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Design of Non-Invasive Glucose and Hemoglobin meter using Near Infrared Technique

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Abstract

The evolution of chronic diabetes and anemia considering as tow of the major health care epidemics of the modern era. Diabetes can also lead to a low level of hemoglobin in the blood, causing anemia. Thus maintaining healthy blood glucose and hemoglobin levels is essential for preventing conditions such diabetes and From multiple heart diseases, stroke, growth problems, obesity and other diseases.

The aim of the project is to design a non-invasive blood glucose and hemoglobin meter using near infrared technology, as well as accurate measurement, reducing the pain of acupuncture to reach patients' capillary or venous blood. Reducing the cost of measurement.We designed our BGHM device by going through multiple stages, beginning with selection photodiode sensor(receptor) helps us get accurate data.selection a red visible light with a wavelength (700nm) that is emitted by its multichip, we also used the green visible led chip with a wavelength (567nm). So that a red light to measure the size and distance of the finger around the measuring handle and a green light to increase absorption glucose in the finger capillaries . Thus, the use of separate light sources for each compound to measure them accurately.selection the Suitable (940nm) wavelength from the multichip emitter and translating the work on the Arduino microcontroller, then making it mobile, and end with the design of a modern structure for the device using modern technology.

Our project has the potential to revolutionize the way blood glucose and hemoglobin levels are monitored. To use a non-invasive, painless, and affordable way to measure blood glucose and hemoglobin levels, making it easier for people with diabetes and anemia, and other conditions to manage their health.

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Introduction

1.1 Introduction

The Hemoglobin and glucose in the blood are two proteins attached to red blood cells, and both are related to the other, as the hemoglobin protein attached to red blood cells transports oxygen to the organs and tissues of the body and returns it to the lungs.

Diabetes is a leading cause of death in many countries. It is a clinical condition characterized by high blood sugar levels (hyperglycemia) due to insufficient insulin. Diabetes is divided into three types: (1) Insulin-dependent type 1 diabetes. This type of diabetes can be caused by problems with the beta cells in the pancreas that make insulin. The patient tests for A1C in the blood. The doctor uses it to find out the extent to which blood sugar is controlled and to know the risks of complications. (2) Diabetes of the second type, which is not dependent on insulin, and this occurs when the pancreas produces insulin in a small percentage or the inability of the body to use the secreted insulin, as the problem is the lack of Cell uptake of glucose. such as fat, liver and muscle cells. Therefore, patients of this type must maintain a healthy weight, eat healthy food, and exercise. Take medications regularly. (3) Gestational diabetes, this type is often detected by doctors in mid- or late-pregnancy. Because a woman's blood sugar passes through the placenta to the fetus, it is important to control gestational diabetes to protect the growth and development of the baby. Because it is more dangerous for the baby before the mother because the baby may suffer from weight gain before birth, difficulty breathing at birth, or an increased risk of obesity and diabetes later on.

Anemia is caused by a decrease in the volume of red blood cells within the body. Anemia may occur along with diabetes due to the kidneys excreting an erythrocyte-producing hormone called erythropoietin (EPO). Early detection and treatment of glucose and hemoglobin, are essential to stop or delay the progression of the disease.

both Measurements are important for patients and doctors, as well as important before the operation, to know the levels of sugar and hemoglobin in the blood, and both have a normal ratio, and any imbalance in this ratio affects human health, so it is important to monitor them in order to stay healthy.

1.2 Motivation and problem definition

The measurement of hemoglobin and sugar is one of the most important vital measurement that the doctor cannot do without in diagnosing the patient's condition.

The patient is also examined before surgery and pregnant women are examined in the last months of pregnancy. People with type 3diabetes also need to check their sugar levels several times a day. Examination of the child immediately after birth to check the sugar if the mother had diabetes during pregnancy. All of the aforementioned examinations are taken in humiliating ways, which causes pain to the patient. These examinations are also expensive for the patient. Likewise, these examinations need materials to perform the examination. These materials are expensive and subject to completion. They also need special circumstances to preserve them. These conditions may cause them to be destroyed if they are not appropriate, which causes errors results. Also the tools with which samples are taken cause infection and environmental pollution if they are not damaged in the correct ways. All these reasons prompted us to create a device that checks hemoglobin and sugar in a non-invasive way with near infrared rays to avoid all the aforementioned problems.

1.3 Objectives

The general objective: is to implementation and design of non-invasive blood glucose and hemoglobin meter using near infrared technique.

The special objectives are include the following:

1-provide the Speed and accuracy of the measurement for a diabetics and anemia patients.

2-Design the transmitter and receiver circuits an excellent and elaborate manner.

3-Reducing the cost of the our device in order to make it easy to purchase for patients.

4-Design the shape of the device using a 3D printer, and make the device portable.

1.4 Methodology

This report contains five chapters for the project divided as following:

Chapter one: This chapter contain a general introduction of the project through problem definition, statement of impact in developing world, project objective.

Chapter two: This chapter presents the medical and engineering background of the project.

Chapter three: This chapter its Project System Design and explains the parts needed to design and build this project, in addition to the design circuit of this project.

Chapter four: This chapter is Implementation and Results of our project and explain how we assembled the parts and the block diagram as well as the System Software of the project.

Chapter five: This chapter expline Conclusions and Recommendations of the our project

Chapter (2)

Background

2.1 Introduction

This chapter, will talk about the medical background of hematopoiesis, hematopoietic organs, red blood cells, red blood cells membrane, red blood cells function, red blood cells destruction, hemoglobin, hemoglobin levels, formation of hemoglobin, hemoglobin function, diseases related to hemoglobin, diabetes mellitus, types, differences between type 1 and type 2 diabetes, etiology of primary diabetes mellitus, tests for the two types of diabetes and prediabetes, blood sugar level and then talking about the engineering background which describes the invasive and non-invasive hemoglobin measurement methods, invasive and non-invasive blood glucose measurement methods.

2.2 Medical Background

2.2.1 Hematopoiesis

Hematopoiesis is production of formed elements of the blood normally, It takes place in the bone marrow. Circulating blood normally contains 3 main types of mature blood cells the red cells (erythrocytes),the white blood cells (leucocytes) and the platelets (thrombocytes). These blood cells perform their respective major physiologic functions: erythrocytes largely concerned with oxygen transport, leucocytes play various roles in body defense against infection and tissue injury, while thrombocytes are primarily involved in maintaining integrity of blood vessels and in preventing blood loss. The lifespan of these cells in circulating blood is variable Neutrophils have a short lifespan of 8-10 hours, followed by platelets with a lifespan of 8-10 days, while the RBCs have the longest lifespan of 90-120 days. The rates of production of these blood cells are normally regulated in healthy individuals in such a way so as to match the rate at which they are at which they are lost from circulation. their concentration is normally maintained within well-defined limits unless the balance is disturbed due to some pathologic processes [1].

2.2.2 Hematopoietic Organs

In the human embryo, the yolk sac is the main site of hematopoiesis in the first few weeks of gestation. By about 3rd month, however, the liver and spleen are the main sites of blood cell formation and continue to do so until about 2 weeks after birth.

Hematopoiesis commences in the bone marrow by 4th and 5th month and becomes fully active by 7th and 8th month so that at birth practically all the bones contain active marrow. During normal childhood and adult life, therefore, the marrow is the only source of new blood cells. However, during childhood, there is progressive fatty replacement throughout the long bones so that by adult life the hematopoietic marrow is confined to the central skeleton (vertebrae, sternum, ribs, skull, sacrum and pelvis) and proximal ends of femur, tibia and humerus (Fig 2.1). Even in these hematopoietic areas, about 50% of the marrow consists of fat (Fig. 1). Non-hematopoietic marrow in the adult is, however, capable of reverting to active hematopoiesis in certain pathologic conditions. The spleen and liver can also resume their foetal hematopoietic role in certain pathologic conditions and is called extramedullary hematopoiesis.

In the bone marrow, developing blood cells are situated outside the marrow sinuses, from where after maturation they enter the marrow sinuses, the marrow microcirculation and then released into circulation [1].

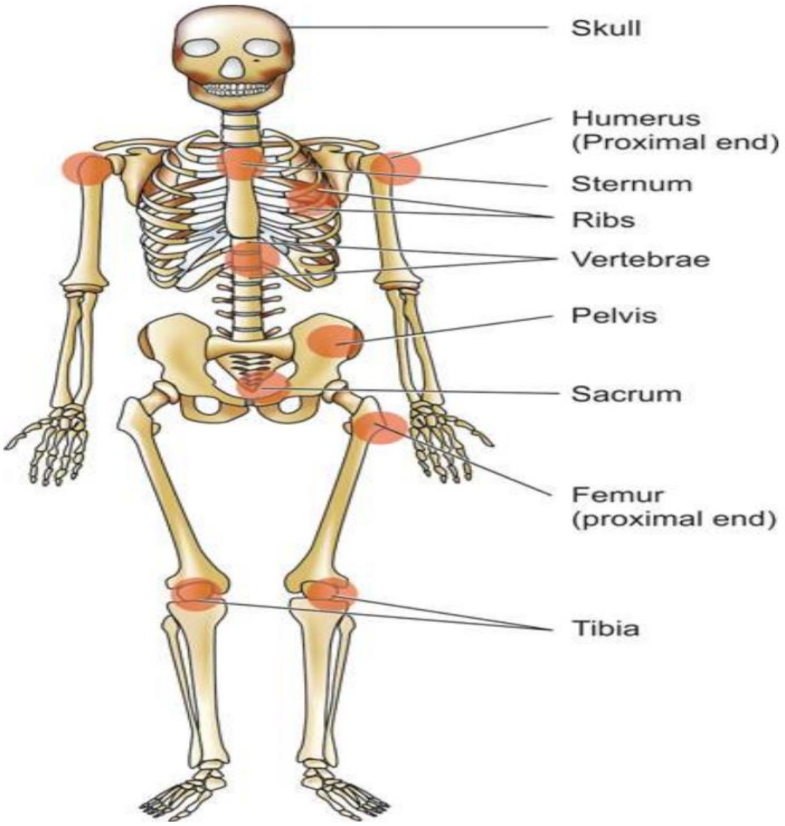

Figure 2.1: Sites of hematopoiesis in the bone marrow in the adult.

2.2.3 The Red Cell

The mature erythrocytes of the human peripheral blood are non-nucleated cells and lack the usual cell organelles. The normal human erythrocyte is a biconcave disc, 7.2 μm in diameter, and has a thickness of 2.4 μm at the periphery and 1 μm in the Centre. The biconcave shape renders the red cells quite flexible so that they can pass through capillaries whose minimum diameter is 3.5 μm. More than 90% of the weight of erythrocyte consists of Hemoglobin. The lifespan of red cells is 120 + 30 day [1].

2.2.4 Red Cell Membrane

The red cell membrane is a trilaminar structure having a bimolecular lipid layer interposed between two layers of proteins.

Important proteins in red cell membrane are band 3 protein (named on the basis of the order in which it migrates during electrophoresis), glycophorin and spectrin.

Important lipids are glycolipids, phospholipids and cholesterol.

Carbohydrates form skeleton of erythrocytes having a lattice-like network, which is attached to the internal surface of the membrane and is responsible for biconcave form of the erythrocytes[1].

A number of inherited disorders of the red cell membrane and cytoskeletal components produce abnormalities of the shape such as: spherocytosis (spherical shape from loss of part of the membrane), ovalocytosis (oval shape from loss of elasticity of cytoskeleton), echinocytosis (spiny processes from external surface due to metabolic abnormalities of red cells), and stomatocytosis (bowl-shaped red cells from expansion of inner membrane on one side [1].

2.2.5 Red Cell Function

The essential function of the red cells is to carry oxygen from the lungs to the tissue and to transport carbon dioxide to the lungs. In order to perform these functions, the red cells have the ability to generate energy as ATP by anaerobic glycolytic pathway (Embden-Meyerhof pathway). This pathway also generates reducing power as NADH and NADPH by the hexose monophosphate (HMP) shunt [1].

1- **Oxygen carrying**

The normal adult hemoglobin, HbA, is an extremely efficient oxygen-carrier. The four units of tetramer of hemoglobin molecule take up oxygen in succession, which, in turn, results in stepwise rise in affinity of hemoglobin for oxygen. This is responsible for the sigmoid shape of the oxygen dissociation curve.

The oxygen affinity of hemoglobin is expressed in term of P50 value which is the oxygen tension (PO_2) at which 50% of the hemoglobin is saturated with oxygen. Pulmonary capillaries have high PO_2 and, thus, there is virtual saturation of available oxygen-combining sites of hemoglobin. The tissue capillaries, however, have relatively low PO_2 and, thus, part of hemoglobin is indeoxy state.

