Palestine Polytechnic University

College of Engineering &Technology
Electrical &Computer Engineering Department

Graduation Project

Design and Implementation a System of Heparin Pump by Stepper Motor

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Hebron – Palestine

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Graduation Project Report

Submitted to the Department of Electrical and Computer Engineering
in the College of Engineering and Technology

Palestine Polytechnic University

Approved by ____
Chairperson of Supervisory Committee

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Date ____

بسم الله الرحمن الرحيم

جامعة بوليتكنك فلسطين

كلية الهندسة و التكنولوجيا

اسم المشروع

DESIGNE A SYSTEM OF HEPARIN PUMP BY STEPPER MOTOR

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....

Abstract

The main objective of the project is to design and implement a control system for providing a precise amount of heparin during hemodialysis procedure using stepper motor.

Heparin is injected into the blood stream between blood pump and dialyzer by syringe pump with capacity of 60 ml. An inductive proximity sensor is used to determine the level of heparin inside the syringe.

The designed system is based on a microcontroller that controls the whole system and all heparin pump parameters.

ملخص المشروع

نهدف في مشروعنا هذا إلى تصميم وبناء نظام يتحكم بتزويد كميات معينة من مادة الهيبارين (المضادة لتخثر الدم) خلال عملية غسيل الكلى باستخدام ماتور الخطوات .

يتم حقن هذه الكمية من الهيبارين بين مضخة الدم ومرشح الدم في جهاز غسيل الكلى وهذه الكمية تعادل 60 مليلتر . ويتم استخدام المجس الحثي لتحديد كمية الهيبارين داخل الإبرة.

إهداء

إلى الزهرة التي لا تذبل.....................نبع الحنان..................... أمي

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

إلى ملائكة الأرض.....................شقائق النعمان.....................أشقائي

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

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

إلى صناع الكرامة.....................رايات المجد.....................الشهداء

إلى من رفضوا الخضوع.....................من طلبوا العزة.....................أسرانا

....اليكم جميعا احبتنا ....

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Chapter one
Introduction

1.1 Overview

It is obvious that Biomedical Engineering Technology has a great importance on the health-care field which makes our life safe by designing biomedical devices to achieve better diagnostic and treatment of diseases. Some of these devices are used as treatment devices to decrease the ability of infection by keeping the balance required.

Our project "Design and Implementation a system of heparin pump which is used in hemodialysis using a stepper motor.

Stepper motor is an automatic device for slowly discharging the contents of a syringe through a cannula into a vein. It is normally a simple electromechanical device.

1.2 Project Objectives

In this project we aim to design and implement a system of heparin pump which is used in hemodialysis using a stepper motor to:

1. Adjust the amount of heparin injected in the blood according to the operations of arithmetic.
2. Design a drive circuit for stepper motor.
3. Design a control system using PIC microcontroller.

1.3 Project Importance

Since the inception of the chronic hemodialysis procedure in the 1960s, anti coagulation has remained an important component of adequate treatment management. Traditionally, the challenging task of preventing clotting of the extracorporeal circuit without placing the patient at increased risk for bleeding, complications has been managed and solved using heparin.

heparin is injecting by syringe pump into the segment between the blood pump and the dialyser.

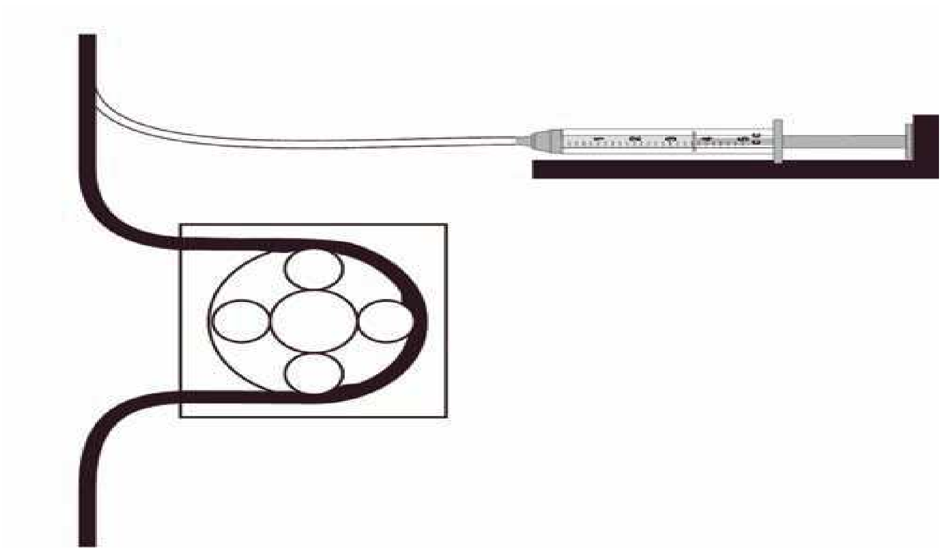

Figure 1.1 Heparin infusion line

From The importance of heparin to the patient life care and to prevent blood clotting during the treatment we see the importance of our project to facilitate the delivery of heparin to the patient in limited quantities and in times of need, through the pump controlled by the stepper motor and PIC microcontroller.

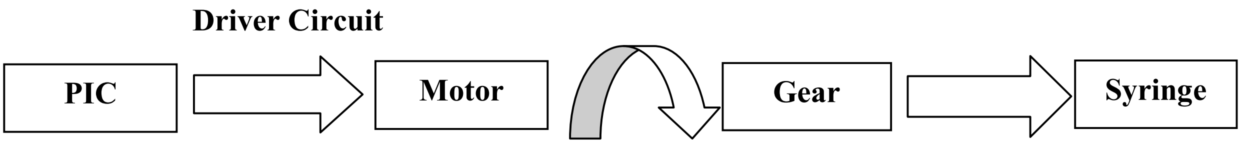

Figure 1.2 Heparin Delivery System

1.4 Literatures Review

Activated clotting time (ACT) and the whole blood partial thromboplastin time (WBPTT) have been used to measure the anticoagulability of heparin. Both these tests use whole blood, and can produce results in minutes, making them desirable for clinical use. Following enactment of the Clinical Laboratory Improvement Amendments (CLIA) of 1988.

Automated clotting time measurement systems replaced the manually performed WBPTT as the means of monitoring anticoagulation during hemodialysis in the United States Such procedures are associated with increased overhead costs and are difficult to incorporate into everyday use in a busy hemodialysis center, an alternative anticoagulation strategy uses intermittent heparin dosing. An initial loading dose of heparin is administered, followed by one or more additional bolus doses during dialysis. Intermittent dosing is simple and eliminates the need for an infusion pump and syringe.

In 1994: describes the use of a computer-controlled system that uses sparse the activated clotting time (ACT) measurements as the basis for automatically adjusting the heparin infusion rate to provide a target level of anticoagulation

The infusion regimen is delivered by means of a computer-controlled syringe pump. A menu-driven program allows the operator to enter patient data, verify parameters such as the syringe size and concentration of heparin in the syringe.[15]

1.5 Scheduling Table

The timing management will divide the system hierarchy according to the actions:

T1: *Preparing to the project:* this stage of the project primarily aims to identify the contents of it, discuss the initial information, and evaluate the project tasks and levels.

T2: *The project analysis:* the analysis process includes extensive study for all possible design options of the project.

T3: *Conceptual Design:* project objectives, design block diagram that will be done and we will show how our system will work.

T4: *Studying project component and schematic analysis:* it is necessary to study the specifications of project components to meet the requirements of the project.

T5: *Preparing project parts*: determining the appropriate electrical and mechanical components that are suitable for our design.

T6: *Programming microcontroller:* writing subprograms from project, and testing them on subsystem circuits in order to build whole system program.

T7: *Hardware implementation:* include building electronic circuits, mechanical subsystems, and finally combining them together.

T8*: Testing the system:* testing the system, calibration, discovering the problems, and solve them.

T9: *Writing the documentation:* writing the documentation of project.

Table 1.1: The Task Duration

Task	Duration(weeks)	Dependencies
T1	3	--------
T2	3	--------
T3	4	T1,T2
T4	2	T3
T5	2	-------
T6	8	T5
T7	8	T5
T8	3	T6,T7
T9	20	--------

Table 1.2: Timing plane

Task / Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
T1															
T2															
T3															
T4															
T9															
Task / Week	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
T5															
T6															
T7															
T8															
T9															

1.6 Estimated Cost

This section lists the overall cost of the components that are considered in implementing the system.

There are many electrical and mechanical parts with expected cost as follow.

Table 1.3: Hardware Cost

Item No.	Component	Cost
1	GEAR	55
2	Rack gear	40
3	Shaft	35

4	**Bearing**	**28**
5	**Stepper motor**	**85**
6	**Motor controller**	**11**
7	**Inductive sensor**	**62**
8	**Bleat form and support beam**	**26**
Total cost		**342 JD**

1.7 Project Risk Management

There are a lot of risks that occur and we have to declare them in the early time of the project designing and manipulation, when we find a problem we should try to solve it without affecting on the whole project.

1.7.1 Hardware Risks

The most important hardware parts in our project are the PIC microcontroller, syringe pump, inductive sensor, stepper motor, rack and pinion gears. The predicted risks are:

- Gear designing problem.
- The inductive sensor does not respond.
- Wrong connection of microcontroller.
- Stepper motor accuracy.

1.7.2 Group Risks

- Illness of one or more of group members.
- Group meeting difficulties.

1.7.3 Project Risks

- Inaccurate schedule.
- Latency of devices arrival.

Recovery

- Demand device at earlier time.
- Start working on the implementation earlier.
- Use alternate devices with the same functionality and less cost.

1.8 Report Contents

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

Chapter 1: Introduction

This chapter presents overview, project objectives, Project importance, project scheduling, Literatures Review, estimated cost, and report contest.

Chapter 2: Physiological Background

This chapter discusses the circulatory system, blood system renal system and dialysis machine with its block diagram.

Chapter 3: Theoretical Background

This chapter discusses the stepper motor, inductive sensor, pic microcontroller and power supply.

Chapter 4: Project Conceptual Design

This chapter discusses the project objectives, project design and block diagram.

Chapter 5: Detailed Technical Project Design

This chapter discusses the subsystem detailed design.

Chapter 6: Software

This chapter includes software of the project and flowchart of the process.

Chapter 7: System Implementation and Testing

This chapter includes implementation and testing of our design.

Chapter 8: Conclusion and Future Work

This chapter includes conclusion and suggestions for development.

2

Physiological Background

Before we start in project design, we must have strong physiological background about the project and its components, so this chapter will discuss this topic.

Chapter Two

Physiological Background

2.1 Circulatory System

2.1.1 Circulatory System Definition

The circulatory system is made up of the vessels and the muscles that help and control the flow of the blood around the body. This process is called circulation. The main parts of the circulatory system are the heart, arteries, capillaries and veins.

The blood begins to circulate; it leaves the heart from the left ventricle and goes into the aorta. The aorta is the largest artery in the body. The blood leaving the aorta is full of oxygen. This is important for the cells in the brain and the body to do their work. The oxygen rich blood travels throughout the body in its system of arteries into the smallest arterioles.

