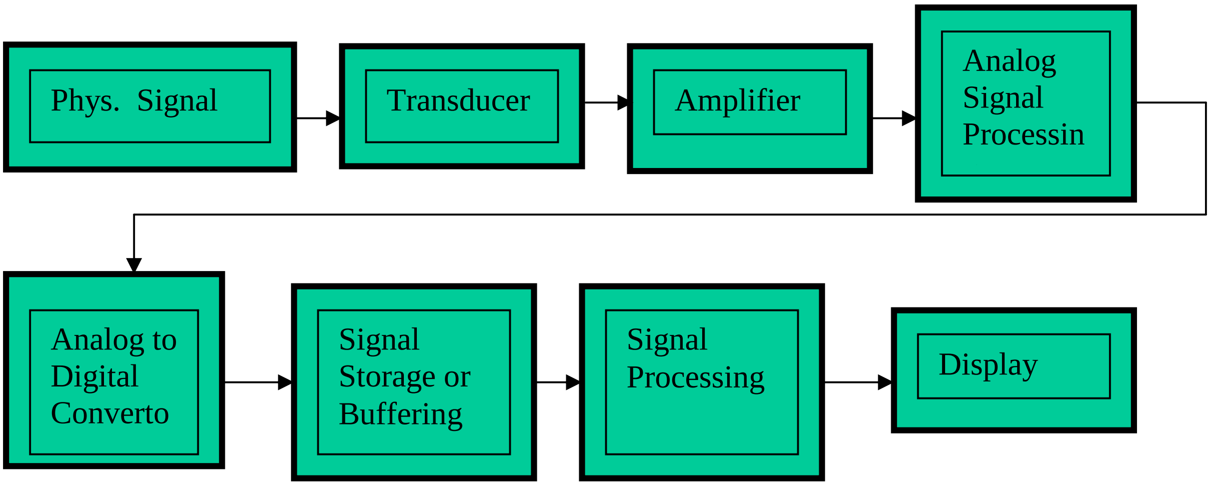
Chapter Five

Design Concept

Chapter Five
Design Concept

5.1 Introduction

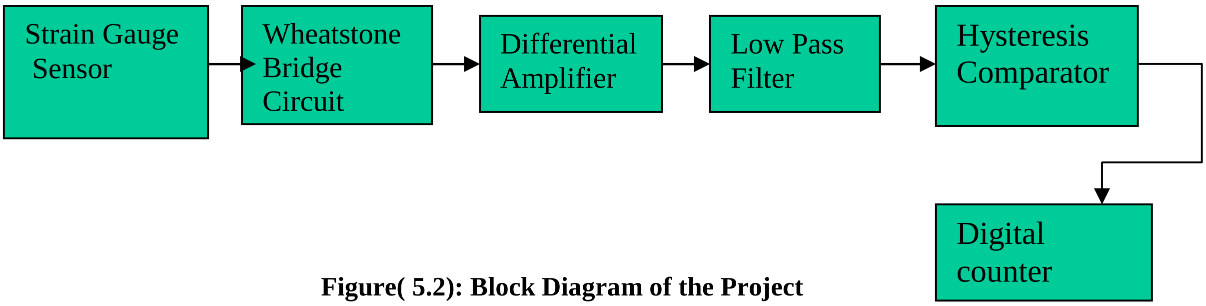
A typical biomedical measurement system is shown in figure 5.1. The term measurement includes image acquisition or the acquisition of other forms of diagnostic information.



Figure(5.1): Schematic Representation of Typical Bioengineering Measurement System[9].

The physiological process of interest is converted into an electrical signal via the transducer or electrodes. Some analog signal processing is usually required, often including amplification and low-pass(or band-pass) filtering. Since most signal processing is easier to implement using digital method, the analog signal is converted to digital formats using an analog to digital converter. Once converted , the signal is often stored, or buffered, in memory to facilitated subsequent signal processing. Alternatively, in some real –time applications, the incoming data must be processed as quickly as possible with minimal buffering, and may not need to be permanently stored. Digital signal processing algorithms can then be applied to the digitized signal these signal processing techniques can take a wide variety of forms and various levels of sophistication. Some sort of output is necessary in any useful system. This usually takes the form of a display, as in imaging system, but may be some type of an effecter mechanism such as in an automated drug delivery system[9].

5.2 The Project Block Diagram



Figure(5.2): Block Diagram of the Project

5.2.1Strain Gauge Sensor

in my project I will use a metallic foil strain gauge which have the 2 gage factor and it will fix on ring as it will see in chaptet6.