The extent to which oxygen is released from hemoglobin at PO_2, in tissue capillaries depends upon 3 factors—the nature of globin chains, the pH, and the concentration of 2,3-biphosphoglycerate (2,3-BPG) [1].

A- Normal adult hemoglobin (HbA) has lower affinity for oxygen than foetal hemoglobin and, therefore, releases greater amount of bound oxygen at PO_2 of tissue capillaries [1].

B- A fall in the pH (acidic pH) lowers affinity of oxyhaemoglobin for oxygen, so called the Bohr Effect, thereby causing enhanced release of oxygen from erythrocytes at the lower pH in tissue capillaries [1].

C- A rise in red cell concentration of 2,3-BPG, an intermediate product of Embden-Meyerhof pathway, as occurs in anemia and hypoxia, causes decreased affinity of HbA for oxygen. This, in turn, results in enhanced supply of oxygen to the tissue [1].

2-CO_2 transport

Another important function of the red cells is the CO_2 transport. In the tissue capillaries, the pCO_2 is high so that CO_2 enters the erythrocytes where much of it is converted into bicarbonate ions which diffuse back into the plasma. In the pulmonary capillaries, the process is reversed and bicarbonate ions are converted back into CO_2. Some of the CO_2 produced by tissues is bound to deoxyhaemoglobin forming carbamino-haemoglobin. This compound dissociates in the pulmonary capillaries to release CO_2 [1].

2.2.6 Red cell destruction

Red cells have a mean lifespan of 120 days, after which red cell metabolism gradually deteriorates as the enzymes are not replaced. The destroyed red cells are removed mainly by the macrophages of the reticuloendothelial (RE) system of the marrow, and to some extent by the macrophages in the liver and spleen. The breakdown of red cells liberates iron for recirculation via plasma transferrin to marrow erythroblasts, and protoporphyrin which is broken down to bilirubin. Bilirubin circulates to the liver where it is conjugated to its diglucuronide, which is excreted in the gut via bile and converted to stercobilinogen and stercobilin excreted in the faeces. Part of stercobilinogen and stercobilin is reabsorbed and excreted in the urine as urobilinogen and urobilin. A small fragment of protoporphyrin is converted to carbon monoxide and excreted in exhaled air from the lungs. Globin chains are broken down to amino acids and reused for protein synthesis in the body [1].

2.2.7 Hemoglobin

Hemoglobin is a protein in your red blood cells that carries oxygen to your body's organs and tissues and transports back to your lungs [1].

2.2.8 Hemoglobin levels

Normal Hemoglobin Levels Chart

Age	Normal hemoglobin Level (g/dl)
Newborns	13.5 - 24
<1 month	10 - 20
1-2 months	10-18
0.5 to 2 years	10.5-13.5
2 to 6 years	11.5-13.5
6-12 years	11.5-15.5
Female: 12-18 years	12.0-16.0
Male: 12-18 years	13.0-16.0
Female: >18 years	12.1-15.1
Male: >18 years	13.6-17.7
Men after middle age	12.4-14.9
Women after middle age	11.7-13.8

Table2.1: Normal Hemoglobin levels Chart

2.2.10 Formation of Hemoglobin

The synthesis of hemoglobin is initiated in the proerythroblasts and progresses into the reticulocytes phase of the RBCs. Hence, when reticulocytes exit from the bloodstream, it continues forming trace quantities of hemoglobin for some more time till they turn into mature erythrocytes. Iron is a major component of hemoglobin [1].

2.2.11 Hemoglobin Function

The main function of Hb is to carry and transport oxygen to various tissues .The binding of oxygen to Hb is cooperative binding. The binding and release of oxygen from Hb in the lungs and tissues respectively is due to the transition between low oxygen affinity T state (Tense) and high oxygen affinity R state (Relaxed) [1].

Transport of oxygen:

The affinity of oxygen to Hb is affected by PH, 2,3BPG (2,3-Bisphoglyceric acid). Low PH, high BPG and CO_2 present in tissues favor T-state and oxygen are released, whereas R-state is favored in the alveoli due to high PH, low CO_2 and BPG concentration, which leads to the binding of oxygen to Hb.

Binding of oxygen is also regulated by the partial pressure of oxygen. in the lungs where PO2 is high, oxygen binds with Hb and in tissue, where PO2 is low oxygen is released[2].

Every 100ml of oxygenated blood carriers 5ml of O2 to the tissues.

Binding of the first oxygen molecule to the heme unit of one subunit of the deoxhaemoglobin (T-state) causes conformational changes leading to an increase in the affinity, thereby the second molecule binds more rapidly. The binding of the fourth molecule occurs, when it is already in the R state. The binding of oxygen to Hb shows a sigmoid curve.

This type of binding is known as allosteric binding, where binding at one site affects the affinities of the remaining binding sites.

The pulse oximeter measures the amount of oxygen present in the blood. It is used to diagnose hypoxia. It is based on the fact that oxyhemoglobin and deoxyhemoglobin have different absorption spectra [2].

Transport of carbon dioxide:

Around 20-25% of CO_2 is transported bound to hemoglobin as carbaminohaemoglobin. In tissue where PCO_2 is more and PO2 is less, binding of carbon dioxide is favored and in the alveoli dissociation of carbaminohemoglobin takes place due to high PO2 and low PO2. Rest of the CO_2 is transported as bicarbonate, which is facilitated by an enzyme called carbonic anhydrase [1].

Ever 100 ml of deoxygenated blood carries 4 ml of CO_2 to the alveoli.

Hemoglobin also transport also transports nitric oxide bound to the globin protein.

It binds to the thiol groups present in the globin chains.

Carbon monoxide can also bind to hemoglobin and forms the carboxyhemoglobin complex [1].

Hemoglobin has 250 times higher affinity for carbon monoxide than oxygen.

So even the slightest concentration of CO can affect the binding of oxygen.

So inspiring air rich in CO can cause headache, it can block 20% of active binding sites of sites of oxygen in heave smokers [2].

2.2.12 Diseases related to Hemoglobin

There can be various reason for hemoglobin deficiency. Hemoglobin deficiency leads to the lower oxygen-carrying capacity of the blood. It can be due to nutritional deficiency, cancer, kidney failure or any genetic defects. Higher that normal hemoglobin level is associated with various heart and pulmonary diseases [1].

Sickle cell anemia:

It is due to a defect in the hemoglobin gene. There is a single nucleotide or point mutation in the **β** globin chain. 'GAG' gets converted into 'GTG' leading to the replacement of glutamic acid by valine at the 6^{th} position [1].

Thalassemia:

It is caused due to less production of hemoglobin. There are two types of thalassemia, α-thalassemia and β-thalassemia. It is also caused due to defective genes and severity depends on how many genes are missing or defective.

Hemoglobin level is commonly used as a diagnostic tool. The HbA1c level, i.e. glycosylated Hb or Hb linked with sugar is a marker for average glucose level in the blood of a diabetic patient [2].

2.2.13 Blood glucose

Blood glucose is a sugar that the bloodstream carries to all cells in the body to supply energy.

2.2.14 How The Body Makes Glucose

It mainly comes from foods rich in carbohydrates, like bread, potatoes, and fruit. As you eat, food travels down your esophagus to your stomach. There, acids and enzymes break it down into tiny pieces. During that process, glucose is released. It goes into your intestines where it's absorbed. From there, it passes into your bloodstream. Once in the blood, insulin helps glucose get to your cells.

2.2.15 Diabetes Mellitus

Diabetes mellitus (DM) is clinical syndrome characterized by chronic hyperglycemia and disturbance in carbohydrate, lipid and protein metabolism. The disease may result from defects in insulin secretion, insulin action (resistance) or both. Prevalence of diabetes mellitus is about 2-3% [3].

Types:

Primary Diabetes Mellitus

- Insulin dependent diabetes mellitus (IDDM)
- Non-insulin dependent mellitus(NIDDM)

Secondary Diabetes Mellitus

Pancreatic diseases:

- Pancreatitis
- Hemochromatosis
- Cystic fibrosis
- Pancreactomy

Drug-induced:

- Corticosteroid therapy
- Thiazide diuretics
- Phenytoin

Gestational diabetes:

- Diabetes of pregnan

Endocrine diseases:

- Cushing's syndrome
- Acromegaly
- Theochromocytoma
- Glucagonoma

Associated with genetic syndromes:

- Freidreich's alaxia
- Myotonic dystrophy
- Down's syndrome
- Klinefelter's syndrome
- Turner's syndrome

2.2.16 Differences between type 1 and 2 diabetes

Type 1 DM results from autoimmune destruction of the pancreatic islet beta cells with absolute loss of insulin secretion while the type 2 DM results from a combination of insulin resistance and insulin secretory defects [3].

Type 1 usually manifests in childhood with a peak age at 10-13 years, but it can present at any age. Type 1 can also occur in elderly and is described as latent autoimmune diabetes in adults. Type 2 diabetes usually manifests above 30 years, however type 2 diabetes is diagnosed in children as young as 6 years [3].

2.2.17Etiology of Primary Diabetes Mellitus

Type1 (IDDM)

1-Genetic susceptibility:

Is moderate; environmental factors required for expression, 30-35% concordance in monozygotic twins.

2-Inheritance:

The child of an insulin dependent diabetic patient has an increased chance of developing IDDM. This risk is greater with diabetic farther than that diabetic mother.

3-HLA system:

95% of IDDM patient carries HLA-DR3, HLA-DR4 or both genes.

4-Viral infection:

Antibodies to coxsackie, s virus B4 has been found in 20-30% patients, which reflects that viruses may be responsible for initiation or precipitation of the disease.

5-Pancreatic Pathology:

Pancreas in prediabetes stage shows insulitis-infiltration with mononuclear cells Islet cell antibodies can be detected before the clinical evidence of IDDM.

6-Immunological factors

IDDM is a slow T-cell mediated autoimmune disease hyperglycemia accompanied by classical symptoms of diabetes occur only when 90% of beta cells have been destroyed.

Type 2(NIDDM)

1-Genetics

Identical twins of a patient with NIDDM have an almost 100% chance of developing diabetes. A bout 25% of patients have a first-degree relative with NIDDM.

2-Environmental factors

Life-style: overeating especially when combine with obesity probably acts as a diabetogenic factor (increasing resistance to the action of insulin).

3-pancreatic pathology

There are two pathological features in pancreas with NIDDM.

- Reduction of insulin secreation cells.
- Resistance to insulin action.
- Delayed insulin secretion in response to oral glucose.

2.2.18 Tests for type 1 and 2 diabetes and prediabetes

- **Glycated hemoglobin (A1C) test**

  This blood test, which doesn't require not eating for a period of time (fasting), shows your average blood sugar level for the past 2 to 3 months. it measures the percentage of blood sugar attached to hemoglobin, the oxygen-carrying protein in red blood cells.

  The higher your blood sugar levels, the more hemoglobin you'll have with sugar have prediabetes [4].

  Below 5.7% is considered normal.

- **Random blood sugar test**

  A blood sample will be taken at a random time. No matter when you last ate, a blood sugar level of 200 milligrams per deciliter (mg/dl)-11.1 millimolse per liter (mmol/L)-or higher suggests diabetes [4].

- **Oral glucose tolerance test**

  For this test, you fast overnight. Then the fasting blood sugar level is measured. Then you drink a sugar liquid, and blood sugar levels are tested regularly for the next two hours [4].

- **Blood sugar level**

  A blood sugar level less than 140mg/dl (7.8 mmol/L) is normal. A reading of more then 200 mg/dl (11.1 mmol/L) means you have prediabetes [4].

