# DESIGN OF LIQUID SUBSTANCE CONCENTRATION USING LIGHT ABSORPTION TECHNIQUE


**BY**

**BASSAM DAGHAMEEN** **BILAL NU'EIRAT**

**SAEED SHALABI**

**SUPERVISED BY**

**ENG. ABDALLAH ARMAN**




**ELECTRICAL AND COMPUTER ENGINEERING DEPARTMENT**

**COLLEGE OF ENGINEERING AND TECHNOLOGY**

**PALESTINE POLYTECHNIC UNIVERSITY**

**HEBRON-WEST BANK**

**PALESTINE**



**JUNE 2006**

# Design of Liquid Substance Concentration Using Light Absorption Technique

**By**

**Bassam Daghameen** **Bilal Nu'eirat**

**Saeed Shalabi**

A project Report Submitted Partial Fulfillments Requirements
for the Degree of Bachelor of Engineering
In
Electrical and Computer Engineering Department

**Supervised By**
**Eng. Abdullah Arman**

**Electrical Computer Engineering Department**
**College of Engineering and Technology**
**Palestine Polytechnic University**

**Hebron-West Bank**
**Palestine**
**June 2006**

# إهداء

إلى الشمعة التي تحترق لتضيئ دربي.....نبع الحنان .....أمي

إلى الملس الذي لا ينكسر.....نبع العطاء.....والدي

إلى ملائكة الأرض.....بشقائق النعمان.....أشقائي

إلى قناديل الدرب.....الشموع التي لا تنطفئ.....أساتذتي

إلى رفاق الدرب..... بناة المستقبل.....أصدقائي

إلى من رووا بدمائهم ارض فلسطين..... صناع الكرامة.....الشهداء

إلى من رفضوا الذل في زمن الانكسار.....طلاب المجد.....أسرانا

الى من تجرعوا الم الحرمان..... عشاق الارض.....المغتربين

الى كل حر ..... محب لفلسطين..... أوفياء الأمة

إليكم جميعا أحبتي اهدي هذا الجهد المتواضع

# Abstract

The "Design of Liquid Substance Concentration Using Light Absorption Technique" is using light absorption property of the liquid substances to measure elements concentrations in blood and urea.

A light measuring technique is incorporates filters to isolate and project particular wavelengths of electromagnetic radiation through a sample (serum or urea), and a detector to measure the amount of radiation which has passed through the sample. By applying Lamberts and Beers laws we can find the concentration of elements in blood and urea.

This technique is commonly used in clinical laboratory devices as spectrophotometer and chemistry analyzer, these devices are core of clinical lab's work.

# Acknowledgements

We thanks our Allah to help us and his successfulness to complete our project, then we would to thank parents for all their support. Thanks to Eng. Abd Allah Arman for his supervision. Thanks for every body shared in the success of our project. Thanks to assistant Eng.Jammal Hleqawi, Eng.Fuad Abu Zeid, Jenin Hospital. Eng.Khalid Bader, Jamal Al-asharabatee InterMedPal for helpful advice, finally special thanks for Hossam Amro.

# Chapter One

# Introduction

## 1.1 Introduction

Our project "Design of Liquid Substance Concentration using Light Absorption Technique" is used in clinical laboratory devices like spectrophotometer and chemistry analyzer, these devices are the core of clinical lab's work.

This technique is used to measure the concentration of many organic substances in human body by using the light absorption to measure the concentration of these substances in blood and urea.

To know the concentration of these substances is helping doctors to diagnose many diseases; there are many diseases that are affected by the concentration of organic substances in blood and urea.

## 1.2 Project Objectives

1 Measuring the concentration of organic substances in blood and urea by using light absorption property.
2 Using the PC to read the system output and compare it with a reference data to diagnose the disease.
3 To be used as an instructional purpose in the biomedical laboratory in our university.

## 1.3 Project importance

1. Studying this important technique that is widely applied in many devices used in clinical laboratories and other technical fields.
2. This project could be used for instructional purposes in university biomedical laboratories.

## 1.4 Previous Studies

No graduation projects could be used as previous studies for our project "Design of Liquid Substance Concentration using Light Absorption Technique ".

### 1.5 Cost Table

Table (1.1): Table Cost

| # | Consumed Type | *Cost* |
|---|---|---|
| **1** | **Chips and Other Piece** | ***80$*** |
| **2** | **Interference Filter** | ***150$*** |
| **3** | **Case** | ***34$*** |
| ***4*** | ***Others*** | ***67$*** |

## 1.6 Project contents

Our project is divided into six chapters; these chapters could be described as follow:

**Chapter One:** Introduction.
This chapter will discuss mainly the objectives, and the importance of our project.

**Chapter Two:** Physiology of Blood and Urea.
This chapter is talking about the concentration of the elements in blood and urea and it is relation with human diseases.

**Chapter Three:** The Electromagnetic Spectrum.
This chapter will explain the visible and ultra violet electromagnetic spectrums.

**Chapter Four:** Theoretical Background.
This chapter is a theoretical background not only but also it will discuss the main principle of our project "design of liquid substance concentration using light absorption technique".

**Chapter Five:** Design Concept.
In This chapter we will explain the project block diagram and illustrating the elements that will be used.

**Chapter Six:** Software System.
This chapter will illustrate a simple flowchart that is explaining the interfacing software for the project.
**Chapter Seven :** Conclusion and Recommendation

This chapter summarize our results and the problems that faced us, and we explain some recommendations to the future projects.

# Chapter Two

# Physiology of Blood and Urea

## 2.1 Blood

### 2.1.1 Introduction

Blood is a circulating tissue composed of fluid plasma and cells (red blood cells, white blood cells, platelets). See figure (2.1).

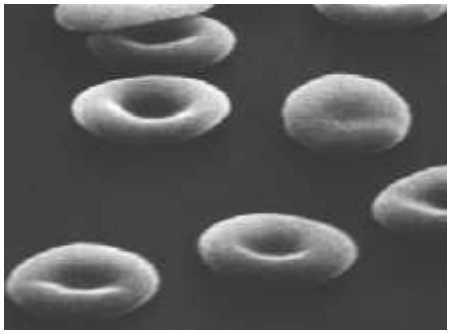


Figure (2.1): Blood cells

The main function of blood is to supply nutrients (oxygen, glucose) and constitutional elements to tissues and to remove waste products (such as carbon dioxide and lactic acid). Blood also enables cells (leukocytes, abnormal tumor cells) and different substances (amino acids, lipids, hormones) to be transported between tissues and organs. Problems with blood composition or circulation can lead to downstream tissue dysfunction.

### 2.1.2 Anatomy of blood

Blood is composed of several kinds of corpuscles; these formed elements of the blood constitute about 45% of whole blood the corpuscles:

1. Red blood cells or erythrocytes (96%). In mammals, these corpuscles lack a nucleus and organelles, so are not cells strictly speaking. They contain the blood's hemoglobin and distribute oxygen. The red blood cells (together with endothelial vessel cells and some other cells) are also marked by proteins that define different blood types.
2. White blood cells or leukocytes (3.0%) are part of the immune system; they destroy infectious agents.
3. Platelets or thrombocytes (1.0 %) are responsible for blood clotting or coagulation and are involved in inflammation.

The other 55% is blood plasma, a yellowish fluid that is the blood's liquid medium. The normal pH of human arterial blood is approximately 7.40. Blood is about 7% of the human body weight, so the average adult has a blood volume of about 5 liters, of which 2.7-3 liters is plasma. The combined surface area of all the erythrocytes in the human anatomy would be roughly 2,000 times as great as the body's exterior surface.

## 2.2 Blood plasma

Blood plasma is the liquid component of blood, in which the blood cells are suspended. Serum is the same as blood plasma except that clotting factors (such as fibrin) have been removed. Figure (2.2) show the component of blood.


figure(2.2): Blood component .

### 2.2.1 Albumin

Albumin is a blood plasma protein that is produced in the liver and forms a large proportion of all plasma protein. Substances containing albumin.

The normal range of albumin concentrations in human blood is 3.5 to 5.0 g/dL, and albumin normally constitutes about 60% of plasma protein; all other proteins present in blood plasma are referred to collectively as globulin. Albumin is essential for maintaining the osmotic pressure needed for proper distribution of body fluids between intravascular compartments and body tissues. Albumin is negatively charged.

### 2.2.2 Electrolyte

An electrolyte is a substance which dissociates into free ions when dissolved (or molten), to produce an electrically conductive medium. Because they generally consist of ions in solution, electrolytes are also known as ionic solutions. Electrolytes generally exist as acids, bases or salts.

An electrolyte may be described as concentrated if it has a high concentration of ions; or dilute, a low concentration of ions. If a high proportion of the dissolved solute

dissociates to form free ions, the solution is strong; if most of the dissolved solute does not dissociate, the solution is weak. The properties of electrolytes may be exploited via electrolysis to extract constituent elements and compounds contained within the solution.

## 2.3 Physiology of salts ions

In physiology, the primary ions of electrolytes are sodium, potassium, calcium, magnesium, chloride, phosphate, and bicarbonate. All higher life forms require a subtle and complex electrolyte balance between the intracellular and extracellular milieu. In particular, the maintenance of precise osmotic gradients of electrolytes is important. Such gradients affect and regulate the hydration of the body, blood pH, and are critical for nerve and muscle function.

Electrolyte balance is maintained by oral intake of electrolyte-containing substances, and is regulated by hormones, generally with the kidneys flushing out excess levels. In humans, salt homeostasis is regulated by hormones such as antidiuretic hormone, aldosterone and parathyroid hormone. Serious electrolyte disturbances may lead to cardiac and neurological complications, and most are medical emergencies.

Measurement of electrolytes is a commonly performed diagnostic procedure, performed via blood testing or urinalysis. The interpretation of these values is

somewhat meaningless without analysis of the clinical history, and is often impossible without parallel measurement of renal function. Electrolytes measured most often are sodium and potassium. Chloride levels are rarely measured except for arterial blood gas interpretation, as they are inherently linked to sodium levels. See table(2.1).

Table(2.1) : Common Chemical Blood Tests and Normal Ranges.

| Test | Normal Ratings | Units |
|---|---|---|
| **Sodium** | **135-145** | **M Eq/L** |
| **Potassium** | **3.5-5** | **M Eq/L** |
| **Chloride** | **95-105** | **M Eq/L** |
| **Blood urea nitrogen** | **8-16** | **mgN/100mL** |
| **Glucose** | **70-90** | **mgN/100mL** |
| **Calcium** | **9-11.5** | **mgN/100mL** |
| **Albumin** | **4-6** | **g/100mL** |

### 2.3.1 Physiology of sodium ions

Sodium ions play a diverse and important role in many physiological processes. Excitable cells, for example, rely on the entry of $Na^+$ to cause a depolarization. An example of this is signal transduction in the human central nervous system.

### 2.3.2 Physiology of Potassium ions

Potassium is a necessary mineral in daily nutrition; it assists in muscle contraction and in maintaining fluid and electrolyte balance in body cells. Potassium is also important in sending nerve impulses as well as releasing energy from protein, fat, and carbohydrates during metabolism. A shortage of potassium can cause a potentially fatal condition known as hypokalemia. Eating a variety of foods that contain potassium is the best way to get an adequate amount. Healthy individuals who eat a balanced diet rarely need supplements.

### 2.3.3 Physiology of Calcium ions

Calcium plays a vital role in the anatomy, physiology and biochemistry of organisms and of the cell, particularly in signal transduction pathways. The skeleton acts as a major mineral storage site for the element and releases $Ca^{2+}$ ions into the bloodstream under controlled conditions. Circulating calcium is either in the free, ionized form or bound to blood proteins such as albumin. The hormone secreted by the parathyroid gland, parathyroid hormone, regulates the resorption of $Ca^{2+}$ from bone.

### 2.3.4 Physiology of Chloride ions

Chloride ions have important physiological roles. For instance, in the central nervous system. The chloride-bicarbonate exchanger biological transport protein relies on the chloride ion to increase the blood's capacity of carbon dioxide, in the form of the bicarbonate ion.

### 2.3.5 Physiology of Bicarbonate (Glucose)

Glucose is a ubiquitous fuel in biology. Carbohydrates are the human body's key source of energy, providing 4 calories (17 kilojoules) of food energy per gram.

### 2.3.6 Physiology of Magnesium

Organic magnesium is important in both plant and animal life. Chlorophylls are magnesium-centered porphyrins. The adult daily nutritional requirement, which is affected by various factors including gender, weight and size, is 300-400 mg/day. Many enzymes require the presence of magnesium ions for their catalytic action, especially enzymes utilizing ATP. Inadequate magnesium intake frequently causes muscle spasms,

and has been associated with cardiovascular disease, diabetes, high blood pressure and osteoporosis.

## 2.4 Urea

Urea is an organic compound of carbon, nitrogen, oxygen and hydrogen, with the formula $CON_2H_4$ or $(NH_2)_2CO$. Urea is essentially a waste product: it has no physiological function. It is dissolved in blood (in humans in a concentration of 2.5 - 7.5 mmol/liter) and excreted by the kidney.