On its way back to the heart, the blood travels through a system of veins. As it reaches the lungs, the carbon dioxide (a waste product) is removed from the blood and replace with fresh oxygen. [5]

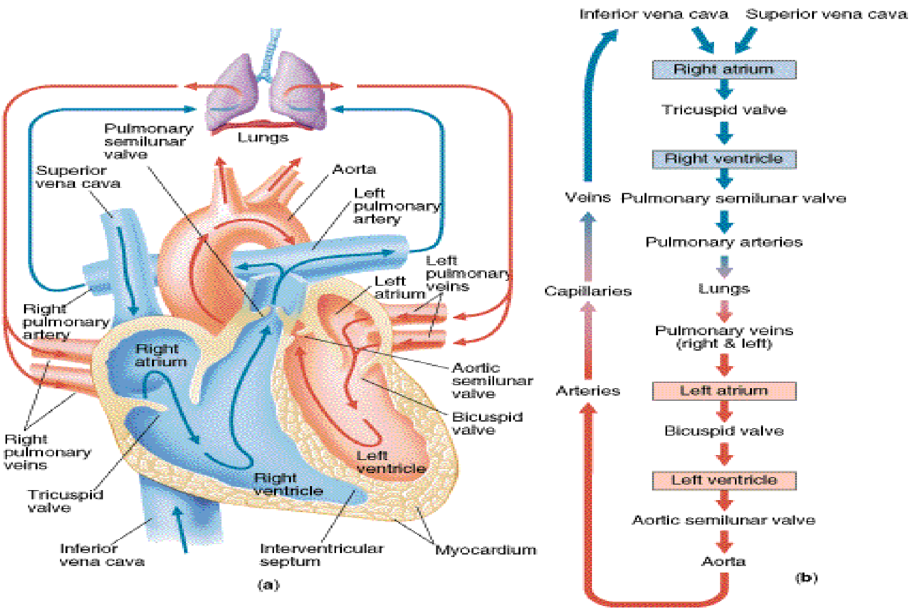

Figure 2.1 Blood Circulatory System

2.1.2 Circulatory System Main Parts

The main parts of the system are the heart, arteries, veins and capillaries.

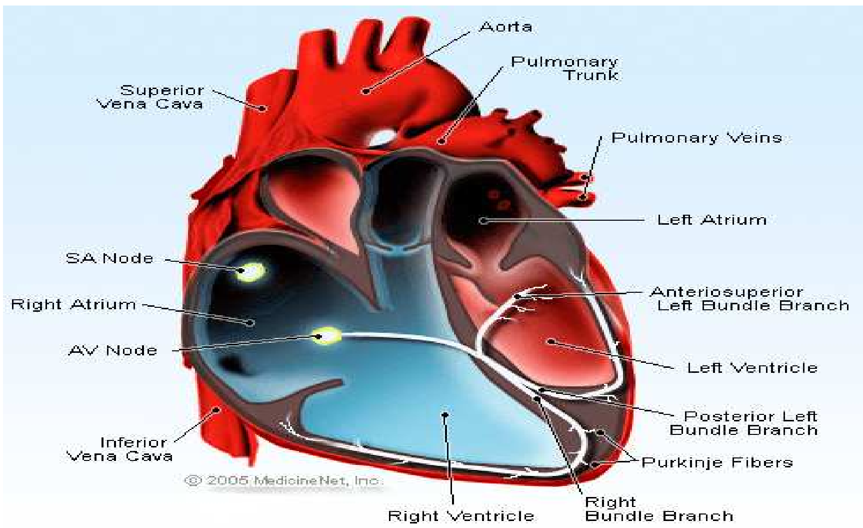

Figure 2.2 Heart & Blood Vessels System

2.1.2.1 The Heart.

The muscle that pumps blood received from veins into arteries throughout the body. It is positioned in the chest behind the sternum, in front of the trachea, esophagus, and aorta; and above the diaphragm muscle that separates the chest and abdominal cavities. The normal heart is about the size of a closed fist, and weighs about 10.5 ounces. It is cone-shaped, with the point of the cone pointing down to the left. Two-thirds of the heart lies in the left side of the chest with the balance in the right chest

.

The heart is composed of specialized cardiac muscle, and it is four-chambered, with a right atrium and ventricle, and an anatomically separate left atrium and ventricle. The blood flows from the systemic veins into the right atrium, thence to the right ventricle, from which it is pumped to the lungs, then returned into the left atrium, thence to the left ventricle, from which it is driven into the systemic arteries.

The heart is thus functionally composed of two hearts: the right heart and the left heart. The right heart consists of the right atrium, which receives deoxygenated blood from the body, and the right ventricle which pumps it to the lungs under low pressure; and the left heart, consisting of the left atrium, which receives oxygenated blood from the lung, and the left ventricle, which pumps it out to the body under high pressure.

2.1.2.2 The Arteries

Arteries are tough, elastic tubes that carry blood away from the heart. As the arteries move away from the heart, they divide into smaller vessels. The largest arteries are about as thick as a thumb. The smallest arteries are thinner than hair. These thinner arteries are called arterioles. Arteries carry bright red blood! The color comes from the oxygen that it carries.

The muscular wall of the artery helps the heart pump the blood. When the heart beats, the artery expands as it fills with blood. When the heart relaxes, the artery contracts, exerting a force that is strong enough to push the blood along. This rhythm between the heart and the artery results in an efficient circulation system.

2.1.2.3 The Veins

Veins carry the blood to the heart. The smallest veins, also called venules, are very thin. They join larger veins that open into the heart. The veins carry dark red blood that doesn't have much oxygen. Veins have thin walls. They don't need to be as strong as the arteries because as blood is returned to the heart, it is under less pressure.

Veins receive blood from the capillaries after the exchange of oxygen and carbon dioxide has taken place. Therefore, the veins transport waste-rich blood back to the lungs and heart. It is important that the waste-rich blood keeps moving in the proper direction and not be allowed to flow backward. This is accomplished by valves that are located inside the veins. The valves are like gates that only allow traffic to move in one direction.

The vein valves are necessary to keep blood flowing toward the heart, but they are also necessary to allow blood to flow against the force of gravity. For example, blood that is returning to the heart from the foot has to be able to flow up the leg. Generally, the force of gravity would discourage that from happening. The vein valves, however, provide footholds for the blood as it climbs its way up.

2.1.2.4 **The capillaries**

Capillaries are very thin and fragile. The capillaries are actually only one epithelial cell thick. They are so thin that blood cells can only pass through them in single file. The exchange of oxygen and carbon dioxide takes place through the thin capillary wall. The red blood cells inside the capillary release their oxygen which passes through the wall and into the surrounding tissue. The tissue releases its waste products, like carbon dioxide, which passes through the wall and into the red blood cells.

Arteries and veins run parallel throughout the body with a web-like network of capillaries, embedded in tissue, connecting them. The arteries pass their oxygen-rich blood to the capillaries which allow the exchange of gases within the tissue. The capillaries then pass their waste-rich blood to the veins for transport back to the heart.

2.2 Blood System

2.2.1 Blood Definition

Blood is a liquid that flows within blood vessels. It is constantly in motion as the heart pumps blood through arteries to the different organs and cells of the body. The blood is propelled back to the heart in the veins. When muscles contract, they squeeze the veins and allow the blood to be pushed back to the heart.[5]

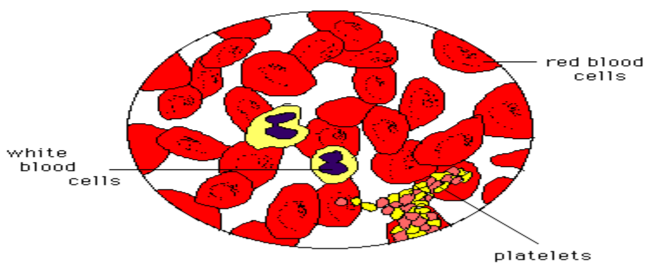

Figure 2.3 Blood Cells

Because it contains living cells, blood is alive. Red blood cells which containing hemoglobin and white blood cells that fight infection are responsible for nourishing and cleansing the body.

Vitamins and Minerals keep the blood healthy. The blood cells have a definite life cycle, just as all living organisms do. Approximately 55 percent of blood is plasma, a straw-colored clear liquid. The liquid plasma carries the solid cells and the platelets which help blood clot.

Blood performs many important functions within the body including:

- Supply of oxygen to tissues by hemoglobin included in red blood cells..
- Supply of nutrients such as glucose, amino acids, and fatty acids .
- Removal of waste such as carbon dioxide, urea, and lactic acid.
- Immunological functions, including circulation of white blood cells, and detection of foreign material by antibodies.
- Coagulation, which is one part of the body's self-repair mechanism.
- Messenger functions, including the transport of hormones and the signaling of tissue damage.
- Regulation of body pH.

2.2.2 Blood Clots

Blood clotting is an important mechanism to help the body repair injured blood vessels. When the human body loses a little bit of blood through a minor wound, the platelets cause the blood to clot so that the bleeding stops. Because new blood is always being made inside of your bones, the body can replace the lost blood.

Platelets are irregularly-shaped, colorless bodies that are present in blood. Their sticky surface lets them, along with other substances, form clots to stop bleeding.

A clot begins to form when the blood is exposed to air. The platelets sense the presence of air and begin to break apart. They react with the fibrinogen to begin forming fibrin, which resembles tiny threads. The fibrin threads then begin to form a web-like mesh that traps the blood cells within it. This mesh of blood cells hardens as it dries, forming a clot.

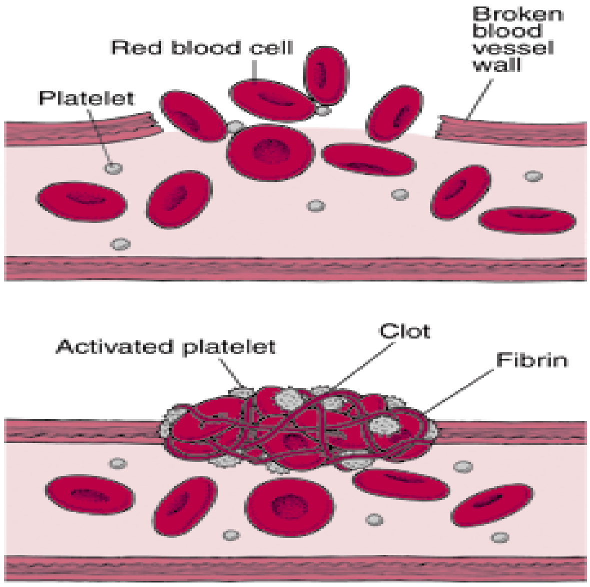

Figure 2.4 Blood Clots

2.3 Urinary System

2.3.1 Urinary System Definition

The urinary system consists of all the organs involved in the formation and release of urine. These organs control the amount of water and salts that are absorbed back into the blood and what is taken out as waste. This system also acts as a filtering mechanism for the blood. It includes the kidneys, ureters, bladder and urethra.