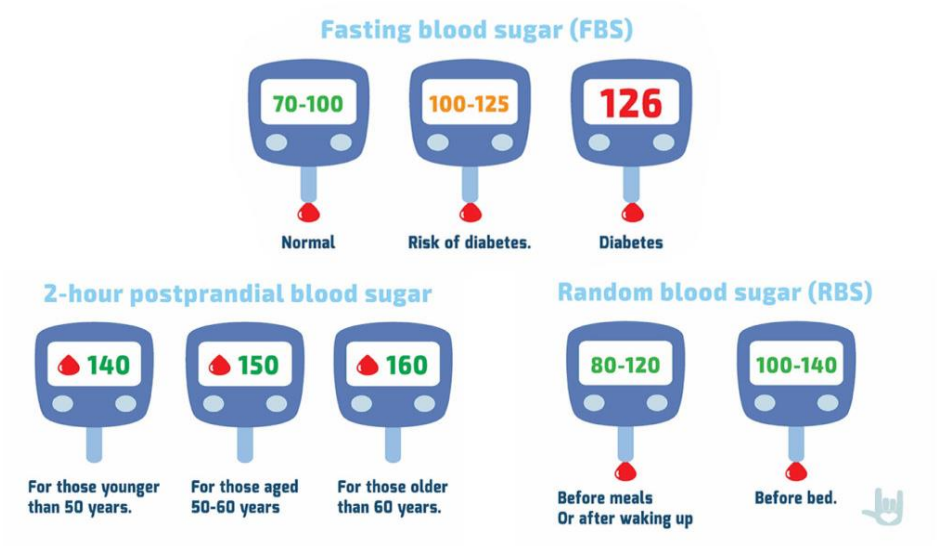

Figure 2.2: Fasting Blood Sugar,2 Hour postprandial blood sugar Random blood sugar normal values

2.3 Engineering background

2.3.1 Introduction

The role of technology in haemoglobin and glucose testing has led the way for the creation of innovative devices and techniques work for the invasive and non-invasive methods.

2.3.2 Invasive haemoglobin measurement methods

- **Hemo Spark Haemoglobin meter**

Hemo Spark Hemoglobin (Hb) is a device intended for the quantitative determination of hemoglobin in capillary whole blood or arterial or venous whole blood. The system is intended for healthcare professionals and anemic people to measure hemoglobin. So that the patient adds a drop of blood to the test strip, and the result will appear on the screen in 15 seconds. Principle of operation of the method The hemoglobin test strip includes a sample reaction zone. Sample is applied to the center of the sample reaction zone. The mesh functions to separate the sample evenly over the entire reaction layer. The reagents on the reagent layer function to hemolyze and release haemoglobin. The haemoglobin is converted to methaemoglobin to cause a color change on the cartridge/strip. The meter reads the reflection of the strip at every second until the reaction end point of the reaction is detected. The reflection at the end point is directly proportional to the hemoglobin concentration. The end point is defined as follows: reflectance changes between ±1% in three continuous seconds. Then the reflection will be read at the last second as an end point. The test requires only one 10 µL drop of whole blood. The meter can store up to 1,000 results and can be powered by three (1.5V) batteries or an optional AC adapte as shown in
(figure 2.3) [5].

Figure 2.3: Hemo spark hemoglobin meter.

- **Components of the hemoglobin meter**

1. LCD (Liquid Crystal Display) 2.On/Off Button
3. Right Arrow Button 4. Left Arrow Button
5. Code Chip Slot 6. Printer Interface
7. Battery Cover 8. strip channel
9. USB interface 10. setup Button

- **Haematology Analyser**

A Complete Blood Count (CBC) is a broad screening test used to check for certain disorders relating to the blood. Whenever a CBC is requested from the clinical laboratory, samples are processed on a hematology analyzer. A standard CBC includes: RBC count, WBC count, hemoglobin, HCT, Mean Corpuscular Volume (MCV), Mean Corpuscular Hemoglobin (MCH), Mean Corpuscular Hemoglobin Concentration (MCHC), and platelet count. Using the Coulter Principle, the analyzer can electronically count and size the red blood cells. In addition to electronic particle counting, hematology analyzers use HiCN or azidemethemoglobin methods to spectrophotometrically measure total hemoglobin and the dyshemoglobin content. Hemiglobincyanide (HiCN) method chemically converts hemoglobin to HiCN, a form of hemoglobin that can be measured spectrophotometrically and has a relatively broad absorption maximum around a wavelength of 540 nm. This technique is the most broadly used and appears in various technologies including: hematology analyzers, blood gas analyzers, stand-alone CO-oximeters and point of care testing devices. In general, blood samples are sent through a lyzing chamber to prepare the specimen for measurement. The cell membranes rupture releasing the hemoglobin. After the sample is diluted by a lyzing agent, a second substance, Drabkin‟s reagent, is added. This converts the hemoglobin to cyanmethemoglobin or HiCN . Drabkin‟s reagent contains

iron, potassium, cyanide, and sodium bicarbonate.The hemoglobin concentration is determined by absorbance .The absorbance at a particular wavelength is measured and related to the hemoglobin concentration [7].

2.3.3 Non-Invasive Haemoglobin Measurement Methods

With the availability of new technologies to detect the spectral pattern and concentration of haemoglobin, non-invasive methods have become more frequently used. Some non-invasive devices use pulse oximetry while others rely on white light and the capturing of transmission data to measure haemoglobin concentrations in tissue capillaries.

- **Optical method**

Haemoglobin has different forms in the blood. such as oxyhemoglobin, reduced haemoglobin, carboxyhaemoglobin, and methaemoglobin. Oxyhemoglobin (HbO2) and reduced haemoglobin (Hb) are the main forms that are available in the blood. The other forms are available only in traces. Oxyhemoglobin is mainly available in arteries and the reduced haemoglobin is available in veins, but in capillaries, both the forms are available the oxyhemoglobin and reduced haemoglobin have a different absorption of light at different wavelengths. (Figure2.4) shows the variation in molar extinction coefficient of light (μa) of the two haemoglobin forms with wavelength variation. The pulse oximetry method based on this property for finding the oxygenation of haemoglobin percentage (SaO2). SAO2 is the direct measurement of O2 bound to the protein haemoglobin in the blood. SpO2 measurement is a pulse oxidative measure of functional saturation of haemoglobin with O2 [6].

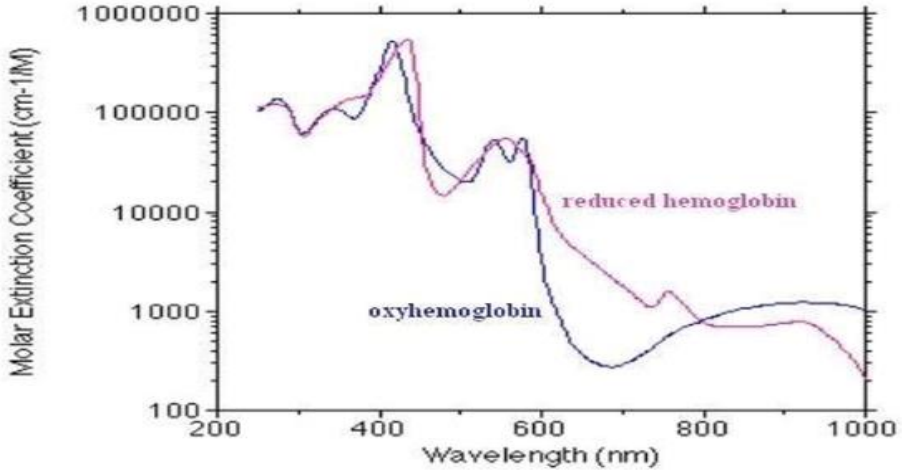

Figure2.4: Molar extinction coefficient of light of HB.

- **Multi-wavelength pulse co-oximetry technique**

Increase in number of wavelengths of light emitting diodes led to more accurate and calibrate values of HB can be obtained. Using principle of pulse oximeter, improved multi-wavelength pulse co-oximetry technique is introduced in which several wavelengths are used. According to principal of pulse oximeter LED light is passed through finger and transmitted signals are received by photo-detector. These signals are correlated with the help of Beer-Lambert law and oxygen saturation can be calculated. In multi-wavelength pulse co-oximetry technique instead of two wavelengths multiple wavelengths are used and algorithm is modified through which different multiple signals are taken simultaneously for calculation of total haemoglobin along with fractional haemoglobin. Profits and impediments
are stated as

- Introduced system tends to increase in accuracy as a result increase in safety for patients. It provides more accurate oxygen saturation level and hemoglobin fractions such as methemoglobin, carboxyhemoglobin results into immediate treatments. There is 1.5g/dl of biasing between non-invasive pulse co-oximetry results and standard laboratory result when observed in critical spin surgery.
- According to this concept algorithm, which is to be used is more challenging task due to number of signals. As specified, it has multiple wavelengths, which may result in more complicated module.

  Masimo introduced in their technology that motion to the body may affects the results of systems. According to the research, comparing results of laboratory values and other devices such as space labs and Hewlett-Packard have 23% and 13% of lower values. According to Masimo, for accurate results reference signal is required. There are always arterial and no-arterial components during motion, which produces pulsatile signals and cannot be separated from arterial signals. So, considering reference signals accurate values can be obtained. Adaptive filter matches the input signal with reference signal and give final results. While increasing number of wavelengths with same technique more fine results can be obtained [8].

- **Masimo Pronto-7 device**

It is a pronto 7 multiwavelength device introduced by Masimo Corporation that offers greater accuracy in HB measurement than other Masimo devices. This technology tracks the signals of the pulsating movement of arterial blood by passing light through the fingertip. The sensor consists of a left ventricular assist device (LVAD) that detects the change of blood flow during states of systole and diastole.

The basic operating principle of this instrument is the differential absorption of multiple wavelengths of visible light (using spectrophotometry) to distinguish between oxyhemoglobin (oxygenated blood), deoxyhemoglobin (deoxygenated blood), carboxyhemoglobin (blood carbon monoxide), methemoglobin (oxygenated blood hemoglobin) and other components of blood plasma. The amount of blood in the tissue fluctuates with the patient's pulse (photoplethysmography) and thus the amount of light absorbed changes. Data are obtained by sending several infrared beams (500 to 1300 nm) through the capillary surface at the patient's fingertip and measuring changes in light absorption during the pulsating blood cycle. The detector receives the light, converts it into an electronic signal, and sends it to the device for calculations. Masimo converts the signal from the sensor to calculate oxygen saturation, pulse, and total hemoglobin concentration (SpHb [g/dL]) in the patient. By using different software consisting of mathematical algorithms to get the values [8]**.**

Figure 2.5: Massimo pronto-7 device.

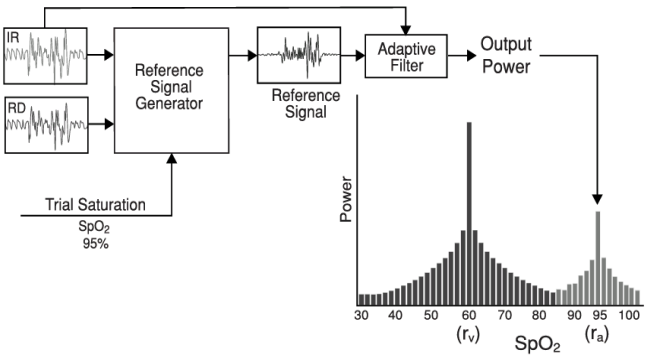

Figure 2.6: Block diagram of Multi-wavelength pulse co-oximetry method by Massimo.

2.3.4 Invasive blood glucose measurement methods

- **Self-Monitoring Blood Glucose—SMBG method**

SMBG devices are the typical glucometers requiring finger pricking with a lancet to access the capillary blood. The glucose measurement method is that the complete reaction and detection takes place in a glucose test strip connected to a meter. After putting a drop of the blood sample on the test strip, the glucose oxidizes in the presence of an enzyme to produce a certain amount of current proportional to the glucose level. The electrons then travel to the meter containing a current-to-voltage converter to provide a voltage proportional to the level of glucose.

The test strip contains the enzyme and an arrangement of three electrodes (Figure2.7)the working electrode, which senses the actual current of the reaction; the reference electrode, holding a voltage always constant respect to the working electrode to aid with the chemical reaction; and the counter electrode, supplying the current to the working electrode[11].

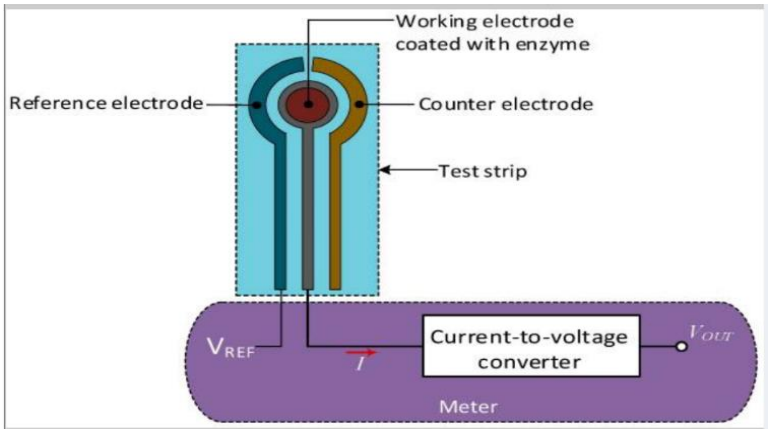

Figure 2.7: Block diagram of the device for glucose measurement with finger-pricking method.

Figure 2.8: Accu-chek Aviva plus blood glucose meter.