### 2.4.1 Physiological diagnosis

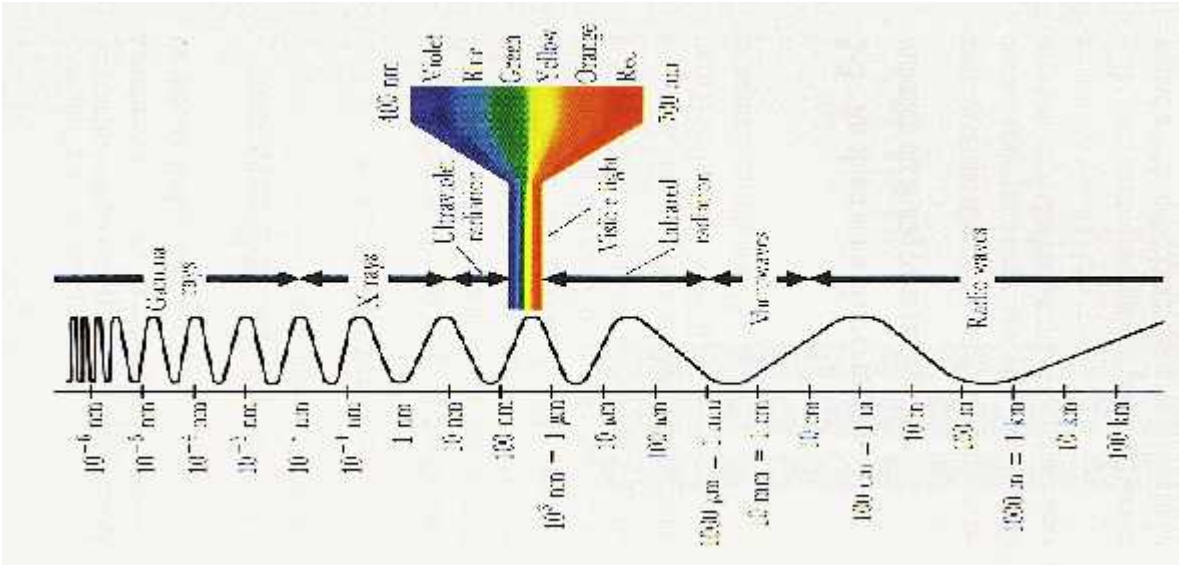
Because urea is produced and excreted at a roughly constant rate, high levels of urea in the blood indicate a problem with the removal or, more rarely, the over-production of urea in the body.

The most common cause of uremia is renal problems. It is measured along with creatinine to indicate direct problems with the kidneys (e.g., chronic renal failure) or secondary problems such as hypothyroidism.

# Chapter Three

# The Electromagnetic Spectrum

## 3.1 Introduction




Figure(3.1): The electromagnetic spectrum.

Since spectrophotometery involves measurements of transmitted electromagnetic radiation by detectors it is essential to understand the characteristics of electromagnetic radiation. Electromagnetic radiation consists of gamma rays, x-Rays, Ultraviolet (UV), visible infrared (IR), microwaves and radio waves. Gamma rays have

the highest energy (short wavelength), and radio waves have the least energy (long wavelength). In spectroscopy the term light describes the visible form of electromagnetic radiation as will as the UV of electromagnetic radiations, which are invisible. In absorbance of spectrophotometery, the UV (195 to 380 nm), visible (380 to 740nm) regions of the electromagnetic spectrum are used. The UV and visible forms of electromagnetic radiation are used in most instruments in the clinical chemistry laboratory. Infrared spectroscopy is occasionally used in the toxicology laboratory in the identification and confirmation drugs or toxic chemicals. Gamma rays are used in radioimmunoassay counters. See figure (3.1).

The spectrum is smoothly continuous and the labelling and assignment of separate ranges are largely a matter of convenience.

**3.2 Ultraviolet Spectrum:**

The UV region is generally defined as the wavelength range from 195 to 380 nm. This spectral region is obtained by energy transitions in the valence electrons of the molecules. The UV is a very high energy region. It can cause damage to the human eye as well as the common sunburn. Compounds containing isolated double bonds, triple bonds, peptide bonds, aromatic compounds, carbonyl groups, and other hetero atoms have maximum absorbance in the UV region. Factors such as pH, salt concentration, and solvent charge that increase or decrease the charge on the molecule will shift the UV spectra. The UV region is important for the qualitative and quantitative determination of organic compounds. UV radiation has wide application in clinical chemistry. Sources of UV radiation include discharge tubes containing hydrogen or

deuterium at reduced pressure. High-pressure mercury and xenon arc lamps are also used.

### 3.3 Visible Spectrum:

The visible region is defined as the wavelength range visible to the human eye. Within this region ranging from 3٨0 to 7٤0 nm, a continuous spectrum is obtained with a distinct visible color in a specified portion of wavelengths.

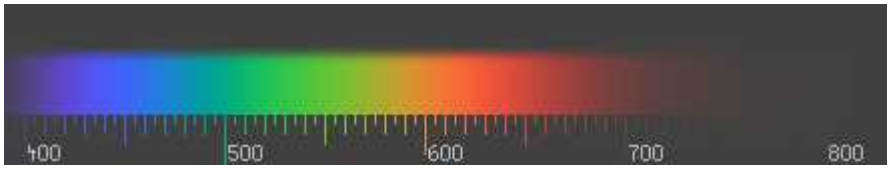
The order of the colors starting with the shortest wavelength is violet — blue — green — yellow — orange — red (ViBGYOR), as shown in Table( ٣.١).

The visible color of a solution corresponds to the wavelengths of light that are transmitted, not absorbed, by the solution. The absorbed color is the complementary of the transmitted color. Thus, to make absorption measurements, one must use the wavelength at which a colored solution absorbs light.

Table (3.1): Characteristics of Visible Spectrum

| Color | Wavelength interval | Frequency interval |
|---|---|---|
| violet | ~ 380 to 430 nm | ~ 790 to 700 THz |
| blue | ~ 430 to 500 nm | ~ 700 to 600 THz |
| cyan | ~ 500 to 520 nm | ~ 600 to 580 THz |
| green | ~ 520 to 565 nm | ~ 580 to 530 THz |
| yellow | ~ 565 to 590 nm | ~ 530 to 510 THz |
| orange | ~ 590 to 625 nm | ~ 510 to 480 THz |
| red | ~ 625 to 740 nm | ~ 480 to 405 THz |

Continuous spectrum




Figure(3.2): The spectrum of visible light

A red solution absorbs green light and transmits red light. Therefore, a red solution should be measured at 490 to 580 nm. The visible region of the spectrum has been used extensively in clinical laboratories. Both colored and colorless compounds that can be converted to colored products by reaction with suitable reagents can be analyzed in this region. The source of visible radiation is usually a tungsten lamp. This lamp does not provide enough energy below 320 nm.

It is important to note that all natural radiation is a form of energy and that energy is inversely proportional to wavelength: the shorter the wavelength the higher the energy.

All electromagnetic radiation travels at a fixed speed of 3 x $10^{10}$ cm per sec which is the speed of light (or c) in a vacuum. The distance between two peaks along the line of travel is the wavelength, or λ, and the number of peaks passing a point in unit time is the frequency, *ν*(nu), usually expressed in cycles (hertz) per sec. (Figure3.3)

The arithmetic relationship of these three quantities is expressed by

$$c = {}^{a}\nu \qquad (1)$$

The laws of quantum mechanics may be applied to photons to show that

$E = h\nu$ (2)

Where E is the energy of the radiation, v is the frequency and h is Planck's constant. In (1) above it has been shown that

$c = {}^{a}\nu$

Therefore $E = \frac{hc}{a}$ (3)

In the visible region it is convenient to define wavelength in nanometers (nm) that is in units of 10-9 meters although other units may be encountered such as millimicron (mμ) or Angstrom ($A^0$).

1 nanometer =1 nm=$1\times10^{-3}$μm=10 $A^0$

The visible spectrum is usually considered to be 380—740 nm and the ultraviolet region is normally defined as 195—380 nm.

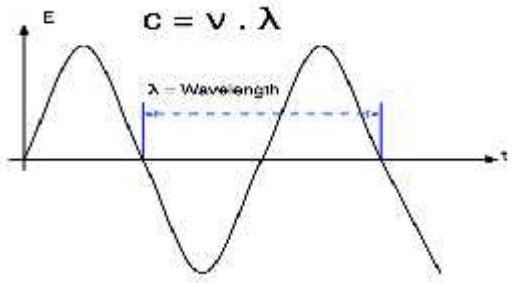



Figure (3.3): Wavelength: distance between two successive peaks.

# Chapter Four

# Theoretical Background

## 4.1 Introduction

We are going to use absorption techniques to measure the concentration of solutes in solution. To do this, we will measure the amount of light that is absorbed by the solutes in solution in a cuvette in absorption techniques, absorption techniques takes advantage of the dual nature of light. Namely, light has:

1. A particle nature which gives rise to the photoelectric effect.
2. A wave nature which gives rise to the visible spectrum of light.

Absorption measures the intensity of a light beam after it is directed through and emerges from a solution. As an example, let's look at how a solution of copper sulfate (CuS04) absorbs light.

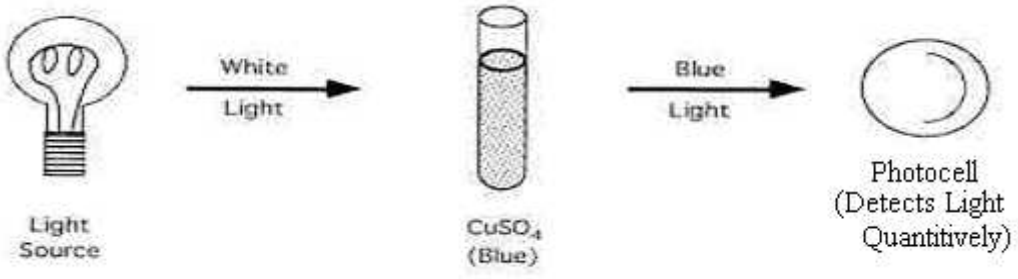



Figure (4.1): Absorption technique.

The red part of the spectrum has been almost complete absorbed by CuSO4 and blue light has been transmitted. Thus, CuSO4 absorbs little blue light and therefore appears blue.

In absorption techniques we can gain greater sensitivity by directing red light through the solution because CuSO4 absorbs strongest at the red end of the visible spectrum. But to do this, we have to isolate the red wavelengths.

### 4.2 Spectrum of Visible Light

How do you isolate the red wavelengths of light? In absorption technique, a light source gives off white light which strikes a prism, separating the light into its component wavelengths:

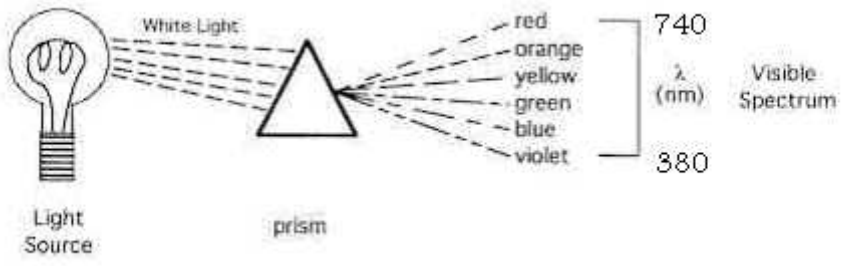



Figure (4.2): Separation of light.

Now, all we have to do is isolate the red wavelengths and pass them through the CuSO4 solution and measure the amount of red light absorbed. The absorption technique will actually measure the amount of light transmitted by the CuSO4 solution.

The important point to note here is that, colored compounds absorb light differently depending on the I of incident light.

The solutes absorb photons (light) energy within characteristic wavelength bands because atoms and molecules absorb light energy in such a manner that an alteration in atomic or molecular energy state occurs. In light absorption changes can occur in atomic or molecular energy states in one of three ways:

1. By the boosting of e- to higher energy levels.
2. By increasing the rate at which atoms within a molecule vibrate relative to one another.
3. By increasing the rotational speed of molecules in the solution.

**4.3 Main Principle of Liquid Substance Concentration using Light Absorption Technique**

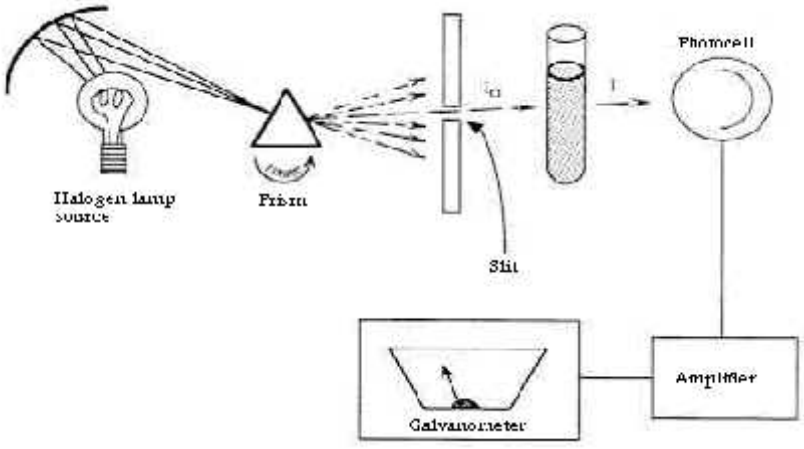



Figure (4.3): Simple block diagram of Liquid Substance Concentration using Light Absorption Technique.