5.2.2Wheatstone Bridge Circuit

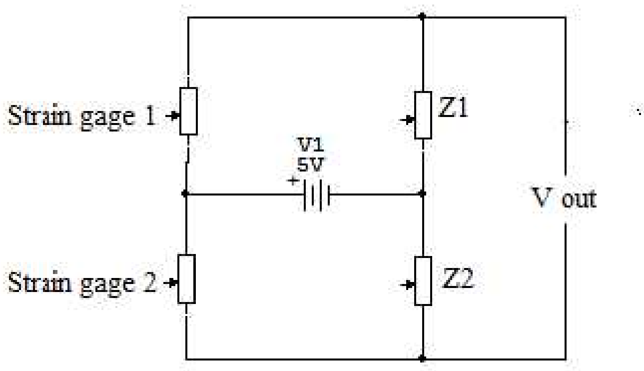


Figure (5.3): Wheatstone Bridge Circuit

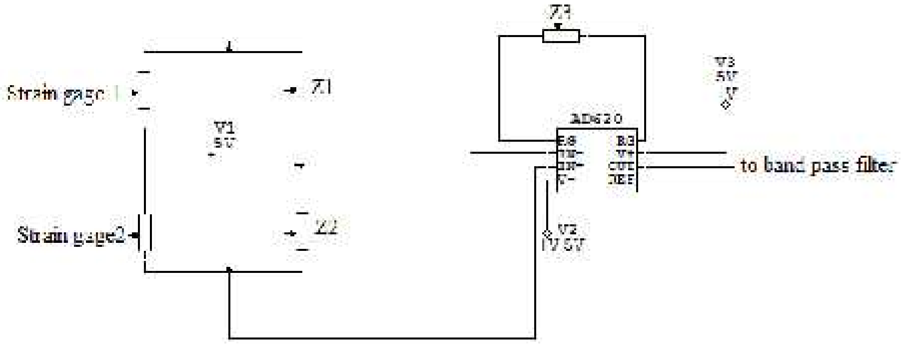
Wheatstone bridge circuit contains four elements Strain gage1 , Strain gage2 ,Z1 And Z2.

The value of resistance of each strain gage is 350 Ω the two other variable resistance (Z1, Z2) are calibrate to be 350 Ω; to make the output of bridge equal zero this mean that the bridge is balanced this mean that:

(Z of Strain gage1 / Z1) = (Z of Strain gage2/Z2).

any applying strain to the gages, the change in the Z of each sensor will unbalance the bridge and Vout will become nonzero.

5.2.3Differential Amplifier



Figure(5.4): Wheatstone Bridge With AD620 Amplifier

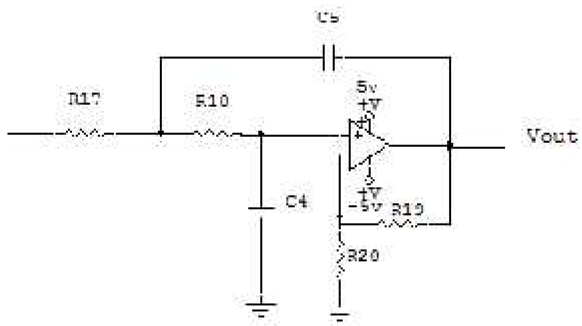
The AD620 is a low cost, high accuracy instrumentation amplifier that requires only one external resistor to set gains of 1 to 1000. The gain is set of 100, so the resistance is set to 0.5KΩ, where:

gain = 1+(49.4kΩ/ RG) = 1+(49.4kΩ/ 0.5kΩ) = 100.

AD620 has very important characteristics such as:

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

5.2.4 Low Pass Filter



Figure(5.5):Low Pass Filter

2nd order low pass filter cutoff frequency = 1/(2πC4R17) = 1.2Hz.

Suppose that the C4 = C5 = 1μF.

R17 = R18 = 132KΩ.

The gain of the 2nd order low pass filter = 10 = (1+(R19/R20))

Suppose that R19 = 9KΩ

R20 = 1KΩ

5.2.5Hysteresis Comparator

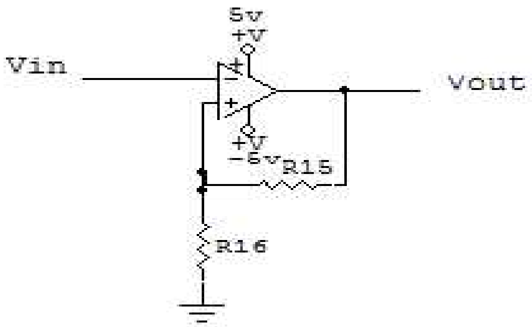


Figure (5.6):Hysteresis Comparator

The output of hysteresis comparator is either negative or positive Saturation voltage Vcc.

The upper threshold voltage VUT and the lower threshold voltage VLT can be determined by R15 and R16, as expressed in the foll Wing equations.

VUT = +Vcc*R16/(R16+R15).

VLT = -Vcc*R16/(R16+R15).