- **Continuous glucose monitoring (CGM) method**

CGM devices consist of three essential parts: a wireless receiver, a transmitter and a sensor. The receiver has a monitor displaying the glucose reading. The transmitter is attached to the sensor and transmits the measurements to the receiver via RF waves. The sensor is a tiny sensing device inserted into the subcutaneous tissue, extending just far enough to get access to the Interstitial fluid (ISF) it's a thin layer of fluid that surrounds the body's cells, feeding them glucose, minerals, fatty acids, and more. Interstitial fluid makes up about 20% of the total body weight. Then, by the electrochemical technique, the sensor uses GOx to oxidize the glucose present in the ISF, just as a test strip in SMBG devices does. The resulting peroxide reacts with platinum, to produce the electrical current, which travels along a thin wire to the transmitter, located outside of the skin. Once the receiver gets the data from the transmitter, it processes the information and calculates the glucose level.

CGM devices can cost several thousand dollars, and while blood monitors are relatively inexpensive, the electrodes are disposable and become costly over time. A single-use blood electrode strip costs about $1, and a CGMS 3-7-day sensor can cost $30$50. For people who measure their blood glucose level several times a day, the measurement strips can become a significant expenditure [9] , [11].

Figure 2.9: Medtronic CGM device.

2.3.5 Non-invasive blood glucose measurement methods

Non-invasive glucose monitoring technologies have generated extensive scientific papers and research over the past decades. We will talk about non-invasive techniques for non- invasive measuring glucose level in the blood: chemical analysis of breath method, temperature-modulated local reflectance method, Raman spectroscopy method, Metabolic Heat Conformation (MHC) method, Optical coherence tomography method, Photoacoustic Spectroscopy (PAS) method, and other noninvasive methods for blood glucose measurements. Although these non-invasive techniques for measuring blood glucose are promising. However, it needs further development to give excellent accuracy and its reliability is somewhat higher.

- **Chemical analysis of breath method**

The chemical analysis of breath method involves measuring acetone in the exhaled process of breathing. Acetone is a ketogenic chemical produced when the body uses fat for energy instead of glucose, and the increase in the level of acetone in the exhaled breath is sharp in diabetics, which leads to acidity in the blood, which leads to coma for diabetics. So a system was designed that could chemically analyse exhaled air, which could be use to determine blood glucose levels.[9].

- **Temperature-modulated local reflectance method**

This method is based on the observation that temperature changes causes variations in the tissues refractive index (which influences the light scattering), but on the other hand the entity of these changes depend upon glucose concentration. More specifically, the temperature modulation of the localized reflected light due to scattering is analyzed. Glucose concentration is estimated with localized reflectance signals between 590 and 935 nm. In some studies, a probe was placed in contact with the skin and the probe temperature was varied between 22 and 38 C. After each variation, skin was equilibrated for some minutes. During each of those intervals some light packets were collected, related to glucose concentration. Several parameters can affect this kind of measurements, both physiological and technical (such as the probe position).

Also a peculiar health status, such as an inflammatory state with possible fever condition, can in fact affect the measurement [10].

- **Raman spectroscopy method**

Raman scattering determines the degree of scattering of monochromatic light based on the Raman Effect. When single-wavelength light hits a target, it produces scattered light travelling in all directions. The majority of this radiation, called elastic or Rayleigh scattering, has the same wavelength as the incident light, while the rest is just a small amount of scattered radiation with a different wavelength, called “inelastic scattering” or “Raman scattering”. Such a wavelength difference is the Raman shift, and it represents the difference between the initial and final vibrational states of the molecule under study. As such, Raman spectroscopy is dependent on the rotational and vibrational states within molecules, and it can be used to detect specific absorption bands and quantify the corresponding molecules,

meaning that peak locations in the Raman spectrum show the vibrational modes of each functional group within the molecule. Hence, indicating that the Raman shift (expressed in wavenumbers, cm−1) will be the same regardless of the

wavelength of the incident light. In case of glucose, the most representative vibration modes are those linked to the C—H stretching band, around 2900 cm−1, and the C—O and C—C stretching bands between 800 and 1300 cm−1[11].

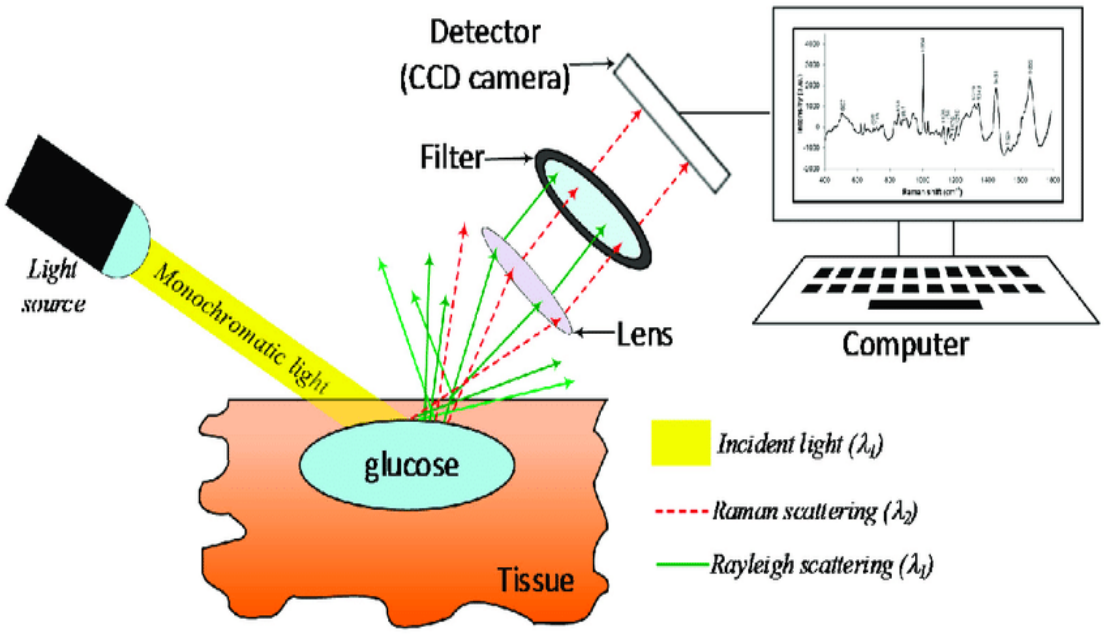

Figure 2.10: Schematic representation of a basic Raman spectroscopy instrument.

As shown in (Fig,2.10), the basic configuration of a Raman spectrometer consists of a lens capturing part of the scattered radiation and directing it to a filter to let only the Raman scattered light to be sensed by the detector. The computer does the processing of the signal and provides the corresponding Raman shift. Unfortunately, interference and instability issues, as shown in Table 2, prevent Raman spectroscopy from providing accurate glucose measurements in-vivo [11].

Raman spectroscopy	
Advantages	**Disadvantages**
• Less sensitive temperature changes.	• Prone to interference from other molecules such as hemoglobin.
• Minimally sensitive to water.	• Unstable laser wavelength and intensity.
• Suitable on any surface since it measures scattered light, including opaque substrates.	• Long collection time.
• High specificity.	• Susceptible to noise interference (low signal to noise ratio), fluorescence and turbidity.

Table 2.2: Advantages and disadvantages of Raman spectroscopy.

- **Metabolic Heat Conformation (MHC) method**

MHC technology consists of measuring the glucose concentration level by measuring physiological parameters associated with the generation of metabolic heat and local oxygen supply . The technique relies on the fact that the metabolic oxidation of glucose not only produces most of the necessary energy for all cellular activities but also generates a certain amount of heat as a byproduct that correlates with the amount of glucose and oxygen levels in the body. The heat emitted to the environment can be in the form of radiation, convection and evaporation. The heat emitted as radiation and convection is linked to the skin and ambient temperatures, whereas the heat dissipated by evaporation, represents the amount of evaporation from the skin.

The parameters recorded by the sensors include thermal generation, haemoglobin (Hb), oxyhemoglobin concentration (O2Hb), and blood flow rate. They are all measured in the fingertip by multi-wavelength spectroscopy methods, along with temperatures in the fingertip, ambient and background radiation. The data is then analysed with different statistical tools, including regression, multivariate and discriminant analyses (Figure2.11). However, as shown in Table 3, this technique is also sensitive to interference from temperature variations and sweat [11].

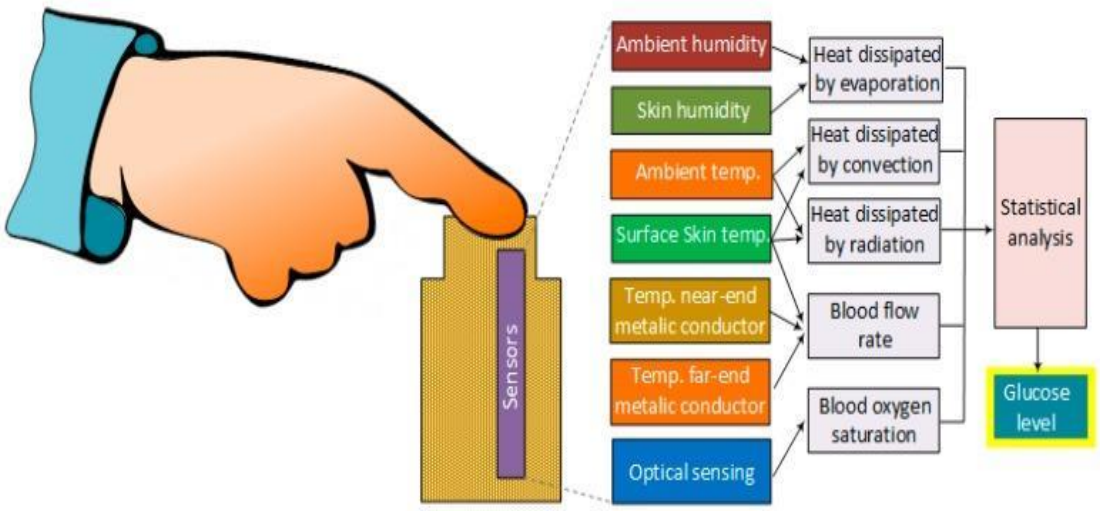

Figure 2.11: Schematic glucose measurement using (MHC) method.

Metabolic Heat Conformation	
Advantages	**Disadvantages**
• Physiological parameters are relatively easy measure using well established technologies.	• Susceptible interference by environmental conditions including temperature • Sensitive to sweat.

Table 2.3: Aadvantages and disadvantages of Metabolic Heat Conformation.

- **Optical coherence tomography method**

Optical Coherence Tomography OCT is an imaging technology based on the principles of low coherence interferometry with coherent radiation, that is capable of detecting changes of optical characteristics of bio-tissues at micrometre resolutions. Despite being initially developed for tomographic imaging of the eye, it can nowadays measure glucose concentration through the skin with acceptable accuracy and specificity.

The technology consists of radiating the skin with coherent light, with a wavelength between 800 and 1300 nm. The backscattered radiation generated is then combined with a reference to produce an interferometric signal that is sensed by a photodetector, as shown in Figure13. Hence, if an increase of glucose occurs, it will increase the refractive index and decrease the scattering coefficient, creating a mismatch reduction of the refractive index between the medium and the reference, proportional to the glucose concentration [11].

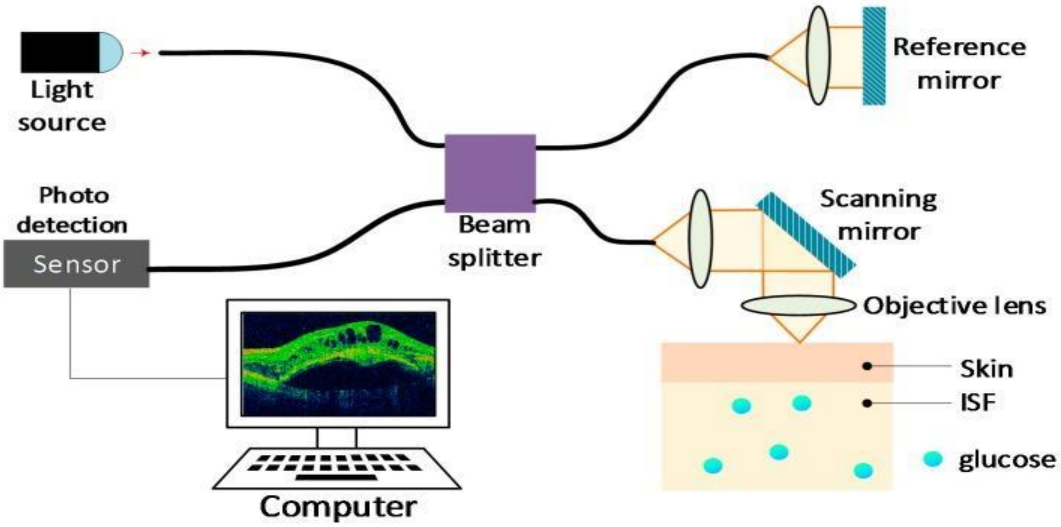

Figure 2.12: Principle of (OCT) scanning for glucose monitoring.