Io is the incident light and represents 100% of the light striking the cuvette. I is the transmitted light. This is the light which has not been absorbed by the solution in the cuvette and will strike the photocell. The photons of light which do strike the photocell will be converted into electrical energy. This current which has been produced is very small and must be amplified before it can be efficiently detected by the galvanometer. The deflection of the needle on the galvanometer is proportional to the amount of light which originally struck the photocell and is thus an accurate measurement of the amount of light which has passed through (been transmitted by) the sample.

**The Blank**: In order to effectively use a Liquid Substance Concentration using Light Absorption Technique we must first zero the machine, we do this using "the blank." The blank contains everything except the compound of interest which absorbs light. Thus, by zeroing the machine using "the blank," any measured absorbance is due to the presence of the solute of interest.

### 4.4 Absorption Spectrum

Because each electron in a molecule has unique ground state energy and because the discrete levels to which it may jump are also unique it follows that there will be a finite and predictable set of transitions possible for the electrons of a given molecule. Each of the transitions, or jumps, requires the absorption of a quantum of energy and if that energy is derived from electromagnetic radiation there will be a direct and permanent relationship between the wavelength of the radiation and the particular transition that it stimulates. That relationship is known as specific

absorption and a plot of those points along the wavelength scale at which a given substance shows absorption ‘peaks’, or maxima, is called an absorption spectrum. See figure (4.4) the absorption spectrum of a compound is one of its most useful physical characteristics, both as a means of identification (qualitative analysis) and of estimation (quantitative analysis).

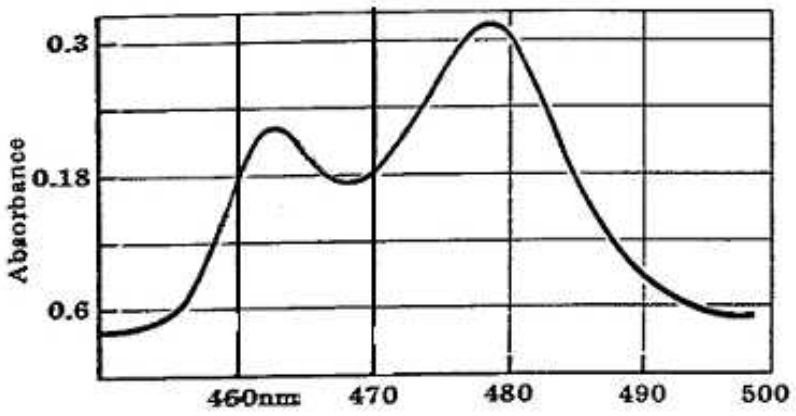



Figure (4.4): Typical absorption spectrum in visible region.

If there is absorption in the visible and that absorption occurs in the red then the substance will be seen as blue since red and blue are **complementary colors**(is two colors on opposite sides of the colour wheel, which when placed next to each other make both appear brighter. The complementary color of a primary color (red, blue, and yellow) is the color you get by mixing the other two (red + blue = purple; blue + yellow = green; red + yellow = orange). So the complementary color for red is blue, for blue it's orange, and for yellows its purple.). See figure (4.5)

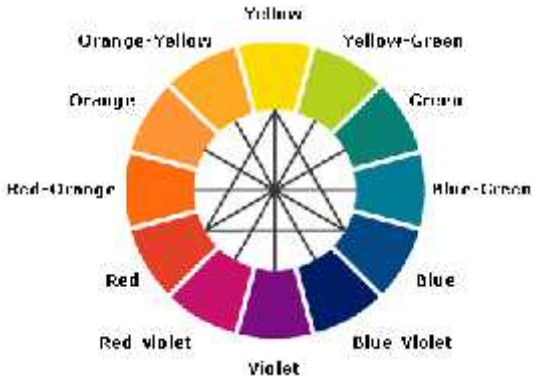



Figure (4.5): Complementary colour: If the solution has one of the colours it will absorb the obverse colour.

The chemical group most strongly influencing molecular absorption characteristics is called a chromophore. Chromophores which can be detected by UV/Vis absorption technique always involve a multiple bond (such as C=C, C=O or C≡O) and may be conjugated with other groups to form complex chromophores. A typical example is the benzene ring which has an absorption peak at 254 nm.

$$a_{max} = 254nm$$

Increasingly complex chromophores move the associated absorption peak towards longer wavelengths and generally increase the absorption at the maxima.

Although the emphasis on the value of UV/Vis absorption technique is naturally towards organic compounds, there is a wide range of inorganic substances that lend themselves to similar methods of analysis. Species with a non-metal atom double- bonded to oxygen absorb in the ultraviolet region and there are several inorganic double-bond chromophores that show characteristic absorption peaks. In

some instances measurement of inorganic materials may- demand a secondary process such as complexation with a colour-forming reagent or oxidation – e.g. manganese (II) oxidized to manganese (VII) and measured as the $MnO_4^-$ ion (permanganate).

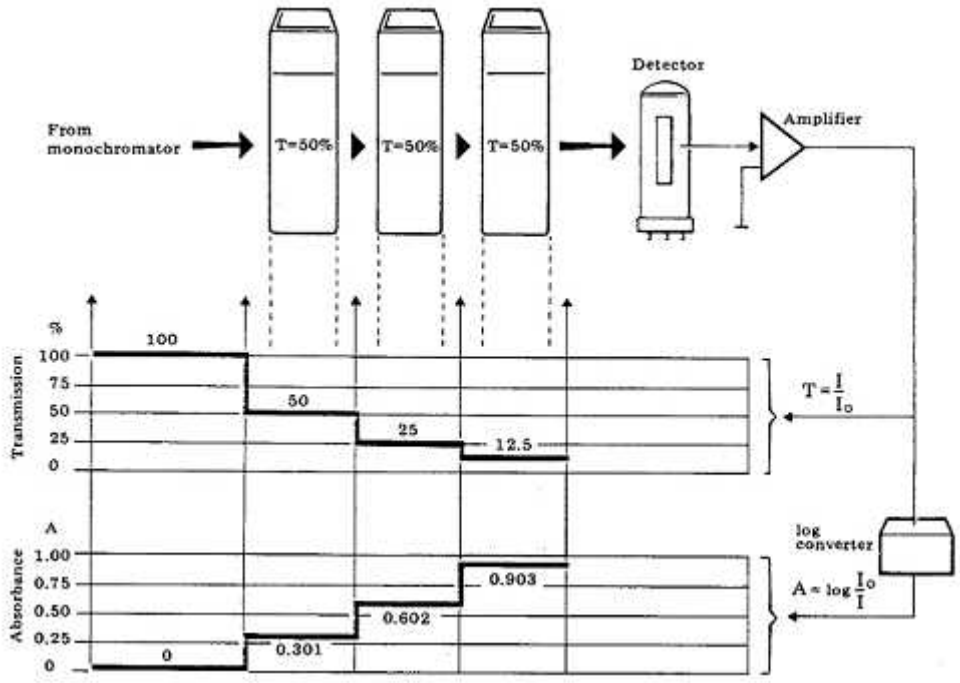



Figure (4.6): Diagrammatic representation of relationship between Transmission and Absorption.

For analytical purposes, two main propositions define the laws of light absorption.

**A. Lambert's Law** The proportion of incident light absorbed by a transparent medium is independent of the intensity of the light (provided that there is no other physical or chemical change to the medium). Therefore successive layers of equal thickness will transmit an equal proportion of the incident energy. See figure (4.6)

Lambert's law is expressed by

$$\frac{I}{I_0} = T \qquad (1)$$

Where I = the intensity of the transmitted light

$I_0$ = the intensity of the incident light

T = Transmittance.

It is customary to express transmittance as a percentage:

$$\%T = \frac{I}{I_0} \times 100 \qquad (2)$$

**B**. **Beer's Law** The absorption of light is directly proportional to both the concentration of the absorbing medium and the thickness of the medium in the light path.

A combination of the two laws (known jointly as the Beer-Lambert Law) defines the relationship between absorbance (A) and transmittance (T).

$$\mathrm{A} = \log \frac{\mathrm{I}_0}{\mathrm{I}} = \log \frac{100}{\mathrm{T}} = a\mathrm{cb} \qquad (3)$$

Where

A= absorbance (no unit of measurement)

a = absorptivity, a factor that depends on the absorbing substance and the optical wavelength at which the measurement is performed.

c= concentration of the absorbing substance.

b = path length of the cuvette.

It is important to note that *a* is a function of wavelength and so the Beer-Lambert law is true only for light of a single wavelength, or monochromatic light.

Figure(4.6) illustrates the conditions when three samples (e.g. standard solutions) having identical absorption are introduced into a beam of monochromatic light. Each of the samples is chosen so that precisely one half of the intensity of the incident radiation is transmitted (T = 50%).

If the intensity of the incident radiation is 100%T then the intensity after each sample

Will be:

after $S_1 = l \times 0.5 = 50\%T$

after $S_2 = 50\% \times 0.5 = 25\%T$

after $S_3 = 25\% \times 0.5 = 12.5\%T$

The three samples may be considered as known concentrations of an absorbing medium and it therefore becomes possible to plot concentration against transmission. It will be found that the resultant graph is exponential, see figure (4.7) and so of limited value.

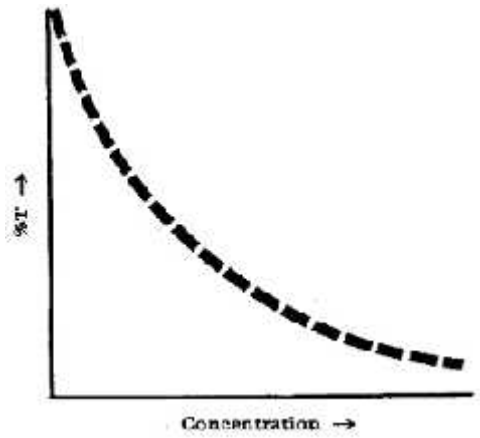



Figure (4.7): Transmission plotted against concentration.

However, providing the light is entering the concentration value of the monochromatic and the Beer-Lambert law standard or the factor to the calculation so is obeyed, it becomes possible to define the Beer-Lambert law is obeyed; it becomes possible to define the process in terms of absorbance (A).

In the example above, the expression related A to T ( $A = \log \frac{100}{T}$ ) shows that the absorbance after each sample will be:

after $S_1$ = 0.301

after $S_2$ = 0.602

after $S_3$ = 0.903

It can at once be seen that a plot of absorbance against concentration will be linear. Figure (4.8) it is therefore more convenient to express results in absorbance rather than transmission when measuring unknown concentrations since linear calibration plots will be available.

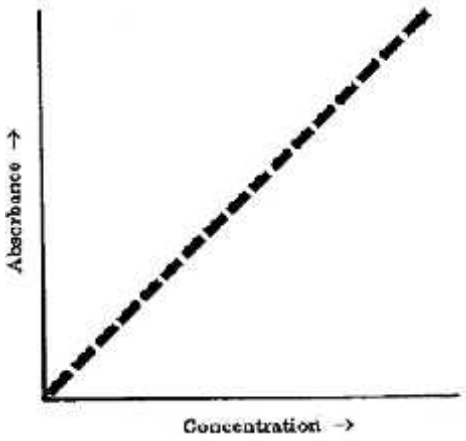



Figure (4.8): Absorbance plotted against concentration.

The absorbitivity can be obtained by measuring the absorption a solution with known concentration, called standard.

$C = kA$ (4)

where C = the concentration of the unknown

A = the measured absorbance of the unknown

and k is a factor derived from the reference or standard solution.

If $A_s$ is the absorption of the standard, and $C_s$ the concentration of the standard, then K is:

$$k = \frac{concentration(\text{Standard})}{absorbance(\text{Standard})} = \frac{C_s}{As} \quad (5)$$

If $A_u$ the absorption of an unknown solution, and $C_s$ the concentration of standard solution, then the concentration of unknown is

$$C_u = kA_u \qquad (6)$$

$$\rightarrow C_u = C_s \frac{A_u}{A_s} \qquad (7)$$

In many of today's devices us absorption technique the output electronics provide the means of entering the concentration value of the standard or the factor to the calculation so that instrument readings are directly in concentration units.