The kidneys are bean-shaped organs which help the body produce urine to get rid of unwanted waste substances. When urine is formed, tubes called **ureters** transport it to the urinary bladder**,** where it is stored and excreted via the urethra**.** [8]

2.3.2 Components of the Urinary System

Urinary System includes the kidneys, ureters, bladder and urethra as shown below:

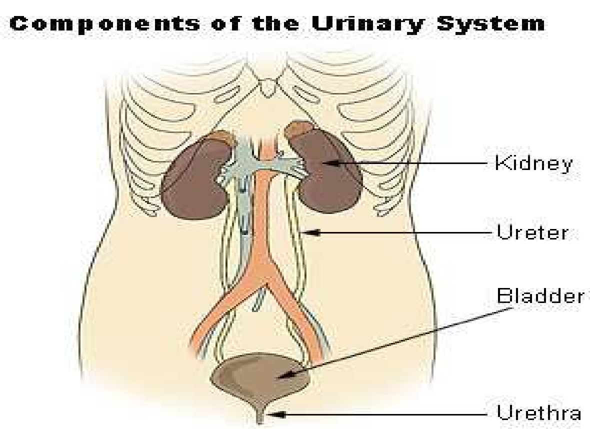

Figure 2.5 Urinary System Components

2.3.2.1 Kidneys

The kidneys are the primary organs of the urinary system , kidneys are large, bean-shaped organs towards the back of the abdomen. They lie behind a protective sheet of tissue within the abdomen. One side of the kidney bulges outward (convex) and the other side is indented (concave). The kidneys perform many vital functions which are important in everyday life. The kidneys are the organs that filter the blood, remove the wastes, and excrete the wastes in the urine.

The most basic structures of the kidneys, are nephrons. There are over one million nephrons in each human kidney and together they are responsible for the complex water regulation and waste elimination functions of the kidneys.

The renal artery delivers blood to the kidneys each day. Over 180 liters (50 gallons) of blood pass through the kidneys every day. When this blood enters the kidneys it is filtered and returned to the heart via the renal vein.

The process of separating wastes from the body's fluids and eliminating them, is known as excretion. The body has four organ systems that are responsible for excretion. The urinary system is one of the main organ systems responsible for excretion. It excretes a broad variety of metabolic wastes, toxins, drugs, hormones, salts, hydrogen irons and water. The kidneys are the main organs of the urinary system.

2.3.2.1.1 Kidney Functions

- Control of the body's water balance.
- Regulation of blood pressure via the renin-angiotensin-aldosterone system.
- Regulation of blood electrolyte balance - Na^+, Ca^{2+}, K^+ etc.

- Excretion of metabolic wastes such as urea, creatinine and foreign substances such as drugs and the chemicals we ingest with our food.
- Help in the regulation of the body's acid base balance.
- Regulation of red blood cell production via the hormone erythropoietin.

2.3.2.1.2 KIDNEY FAILURE

Acute kidney failure occurs when illness, or injury temporarily damages the kidneys. Consequently, the kidneys cannot adequately remove fluids and wastes from the body or properly regulate certain chemicals in the bloodstream. Although this can cause some problems in the short term, with proper and timely treatment, it can typically be reversed. Often there is no permanent damage to the kidneys.

Chronic kidney failure unlike acute kidney failure which is temporary, failure long term and in most cases, irreversible. This is extremely serious and could eventually lead to a total shut down of the kidneys (end stage renal failure). Without proper treatment, to remove the wastes and fluids from the bloodstream, this condition is fatal.

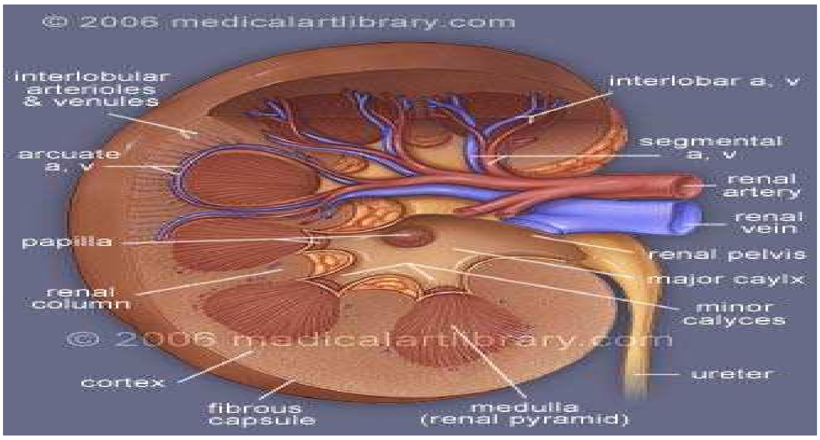

Figure 2.6 Kidney Anatomy Internal

2.3.2.2 Ureters

The ureters are two tubes that drain urine from the kidneys to the bladder. Each ureter is a muscular tube about 10 inches (25 cm) long. Muscles in the walls of the ureters send the urine in small spurts into the bladder

2.3.2.3 Bladder

The bladder is a pyramid-shaped organ which sits in the pelvis (the bony structure which helps form the hips). The main function of the bladder is to store urine and, under the appropriate signals, release it into a tube which carries the urine out of the body. Normally, the bladder can hold up to 500 mL of urine. The bladder has three openings: two for the ureters and one for the urethra (tube carrying urine out of the body).

2.3.2.4 Urethra

The urethra is a muscular tube that connects the bladder with the outside of the body. The function of the urethra is to remove urine from the body.

2.4 Hemodialysis Machine

Medical Instruments and tools that are used in medical field especially in kidney frailer treatment clinics, for removing waste products such as creatinine and urea, as well as free water from the blood when the kidneys are in renal failure

2.4.1 Hemodialysis Machine Definition

Dialysis machines are artificial kidneys that perform most, but not all, kidney functions for patients who have permanent or temporary renal failure. The machines use hemodialysis to cleanse the blood and balance its constituents. With this process, the patient's blood is circulated through the machine where it is filtered and balanced for electrolytes, pH, and fluid concentration before being returned to the patient. One Common problem with renal failure is water retention, so it is common for the process to remove several pints of fluid from the patient's blood.

There are two basic classes of dialysis machines: clinical units, which are commonly cabinet-size machines operated by trained technicians; and home-use dialysis machines, which are smaller and sometimes portable.

Normally, patients with complete loss of kidney function would need to visit the clinic at least three times per week and spend about four hours connected to the machine.

With home-use machines, patients have more flexibility in scheduling dialysis, and they can dialyze for longer periods and more frequently.

2.4.2 History of Dialysis Machine

Dialysis machine passed through several stages of development, side by side with the development in medical field, the following table summaries dialysis machine development hierarchy.[13]

Table 2.1: Historical background about dialysis machine

Year	Development
1854	Thomas Graham ; the first presented the principles of solute transport across a semi permeable membrane.
1913	Abel ; the first developer artificial kidney.
1924	Hass ; the first applied hemodialysis in a human.
1943 - 1945	Kolff ; first developer for artificial kidney into a clinical useful apparatus.
1950	Kolff's, invention of the dialyzer was used for acute renal failure
1962	Scribner ; invented first outpatient dialysis facility

2.4.3 Theory of Operation

The patient's blood is continuously pumped from an artery, a large vein, or a surgically modified vein to allow high blood flow rates. Its pressure is monitored both upstream and downs-tream from the peristaltic blood pump. Before the blood enters the dialyzer, heparin is added to prevent clotting. A syringe pump is used to deliver the heparin at a precisely controlled rate.

The blood then enters the dialyzer where it passes across a large-surface-area, semipermeable membrane with a dialysate solution on the other side. A pressure gradient is maintained across the membrane to ensure the proper flow of compounds out of and into the blood. After cleansing and balancing within the dialyzer, the blood is passed through an air trap to remove any air bubbles before it is returned to the patient. An air bubble sensor ensures that no air bubbles remain.

Blood-pressure, oxygen-saturation, and hematocrit levels (blood cell concentration) are monitored for proper operation of the machine and to ensure patient safety. For maximum effectiveness, fresh dialysate is continually pumped through the dialyzer during operation.[7]

2.4.4 Components and Monitoring

2.4.4.1 Blood tubing

There are two parts of the blood tubing: arterial and venous. The arterial segment is most often color-coded red; the venous segment is most often color-coded blue During hemodialysis, blood from the patient's vascular access (arterial needle) flows to the dialyzer. Blood flows back to the patient's access (venous needle) through blood tubing. The inner diameter of the blood tubing is small and smooth on the inside to reduce clotting and air bubbles.

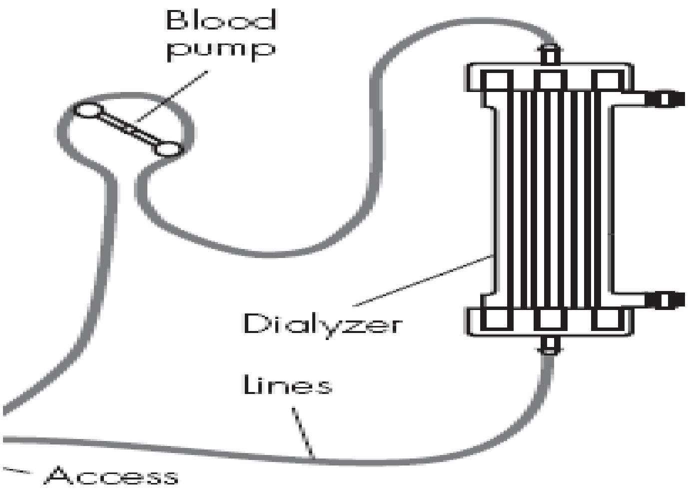

Figure 2.7 Blood Tubing System

2.4.4.2 Dialyzer

The dialyzer is made of thousands of microscopic fiber tubes. These tubes can be likened to drinking straws that have small holes punched in the sides of the straws. These holes in the fibers are too small to allow the blood cells to pass.

The dialyzer is hooked to larger hoses that flow the dialysate through the area around the fibers in the dialyzer (usually in the opposite direction from the blood flow), and by pressure and osmosis, the fluid around the cells in the blood that contains the urea (waste) passes out of the blood and into the dialysate and to the waste system (drain).[16]

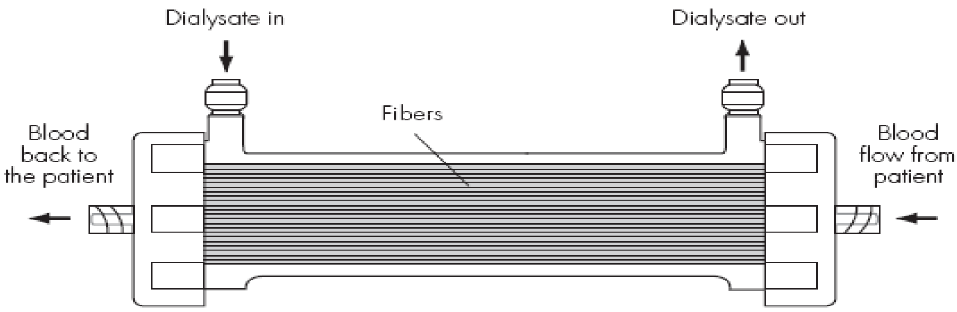

Figure 2.8 Dialyzer System

2.4.4.3 Blood pump/blood flow rate

The blood pump moves blood from the patient's arterial needle through the blood tubing, to the dialyzer, and then back to the patient through the venous needle. Most often, the type of blood pump used is a roller pump. This pump uses a motor that turns a roller head. Speed of the roller head determines blood flow rate, which is set by the staff person.