Optical coherence tomography	
Advantages	**Disadvantages**
• Vary high resolution.	• Sensitive to temperature changes on the skin and motion.
• High signal to noise ratio.	• Susceptible to tissue inhomogeneity
• High penetration depth.	
• No Susceptible to blood pressure heart rate and hematocrit.	

Table 2.4: Advantages and disadvantages of optical coherence tomography (OCT).

- **Photoacoustic Spectroscopy (PAS) method**

This technology uses the same idea of ultrasound waves, but it employs short laser pulses with a wavelength that is absorbed by a specific molecule in the fluid to produce microscopic localized heating, dependent on the specific heat capacity of the tissue under examination . The absorbed heat causes a volumetric expansion of the medium, generating an ultrasound wave that can be detected by an acoustic or pressure sensor. By tracking the peak-to-peak variations of the detected signal, it is possible to correlate them with the variations of glucose level in the blood.

For non-invasive detection of glucose, pulsed and continuous-wave (CW) are the two main forms of excitation. In pulsed-mode, the pulses have durations in the range of nanoseconds, and a pulse-repetition rate of a few kilohertz, leading to a fast and adiabatic thermal expansion of the sample and generating a wide spectrum of acoustic frequenci, along with jitter and acoustic noise in the wide bandwidth of the detector (transducer) . On the other hand, CW excitation employs a modulated continuous wave, generating a single acoustic frequency in the detected spectrum, as well as a higher signal-to-noise ratio if used in a lock-in detection configuration.

(Figure2.13). Shows the basic configuration of PAS sensing. The light emitted by a laser impacts on the sample to generate the ultrasound wave, by the process previously discussed. The generated ultrasonic wave propagates through the acoustic resonator, also known as cell, and reaches the detector, which generally consists of a piezoelectric transducer such as a microphone. The electrical signal at the output of the sensor is subsequently amplified, digitized and sent to the computer for analysis. This configuration, however, has the main drawback of poor sensitivity for in-vivo detection of glucose. So, as suggested by Kottmann et al, an alternative to this method is using two laser sources. One covering wavelengths of strong glucose absorption, and the other covering regions insensitive to glucose, in order to obtain a

large ratio between the two measurements, improving the overall SNR of the system. Currently the configuration has provided good stability, but the sensitivity is still low, although it can be improved by increasing the power of the laser [11]**.**

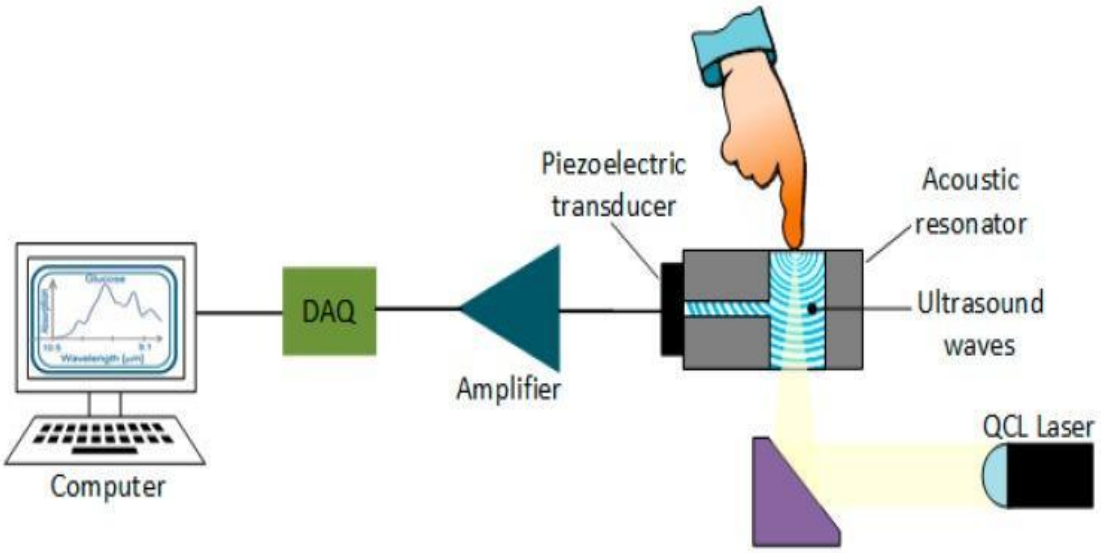

Figure 2.13: Basic optical for non-invasive photoacoustic measurement of glucose.

Photoacoustic spectroscopy	
Advantages	**Disadvantages**
• Relatively simple method.	• Susceptible to changes of temperature, pulsation, motion and surrounding acoustic noise.
• Immune to water distortion.	• Low signal to noise ratio.
• Not susceptible to NaCl, cholesterol, and albumin.	• Long integration time.
• PA signal is not influenced by scattering particles.	

Table 2.5: Advantages and disadvantages of photoacoustic spectroscopy.

Chapter (3)

Project System Design

3.1Introduction

This chapter explains the parts and parts needed to design and build this project, in addition to the design circuit of this project.

3.2Desing Circuit of the project

In design a circuit of our project, we used the Fritzing program, as it shows us the connection between the electronic parts and the Arduino Uno board in the project, where we connected the (anode pin) of the multichip emitter with a resistance of 4kΩ to vcc and a terminal wavelength of 700nm to a digital pin number: 11 and a terminal wavelength 940nm with impedance 800Ω to digital pin number: 10 on the Arduino Uno board, and the positive terminal of the green led chip to the digital pins number: 12 in the arduino uno board and negative to ground GND, the positive terminal of the photodiode sensor is connected to a filter consisting of a resistance of 120kΩ and a ceramic capacitor 100nf to analog pins: A0, and then we connect the ports of the display: tft:Rd,Rw,Rs,Cs, Rst to the analog pins and data pins:D2,D3, D4,D5,D6,D7,D8,D9 to the digital pins of arduino Uno, and the positive end of the screen to 5 volts vcc and negative to ground, and then we connected the battery to the charging circuit and to the project circuit. The TFT Screen Connection:

RD⟶A0, RW⟶A1, RS⟶A2, CS⟶A3, RST⟶A4, 5v⟶5v, GND⟶GND
D2⟶2, D3⟶3, D4⟶4, D5⟶5, D6⟶6, D7⟶7, D0⟶8, D1⟶9

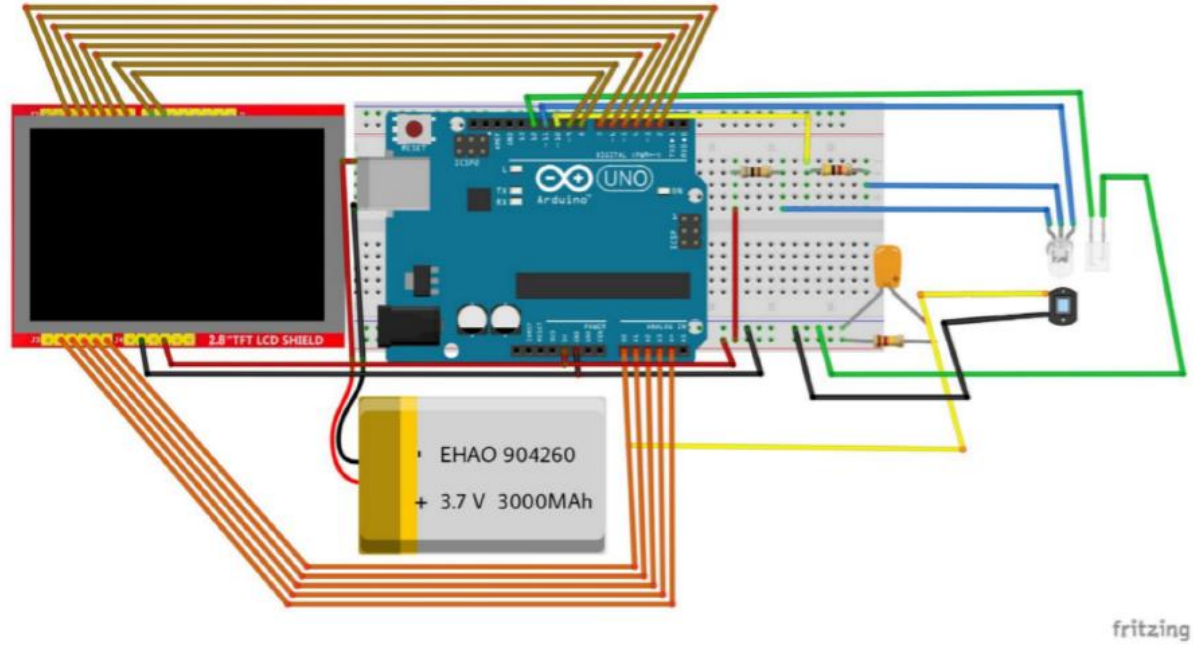

Figure 3.1: The design circuit of the project using fritzing program.

3.3 Infrared radiation

Infrared radiation (IR) is a region of the electromagnetic radiation spectrum where wavelengths range from about 700 nanometers (nm) to 1 millimeter (mm).

Infrared waves are longer than visible light waves but shorter than radio waves. Correspondingly, the frequencies of IR are higher than microwave frequencies but lower than visible light frequencies, ranging from about 300 gigahertz to 400 terahertz (THz).

Infrared light is invisible to the human eye, but heat sensors can detect longer infrared waves. Infrared shares some characteristics with visible light, however. Like visible light, infrared light can be focused, reflected and polarized. Infrared light is safe and more specifically, near-infrared are safe for the eyes and the body.[12]

3.3.1Infrared is commonly separated into

near-, mid- and far-infrared.

- The Near-infrared define as the following:

The near-infrared band contains the range of wavelengths closest to the red end of the visible light spectrum. Near-IR consists of wavelengths that range from 700 nanometers (nm) to 1,300 nm, or 0.7 microns to 1.3 microns. Its frequency ranges from about 215 THz to 400 THz. This group consists of the longest wavelengths and shortest frequencies, and it produces the least heat.[12]

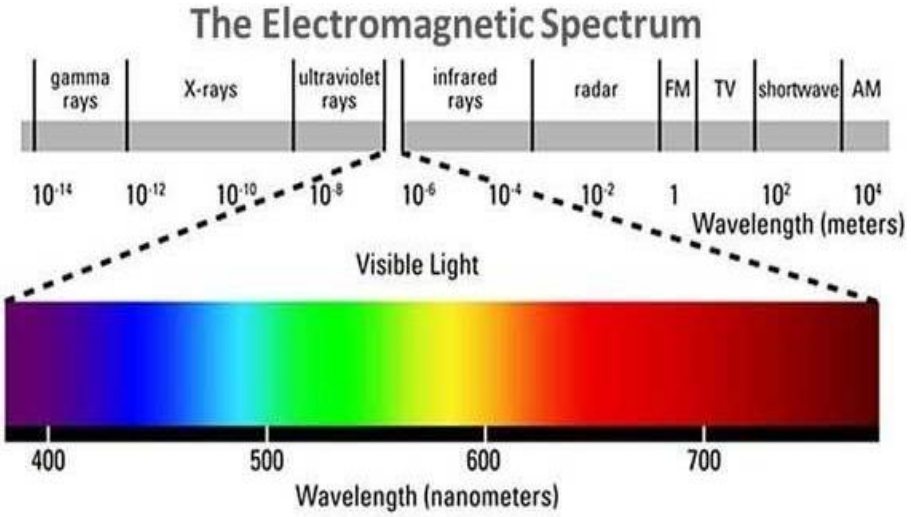

Figure 3.2: The location of infrared and visible light on the electromagnetic spectrum.

3.4 Hardware Components of the Project

Through this section of chapter all hardware components used in the project are discussed, so that features and specifications are discussed.

3.4.1 Multichip Emitter MTMD6788594SMT6

The MTMD6788594SMT6 is a multi-chip emitter designed for applications requiring same emission sources in a small, densely packaged area,

The Peak Emission Wavelength:670nm, 770nm, 810nm, 850nm, 950nm.