Suppose that R15 = 2KΩ, R16 = 4KΩ

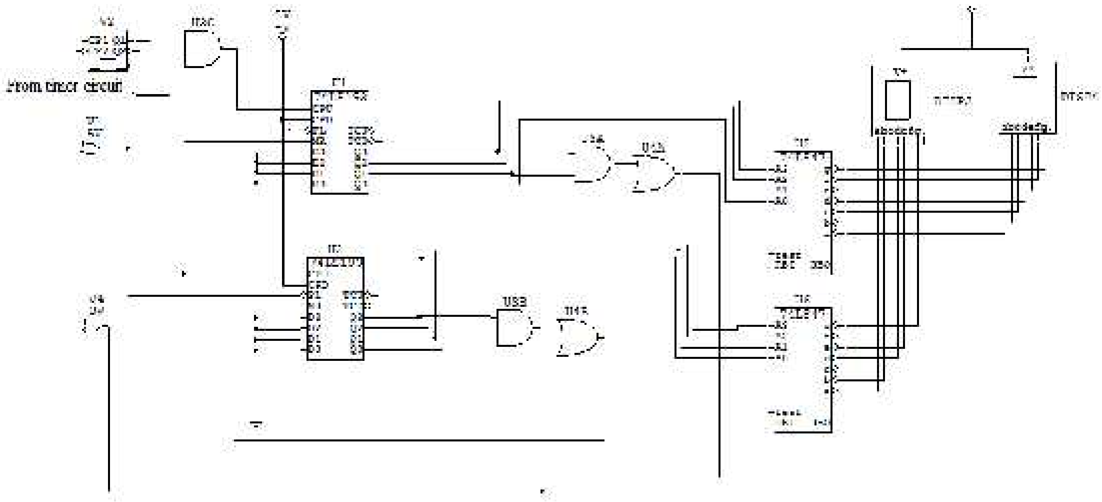
By calculations VUT = 1.66V , VLT = -1.66V

5.2.6 Count and display

There are two way to display and count the pulses one by using PIC and using c language to program it another is to use a digital counter and monistabel timer to choose one minute.

5.2.6.1Digital Counter

It will be used a two 4 bit counter (74LS193) this counter used to count the pulses of respiratory rate.



Figure(5.7): Digital Counter

5.2.6.2Monostabel Timer

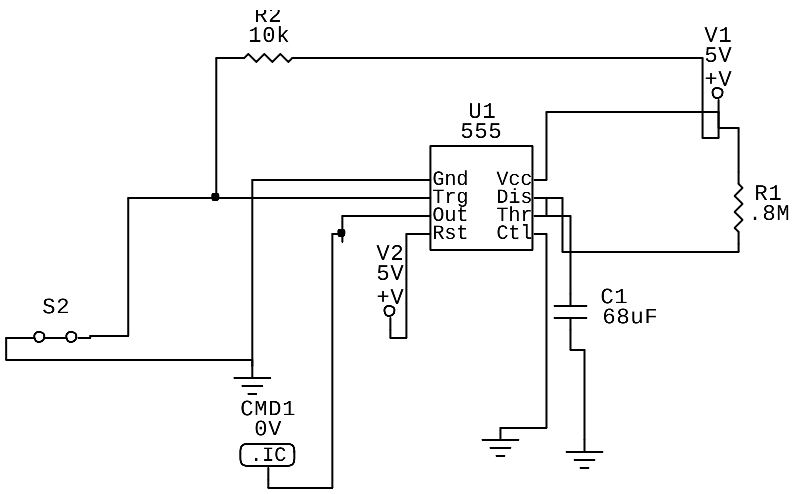


Figure (5.8): Monostabel Timer

5.2.7 Regulators

It will be used 7805 to give 5 volt to supply a LCD and the Vcc of operational amplifier and microcontroller and Wheatstone Bridge Circuit.

It will be used also a 7905 which will give -5volt to supply the –Vcc of operational amplifier.

5.2.8Power supply

Because the instruments is portable it will be used a 9v battery that have these characteristic the total current consume by the IC 500ma so it will use many 3 battery.

Table 5.1: battery specification

6 V	Minimum voltage (v)
250 ma	Current (mA)

6

Chapter Six

Hardware Design

Chapter Six
Hardware Design

6.1Strain Gage Sensor

At the beginning I made some experiment on the semiconductor strain gage which is available; to saw how the output voltage change with stress applied on the sensor. I fixed it on a carton and using an ordinary adhesive to fix it in carton, and I made stress on carton to see the output during bridge but during this I saw that there is no acceptable output as my calculation so I conclude that there is something wrong. During recherché more carefully I conclude that I was making a wrong and this was because I was not finding any application about sensor on my electrical engineering department, I found that the sensor need to suitable adhesive and suitable way to fixed it on the surface.

6.2Strain Gage and Ring Calculation

I start to look to a suitable way to fix the strain gage on the chest and a good way to reach the force of chest to strain gage. I deiced to use a ring and rubber band. The ring it's made of steel it flexible material with 75 mm diameter and thickness is 0.2mm and the width of the material is 10mm.