The blood pump segment of the blood tubing is threaded between the rollers and the pump head. The rollers turn, blocking the tubing and pushing blood out of the segment. After the roller has passed, the segment resumes its shape and blood is drawn in to refill the pump segment. In this way, blood is pulled into and pushed out of the segment at the same time.

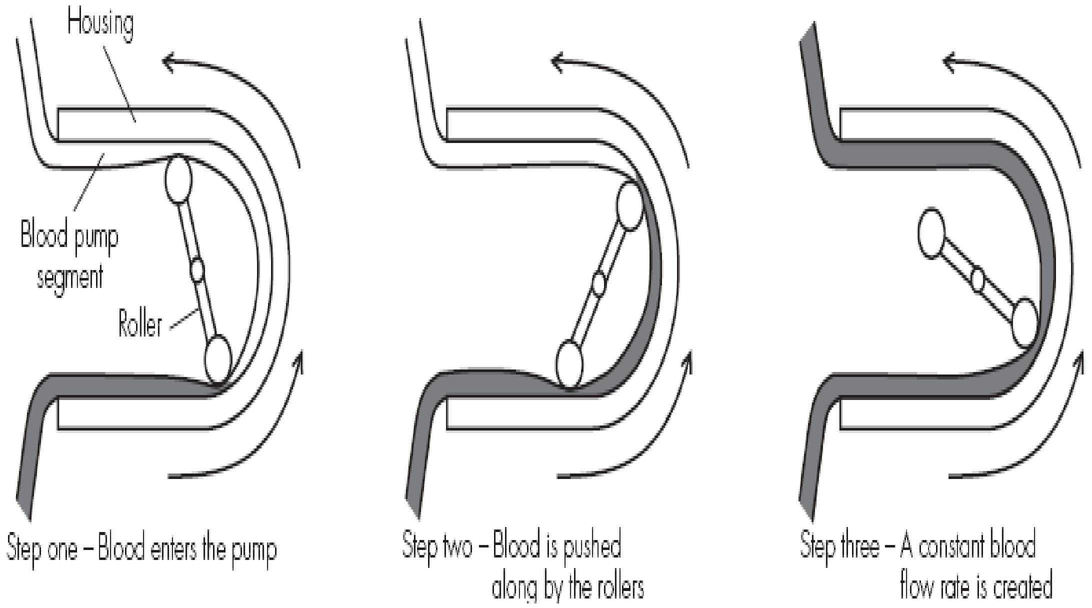

Figure 2.9 Blood Pump

2.4.4.4 Extracorporeal pressure monitors

One of the functions of a hemodialysis machine is to measure and display arterial and venous pressures as well as to notify the operator when these pressures fluctuate outside of an established alarm limit. It is, however, the responsibility of the caregiver who monitors and interprets these pressure readings to determine how effectively or safely a treatment is being performed and to initiate appropriate interventions. A comparison of pressure readings from the patient's previous treatments at like blood pump speeds should be done each treatment to determine if the currently displayed pressures are typical or may be an indication of a problem. It is this comparison and the knowledge of acceptable pressure limits that enable caregivers to provide quality care for hemodialysis patients.

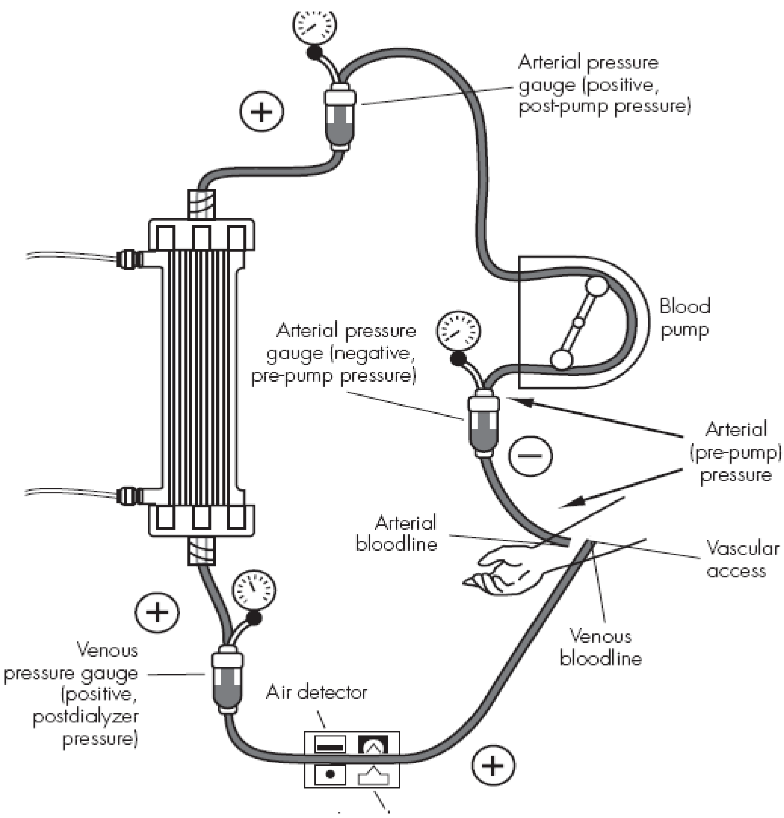

Figure 2.10 Extracorporeal Pressure Monitors

2.4.4.5 Air detectors

Air/foam detectors continuously check the blood in the venous tubing segment for air and foam. The system may check for air at the venous drip chamber or at the blood tubing.

Air detectors are ultrasonic devices that check for changes in a sound wave sent through a cross-section of the blood path. ultrasound travels faster through air than liquid. Therefore, any air in the blood will raise the speed at which the sound wave passes through the blood, setting off an alarm.

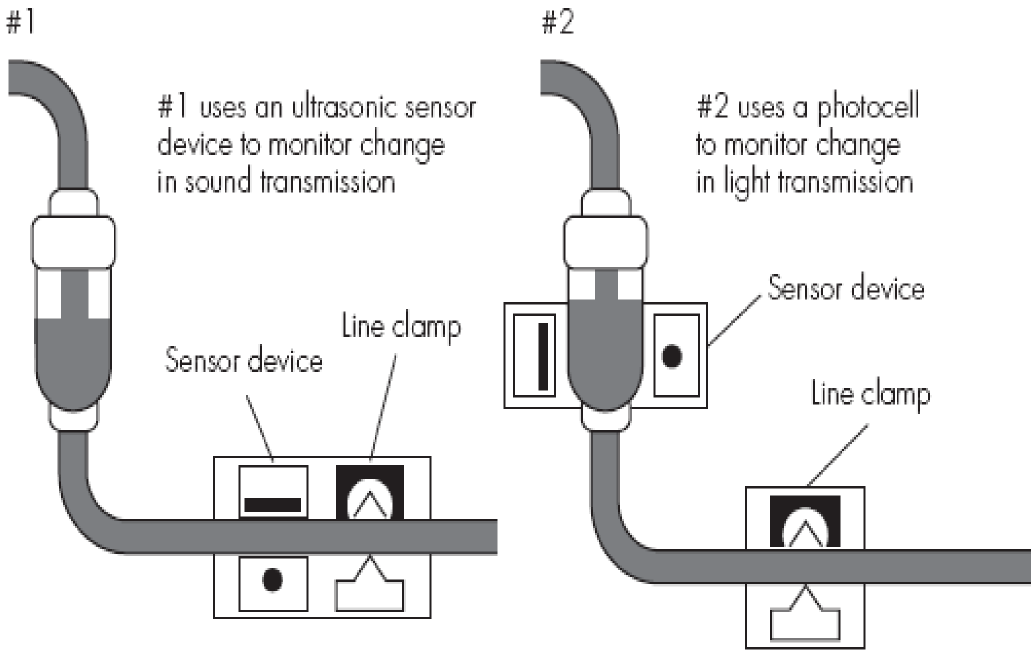

Figure 2.11 Air Detector

2.4.4.6 Blood Leak Monitoring

Used to check for blood in the used dialysate. The detector can sense very small amounts of blood, less than can be seen with the naked eye. The blood leak detector shines a beam of light through the used dialysate and onto a photocell or photoresistor. Normally, dialysate is clear, so the light can pass through. But even a tiny amount of blood will break the light beam. The detector will sense such a break, triggering audible and visual alarms. When a blood leak alarm occurs, the blood pump stops and the venous line clamps to prevent further blood loss.

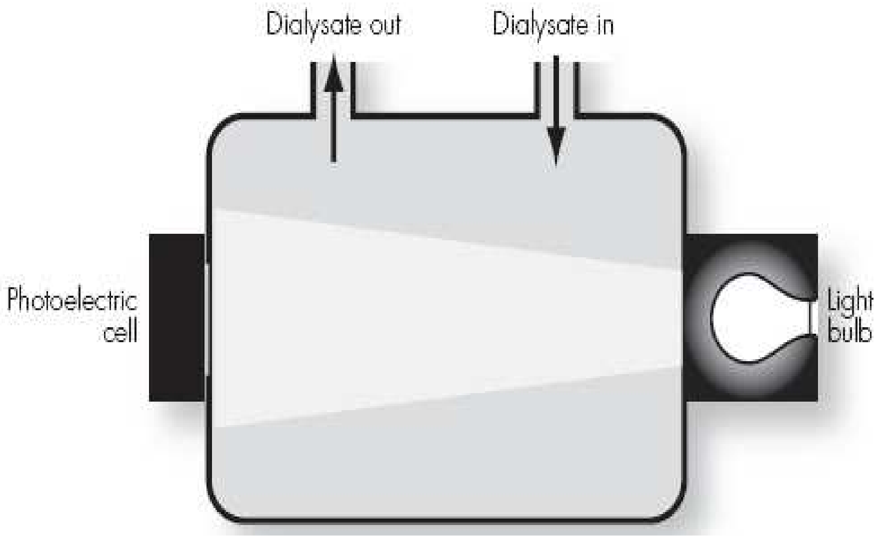

Figure 2.12 Blood Leak Monitoring

2.4.4.7 Heparin system

When the patient's blood touches the artificial materials of the lines and dialyzer, it tends to clot. Heparin, an anti-clotting drug, or anticoagulant, is used to prevent clotting in the extracorporeal blood circuit.

Heparin can be given intermittently (on and off) during dialysis; a prescribed amount is injected into the arterial bloodline at prescribed times. Also can be given by bolus (the full prescribed amount is given all at once just before the treatment.) or can be given by continuous infusion (a prescribed rate throughout the treatment.) A syringe filled with heparin and an infusion pump are used and the pump slowly injects heparin into the extracorporeal circuit

For most patients, heparin is stopped before the end of the treatment so blood clotting can go back to normal.

. A continuous infusion heparin pump has four parts:

1. A syringe holder
2. A piston to drive the plunger of the syringe
3. An electric motor to drive the plunger forward and infuse heparin from the syringe
4. A way to set the prescribed infusion rate

Heparin pumps have variable speeds that can be set to the physician's prescription.