These devices can be custom designed for specific wavelengths and outputs.[13]

Figure 3.3: Multichip Emitter MTMD6788594SMT6.

FEATURES:

1. PLCC-6 Package
2. High Reliability

APPLICATIONS:

1. Medical Instrumentation
2. Currency Validation

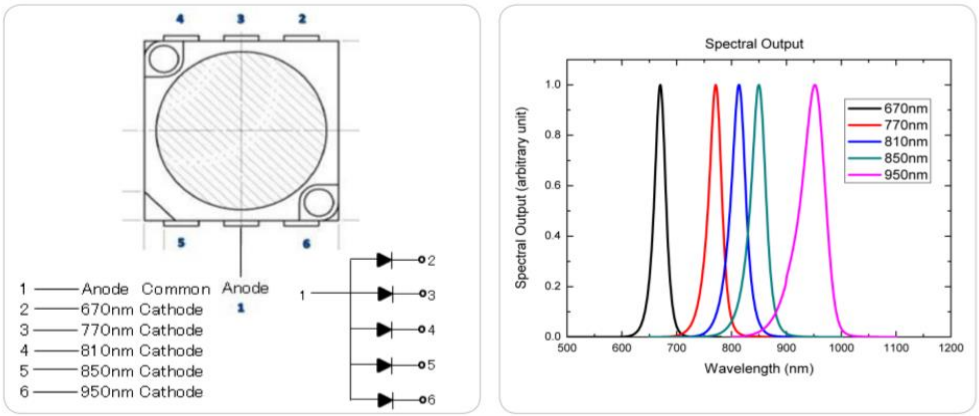

Figure3.4: ports conniction diagram and Spectral Responsivity of Multichip Emitter.

ITEMS	SYMBOL	RATINGS					UNIT
		670	770	810	850	950	
Forward Current (DC)	IF	50	50	80	80	80	mA
Forward Current (Pulse)*1	IFP	0.3	0.5	0.5	0.5	0.5	A
Reverse Voltage	VR			5			V
Power Dissipation	PD	120	160	190	180	160	mW
Operating Temperature Range	Topr	-20 ~ +80					ºC
Storage Temperature Range	Tstg	-30 ~ +100					ºC

Table 3.1: Absolute Maximum Ratings (Ta=25ºC).

3.4.2 Green Chip LED - 0603

We used a green LED chip to increase the light absorption in the human finger, because green light is more absorbent to glucose molecules and to obtain accurate measurement values. [14]

Features:

1. 1.6mm×0.8mm SMT LED, 0.7mm Thickness.
2. Wide Viewing Angle.
3. Ideal for Backlight and Indicator
4. Various Colorus and Lens Types Available.

Applications:

1. Automotive: Backlighing in dashboard and switch.
2. Telecommunication: Indicator and Backlighting in telephone and fax.
3. Flat Backlight for LCD switch and symbol.

Figure 3.5: Green Chip LED – 0603.

3.4.3 Photodiode Sensor (receptor)

- **Introduction:**

Here comes photodiode sensor new Analog Ambient Light Sensor for Arduino or Raspberry Pi. Brand new design and much more convenient to use. This sensor help you to detect the light density and reflect the analog voltage signal back to Arduino controller. You can set the threshold of voltage level to trig other unit on Arduino project. also use the environmental PT550 light sensor and it is more sensitive to light than normal one. [15]

Figure 3.6: Photodiode sensor.

- **Specifications:**
  1. Supply Voltage: 3.3V to 5V
  2. Illumination range: 1 Lux to 6000 Lux
  3. Responsive time: 15us
  4. Interface: Analog
  5. Size:22x30mm

- **Applications:**

1. Automatic screen brightness control

IMPROVEMENT LIST

- **Improvement list:**

1. Wide voltage range from 3.3V to 5V
2. Standard assembling structure (two 3mm holes with multiple of 5cm(1.97") as interval)
3. Easily recognitive interfaces of sensors ("A" for analog and "D" for digital)
4. Icons to simplely illustrate sensor function
5. High quality connector
6. Immersion gold surface

3.4.4 Arduino UNO(Microcontroller)

The Arduino Uno is a microcontroller board based on the ATmega328, It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.

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

"Uno" means one in Italian and is named to mark the upcoming release of Arduino 1.0. The Uno and version 1.0 will be the reference versions of Arduno, moving forward. The Uno is the latest in a series of USB Arduino boards, and the reference model for the Arduino platform.[16]

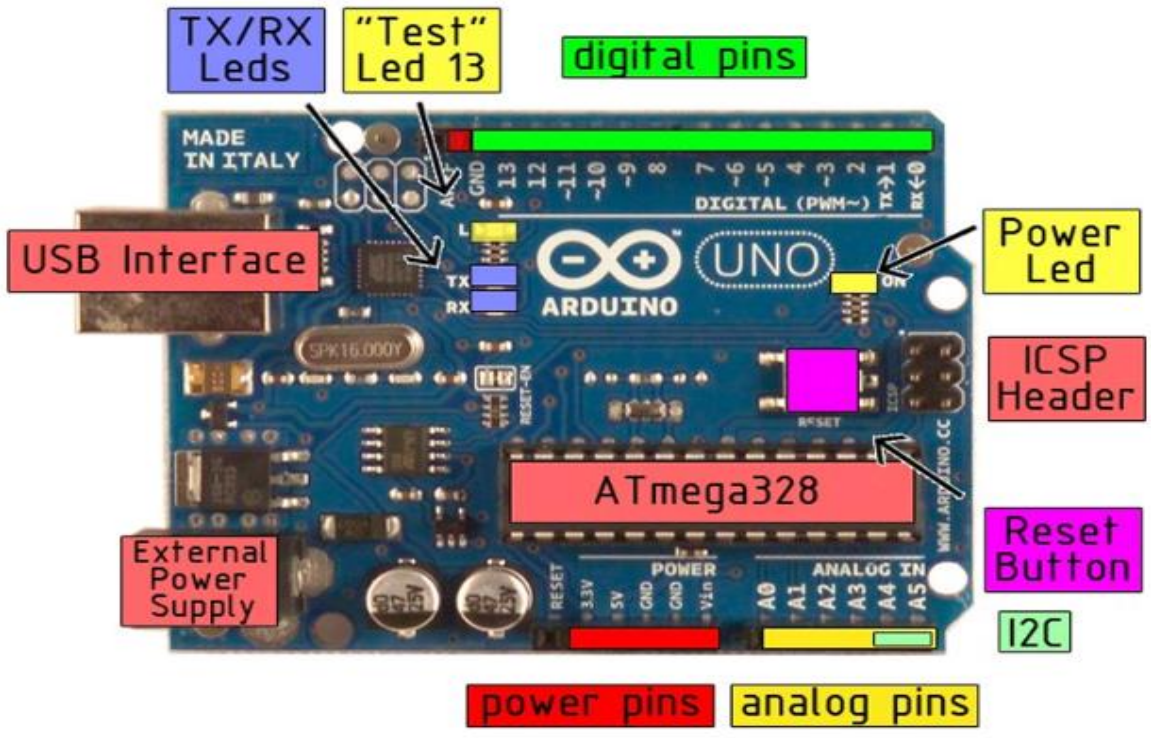

Figure 3.7: Arduino Uno board.

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

Table3.2: Technical Specifications of Arduino Uno.

3.4.5 TFT 2.8 Inch DISPLAYE

This 2.8 Inch SPI TFT LCD ILI9341 240X320 Module is a full color display with a resolution of 240 x 320 pixels. It uses the ILI9341 controller with SPI interface. It also includes a resistive touchscreen with built-in XPT2046 controller. [5]

The display can be used in two modes: 8-bit and SPI. For 8-bit mode, you'll need 8 digital data lines and 4 or 5 digital control lines to read and write to the display (12 lines total). SPI mode requires only 5 pins total (SPI data in, data out, clock, select, and d/c) but is slower than the 8-bit mode. In addition, 4 pins are required for the touchscreen (2 digital, 2 analogs). [17]

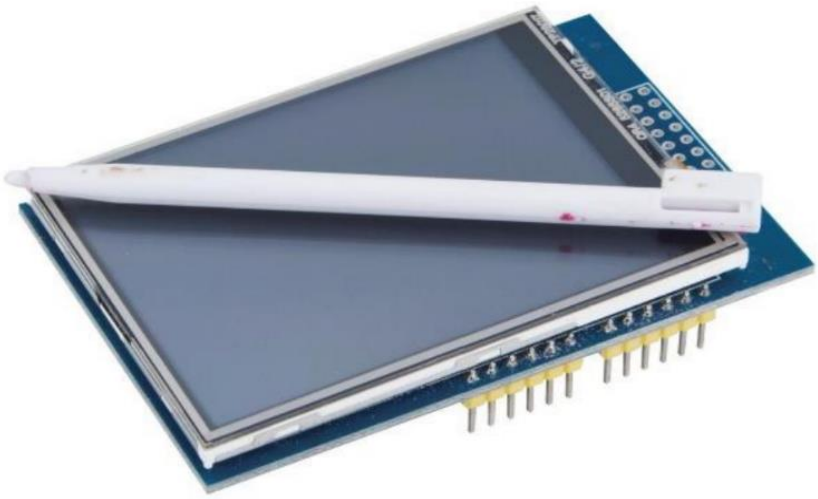

Figure 3.8: 2.8 Inch TFT ILI9341 Display Board.

Features:

1. 2.8″ TFT LCD with 240 x 320 resolution
2. 65K colors with ILI9341 controller
3. Resistive touch screen with XPT2046 controller
4. SPI 4-wire interface
5. 3.6 to 5.5V module operation
6. 3.3V logic compatible only
7. It shows the color depth of 262K/65K.
8. Need at least 4 IOs from your MCU
9. The display has a wide viewing angle.

Big display with good resolution

Specifications:

1. touch screen
2. Screen Size 2.8(inch)
3. Type TFT
4. Driver IC ILI9341
5. Resolution 320*240 (Pixel)
6. Module Interface 4-wire SPI interface
7. Active Area (AA area) 43.2×57.6(mm)
8. Operating Temperature -20℃~60℃
9. Storage Temperature -30℃~70℃
10. VCC power voltage 3.3V~5V
11. Logic IO port voltage 3.3V(TTL)
12. Power Consumption TBD
13. No touch 34(g) / With touch: 43(g)

3.4.6 Connection Wires

We used connection wires to connect the hardware parts used to the microcontroller board (Arduino Uno) and TFT display as well as to the battery bank.

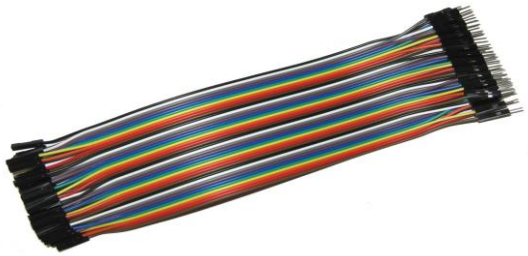

Figure 3.9: connection wires.

3.4.7 Carbon Resistors

Figure 3.10: 120kΩ Resistance.

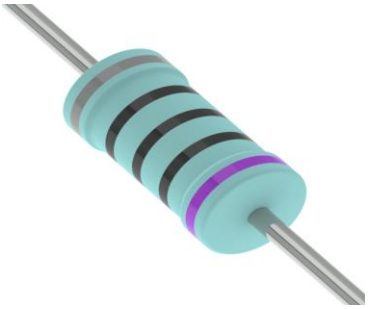

Figure 3.11: 800Ω Resistance.

Figure 3.12: 4kΩ Resistance.

3.4.8 Ceramic 100nf capacitor

- **Information:**

Ceramic 100nF Capacitor can also be represented as a value of 0.1uF and code CC104, it is a passive device used in electricity and electronics to store energy, it is general purpose and is used as an oscillator, filter and other applications. These ceramic capacitors support a maximum voltage of 50 V, this capacitor has a capacitance of 100 pf. [18]

Figure 3.13: Ceramic 100nf capacitor.

3.5 Power Supply circuit and components for the project

It is necessary to find a suitable power source to feed the device system with the required current and voltage. Because the device is required to be portable and lightweight, the charger and discharger unit is a built-in micro-USB interface, and the power bank circuit board can be used to charge other electronic products. We integrated the electircal circuit board of the device with the power bank to protect against overcurrent and overvoltage. This power bank board contains high precision rechargeable battery, sufficient supply voltage, sufficient supply current to feed the device system in an excellent way. So we used the following parts. [19]

3.5.1 TP4056 1A Standalone Linear Lithium-Ion Battery Charger

Figure 3.14: TP4056 1A Standalone Linear Lithium-Ion Battery **Charger**

3.5.2 Push Button Switch

Figure 3.15: Push Button Switch.