Figure 6.1: Flexible Ring

6.1.1 Ring Calculation

From the data sheet the max allowable strain gage of the sensor is 1000µm/m so it must be considered that the strain of the sensor which is done by stress of chest must not exceed this value to be shore it was must do some calculations of ring.

I= (1/12)(b)(h)^^{3}……………………….6.1[16]

I= momentum

b= the width of ring material.

h= the thickness of ring material.

I= (1/12)(10)(0.2)= 0.0067mm^^{4}

M= FR/2[cosɵ-(2/л)]……………………6.2[17]

M= bending moment.

R = the distance from the center of the ring and fixing strain gage.

ɵ = the angle between the fixing strain gage and the horizontal diameter of ring.

F= applying force.

M = (F(40))/2[cos20□-(2/ л)]

M = 6F……………………………………6.3

σ = MC/I……………………………………6.4[17]

σ = stress.

C = h/2 half of the thickness.

σ = (6F(0.1))/(0.0067) = 89.5F………………6.5

E = σ/ ε…………………………………………..6.6[17]

E = elastic modulus and it =207000 to steel.

ε = 89.5F/207000

ε = 0.0004F………………………………………….6.7

Maximum allowable ε is 1000 µm/m so from equation 6.7 the force must not exceed 2.5 N.

6.3Fixing Sensor in Ring by Using Suitable Adhesive

Figure 6.2: fix strain gage on the ring

Figure 6.3 :Using a two rubber band to fixed the ring on chest

It was fixing two strain gage in inner and outer surface of the ring and it was used a two rubber band in the two side to fix the ring on the chest when the inspiration happened the chest will rise and the two rubber band will rise also this will pull the ring in both side and then make a tensile of the outer strain gage and compressive to inner strain gage.

6.4Testing of the Sensors Fixing on Ring

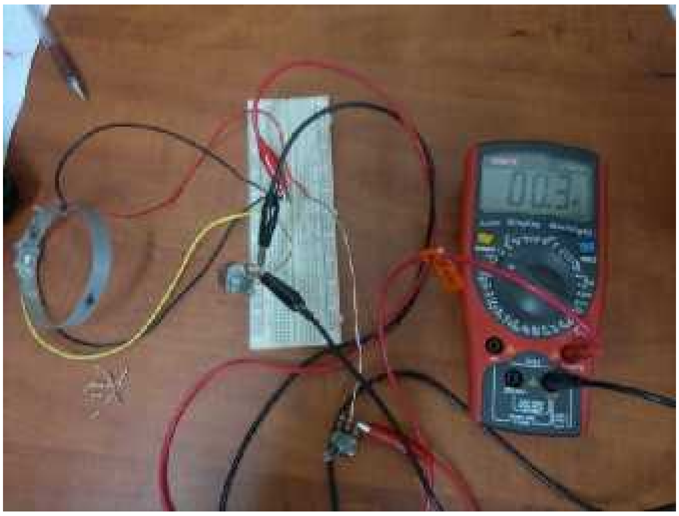


Figure 6.4: the output voltage before pull the ring in two side

The output voltage of bridge is nearly 0v without pulling the ring

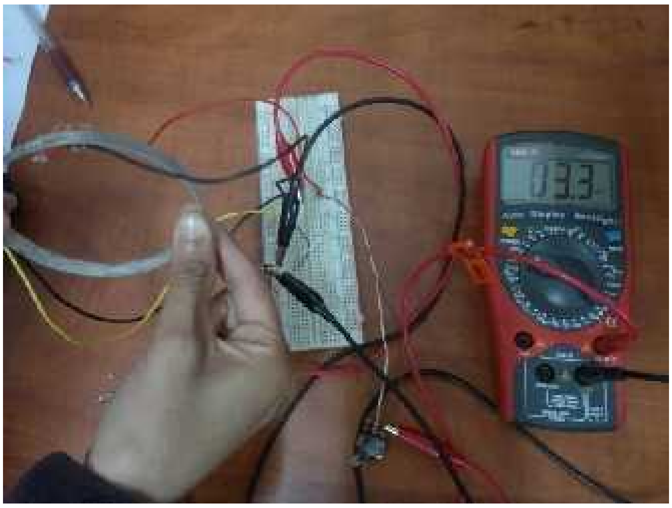


Figure 6.5: the output voltage after pull the ring in two sides

The output voltage of bridge increase by 3mm by making pulling of the ring

6.5 Testing For Each Sensor

After testing the sensor there was problem in measuring output from bridge so it was need to test every sensor, using voltage divider law as in the following circuit.