Heparin is infused into the heparin line on the arterial blood tubing before the dialyzer. Most heparin lines are placed after the blood pump segment. This helps avoid negative pressure at the part of the blood circuit that could otherwise draw air into the extracorporeal circuit through the heparin line. [12]

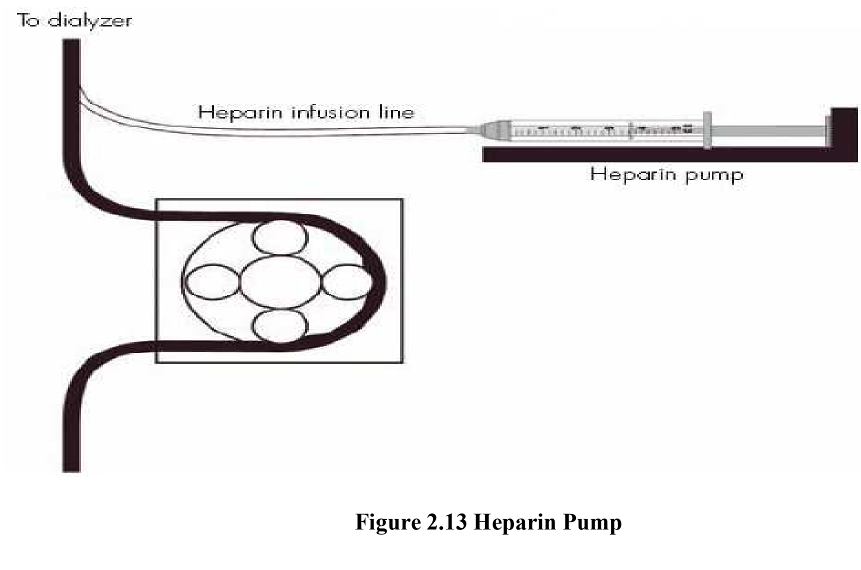

Figure 2.13 Heparin Pump

2.5 Whole Hemodialysis machine diagram

Single-Patient Dialysate Delivery System

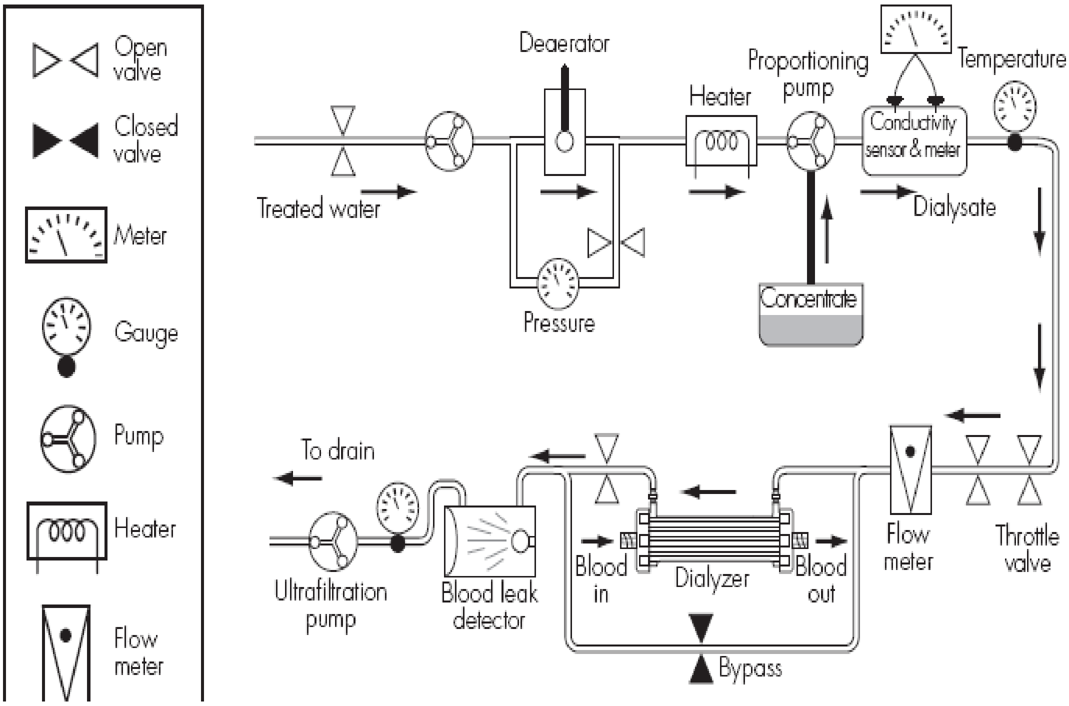

Figure 2.14 Single-patient dialysate delivery system

3

Theoretical Background

Before we start in project design, we must have strong theoretical background about the project and its components, so this chapter will discuss these topics:

Chapter Three

Theoretical Background

3.1 Stepper Motor

3.1.1 Introduction

A stepper motor may be thought of as polyphase synchronous motor, having salient stator poles, the name stepper derives from the most common application for these machines, that is, rotating a fixed angular step in response to each input pulse received by their controller, when this type of motor is supplied from an electronic drive, accurate position control and precise rotational speeds are the natural consequences.

In stepping motors rotation is produced by sequentially switching suitably connected windings to produce discrete angular steps of essentially uniform magnitude.

Stepper motor is an electromagnetic actuator. It is an incremental drive (digital) actuator and is driven in fixed angular steps.

This means that a digital signal is used to drive the motor and every time it receives a digital pulse it rotates a specific number of degrees in rotation. Figure 3.1 describe the basic construction of stepper motor. [9]

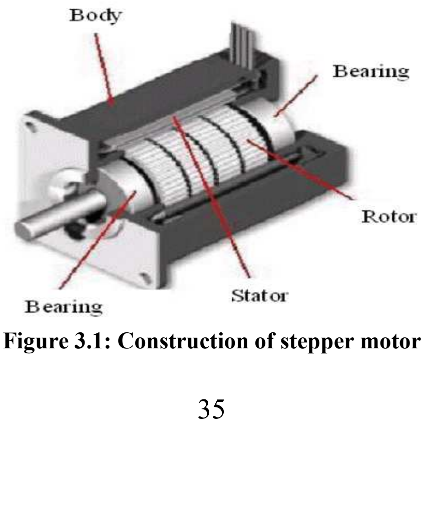

Figure 3.1: Construction of stepper motor

3.1.2 Stepper Motor Advantages

1. Position error is noncumulative. A high accuracy of motion is possible, even under open-loop control.
2. Because of the incremental nature of command and motion, stepper motors are easily adaptable to digital control applications.
3. Torque capacity and power requirements can be optimized and the response can be controlled by electronic switching.
4. Large saving in sensor (measurement system) and controller costs are possible when the open-loop mode is used.
5. Angle of rotation of motor is directly proportional to the number of input pulses.
6. The angle of the error per step is very small and does not accumulate.
7. Stepping motor is also capable of rapid responses (starting, stopping, reversing).
8. Stepper motor needed little maintenance.

3.1.3 Stepper Motor Disadvantages

1. They have low torque capacity (typically less than 14 Nm) compared to DC motors.
2. They have limited speed (limited by torque capacity and by pulse-missing problems due to faulty switching systems and drive circuits).
3. They have high vibration levels due to stepwise motion.
4. Large errors and oscillations can result when a pulse is missed under open-loop control.
5. They consume current regardless of load conditions and therefore tend to run hot.
6. Losses at speed are relatively high and can cause excessive heating, and they are frequently noisy (especially at high speeds).

3.1.4 Stepper Motor Types

There are basically three types of stepping motors; variable reluctance, permanent magnet and hybrid.

3.1.4.1 Variable Reluctance Stepper Motors

Variable Reluctance Motors (also called variableswitched reluctance motors) have three to five windings connected to a common terminal. The variable reluctance motor does not use a permanent magnet, rotor inertia of this motor is low, the response is very quick, when the winding not energized the static torque is zero and this type of construction is good in non industrial applications that do not require a high degree of motor torque.

3.1.4.2 Permanent Magnet Stepper Motor

The permanent magnet motor (permanent magnet rotor) is a relatively low speed, low torque device with large step angles of either 45or 90 degrees, nonzero holding torque when the motor not energized, it possible to obtain step angles 7.5, 11.25,15,18,45 and 90 It’s simple construction and low cost make it an ideal choice for non industrial applications, such as a line printer print wheel positioned. Unlike the other stepping motors, the PM motor rotor has no teeth and is designed to be magnetized at a right angle to its axis.

3.1.4.3 Hybrid Motors.

Hybrid motors share the operating principles of both permanent magnet and variable reluctance stepping motors. The stator and rotor for a hybrid stepping motor are multi-toothed, like the variable reluctance motor, and contains an axially magnetized concentric magnet around its shaft (see Figure 3.2). The teeth on the rotor provide a path which helps guide the magnetic flux to preferred locations in the air gap. The magnetic concentric magnet increases the detent, holding and dynamic torque characteristics of the motor when compared with both the variable reluctance and permanent magnet type Standard hybrid motors have 200 rotor teeth and rotate at 1.80 step angles.

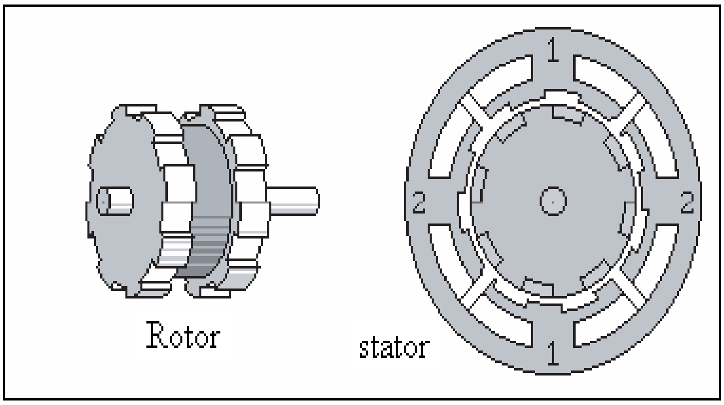

Figure 3.2:Hybrid Stepper Motor.

3.1.5 Stepper Motor Applications

The characteristics of stepper motors make them ideally suited to many applications requiring incremental motion , especially where digital control is used , a few common ones are printer head and paper feed drives in computer printers , disc drives , digital plotter, medical equipments that dispenses precise dosages , computer controlled tools , Process control valves, and design machine for printed circuit board.

3.1.6 Motor Windings.

3.1.6.1 Unifilar.

Unifilar has only one winding per stator pole. Stepper motors with a unifilar winding will have 4 lead wires. The (figure 3.3a) illustrates a typical unifilar motor.

3.1.6.2 Bifilar

Bifilar wound motors means that there are two identical sets of windings on each stator pole. This type of winding configuration simplifies operation in that transferring current from one coil to another one, wound in the opposite direction, will reverse the rotation of the motor shaft. Whereas, in a unifilar application, to change direction requires reversing the current in the same winding. The most common wiring configuration for bifilar wound stepping motors is 8 leads because they offer the flexibility of either a Series or parallel connection. There are however, many 6 lead stepping motors available for Series connection applications. The (figure 3.3b and c) illustrates atypical 6 lead and 8 lead bifilar stepper motor.