# Chapter Five

# Design Concept

## 5.1 The basic elements construction of the project

Our project consists of basic elements as follow:

١. Source of radiation of appropriate wavelength.

2. Plano convex Lenses.

٣. Means of isolating light of a single wavelength - Filter.

4. Means of introducing the test sample into the light beam (Cuvette).

5. Means of detecting and measuring the light intensity.

6. Means of Analog to Digital Converter (ADC).

7. Means of temperature sensor.

8. Means of heating (Heater).

9. Means of read output device (PC).

## 5.2 Block Diagram

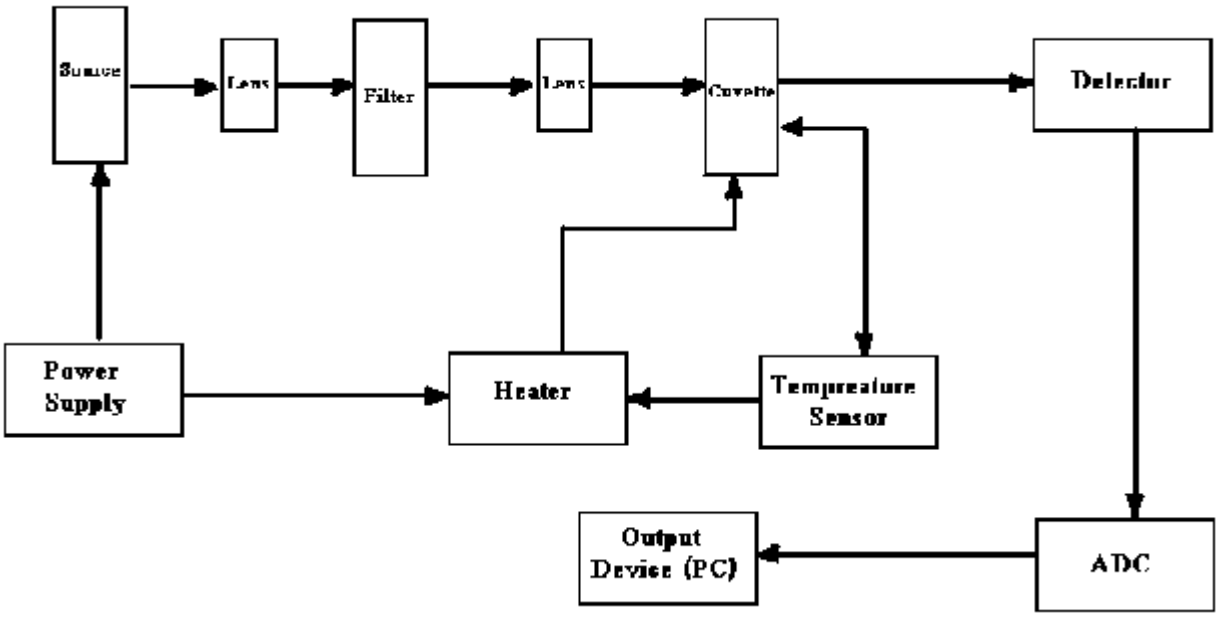



Figure (5.1): Block Diagram.

### 5.2.1 The source

The requirements are that the source should be stable, i.e. that the intensity of emitted radiation should not fluctuate, and that there should be adequate intensity over as large a wavelength region as possible. In practice it is not possible to provide suitable emission from a single source to cover the whole UV/Vis region (say 195 nm to 740 nm) so that a dual source is normally provided.

Ultraviolet light is generally derived from a deuterium arc which provides emission of high intensity and adequate continuity in the 195-380 nm range. A quartz or silica envelope is necessary not only because of the heat generated but also to transmit the shorter wavelengths of the ultraviolet radiation. The limiting factor is normally the lower limit of atmospheric transmission at about 195 nm. Fig.(5.2).

Visible light is normally supplied by a tungsten or, in modern systems, by a tungsten-halogen (also described as quartz-iodine) lamp which has higher relative output in the changeover region (320-380 nm). The long wavelength limit is usually the cut-off of the glass or quartz envelop, normally well beyond the useful visible limit at 770 nm. See fig. (5.2).

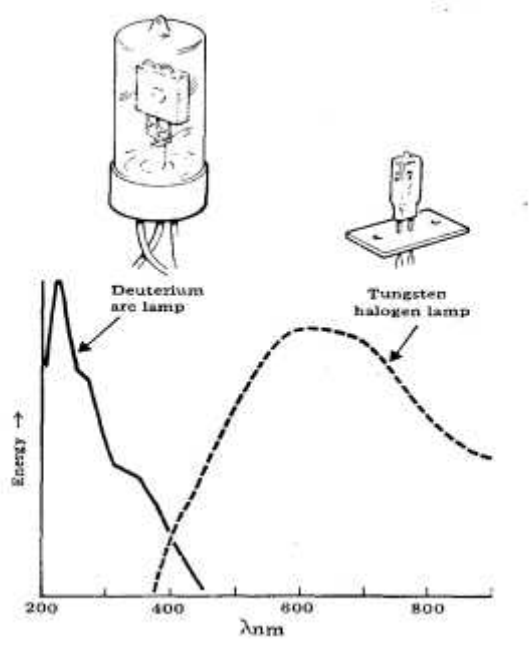



Figure (5.2): UV/VIS light source.

So in our project "Design of Liquid Substances Concentration Using Light Absorption Technique" we used halogen lamp as a source to supply visible light.

#### 5.2.1.1 Halogen lamp

Halogen lamps are high pressure, incandescent lamps that contain halogen gases such as iodine and bromine that allow filaments to work at higher temperatures and higher efficiencies. Halogen lamps consist of a tungsten filament inside a quartz envelope that is filled with halogen gas. In halogen lamps, the quartz envelope is closer to the filament than the glass used in conventional light bulbs. Heating the filament to a high temperature causes the tungsten atoms to evaporate and combine with the halogen gas. These heavier molecules are then deposited back on the filament surface. This recycling process increases the life of the tungsten filament and enables the halogen lamp to produce more light per units of energy. Consequently, halogen lamps are used in a variety of applications.

Halogen lamp performance is measured in rated average life, watts (W). In order to get a very bright light, we need to increase the temperature of the tungsten filament.

### 5.2.2 Lenses

We used used two Plano convex lens the first one that sends a beam of parallel rays to the interference filter. The second one is used to focus the beam in the center of the cuvette.

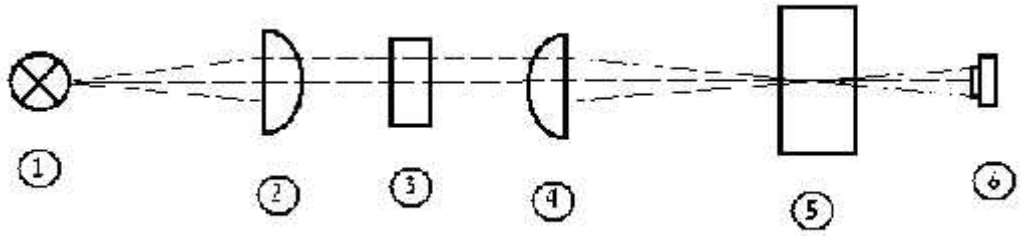



Figure (5.3): Show the principle of Lenses.

Where:

1: Halogen lamp.

2: First Plano convex lens.

3: Interference filter.

4: Second Plano convex lens.

5: Cuvette.

6: Detector.

### 5.2.3 Spectrum Filtration

Two basic methods of wavelength selection may be noted.

1. Filters

2. Dispersing system (a diffraction grating).

Filters of coloured glass or gelatine are the simplest form of selection but they are severely limited in usefulness because they are restricted to the visible region and they have wide spectral bandwidths. Typical bandwidths are rarely better than 30- 40 nm.

**Interference filters:** essentially a substrate (glass normally, but may be silica) on which materials of different refractive indices have been deposited can be constructed with bandwidths of the order of 10 nm or less

.

Many earlier filtrations were designed using color filters for wavelength selection. The use of colored filters offered high energy throughput, which enhanced the sensitivity of these instruments. A filter-based instrument also afforded simplicity in design and function. These earlier instruments, however, suffered considerably by offering poor wavelength discrimination.

This has all changed with the advent of newer generation interference filters. In recent years, the technology underlying modern interference filter design has improved significantly. As a result, interference filters provide features that make

them superior to any other device currently available for wavelength selection in a filtration.

**Gratings Diffraction:** gratings provide an alternative means of producing monochromatic light. A diffraction grating consists of parallel grooves (lines) on a reflecting surface that is produced by taking a replica from a carefully prepared master or, increasingly, may be holographically generated. The grooves can be considered as separate mirrors from which the reflected light interacts with light reflected from neighboring grooves to produce interference, and so to select preferentially the wavelength that is reflected when the angle of the grating to the incident beam is changed.

Among the advantages that gratings offer (compared to prisms) are better resolution, linear dispersion and therefore constant bandwidth and simpler mechanical design for wavelength selection. See figure (5.4).

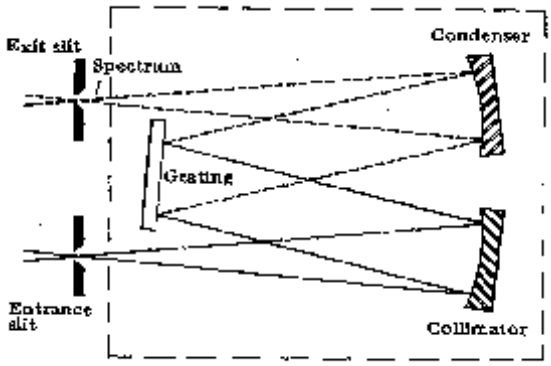



Figure (5.4): Diffraction grating monocromator.

When parallel radiation illuminates a reflecting diffraction grating, the multiple reflections from the mirror grooves will overlap and interfere with each

other. If the reflected waves are in phase interference is said to be constructive and the reflected light is not affected. If the reflected waves are out of phase there is destructive interference and light of the wavelength at which such interference occurs will not be propagated.

The relationship that determines the wavelength of the reflected light is expressed by:

$n\lambda = 2d \sin \theta$.

Where n is the order, d is the separation of the reflecting surfaces (or lines) and θ is the angle of incidence of the radiation. Rotating the grating in the light beam changes θ and so selects the wavelength reflected. See fig. (5.5).

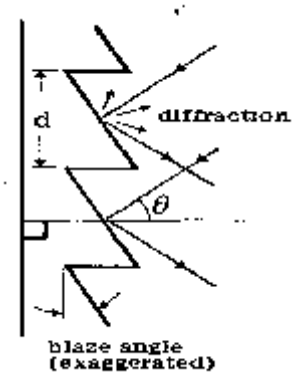



Figure (5.5): Operating principles of a reflecting diffraction grating.

So in our project we used interference filter because use of colored filters offered high energy throughput, which enhanced the sensitivity of these instruments.

### 5.2.3. 1 Interference Filters

Interference filters fig. (5.6) are used in instruments in which measurements are made at fixed wave lengths. Such filters are made of two glass pieces, each with a layer of silver on one side and separated by a dielectric material such as magnesium fluoride. The range of wavelengths that is transmitted by an interference filter depends on the thickness of $MgF_2$ and its refractive index. Only the light for which the exact multiple of the wavelength is equal to the thickness of $MgF_2$ will be transmitted. All other wavelengths will be blocked.

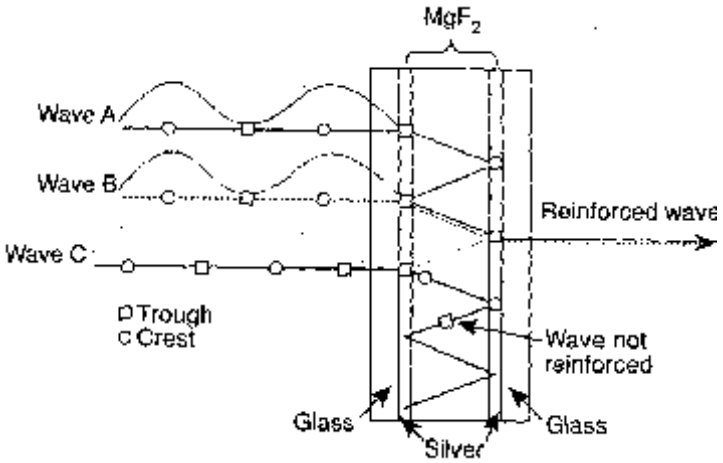



Figure (5.6): Interference Filter.

The wavelength of the filter that we used is 500-520nm. This filter can measure the concentration of glucose in the blood.

### 5.2.4 Sample handling and measurement (Cuvette)

In practice, by far the greater part of all measurements will be made on samples in solution. Vapors and solids can be accommodated but most instruments are designed with a standard cell or (cuvette) as the normal sample container. The design, construction and material of the cuvette are all important to accurate measurements as are operator practice and sample preparation.

#### 5.2.4.1 Type

Cuvettes are made of glass or silica (according to the wavelength range of interest), are fused rather than cemented (to resist the action of some solvents), and have the following characteristics:

١. Optical windows (the sides through which the beam passes) are highly polished, parallel and flat

٢. Entrance and exit surfaces are exactly parallel and orthogonal

٣. Light path (distance between inner surfaces of windows) is tightly controlled.

The holder that locates the cuvette in the light beam must ensure precise and reproducible location with respect to the beam.