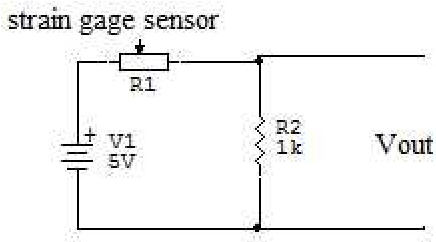


Figure6.6: Testing of strain gage sensors by voltage divider law

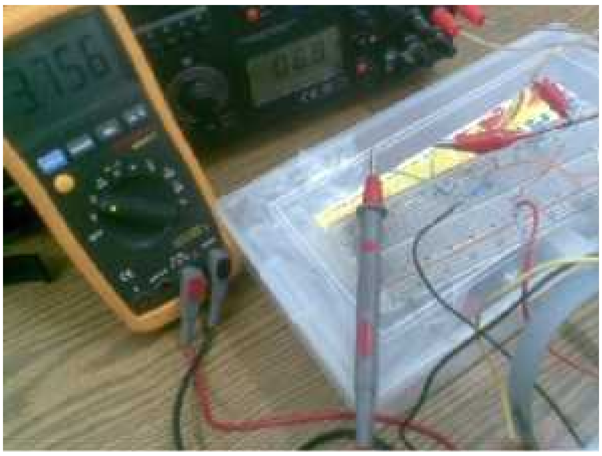


Figure 6.7: The output voltage of the 1k resistance with connection of Inner strain gage sensor without making strain

Figure 6.8 :The output voltage of the 1k resistance with connection of Inner strain gage sensor with making strain

The output voltage of the 1k is increase because the resistance of the sensor decrease This mean that the sensor is compressive.

Figure 6.9: The output voltage of the 1k resistance with connection of outer strain gage sensor without making strain

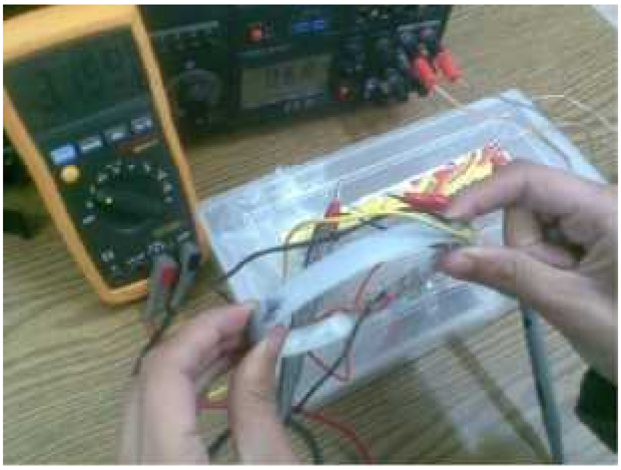


Figure 6.10: The output voltage of the 1k resistance with connection of outer strain gage sensor with making strain

the output voltage of the 1k resistance is decreases because of increase of the resistance of the outer strain gage this mean that the Sesser is tensile.

6.6 fixing the Ring on the Chest

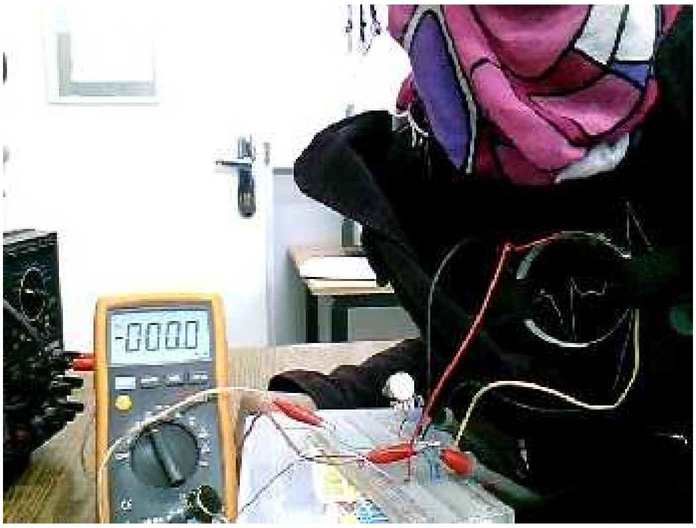


Figure 6.11: the Output Voltage of Bridge Before Inspiration

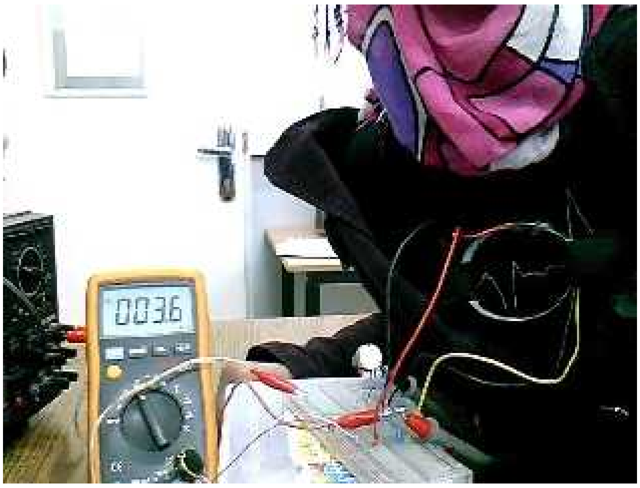


Figure6.12: The Output Voltage of Bridge During Inspiration

During inspiration the output voltage of bridge is increase to reach 3.2mv at maximum this value will be different from person to other because the force of chest is different.