3.5.3 Battery lithium ion 3000mAh 3.7V

This rechargeable Lithium Ion battery has a nominal voltage of 3.7V and an electrical charge of 3000mAh. This type of battery is used in many devices. This model has 2 bare wires: red and black. [19]

Figure 3.16: Battery lithium ion 3000mAh 3.7V.

3.6 The method of work

The person push the energy button, and then enough voltage is connected by the charging circuit to operate the transmitter and receiver circuits, the screen, and the Arduino microcontroller. Then the person inserts his finger into the measurement handle, and then touches the word start on the screen, after which the transmitter circuit emits the near-infrared rays of length A wavelength of (940nm) and a visible red light with a wavelength of (700nm) in order to measure the size and distance of the finger around the measuring handle and a visible green light with a wavelength of (567nm) in order to increase the absorption of light in the glucose molecule,and then the photodiode sensor recept the light signal to compare between the light penetrating from the glucose molecules and hemoglobin in the capillaries and Converting it into an electrical signal in the form of millivolts,Then the filter filters out the noise and improves the voltage deliveres to the Arduino microcontroller from the photodiode sensor. Finally, the Arduino Uno microcontroller translates these electrical signals into mathematical equations and displays them on the TFT screen: HGB: g/dlfor hemoglobin and Glu: mg/dl for glucose.

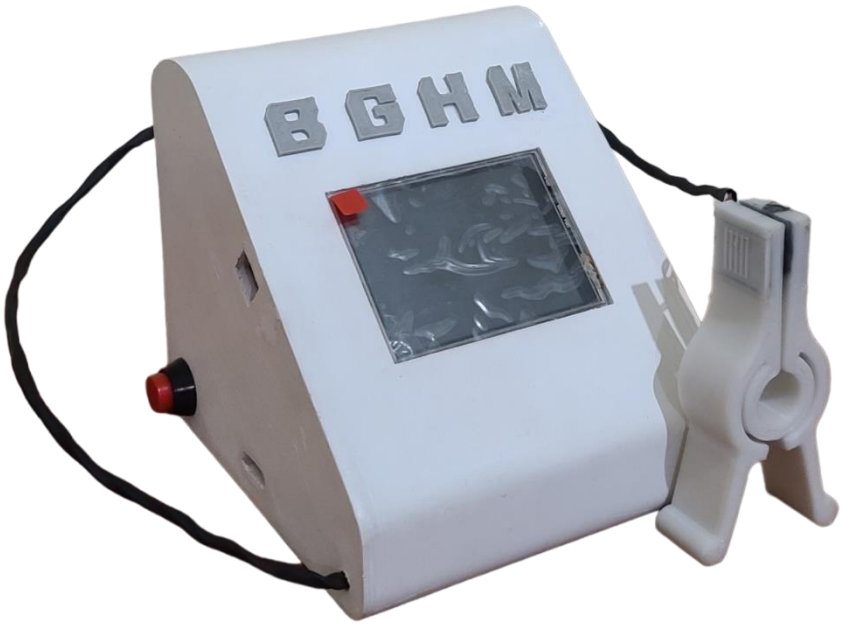

Figure 3.17: Blood glucose and hemoglobin meter.

3.7 Blood Glucose and Hemoglobin Meter overview

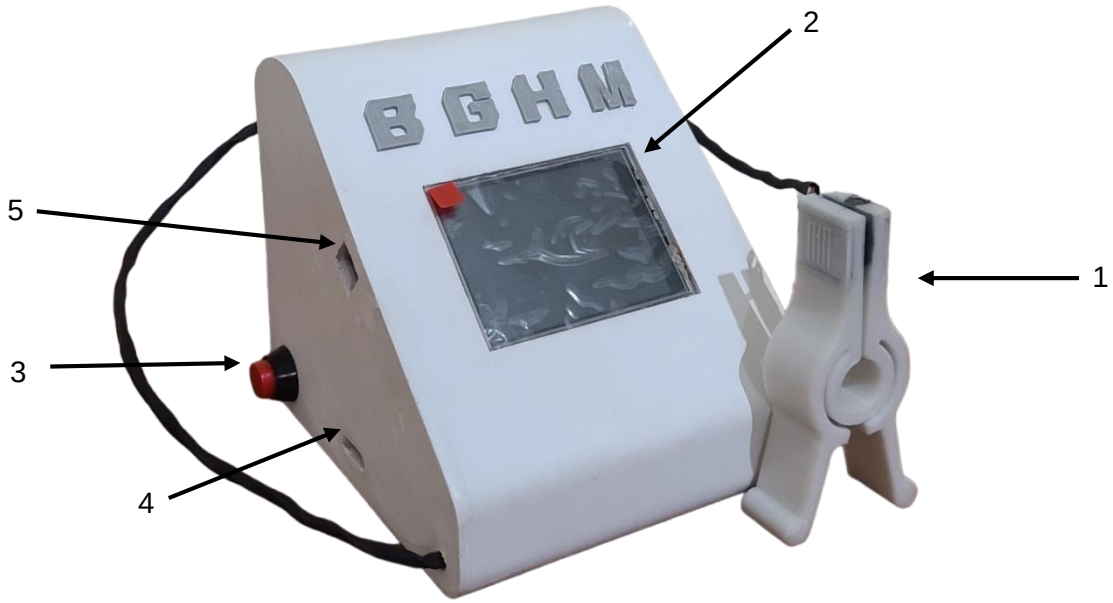

Figure 3.18**:** Blood glucose and hemoglobin meter parts.

1- Measuring handle.
2- Display screen.
3- Push button switch ON/OFF.
4- Charging entrance.
5- Programming entrance.

Chapter (4)

Implementation and Results

4.1 Introduction

In this chapter, we will explain how we assembled the parts and the block diagram as well as the System Software of the project.

4.2 Block diagram

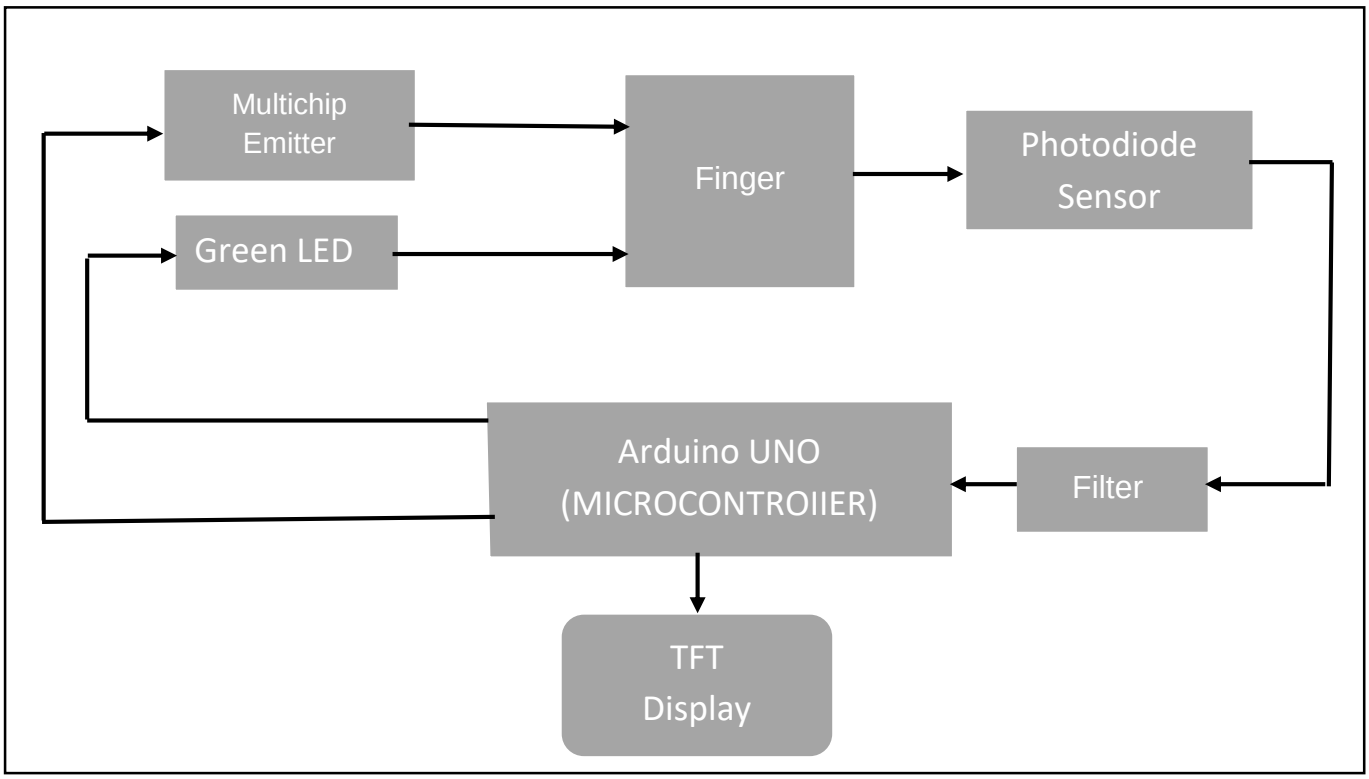

Figure 4.1: Block diagram.

4.3 System Software

4.3.1 System architecture

The system architecture Of Our Project. It illustrates the different levels that were used to construct the project. The levels include a multichip emitter, a green LED chip, a photodiode sensor, a filter to obtain stable values and reduce the noise of the voltages connected to the photodiode sensor (detector), a microcontroller (Arduino Uno), and a TFT screen display. The multichip emitter sends near-infrared radiation with a wavelength of 940 nm and send the visible red light with wavelength 700(nm) to

measure the size and distance of the finger around the measuring handle, and the green LED chip sends a green visible light with a wavelength of 576 nm increase absorption of the Light in the blood glucose from human finger.

The photodiode sensor receives the near-infrared rays and converts them into an electrical signal in the form of millivolts. The microcontroller performs analysis and calculations to differentiate between hemoglobin and glucose molecules in the human finger. Finally, the TFT screen display shows the readings in mg/dl for glucose and g/dl for hemoglobin.

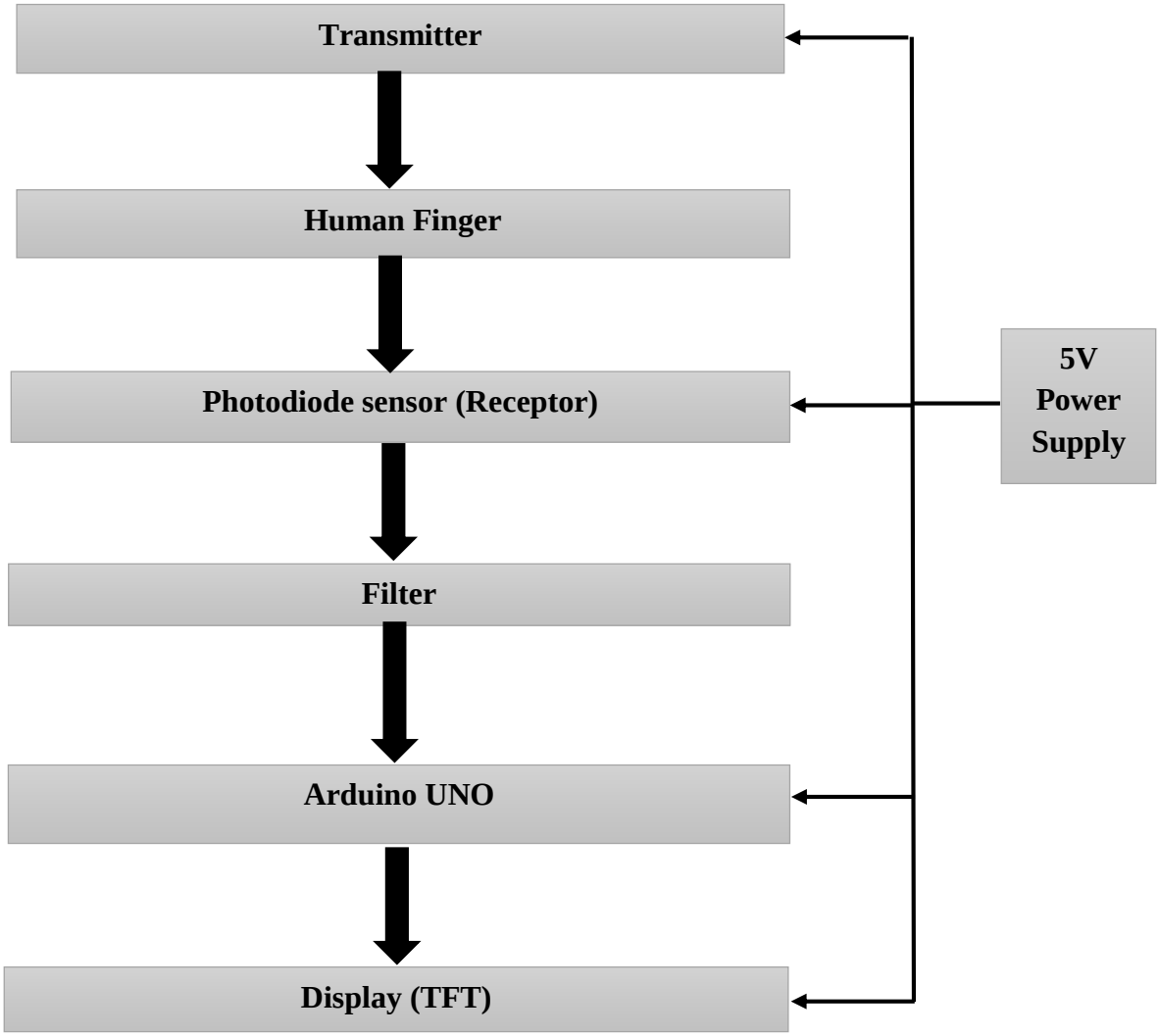

Figure 4.2: System architecture.