The most commonly use cuvette has a light path length of 10 mm but longer or shorter path lengths are useful if concentration or extinction fall outside normal ranges without further processing - e.g. solvent extraction or dilution. Microcells are

particularly useful where sample volumes are restricted: gas cells, flow cells and disposable cells are all available to extend the usefulness of the technique.A range of sample cuvettes is shown in fig. (5.7).

Absorption is a powerful aid to both the identification of the components of an unknown (qualitative analysis) and to the measurement of the amounts of individual components present (quantitative analysis).

In qualitative work it is usually necessary to measure absorption over a range of wavelengths.

#### 5.2.4.2 Size

Cuvettes are available in different form. They may have a rectangular or square cross section or a circular cross section the cuvette with square cross section may have varied internal dimension, but the path length is usually 1cm. The absorbance obtained with square or rectangular cuvettes are more accurate and reproducible than those obtained with test tubes. Test tubes lose some of the incident radiation by reflection and refraction. Such loss is not significant in square or rectangular cuvettes. The cuvette that we used is square cross section which is more accurate than other form, which has less distortion for the light.

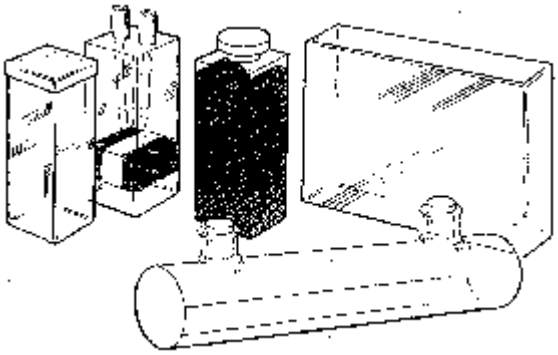


Figure (5.7): Selection of sample cuvett

### 5.2.5 Detectors

The most commonly encountered detectors are the photomultiplier, phototransistor and the silicon diode.Phototubes consist essentially of a glass (or silica) vacuum tube containing coated with an alkali metal and a positively charged anode. When light reaches the cathode electrons are released to the anode giving rise to a potential that is proportional to the intensity of the light.

Photomultiplier tube has rapid response time and high sensitive to the light but we didn't find it in the market, so we going to alternative solution by using phototransistor that we can get good values with it.

**Phototransistors:** are solid-state light detectors with internal gain that are used to provide analog or digital signals. They detect visible, ultraviolet and near-infrared light from a variety of sources and are more sensitive than photodiodes.

The phototransistor that we used is op805ls see fig. (5.8), it sensitivity is function to the collection area (a small area with a constant light intensity will obtain

smaller $I_B$), and the base current $I_B$ is function of the light intensity. This type op805ls has a built in lens that help to focus more light on the base, so when the intensity of light increase, the emitter current will increase that is expressed by the following equation:

$$IE = (IB + IP)(\quad +1) \qquad (1)$$

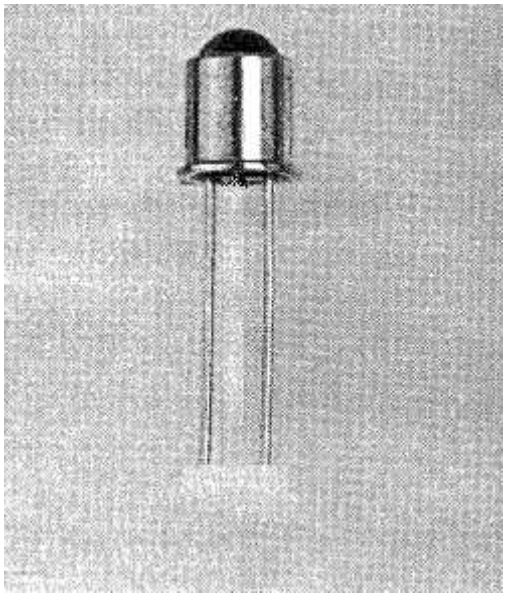


Figure (5.8): Phototransistor/ OP805LS, refer to appendix B(B-1).

### 5.2.6 Temperature Sensor

In the human body the temperature is regulated by brain to keep it around $37C^0$ .when heat of body rise that effect on the metabolism in the body so the concentration of electrolytes is varied proportional to the heat. So in our project we

want to keep the temperature ($37C^0$) of the sample around this value, so we used temperature sensor to control the heater, refer to appendix C**.**

.

### 5.2.6.1 Temperature Sensor (LM35)

- The LM35 series are precision integrated-circuit temperature sensors.
- The output voltage is converted to temperature by a simple conversion factor.
- The sensor has a sensitivity of 10mV / $C^0$.
- Use a conversion factor that is the reciprocal that is 100V / $C^0$.

- The general equation used to convert output voltage to temperature is:
  - $\text{Temperature}(\ ^{o}\text{C}) = \left(\text{Vout} \times 100(^{o}\text{C/V})\right)$
  - The output voltage varies linearly with temperature

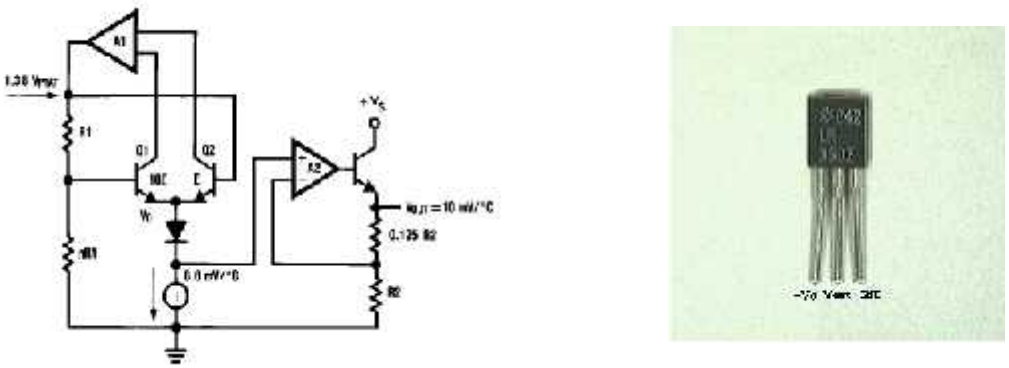


Figure (5.9): The temperature sensor.

### 5.2.6.2 Work of LM35:

- It has an output voltage that is proportional to the Celsius temperature.
- The scale factor is .01V/$C^0$.
- The LM35 does not require any external calibration or trimming and maintains an accuracy of +/-0.4 $C^0$ at room temperature and +/- 0.8 $C^0$ over a range of 0 $C^0$ to +100 $C^0$.

### 5.2.6.3 Connection of LM35:

In this circuit, parameter values commonly used are:

- Vc = 4 to 20v
- 5v or 12 v are typical values used.
- Actually, it can range from 80 KW to 600 KW, but most just use 80 KW, refer to appendix B (B-2).

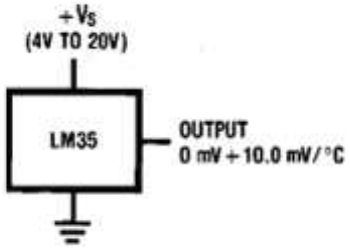



Figure (5.10): Basic Centigrade Temperature Sensor (+2$C^0$ to +150$C^0$)

**5.2.7 OP AMP.:**

An operational amplifier (OP AMP). Is an analog integrated circuit which performs a variety of function in election circuits? One of the applications of op amps is used as amplifier. We use amplifier to amplify signals, because the output signals of most sensors are weak, they need to be amplified before they are processed by electronic circuits. Figure below show typical connection of the amplifier see fig. (5.11), refer to appendex B (B-3).

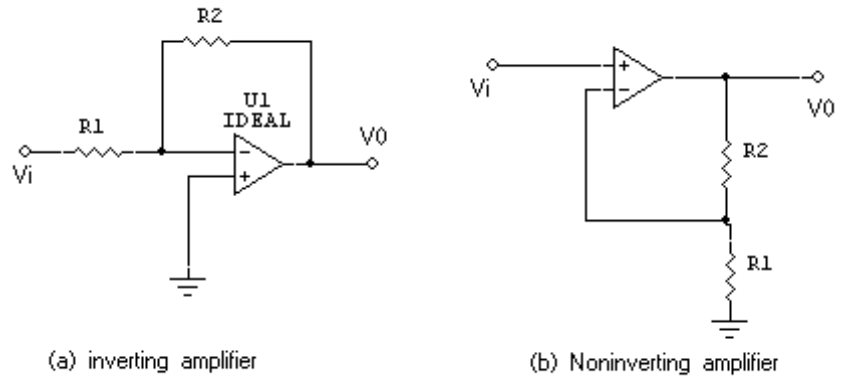



Figure (5.11): a: Inverting amplifier b: Noninverting amplifier

The following equation to measure the gain of inverting amplifier:

$$Vo = -\left(\frac{R2}{R1}\right)Vi \qquad (2)$$

The following equation to measure the gain of Noninverting amplifier:

$$V0 = (1+\frac{R2}{R1})Vi \qquad (3)$$

We used noninverting amplifier with gain's factor equal 10 to ampliefy the signal of LM35 to make the output average in the range of the ADC 0804 input.

### 5.2.8 Fan

The fan cool the air environment around the sample which adjust the sample on the body's temperature to keep the sample on the ideal condition see fig.(5.12).

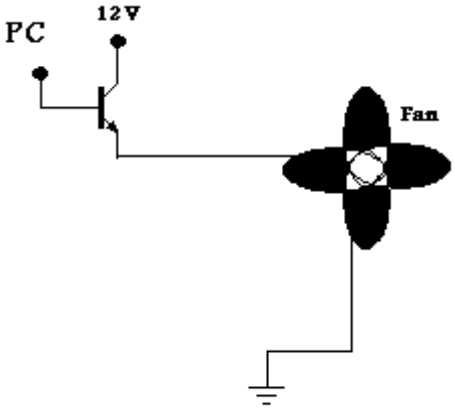



Figure (5.12): Circuit for controlling fan

### 5.2.9 Heater

The heater heats the air environment around the sample, which adjust the sample on the body temperature to keep the sample on the ideal condition see fig. (5.13).

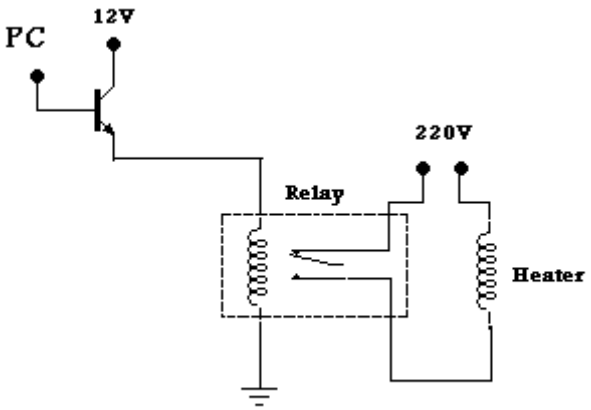



Figure (5.13): Circuit for controlling heater

### 5.2.10 Analog to Digital Converter

Since the analog input may take on any one of an infinite number of values but the output must be resolved into a fixed number of discrete levels or steps, each output step inherently represents a range of input voltages. The process of forming discrete groups from the continuous input is called quantization, so the output doesn't exactly represent a given input value; rather, it represents an approximation.

When the input signal is converted to digital output, we normally expect that steadily increasing values of input will produce equally spaced digital values in the output, see fig. (5.14).

We use 0804 which is 8-pit digital converter, successive-approximation which use a modified potentiometric ladder. This converter appear to the processor as memory locations or I/O ports, The differential analog voltage input has good common de-rejection and permits offsetting the analog zero-input voltage value. In

addition, the voltage reference input can be adjusted to allow encoding any smaller analog voltage span, refer to appendix B (B-4) and appendix C.

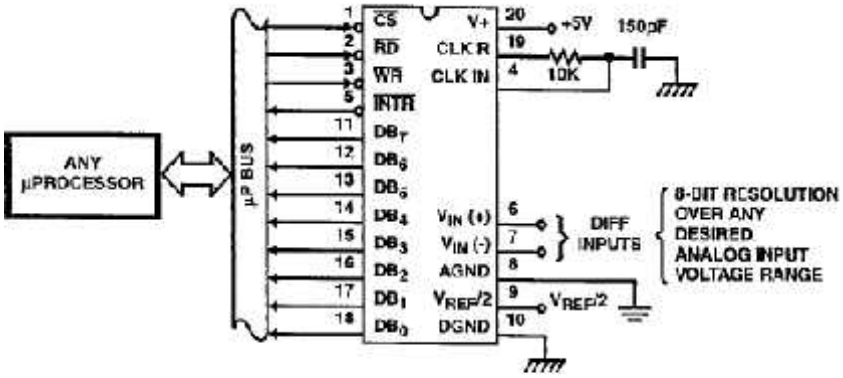



Figure (5.14): 0804A/DC Schematic.

### 5.2.10.1 Restart During a Conversion

If the A/D is restarted (CS and WR go low and return high) during a conversion, the converter is reset and a new conversion is started. The output data latch is not up dated if the conversion in progress is not completed. The data from the previous on version remain in this latch.