6.7 Circuits Design

Figure 6.13: Test of the Bridge and Differential Amplifier Circuit

The output was having a high noise ($50H_Z$) and other noise signal.

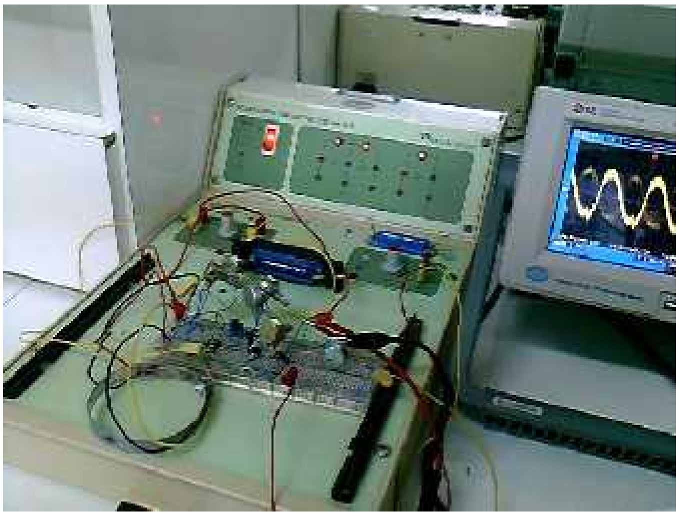


Figure 6.14:Test of the Bridge and Band Pass Filer Circuit

After passing the signal through band pass filter there is still noise In signal

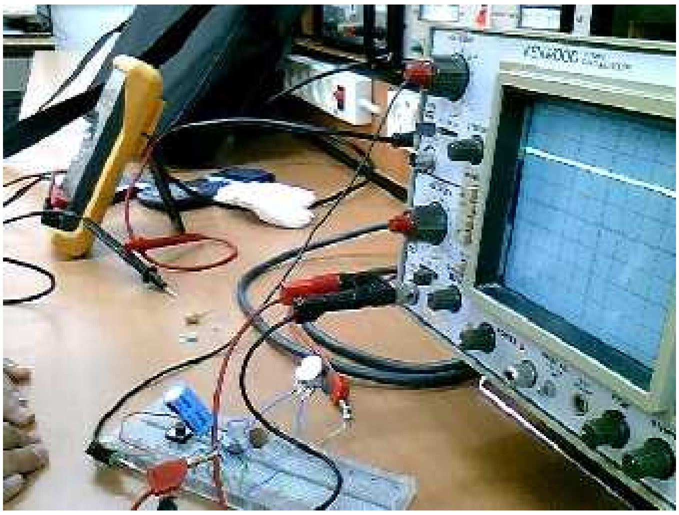


Figure 6.15: Test of Monostabel Timer Circuit

The output on oscilloscope is = Vcc and its be on for one minuet

Project Circuit

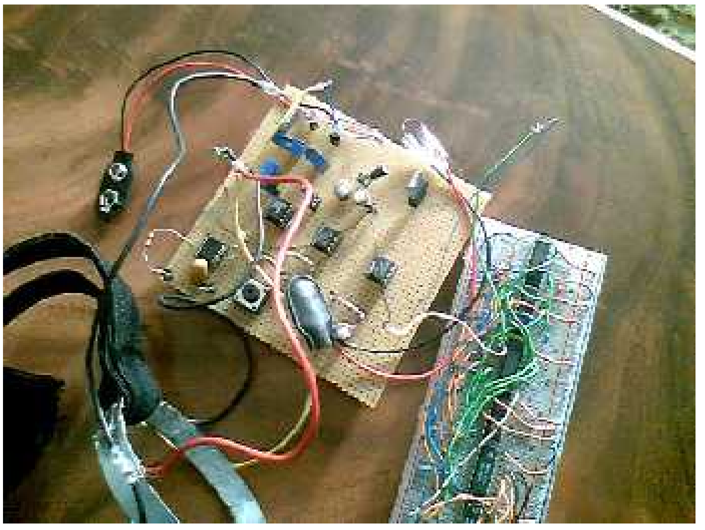


Figure 6.16: Project Circuit

7

Chapter Seven

Circuit's Simulation

Chapter Seven

Circuit's Simulation

7.1 Simulation of AD620

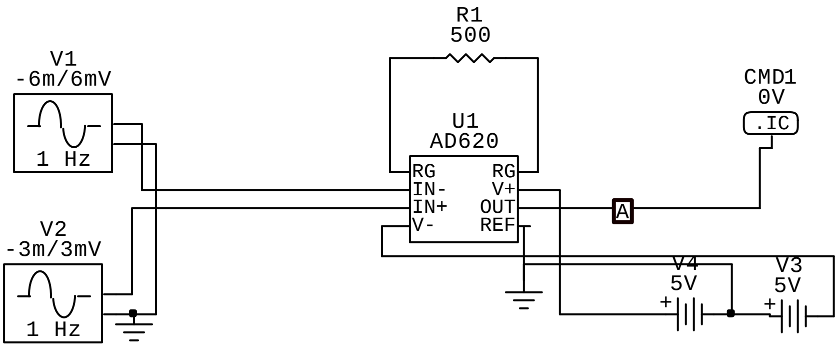


Figure (7.1): AD620 Circuit With Two Analog Signal

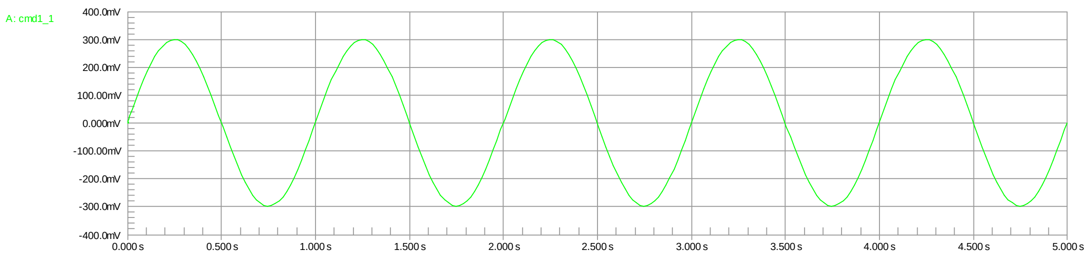


Figure (7.2): The Output ofAD620 Circuit with Two Analog Signal

7.2 Simulation of the Project Using Differential Amplifier

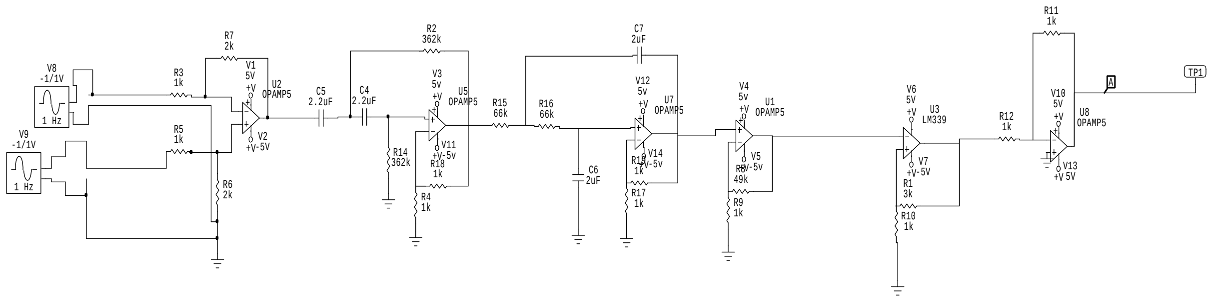


Figure (7.3):Project Circuit Using LM741 as Differential Amplifier

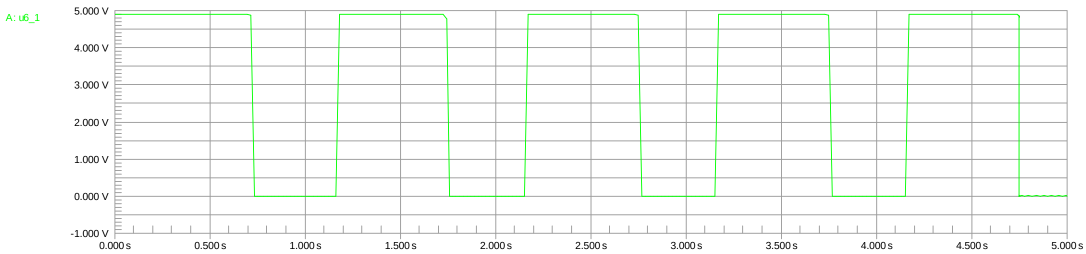


Figure (7.4):The Output of Project Circuit Using LM741 as Differential Amplifier

7.3 simulation of Digital Counter Circuit