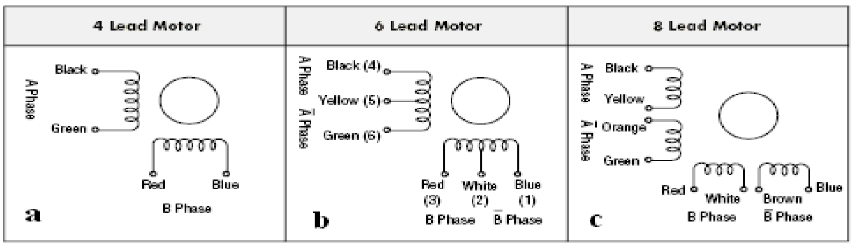

Figure 3.3: a) unifilar -4 lead. b) Bifilar -6 lead. c) Bifilar -8 lead)

3.1.6.3 Unipolar and Bipolar Motors

3.1.6.3.1 Unipolar Motor

Unipolar stepping motors are composed of two windings, each with a center tap. The center taps are either brought outside the motor as two separate wires (as shown in Figure 3.4) or connected to each other internally and brought outside the motor as one wire. As a result, unipolar motors have 5 or 6 wires. Regardless of the number of wires, unipolar motors are driven in the same way. The center tap wire(s) is tied to a power supply and the ends of the coils are alternately grounded.

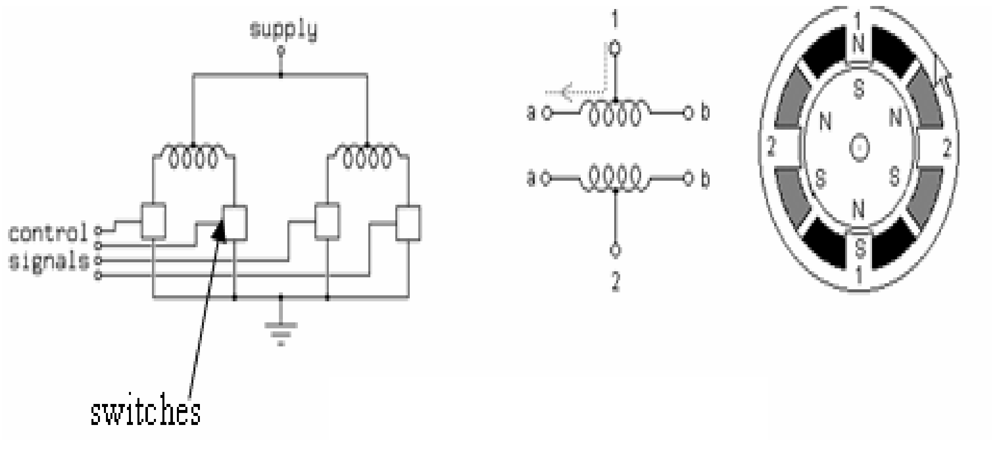

Figure 3.4: Unipolar Stepper Motor

3.1.6.3.2 Bipolar Motors.

Bipolar stepping motors are composed of two windings and have four wires. Unlike unipolar motors, bipolar motors have no center taps. The advantage to not having center taps is that current runs through an entire winding at a time instead of just half of the winding. As a result, bipolar motors produce more torque than unipolar motors of the same size. The draw back of bipolar motors, compared to unipolar motors, is that more complex control circuitry is required by bipolar motors.

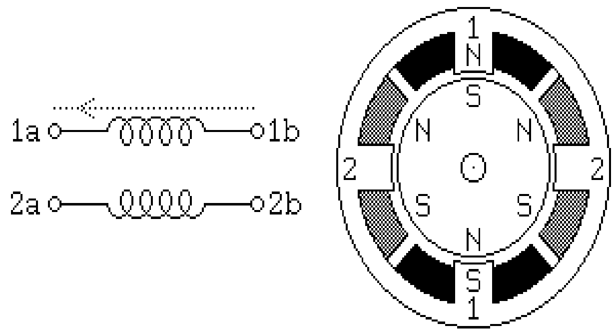

Figure 3.5: Bipolar stepping motors

3.2 Inductive Proximity Sensor

3.2.1 Sensors Types

1 Inductive.
2 Capacitive.
3 Capacitive displacement sensor.
4 Eddy-current.
5 Magnetic, including .
6 Magnetic proximity fuse.
7 Photocell (reflective).
8 Laser rangefinder.
9 Sonar (typically active or passive).
10 Radar.
11 Doppler effect (effect not a sensor).
12 Passive thermal infrared.

13 Passive optical (such as charge-coupled devices).
14 Reflection of ionising radiation.

In our project we will use Inductive proximity sensors

3.2.2 Inductive proximity Sensors Definition

A proximity sensor is a sensor able to detect the presence of nearby objects without any physical contact. A proximity sensor often emits an electromagnetic or electrostatic field, or a beam of electromagnetic radiation (infrared, for instance), and looks for changes in the field or return signal. The object being sensed is often referred to

as the proximity sensor's target. Different proximity sensor targets demand different sensors. For example, a capacitive or photoelectric sensor might be suitable for a plastic target; an inductive proximity sensor requires a metal target.

The maximum distance that this sensor can detect is defined "nominal range". Some sensors have adjustments of the nominal range or means to report a graduated detection distance.

Proximity sensors can have a high reliability and long functional life because of the absence of mechanical parts and lack of physical contact between sensor and the sensed object.

Proximity sensors are also used in machine vibration monitoring to measure the variation in distance between a shaft and its support bearing. This is common in large steam turbines, compressors, and motors that use sleeve-type bearings.

A proximity sensor is divided in two halves and if the two halves move away from each other, then a signal is activated. A proximity sensor can be used in windows, and when the window opens an alarm is activated.[6]

3.2.3 Elements of a Simple Inductive Sensor

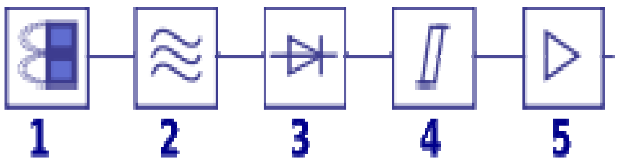

Figure 3.6:Simple Inductive Sensor

1. Field sensor
2.Oscillator
3. Demodulator
4. Flip-flop
5. Output

Figure 3.7 Inductive Proximity Sensor

3.3 Power Supply

A power supply is a system that supplies electrical energy to all project parts.It converts one form of electrical current and voltage to another desired form. This typically involves converting 220 volt AC to a well-regulated lower DC voltage for electronic devices. It is also used to convert 220 volt AC to lower desired AC voltage (for example 12 volts AC).

Power supply unit contains the following:

- Transformer: To transform high AC voltage to lower AC voltage.
- Rectifier: To convert the AC voltage to non-regulated DC voltage.
- Filter: To reduce the variations of output voltage of rectifier.
- Regulator: To produce well-regulated DC voltage.

3.4 PIC Microcontroller

A microcontroller is a computer control system on a single chip. It has many electronic circuits built into it, which can decode written instructions and convert them to electrical signals.

They have a high concentration of on-chip facilities such as serial port, parallel input/output ports, timers, counters, interrupt control, analog-to-digital converters, random access memory, read only memory, etc. these on-chip peripherals of a microcontroller make it powerful digital processors, the degree of control and programmability they provide significantly enhances the effectiveness of the application.

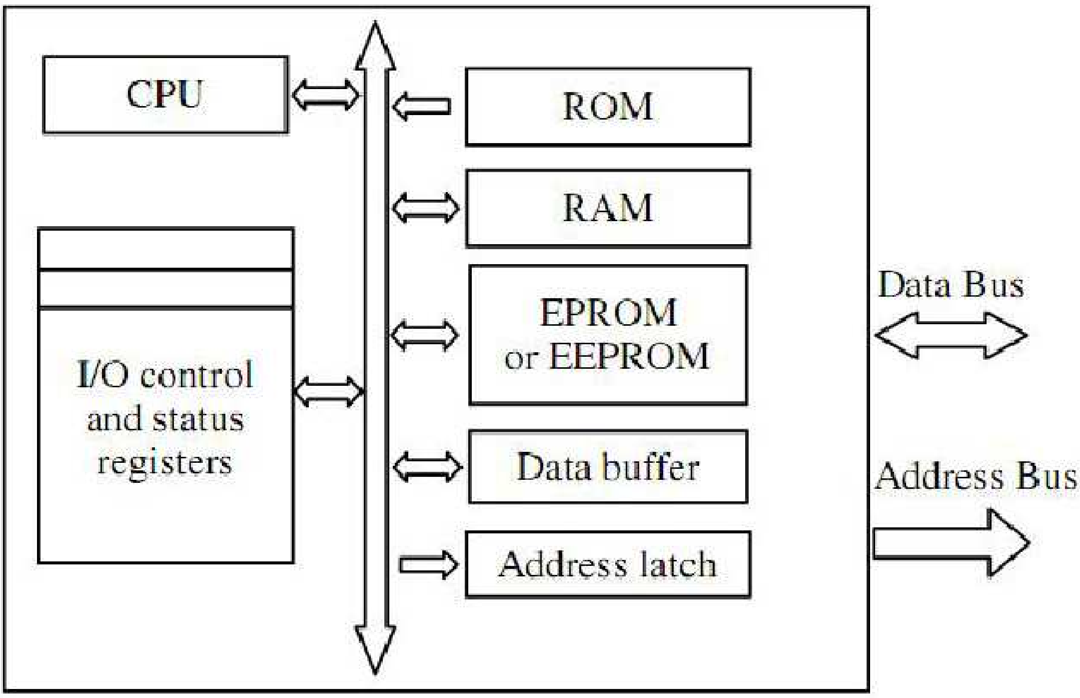

Figure3.8: Microcontroller General Block Diagram

3.4.1 PIC18F452 Features:

- 32kBytes Program Flash Memory.
- 1536 Bytes RAM Memory.
- 256 Bytes EEPROM Memory.
- 8 channels 10-bit analog to digital converter.
- One 16-bit Timer and Four 8-bit Timers.
- 40MHz max operating frequency.
- 5 input/output ports (RA0-5, RB0-7, RC0-7, RD0-7, and RE0-2).
- 40 pin chip.

3.4.2 PIC18F452 Pins

Table 3.1 : Pins Description

Pin	Description	Pin	Description
RA0-5	Input/Output port A.	Vpp	High voltage ICSP programming enable pin.
RB0-7	Input/Output port B.	THV	High voltage test mode control.
RC0-7	Input/Output port C.	VREF+/-	A/D Reference Voltage
RD0-7	Input/Output port D.	SS	SPI Slave Select input.
RE0-2	Input/Output port E.	T0CKI	Clock input to Timer0.
AN0-7	Analog input port.	T1OSO	Timer1 oscillator output.
TX	USART Asynchronous Transmit.	T1OSI	Timer1 oscillator input.
SCK	Synchronous serial clock input.	T1CKI	Timer1/Timer3 external clock input.
SCL	Synchronous serial clock input/output for I2C mode.	PGD	programming data pin. .
DT	Synchronous Data.	PGC	programming clock pin
CK	Synchronous Clock.	PGM	Low Voltage ICSP programming enable pin.
SDO	SPI Data Out (SPI mode).	INT	External interrupt.
SDI	SPI Data In (SPI mode).	RD	Read control for the parallel slave port.
SDA	Data I/O (I2C mode).	WR	Write control for the parallel slave port.
CCP1,2	Capture In/Compare Out/PWM Out.	CS	Select control for the parallel slave.
OSC1/ CLKIN	Oscillator In/External Clock In.	PSP0-7	Parallel slave port Data. .
OSC2/ CLKO UT	Oscillator Out/Clock Out.	VDD	Positive supply for logic and I/O pins.
MCLR	Master Clear input. (Active low Reset).	VSS	Ground reference for logic and I/O pins.