### 5.2.10.2 Continuous Conversions

In this application, the CS input is grounded and the WR input is tied to the INTR output. This WR and INTR node should be momentarily forced to logic low following a power up cycle to insure circuit operation.

The digital-output display can be decoded by dividing the 8 bits into 2 hex characters, one with the 4 most-significant bits (MS) and one with the 4 least-significant bits (LS). The output is then interpreted as a sum of fractions times the full scale voltage:

$$Vout = \left( \frac{MS}{16} + \frac{LS}{256} \right) \times 5.12 \qquad (4)$$

For example, for an output display of 1011 0110, the (MS) character is hex B (decimal 11) and the LS character is hex (and decimal) 6, so:

.

$$Vout = \left( \frac{11}{16} + \frac{6}{256} \right) \times 5.12 = 3.64V \qquad (5)$$

### 5.2.11 Multiplexer (MUX)

The multiplexer is a combinational circuit that selects binary information from one of many input lines and directs it to a signal output line. The selection of the particular input line is controlled by asset of selection lines. Normally, there are $2^n$ input lines and n selection lines whose bit combinations determine which input is selected.

We have two digital values, one from phototransistor and the other from temperature sensor, each value is represent by 8 bit. As we know the parallel port deal with only one input value, so we use the MUX to detect one of them see fig. (5.15), refer to appendix C.

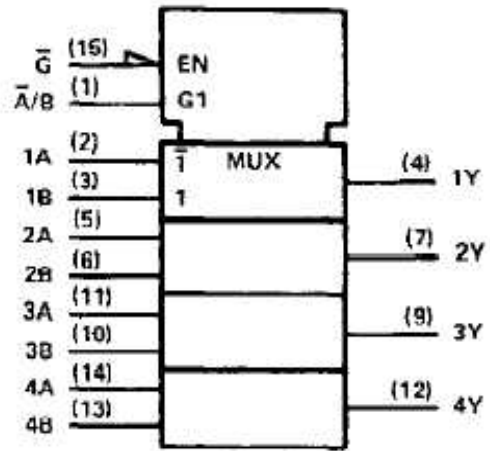



Figure (5.15): LS157 MUX Schematic

We divided the data of analog to digital converter in two frames, each one four bit, the first frame connect to the first MUX and the other frame to the second MUX, the other analog value is divided as the same thing. So each MUX will have 8-bit.Every MUX's IC has CS's pin that is connected with parallel port to detect which of them will be activated, refer to appendix B (B-5).

### 5.2.12 Optocoupler

An optocoupler is usually divided into part: the input part and the output part. The input consists of an infrared light emitting diode (ILED). The output is usually a phototransistor for DC output, or phototriac for AC output. The link between the tow parts is achieved by the infrared light emitted by the diode and

received by the phototransistor. Figure below show typical connection of the optocoupler, see fig. (5.16).

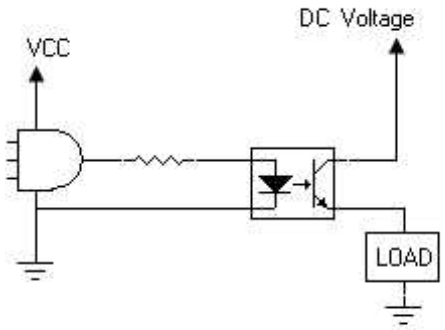



Fig.(5.16): Optocoupler.

When forward current ($I_f$) is passed through the diode, it emits infrared radiation. The radiation energy is transmitted through an optical coupling medium and falls on the surface of the phototransistor. This causes the phototransistor to conduct the electrical current which passes to the load.

The input voltage and current are very small compared to the output voltage and current. This makes optocouples very useful in interfacing circuits where a small electrical signal drives a large signal. It also provides protection for the control circuit from overloading and unexpected changes in the load circuit, refer to appendix B (B-6)and appendix C.

#### 5.2.13.1 Parallel Port

There are strong arguments for serial interfacing over long distances or if network switching is involved. The number of interconnection pins is fewer and so the cost is minimized.

If the interface lines are short and no switching is involved then strong arguments may be advanced for using parallel data path. If we transfer data at a given rate on one wire serially organized then using eight parallel data paths will give an eight-fold increase in transfer rate. The main difference between serial and parallel interfaces, a part from the number of data lines is that if we can afford them then, we can afford separate lines for synchronization control....etc.

So for a short point-to-point parallel interface, we may have many pins carrying all the signals we need separately. Fig (5.17) illustrated a common printer 6interface that has 8 parallel data lines yet uses 25 pin Connector or 36 pin connector in the older model

Finally we chose this type mainly because it is suitable for short distance communication that is applied in our application, and there is no need to use a microprocessor or micro controller or PLC (Programmable Logic Control).

The original IBM-PCs Parallel Printer Port had a total of 12 digital outputs and 5 digital inputs accessed via 3 consecutive 8-bit ports in the processor's 1/0 space.

- 8 output pins accessed via the DATA Port.
- 5 input pins (one inverted) accessed via the STATUS Port.
- 4 output pins (three inverted) accessed via the CONTROL Port.
- The remaining 8 pins are grounded.

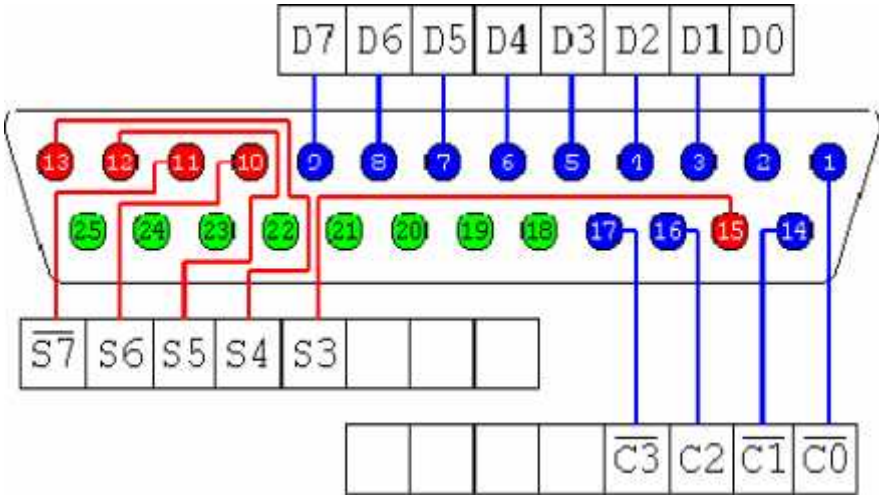



Figure (5.17): 5-way Female D-Type Connector

### 5.2.13.2 Data Cable

A printer cable was used for the interfacing, it contains 25 lines, and 8 lines are used as data lines, while the other 17 lines are u as control or grounding lines between the printer and the computer, see fig.(5.18).

Figure (5.18): Data cable.

### 5.2.14 Read out Device

The magnitude of the electric current from a detector can be displayed on a meter, a digital read out device, or a recorder. The detector output maybe used directly, amplified or unamplified , or sent through a null point system where the detector output is balanced against the output of the reference circuit the result is usually presented in the transmittance units, absorbance units or direct connection units.

A meter reading device displays the analog detector signal by reflecting a needle along a scale. A digital read out device sends the detector signal through an analog to digital converter (A/D) and then to display results using a light emitting diode (led) or Liquid crystal display (LCD) technology or (PC). So in our project we used (PC).

# Chapter six

# Software System

## 6.1 Software System

In this chapter we up to write a software program that reads the output data (Concentration) from the system through the parallel port, then compare this data with the ideal concentration stored in the PC, and diagnose the disease. The figure below shows a simple flow chart for the software.

## 6.2 Program writing:

### 6.2.1 Introduction:

A programming language is a stylized communication technique intended to be used for controlling the behavior of a machine (often a computer). Like human languages programming languages have syntactic and semantic rules used to define meaning.

Thousands of different programming languages have been created and new ones are created every year. Few languages ever become sufficiently popular that they are used by more than a few people, but professional programmers are likely to use dozens of different languages during their career.

In our project we choose the visual basic language (VB) for writing our program for controlling the behavior of our machine.

### 6.2.2 What Is Visual Basic?

Programmers have undergone a major change in many years of programming various machines. For example what could be created in minutes with Visual Basic could take days in other languages such: as "C" or "Pascal". Visual Basic provides many interesting sets of tools to aid you in building exciting applications. Visual Basic provides these tools to make your life far more easier because all the real hard code is already written for you.

### 6.2.3 Language Features

1. Visual Basic is not only a programming language, but also a complete graphical development environment.

2. Visual Basic's main selling point is the ease with which it allows the user to create nice looking, graphical programs with little coding by the programmer, unlike many other languages that may take hundreds of lines of programmer keyed code.

3. Work under windows environment without any problems because this language is created by Microsoft Company.

4. This language cans easily dealing and controlling with parallel port which using in our project.

5. The visual basic language is easy to learn.

Visual Basic is ideal for developing applications that run in the Windows Me and other windows operating system. VB presents a 3-step approach for creating programs:

1. Design the appearance of your application.
2. Assign property settings to the objects of your program.
3. Write the code to direct specific tasks at runtime.

Our program code is added to the appendix c.

# Chapter Seven

# Experimental Results and Conclusion

## 7.1 Experimental Results:

The concentration is calculated by the main equation:

$$C_u = C_s \frac{A_u}{A_s}$$

Where:

$C_u$= Concentration of the unknown solution.

$C_s$= Concentration of the standard solution (in our project we use standard solution with concentration=100ml/dl).

$A_u$= absorption of the unknown solution.

$A_s$= absorption of the standard solution.

But by using Beer's law:

$$A = \log \frac{V_0}{V}$$

Where:

$V_0$: The output voltage from transmittance light through distilled water

V: The output voltage from transmittance light through the solution.

So we put distilled water in our device to measure $V_0$.

$V_0$= 1.55 volt.

Now to measure absorption of standard solution($A_s$) we put standard solution and measure the output voltage.

$V_s$= 1.4 volt

$$A_s = \log \frac{V_0}{V} = \log \frac{1.55}{1.4} = 0.044$$

From previous we can write the final equation that we use it in the visual basic program to calculate the concentration of unknown solutions (concentration of glucose).

$$C_u = C_s \frac{A_u}{A_s} = 100 \frac{\log \frac{1.55}{V_u}}{0.044} = 2272.72 \times \log \frac{1.55}{V_u}$$

Now the concentration of unknown solution is calculated by this equation so when we run the visual basic program the program read the output voltage from transmittance light through the unknown solution and applied the previous equation to calculate the concentration of glucose.

After these steps we got an unknown glucose in solution, this solution is prepared by operator in clinical laboratory the conclusion that we got it:

The out put voltage ($V_u$) =1.36V.

By running the program the concentration of glucose:

$$C_u = C_s \frac{A_u}{A_s} = 100 \frac{\log \frac{1.55}{V_u}}{0.044} = 2272.72 \times \log \frac{1.55}{1.36} = 129.074\ ml\ /\ dl$$

But we measure the concentration of glucose in this sample by spectrophotometer in clinical laboratory in hospital, though that we can calculate the error.

Now we will calculate the error:

$$\text{The error} = \frac{\text{true value - read value}}{truevlaue} \times 100\% = \frac{250 - 129.074}{250} \times 100\% = 48.37\%$$

We note that the error is big but this error is justified in conclusions.

## 7.2 Conclusions:

1. We approach the target of our project by getting variations in the output voltage compare with variations in the concentration.

2. We able to connect our project to the PC and process output data and control of the temperature.

3. We faced a big problem to find a suitable filter in our project because it is not found in the local market and has high cost.

4. We can't find a suitable heater in the market so we faced a difficult in heater's control, because the heater reaches to high temperature rapidly.

5. There are an errors were found in the concentration reading was caused by :

    - The detector that we must used photomultiplier , but it isn't exist also in the local market so we used phototransistor(085LS) which has less sensitivity than the photomultiplier, and it has sensitivity at 850 nm wave length, so the error ratio well increased over the ideal result.

    - We have an error, because the smith can't give us high quality in the dark room building.

### 7.3 Recommendations:

1. Our project was for one test sample; in the future projects the students can develop it for more than one sample.

2. To enhance the reading concentration in the future projects, they can use photomultiplier instead of phototransistor and enhance the dark room building.