4.3.1 Flowchart

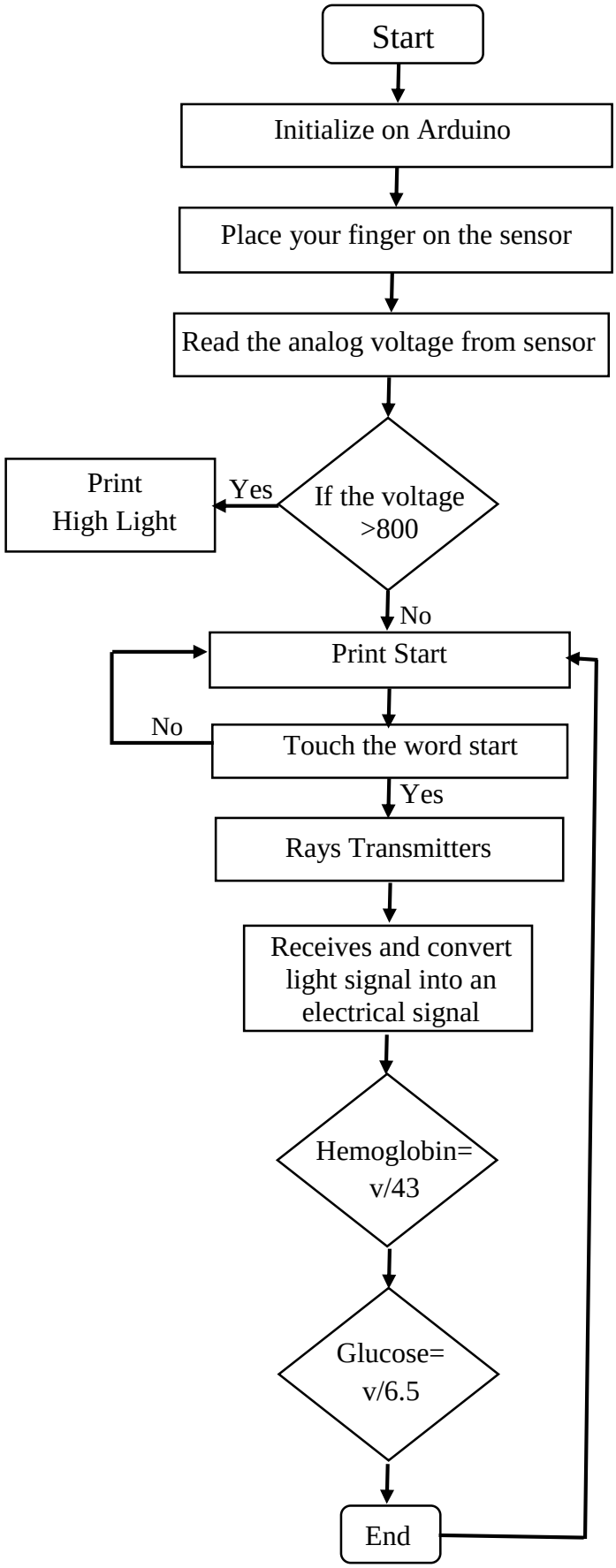

Figure 4.3: Flowchart of the project.

4.4 Results of Hemoglobin and Blood Glucose Concentration

Our device was tested with a variety of people of different ages to compare between the hematology device, the self-glucose meter and our device, as shown in the tables 4.1,4.2 below. Through experiments and comparison of measurements, we noticed that there is a slight difference between the measurement from one person to another due to skin color because the color of the skin affects the absorption of the rays of hemoglobin and glucose molecules in the blood capillaryes.

Nevertheless, the results showed that our device is able to measure the levels of glucose and hemoglobin in the blood with acceptable and excellent accuracy.

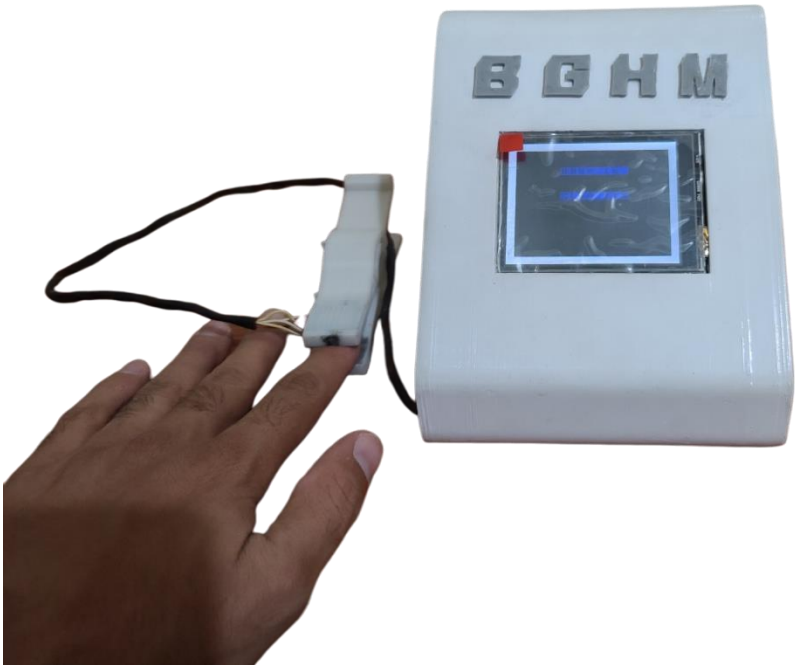

Figure 3.4: Running and testing BGHM.

م	الاسم	العمر	الجنس	لون البشرة	التدخين	الامراض	قياس الهيموجلوبين بالجهاز g/dl	قياس الهيموجلوبين بالفلتيه mv
1	محمد يحيى أحمد	65	ذكر	قمحي	لا	ورم	11.3	381
2	إبراهيم عبدالله محمد ناجي	5	ذكر	اسمر	لا	لا يوجد	13.1	947
3	إيمان أحمد مرشد الأحمدي	14	انثى	اسمر	لا	لا يوجد	13.6	870
4	محمد صغير الأسلمي	70	ذكر	قمحي	لا	ضغط	12.2	489
5	عبد الملك الصوفي	55	ذكر	اسمر	نعم	لا يوجد	18.1	528
6	أزال محمد أحمد	12	انثى	اسمر	لا	لا يوجد	11.7	943
7	مريم عبده ناصر الغولي	50	انثى	ابيض	لا	ورم	13.1	956
8	بسام صالح علي رضوان	38	ذكر	اسمر	لا	ضغط	16.6	523
9	محمد محمد قاسم	50	ذكر	ابيض	لا	لا يوجد	12.5	966
10	محمد أحمد محسن	60	ذكر	اسمر	نعم	لا يوجد	14.9	760
11	سعود أحمد قاسم عطر	60	انثى	اسمر	لا	سكر	13.8	270
12	أحمد علي صالح	75	ذكر	قمحي	نعم	ورم	11.6	947
13	فاطمه أحمد علي	60	انثى	اسمر	لا	لايوجد	14.2	952
14	محمود مثنى الجبازي	26	ذكر	ابيض	لا	لا يوجد	16.3	892
15	هديل علي حسين	23	انثى	قمحي	لا	لا يوجد	13.9	933
16	لبنى محمد السلامي	35	انثى	ابيض	لا	لا يوجد	16.5	956
17	علي صالح سعيد مهدي	50	ذكر	ابيض	نعم	لا يوجد	14.5	915
18	امينه محمد الرسام	52	انثى	ابيض	لا	لا يوجد	11.4	928
19	جاثل عبدالله محمد قارع	39	ذكر	ابيض	نعم	سكر	16.4	843
20	تقية أحمد الزهيري	35	انثي	ابيض	لا	لا يوجد	13.5	929

Table 4.1: Measurements of Hemoglobin Experiments.

م	الاسم	العمر	الجنس	لون البشرة	التدخين	الامراض	قياس السكر بالجهاز mg/dl	قياس السكر بالفلتيه mv
1	أحمد محمد مهدلي	25	ذكر	ابيض	لا	لا يوجد	103	902
2	أشرف عبدالرحيم خليل	30	ذكر	قمحي	لا	لا يوجد	103	890
3	حسام محمد بلكم	18	ذكر	قمحي	لا	لا يوجد	119	709
4	يحيى يحيى أحمد المروحي	61	ذكر	ابيض	لا	القولون	157	901
5	يحيى حمود محمد العبسي	70	ذكر	قمحي	لا	المعدة	114	883
6	أحمد علي صالح	75	ذكر	قمحي	نعم	ورم	115	864
7	احمد محمد علي زقلمة	55	ذكر	قمحي	نعم	سكري	211	895
8	محمود مثنى الجبازي	26	ذكر	ابيض	لا	لا يوجد	85	833
9	هديل علي حسين	23	انثى	قمحي	لا	لا يوجد	139	815
10	لبنى محمد السلامي	35	انثى	ابيض	لا	لا يوجد	91	870
11	نزيهة صالح حزام	50	انثى	قمحي	لا	لا يوجد	97	856
12	علي صالح سعيد مهدي	45	ذكر	قمحي	نعم	لا يوجد	97	853
13	أمينة محمد الرسام	50	انثي	ابيض	لا	لا يوجد	94	866
14	جاذل عبدالله محمد فارع	39	ذكر	ابيض	نعم	سكر	175	843
15	عصام القدسي	23	ذكر	قمحي	لا	لا يوجد	114	755
16	عصام عبده محمد	27	ذكر	اسود	لا	لا يوجد	113	422
17	عبدالرحمن ماجد البطاح	23	ذكر	قمحي	نعم	لا يوجد	103	872
18	ايمن سمير محمد برمومي	23	ذكر	اسود	نعم	لا يوجد	115	302
19	حسن يحيى حسن حزيزي	23	ذكر	اسود	لا	لا يوجد	114	381
20	نشوان جمال الحضرمي	23	ذكر	ابيض	لا	لا يوجد	86	849
21	أسد حمزة محفوض	23	ذكر	قمحي	لا	لا يوجد	83	904
22	اسامة منصور حسن شجون	30	ذكر	اسمر	لا	سكرى	174	706
23	عمار محمد عمر	38	ذكرى	حنطي	لا	لا يوجد	107	566
24	أحمد ماجد عبدالله	23	ذكر	ابيض	نعم	لا يوجد	119	883

Table 4.2: Measurements of Blood Glucose Experiments.

Chapter 5

Conclusions and Recommendations

5.1 Conclusions

1- Our project introduced a non-invasive technique for monitoring blood glucose and hemoglobin levels using near infrared technology.

2- Safe to measure without pain or discomfort for diabetic and anemia patients.

3- Excellent measurement accuracy.

4- Use more LEDs to get more accurate results.

5- The device is mobile and the patient can take it with him to any place he wants.

6-The device itis Low cost , which improves patients' quality of life through effective management of diabetes and anemia.

5.2 Recommendations

We can make future modifications in system performance and improve efficiency, and these modifications include:

1. Developing an Android application and connecting it to the device system via the Internet of Things (IOT) to record and save data.

2.Solve the problem of skin color and use a filter to filter the vibrations of the finger movement during measurement.

3. Using the Raspberry pi to become the device with the most powerful processor.

4. Work to raise the level of accuracy in the device to compete with laboratory equipment.

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