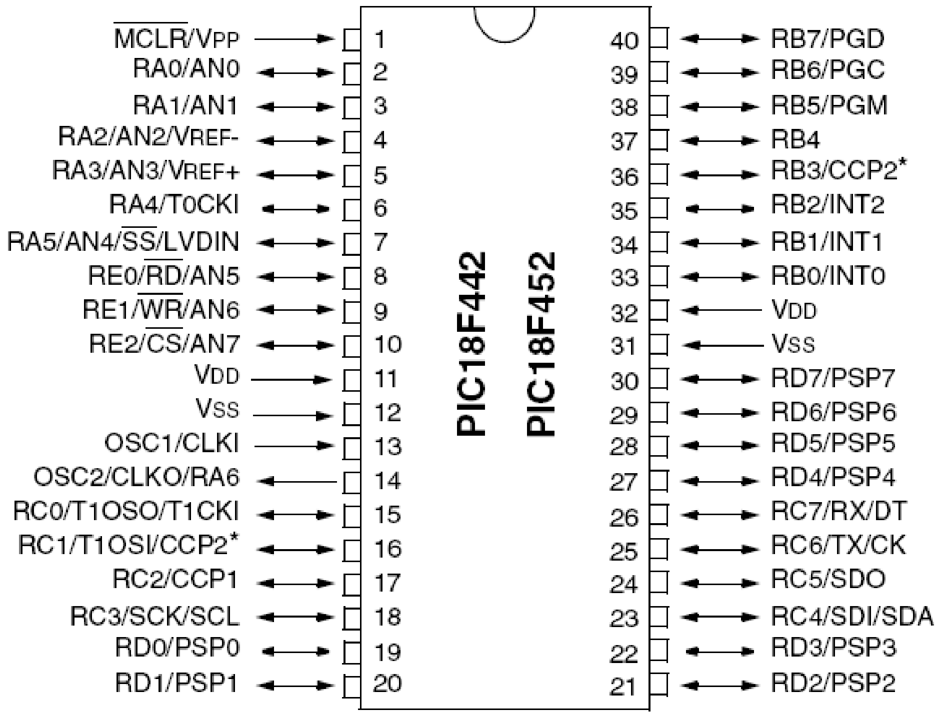

Figure 3.9: Pins of PIC 18F452 Microcontroller

3.5 Gear

A gear is a rotating machine part having cut *teeth*, or *cogs*, which *mesh* with another toothed part in order to transmit torque. Two or more gears working in tandem are calleda transmission and can produce a mechanical advantage through a gear ratio and thus may be considered a simple machine. Geared devices can change the speed, magnitude, and direction of a power source. The most common situation is for a gear to mesh with another gear, however a gear can also mesh a non-rotating toothed part, called a rack, thereby producing translation instead of rotation.[1]

3.5.1 Gears that We will use in our project:

1. Spur gears or straight-cut gears

Spur gears or straight-cut gears are the simplest type of gear. They consist of a cylinder or disk with the teeth projecting radially, and although they are not straight-sided in form, the edge of each tooth is straight and aligned parallel to the axis of rotation. These gears can be meshed together correctly only if they are fitted to parallel axle.[11]

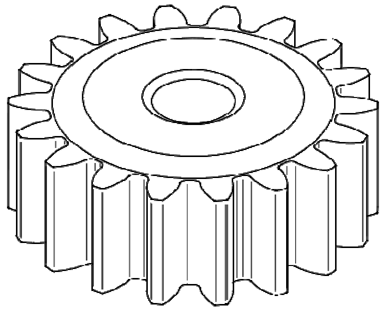

Figure 3.10: spur gear

2- Rack gear

Rack gear is a toothed bar or rod that can be thought of as a sector gear with an infinitely large radius of curvature. Torque can be converted to linear force by meshing a rack with a pinion: the pinion turns; the rack moves in a straight line. Such a mechanism is used in automobiles to convert the rotation of the steering wheel into the left-to-right motion of the tie rod(s).

Racks also feature in the theory of gear geometry, where, for instance, the tooth shape of an interchangeable set of gears may be specified for the rack (infinite radius), and the tooth shapes for gears of particular actual radii then derived from that. The rack and pinion gear type is employed in a rack railway.

Figure 3.11: Rack gear

3.5.2 Formula for Spur Gears Calculation

Table 3.2: Spur Gears Calculation Formula.

Calculate	When Defined	Formula
Diametral Pitch (P)	Pitch Diameter (D) and the Number of Teeth (N)	P = N / PD
Diametral Pitch (P)	Circular Pitch (p)	P = 3.1416/p
Diametral Pitch (P)	Outside Diameter (OD) and the Number of Teeth (N)	P = (N+2)/OD
Pitch Diameter (PD) .	Number of teeth (N) and the Diametral Pitch (P)	PD = N/DP
Outside Diameter (OD)	Number of teeth (N) and the Diametral Pitch (P)	OD = (N+2)/DP
Number of Teeth (N).	Pitch Diameter (D) and the Diametral Pitch (P)	N = PD * DP
Addendum (a) .	Diametral Pitch (P)	a = 1/DP
Dedendum (d)	Whole Depth and Addendum	d = hw - a
Tooth Thickness (t) at the Pitch Diameter	Diametral Pitch (P)	t = 1.5708/P
Working Depth (WD).	Addendum	WD = 2(a)
Center Distance (C)	Normal Diametral Pitch (P) and the Number of Teeth in Both Gears	C = (N1+N2)/2P
Center Distance (C)	Pitch Diameters of both gears	C = (PD1+PD2)/2

Circular Pitch (p)	Diametral Pitch (P)	p = 3.1416 / P
Whole Depth (hw) for 20 Pitch &finer .	Diametral Pitch (P)	hw = 2.2/P + .002
Whole Depth (hw) for Coarser than 20 Pitch .	Diametral Pitch (P)	hw = 2.157/P

3.5.3 Gear Defined Diagram

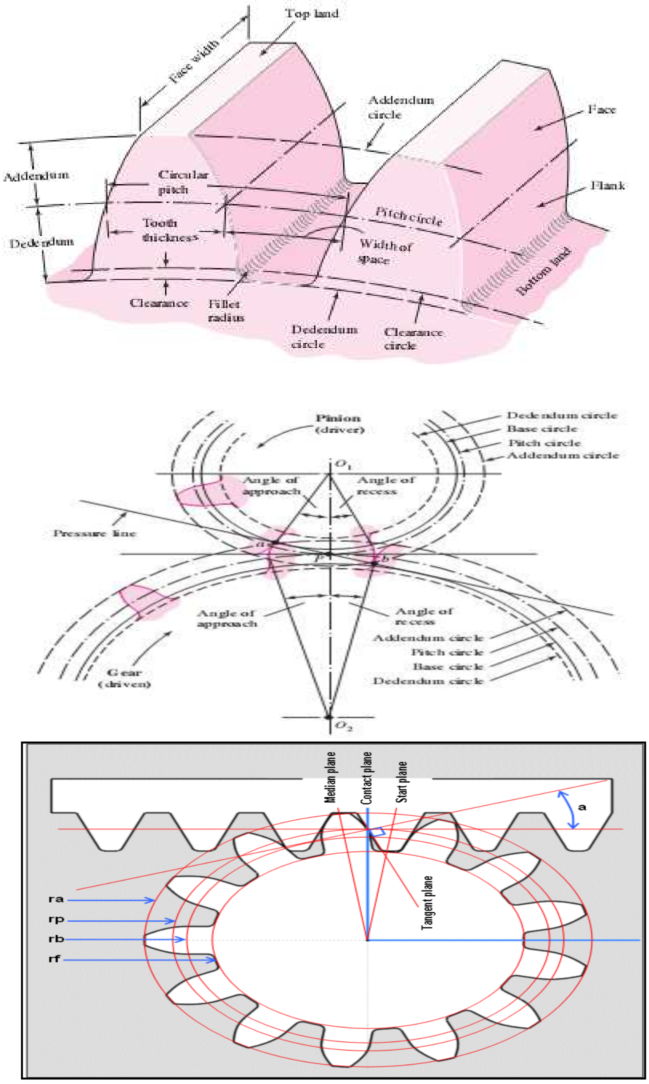

Figure 3.12: Gears Diagram

3.5.4 Calculation Sheet for the Spur Gear

Table 3.3: Calculation Sheet for the Spur Gear

Diametral pitch.	P	16
Number of teeth	N	20
Pressure angle.	Θ	14.5

ITEM	SAMBOL	Spur gear
Addendum.	A	0.0625
Dedendum.	B	0.078125
Pitch diameter.	D	1.25
Outside diameter.	Do	1.375
Chordal addendum.	Ac	0.06442767
Chordal thickness.	Tc	0.27246988
Whole depth.	Ht	0.1348125
Clearance.	c	0.015625
Diametral pitch.	P	16
Pressure angle.	14.5/20/25	14.5
Number of teeth	N	20
Tooth thickness	t	0.098175

Note: all dimension in inch

3.6 Bearing

The terms rolling-contact bearing, antifriction bearing, and rolling bearing are all used to describe that class of bearing in which the main load is transferred through elements in rolling contact rather than in sliding contact. In a rolling bearing the starting friction is about twice the running friction, but still it is negligible in comparison with the starting friction of a sleeve bearing. Load, speed, and the operating viscosity of the lubricant do affect the frictional characteristics of a rolling bearing. It is probably a mistake to describe rolling bearing as “antifriction,” but the term is used generally throughout the industry. [2]

In our design we will use two rolling bearing.

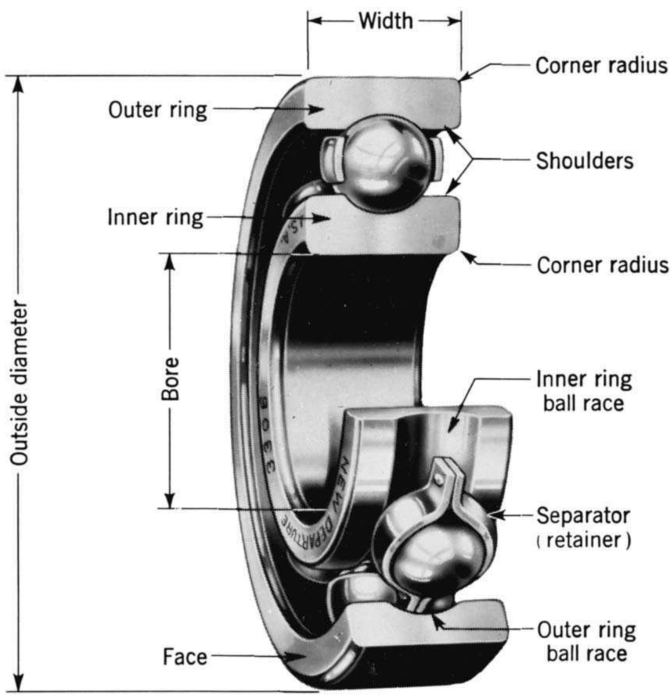

Figure 3.13: Bearing Diagram

4

Project Conceptual Design

After completing the theoretical background about the project and its components, we will explain conceptual design of the project, this include the following points:

4.1 Detailed Project Objectives

4.2 Design Options

4.3 Block diagram

4.4 Description of Block Diagram Components

Chapter four
Project Conceptual Design

4.1 Detailed Project Objectives:

In this project we want to achieve many objectives, these objectives are listed as following:

1. Facilitate the heparin injection into the blood without harming the patient.
2. Use the PIC microcontroller, to control whole processes in the system including , and use special sensors.
3. Use this design in medical field especially in hemodialysis machine.