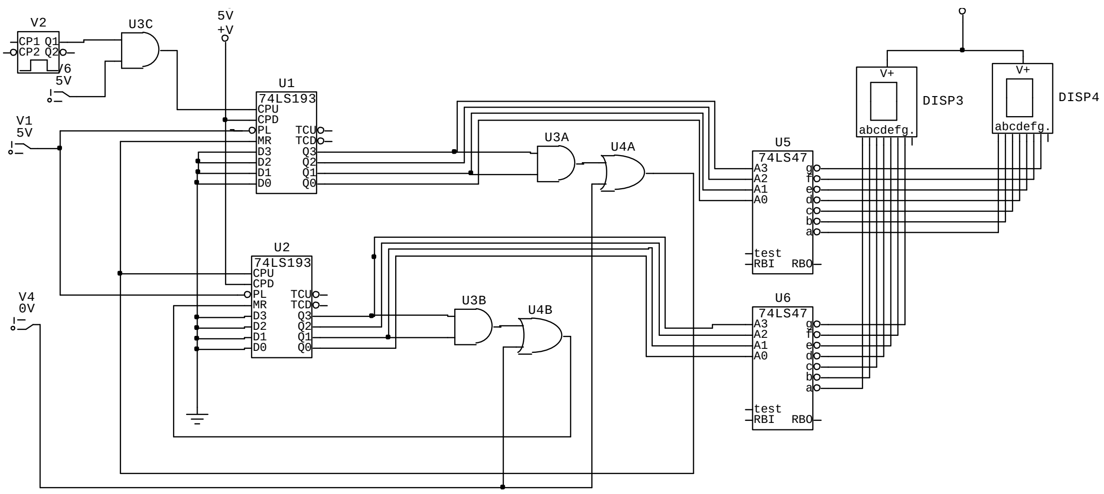


Figure (7.5): Digital Counter Circuit

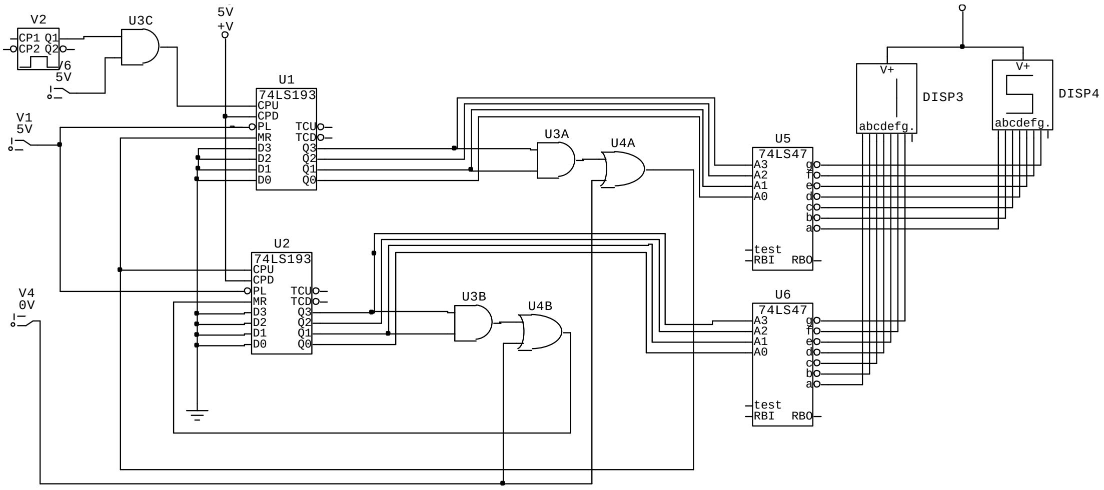


Figure (7.6): Simulation of Digital Counter Circuit

8

Chapter Eight

Conclusions and Future Works

Chapter Eight
Conclusions and Future Works

This chapter describes the most important results which were concluding through constructing this design and discussing the problems which would be faced whether by hardware or software. Also some future studies will be discussed on the same device to develop it. Since this device become one of the devices which should be available in all hospitals and clinics.

8.1 Conclusions

It was conclude that we can use metallic foil strain gage sensor in measuring respiratory rate During designing of this project it was concluded that it must be measured the Appling force of chest for all different people in different ages to be shore that the Appling stress will not make a strain which can exceed the maximum strain.

It was noted that using a software design is better than hardware design because there was a high noise in the signal which taken from op-am and also the signal its small in amplitude and it will different in amplitude from one person to another.

This design can achieve the aims and objectives and have less problems and low cost. This device is can be design as a small size and can be used for ill or not persons.

8.2 Problems

8.2.1 Hardware Problems

The are many hardware problems in testing strain gage and in designing differential op-amp circuit the most problems was in the nose signals. Also in available of strain gage adhesives and available of a strain gage sensor.

8.2.2 Software Problems

Problem in programming a PIC to count pulses for one minute. Also problems in simulation of the project in circuit maker because it do not have the strain gage sensor.

.

. **8.3 Future Works**

It can developed this device to be available to measure respiratory rate for different people in different ages and using software labview or c languge instead of to used hardware design.

8.4 Meaning

Table (8.1): Meaning of Words

The word in English	The meaning in Arabic
Capillaries	أنابيب شعرية
Pulmonary	رئوي
Alveoli	حويصلات هوائية
Systemic Capillaries	جهاز الدوران
Pharynx	البلعوم
Throat	الحنجرة
Bronchi	شعبتا القصبة الهوائية
Trachea	القصبة الهوائية
Rib	ضلع
Diaphragm	الحجاب الحاجز
Oral	تجويف الفم
Epiglottis	اللهاة

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Appendix

Data Sheet