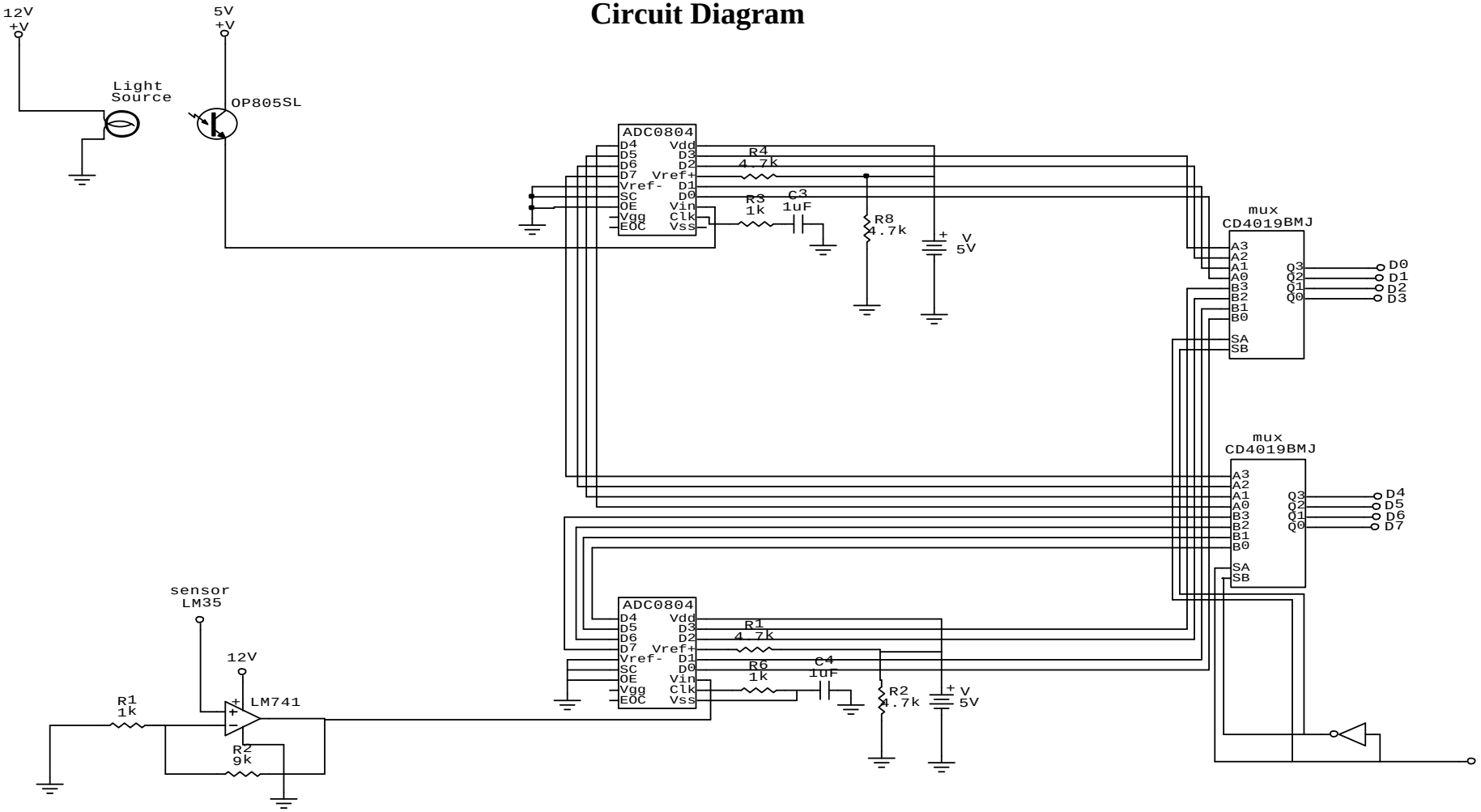
3. We recommend to the electrical department to support the future projects to enhance projects quality.

# Chapter Eight

## Directions for Use

- Connect the power cable to the power source.
- Press on the switch (ON-OFF) to start the machine calibration.
- Prepare the test sample by adding the reagent on it, to get the color that obtained by the reaction.
- After the machine's calibration (15min), put the sample in the cuvett which placed in the dark room.
- Press on the RUN button in the program to start the test.
- Wait for 5mints till the result appear on the program.

# Circuit Diagram



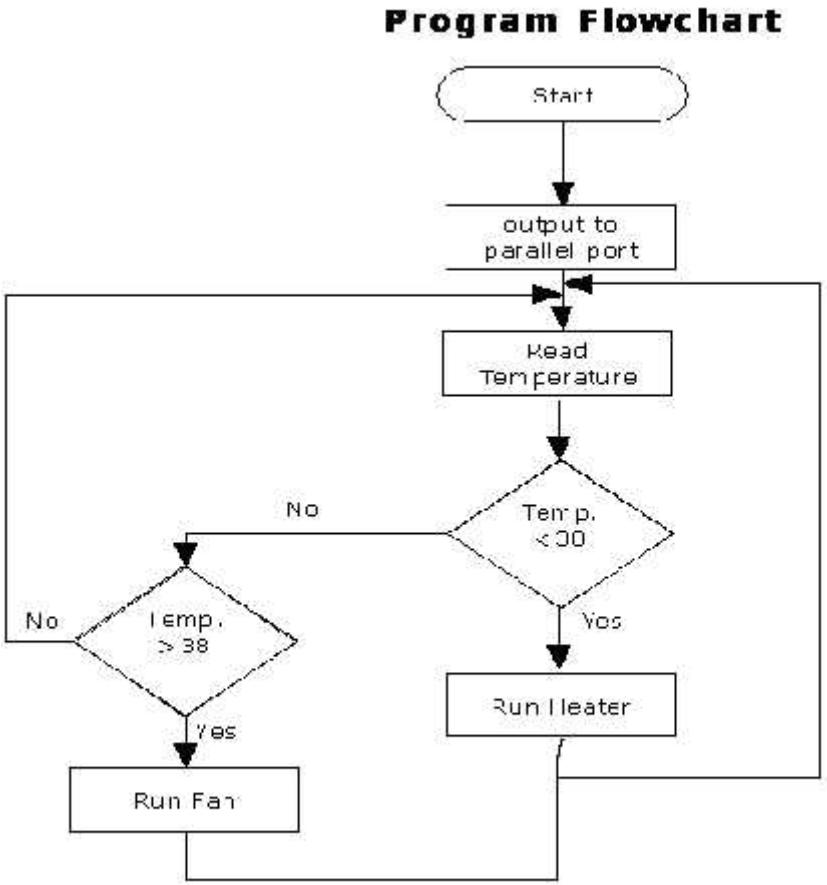
# Software Program

```
Private Declare Sub PortOut Lib "IO.DLL" (ByVal Port As Integer, ByVal Data As
Byte)
Private Declare Sub PortWordOut Lib "IO.DLL" (ByVal Port As Integer, ByVal
Data As Integer)
Private Declare Sub PortDWordOut Lib "IO.DLL" (ByVal Port As Integer, ByVal
Data As Long)
Private Declare Function PortIn Lib "IO.DLL" (ByVal Port As Integer) As Byte
Private Declare Function PortWordIn Lib "IO.DLL" (ByVal Port As Integer) As
Integer
Private Declare Function PortDWordIn Lib "IO.DLL" (ByVal Port As Integer) As
Long
Private Declare Sub SetPortBit Lib "IO.DLL" (ByVal Port As Integer, ByVal Bit As
Byte)
Private Declare Sub ClrPortBit Lib "IO.DLL" (ByVal Port As Integer, ByVal Bit As
Byte)
Private Declare Sub NotPortBit Lib "IO.DLL" (ByVal Port As Integer, ByVal Bit
As Byte)
Private Declare Function GetPortBit Lib "IO.DLL" (ByVal Port As Integer, ByVal
Bit As Byte) As Boolean
Private Declare Function RightPortShift Lib "IO.DLL" (ByVal Port As Integer,
ByVal Val As Boolean) As Boolean
Private Declare Function LeftPortShift Lib "IO.DLL" (ByVal Port As Integer,
ByVal Val As Boolean) As Boolean
Private Declare Function IsDriverInstalled Lib "IO.DLL" () As Boolean
Dim invalues, invaluec As Integer
Dim status(8) As Integer
Dim control(8) As Integer
Dim s1, s2, s3, s4, ms As Integer
Dim c4, c5, c6, c7, ls As Integer
Dim heat As Integer
Dim volt, con As Double

Private Sub Command1_Click(Index As Integer)
Shape1.BackColor = &HFF00&

Call PortOut(888, 1)

End Sub
```

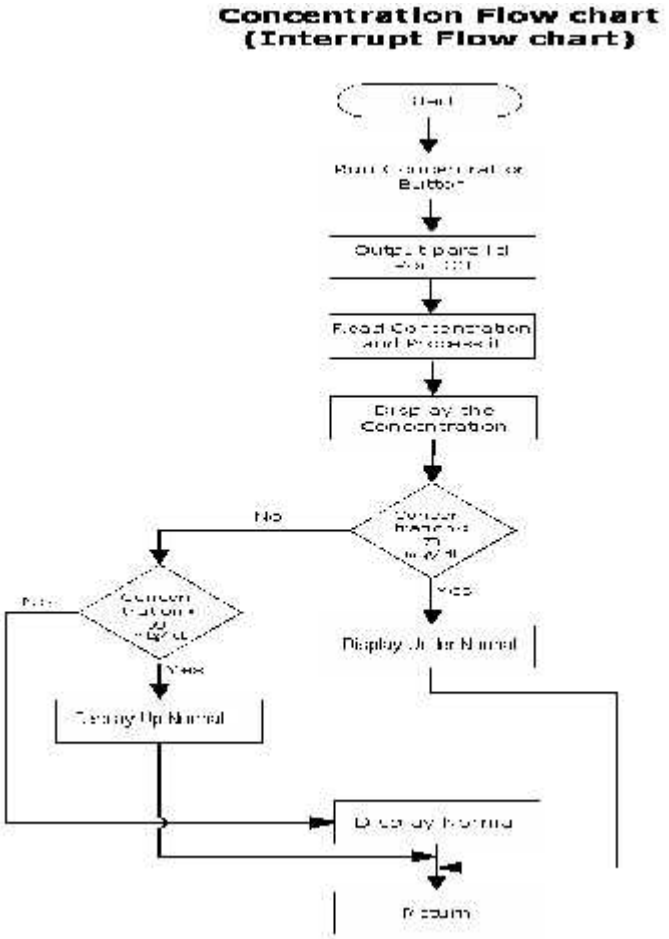
```
Private Sub Command2_Click()
Shape1.BackColor = &HFF&
Call PortOut(888, 0)
End Sub


Public Function d_to_b(invalues)
For i = 0 To 7
If invalues Mod 2 = 0 Then
status(i) = 0
Else
status(i) = 1
End If
Next i
End Function
Public Function d_to_b_control(invaluec)
For i = 0 To 7
If invaluec Mod 2 = 0 Then
control(i) = 0
Else
conterol(i) = 1
End If
Next i
End Function



Private Sub Command3_Click()
Call PortOut(888, 3)
volt = heat / 10
con = (12 / 6) * VBA.Log(4 / volt)
Text2.Text = con
End Sub

Private Sub Form_Load()

invaluec = PortIn(890)
d_to_b (PortIn(889))
If status(0) = 0 Then
s1 = 8
Else
s1 = 0
End If
s2 = status(1) * 4
```

```
s4 = status(3) * 1
ms = s1 + s2 + s3 + s4

If control(7) = 0 Then
c7 = 1
Else
c7 = 0
End If
If control(6) = 0 Then
c6 = 2
Else
c6 = 0
End If
If control(4) = 0 Then
c4 = 8
Else
c4 = 0
End If
c5 = control(5) * 4
ls = c7 + c6 + c5 + c4


heat = ((ms / 16) + (ls / 256)) * 51.2
Text1.Text = heat

If heat < 30 Then
Call PortOut(888, 5)
Else
If heat > 40 Then
Call PortOut(888, 9)
Else
Call PortOut(888, 1)
End If
End If


End Sub
```

## Flow Chart

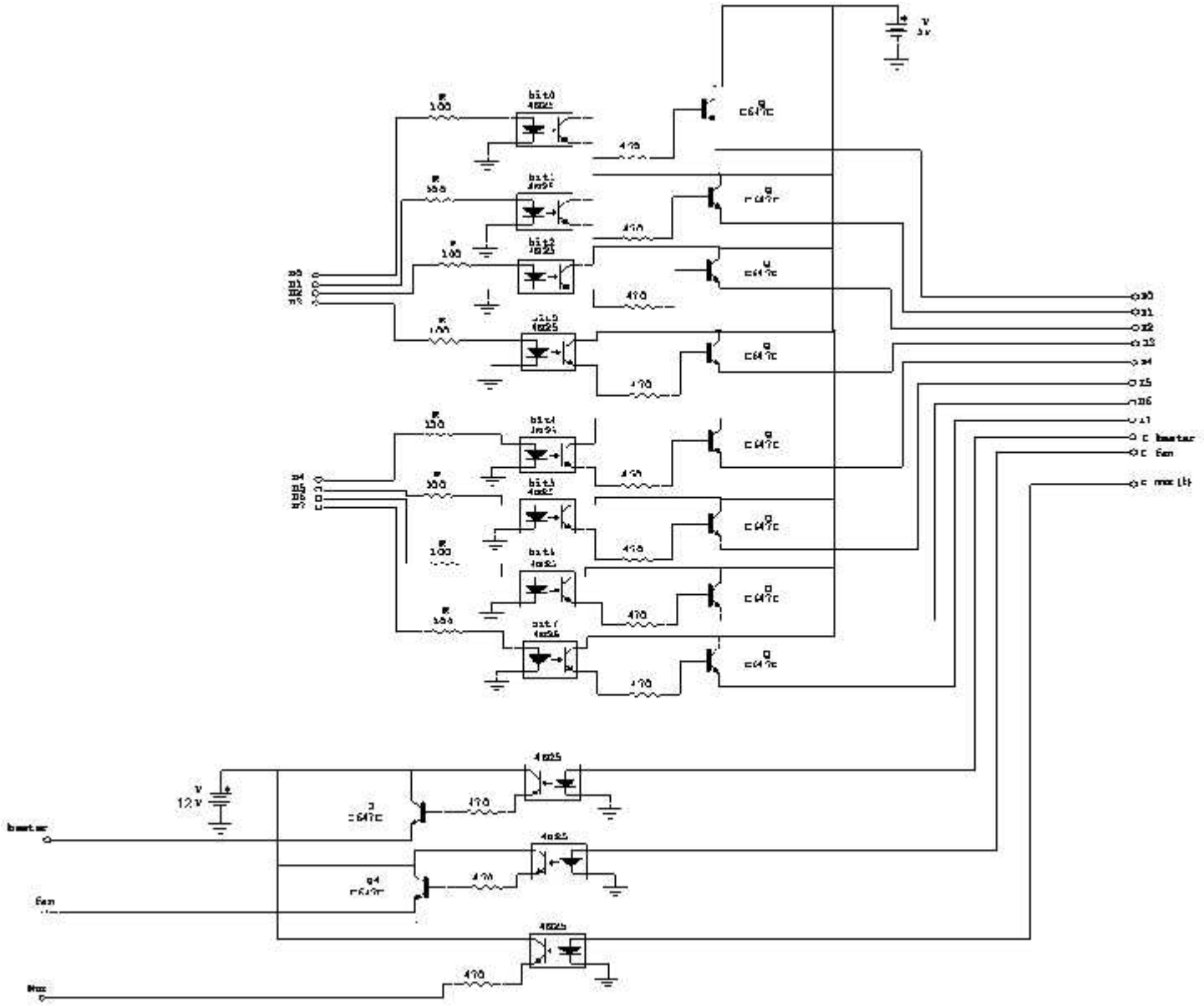



Figure(6.1): Program Flow Chart




Figure(6.2): Concentration Flow Chart

# Interface Circuit



# List of Table


| | | |
|---|---|---|
| **Table 1.1** | **Cost Table** | **3** |
| **Table 2.1** | **Common Chemical Blood Tests and Normal Ranges** | **10** |
| **Table 3.1** | **Characteristics of Visible Spectrum** | **16** |

# References


[1].John G. Webster , Editor. "Medical Instrumentation Application and Design ", John Wiley and Sons , Second Edition, 1995.

[2].Thomas L. Floyd," Electronic Device", Prentise Hall , Sixth Edition, 2002.

[3].Leslie Cromwell, Fred J. Weibell, Rick A. "Biomedical Instrumentation and Measurments",Secon Edition , Prentice Hull 1980.

[4].Robert F. Schmidt and Gerhard Thews ,"Human Physiology " ,First Edition, Springer-Verlag Berline Hedelberg New york 1983.

[5].Norbert W. Tietz,Ph.D ,"Fundamentals of Clinical Chemistry", Third Edition,W.B.Sanders Company 1987.

[6].John G. Webster, "Encyclopedia of medical Devices and Instrumentations", John Wiley and Sons. INC. 1988.

[7]. http://www.pubmed.org.

[8]. http://en.wikipedia.org/wiki/Blood

[9].http://www.datasheetarchive.com/

[10]. http://www.chm.davidson.edu/java/spec/spec.html

# Table of Contents


| | | |
|---|---|---|
| **Title** | | **i** |
| **Dedication** | | **ii** |
| **Acknowledgments** | | **iii** |
| **Abstract** | | **iv** |
| **Table of Contents** | | **v** |
| **List of Figures** | | **vii** |
| **List of Tables** | | **x** |

**Chapter One:- Introduction**

| | | |
|---|---|---|
| **1.1** | **Introduction** | **1** |
| **1.2** | **Project Objective** | **2** |
| **1.3** | **Importance of Project** | **2** |
| **1.4** | **Previous Studies** | **2** |
| **1.5** | **Cost Table** | **3** |
| **1.6** | **Project Contents** | **4** |

**Chapter Two:- Physiology of Blood and Urea**

| | | |
|---|---|---|
| **2.1** | **Blood** | **5** |
| **2.1.1** | **Introduction** | **5** |
| **2.1.2** | **Anatomy of Blood** | **6** |
| **2.2** | **Blood Plasma** | **7** |
| **2.2.1** | **Albumin** | **8** |
| **2.2.2** | **Electrolytes** | **8** |
| **2.3** | **Physiology of Salts Ions** | **9** |
| **2.3.1** | **Physiology of sodium ions** | **10** |

**2.3.2 Physiology of Potassium ions 11**
**2.3.3 Physiology of Calcium ions 11**
**2.3.4 Physiology of Chloride ions 12**
**2.3.5 Physiology of Bicarbonate (Glucose) 12**
**2.3.6 Physiology of Magnesium 12**
**2.4 Urea 13**
**2.4.1 Physiological diagnosis 13**

**Chapter Three: - The Electromagnetic Spectrum**

**3.1 Introduction 14**
**3.2 Ultraviolet Spectrum 15**
**3.3 Visible Spectrum 16**

**Chapter Four: - Theoretical Background**

**4.1 Introduction 19**
**4.2 Spectrum of Visible Light 20**
**4.3 Main Principle of Liquid Substance Concentration Using Light Absorption Technique 21**
**4.4 Absorption Spectrum 22**

**Chapter Five: - Design Concept 31**

**5.1 The Basic Element Construction of the Project 31**
**5.2 Block Diagram 32**
**5.2.1 The Source 32**
**5.2.2 Lenses 35**

**5.2.3 Spectrum Filtration** **36**
**5.2.4 Sample Handling and Measurement** **40**
**5.2.5 Detectors** **42**
**5.2.6 Temperature Sensor** **43**
**5.2.7 OP AMP** **46**
**5.2.8 Fan** **47**
**5.2.9 Heater** **47**
**5.2.10 Analog Digital Converter** **48**
**5.2.11 Multiplexer (MUX)** **50**
**5.2.12 Optocoupler** **51**
**5.2.13 Parallel Port** **52**
**5.2.14 Read Out Device** **55**

**Chapter Six:- Software System**

**6.1 Software System** **56**
**6.2 Program Writing** **58**

**Chapter Seven:- Conclusion and Recommendations**

**7.1 Experimental Results** **60**
**7.2 Conclusions** **63**
**7.3 Recommendations** **64**

**Chapter Eight:-Directions for Use**

**References**
**Appendix A**
**Appendix B**
**Appendix C**

# Appendix A Defintion

# Appendix
# B
# Data Sheets

# Appendix
# C
# Schematic Circuit
# and
# Program

## Definition

| | |
|---|---|
| **cuvette** | A cuvette is a kind of laboratory glassware, usually a small square tube, sealed at one end, made of plastic, glass, or optical grade quartz and designed to hold samples for spectroscopic experiments. The best cuvettes are as clear as possible, without impurities that might affect a spectroscopic reading. |
| **Complementary Colors** | Colors which appear opposite one another on a color wheel. When placed next to one another, complementary colors are intensified and often appear to vibrate. When mixed, brown or gray is created. |
| **Detectors** | Any device or instrument used to sense the presence of a signal, detect the presence of radiation or particles, or convert a signal from one form to another. |
| **Electrolyte** | An electrolyte is a substance which dissociates into free ions when dissolved (or molten), to produce an electrically conductive medium |
| **Filters** | A device which selectively transmits light having certain properties (often, a particular range of wavelengths, that is, range of colors of light, or polarizations), while blocking the remainder. They are commonly used in photography, in many optical instruments, and to colour stage lighting. |
| **Frequency** | The number of wave oscillations per unit time or the number of wavelengths that pass a point per unit time. |
| **GABA** | a chemical messenger in the brain, spinal cord, heart, lungs, and kidneys, which sends messages telling the body to slow down. GABA is the primary inhibitory neurotransmitter in the brain. |
| **Hypokalemia** | abnormally low level of potassium in the circulating blood leading to weakness and heart abnormalities; associated with adrenal tumors or starvation or taking diuretics |

| | |
|---|---|
| **Inhibitory** | Shutting off or decreasing brain electrical activity; causing nerve cells to stop firing. |
| **Leukocytes** | White blood cells. Found in blood and bone marrow, they accumulate in areas of inflammation. |
| **Plasma** | The yellow fluid portion of the blood in which the red cells, white cells, and platelets are suspended. Like other blood components, it can be separated out from the whole blood for use in component therapy. Plasma contains many clotting proteins. |
| **Prism** | Triangular-shaped glass or other transparent material through which, when light is passed, its wavelengths refract into a rainbow of colors. A demonstration that light is composed of colors and indication of the arrangement of colors in the visible spectrum. |
| **Reagent** | compound involved in a chemical or biochemical reaction, especially one used in chemical analysis to produce a characteristic reaction in order to determine the presence of another compound |
| **Serum** | The clear, thin and sticky fluid portion of the blood that remains after coagulation. Serum contains no blood cells, platelets or fibrinogen. |
| **Spectrum** | The result of the separation of white light into its component light waves. |
| **UV** | Ultra Violet: a band of wavelengths within the electromagnetic spectrum invisible to the human eye which are shorter than the blue end of the spectrum. |

| | |
|---|---|
| **Visible Light** | The portion of the electromagnetic spectrum that produces light that can be seen. Wavelengths range from 380 to 740 nanometers. |
| **Wavelength** | Distance from one wave peak to another. |

# List of Figures


| | | |
|---|---|---|
| **Figure 2.1** | **Blood Cells** | **5** |
| **Figure 2.2** | **Blood Component** | **7** |
| **Figure 3.1** | **The Electromagnetic Spectrum** | **14** |
| **Figure 3.2** | **The Spectrum of Visible Light** | **17** |
| **Figure 3.3** | **Wave Length** | **18** |
| **Figure 4.1** | **Absorption Technique** | **19** |
| **Figure 4.2** | **Separation of Light** | **20** |
| **Figure 4.3** | **Simple Block Diagram of "Liquid Substance Concentration Using Light Absorption Technique"** | **21** |
| **Figure 4.4** | **Typical Absorption Spectrum in Visible Region** | **23** |
| **Figure 4.5** | **Complementary Color** | **24** |
| **Figure 4.6** | **Diagrammatic Representation of relationship Between Transmission an Absorption** | **25** |
| **Figure 4.7** | **Transmission Plotted Against Concentration** | **28** |
| **Figure 4.8** | **Absorbance Plotted Against Concentration** | **29** |
| **Figure 5.1** | **Block Diagram** | **32** |
| **Figure 5.2** | **UV/VIS Light Source** | **33** |
| **Figure 5.3** | **Show the Principle of Lenses** | **35** |
| **Figure 5.4** | **Diffraction Grating Monocromator** | **37** |
| **Figure 5.5** | **Operating Principle of a Reflecting Diffraction Grating** | **38** |
| **Figure 5.6** | **Interference Filter** | **39** |
| **Figure 5.7** | **Selection of Sample Cuvette** | **42** |
| **Figure 5.8** | **Phototransistor/ OP805LS** | **43** |
| **Figure 5.9** | **The temperature sensor** | **44** |

| | | |
|---|---|---|
| **Figure 5.10** | **Basic Centigrade Temperature Sensor (+2C$^0$ to +150C$^0$)** | **45** |
| **Figure 5.11** | **a: Inverting amplifier b: Noninverting amplifier** | **46** |
| **Figure 5.12** | **Circuit for controlling fan** | **47** |
| **Figure 5.13** | **Circuit for controlling heater** | **48** |
| **Figure 5.14** | **0804A/DC Schematic** | **49** |
| **Figure 5.15** | **LS157 MUX Schematic** | **51** |
| **Figure 5.16** | **Optocoupler** | **52** |
| **Figure 5.17** | **5-way Female D-Type Connector** | **54** |
| **Figure 5.18** | **Data Cable** | **54** |
| **Figure 6.1** | **Program Flow chart** | **56** |
| **Figure 6.2** | **Concentration Flow Chart** | **57** |

## To the Department of Electrical and Computer Engineering:

This graduation project report entitled "Design of Liquid Substance Concentration using Light Absorption Technique" which prepared by Bilal Nu'eirat, Saeed Awwad, and Bassam Dagamen is presented to the Department of Electrical and Computer Engineering at the College of Engineering and Technology at Palestine Polytechnic University. We recommend that it be accepted in partial fulfillment of the requirements for the degree of Biomedical Engineering for the three students.

## We have reviewed this report and we recommend its acceptance:

**Projects Supervisor:**
Eng. Abdullah Erman

---

**Head of Department:**
Dr. Abdolkarim Dawod

---

تم بحمد الله