4.2 Design Options

Now we will show the options of project design including control unit options and Programming Language Options

4.2.1 Control Unit Options

We can control the processes of this project using:

- Microprocessor.
- PIC microcontroller.

In our project we used PIC Microcontroller; because it has all necessary parts (CPU, ROM, RAM, and timers) integrated inside one IC, while Microprocessor needs other ICs around it (like ROM, RAM and timers) to work and a lot of wire connection.

4.2.2 Programming Language Options

To program the microcontroller we can use:

- Assembly language
- C language.

PIC microcontroller can be programmed using C-language or assembly. We programmed the PIC microcontroller using C-language because it is easier.

4.3 Block diagram:

Here an overview of the project as a block diagram, the block diagram shows briefly the project parts of the system.

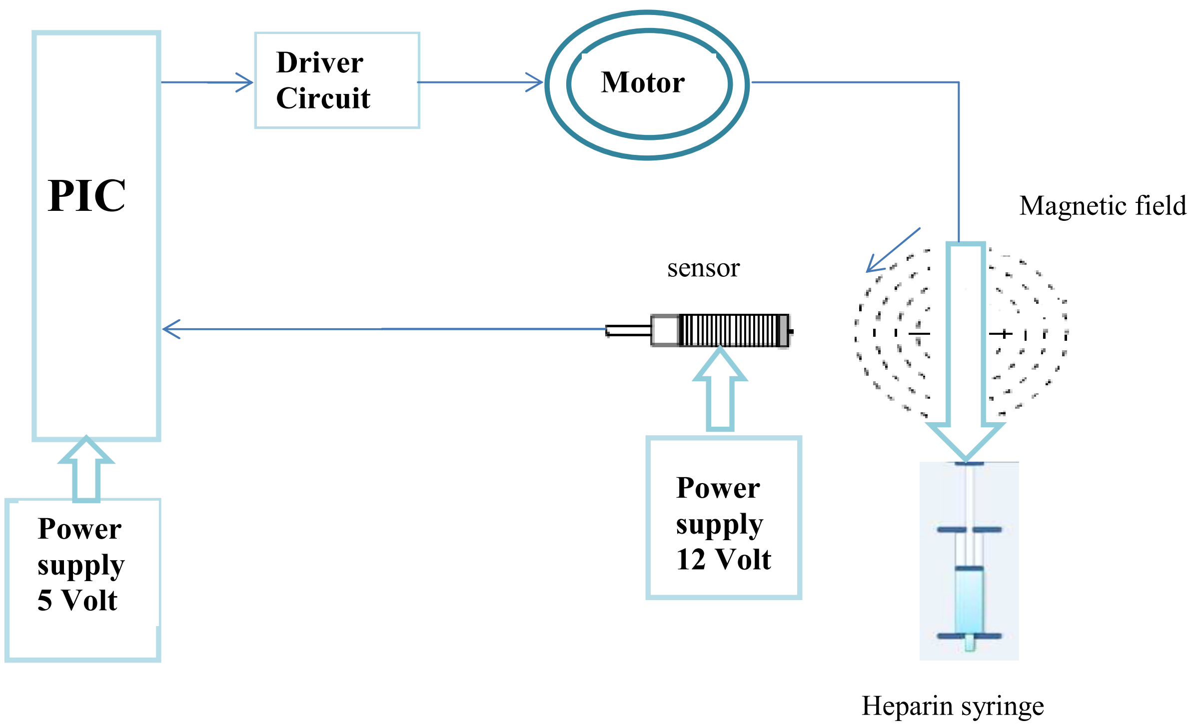

Figure 4.1: Project Block Diagram

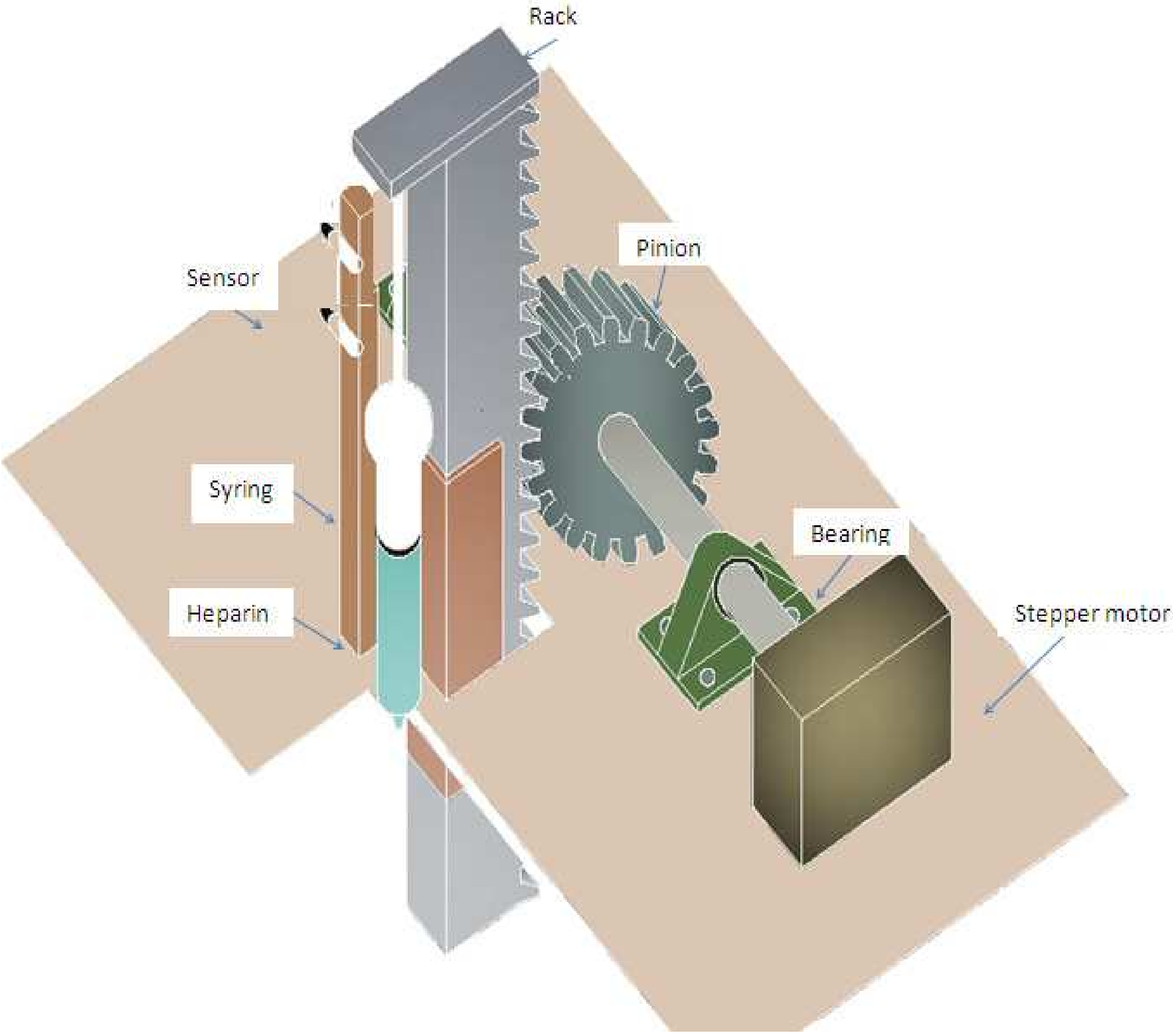

Figure 4.2: Mechanical Parts of the Project

4.4 Descriptions of Block Diagram Components

The block diagram of our project consists of major parts, which work together to achieve facilitate the heparin injection into the blood and these parts are:

1. **Power supply:**

- 220 v / 50 Hz.
- Supplies DC voltage to feed the electrical circuits IC's and motor.

2. **Pic microcontroller:**

- Controls the whole parameters of heparin pump.
- It is 18F452 PIC microcontroller.

3. **Stepper motor:**

- Controls the injection from the syringe.
- Rotates the pinion of rack and pinion mechanism.
- Pinion moves the rack and the plunger foot moves the heparin syringe plunger to the same distance.

4. **Heparin syringe:**

- Capacity syringe is 60 ml.
- Infuse the heparin into extracorporeal line.

5. **Sensor:**

- Detect the distance that the metal piece shifted.

5

Detailed Technical Project Design

After completing the project theory and block diagram, we want to explain the design of this project in specific way, so these topics will be discussed in this chapter:

5.1 Power Supply

5.2 Inductive Proximity Sensors Circuit

5.3 Stepper Motor

5.4 Force Calculation

5.4.1 Bernoulli's equation

5.4.2 Motion Direction

5.5 Gear Speed

Chapter five
Detailed Technical Project Design

Now we will express the specification and schematics of subsystems of the project:

5.1 Power Supply

A power supply is a mean of providing electrical power to the project parts; it consists of many stages, as shown in figure (5.1).

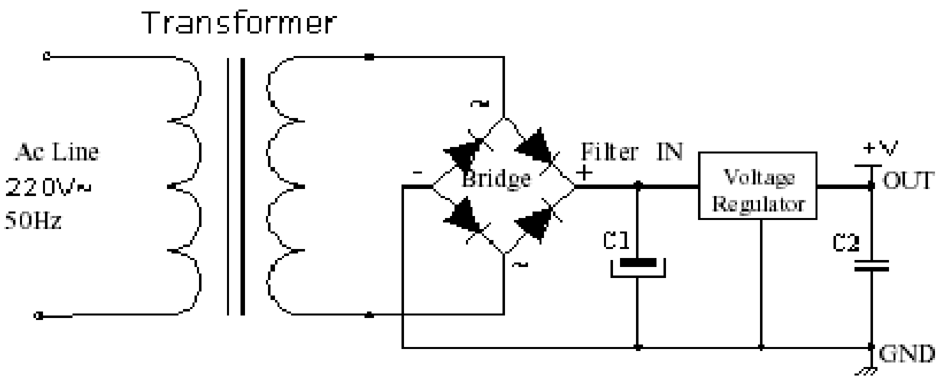

Figure 5.1 : Power Supply Circuit

From the previous figure, power supply contains four stages to convert 220V AC 50Hz to lower DC voltage, these stages as follows:

1. A transformer is the starting point, step down main AC voltage to a lower required AC voltage.

The output voltage at the secondary coil of the transformer depends on the turn's ratio, which is given using this formula: $n = N_S / N_P = V_S / V_P$ ....*(5.1)*

2. Full wave rectifier changes an alternating current to non-regulated direct current.

The peak input voltage to the rectifier is *V(peak)=* V *S (RMS)** $\sqrt{2}$ *....(5.2)*

The output of the rectifier is: V out= *V(peak)-1.4 ……(5.3)*

1. The filter (C1) will smooth the voltage signal more and more. As mentioned the filter will smooth the voltage, but there is a ripple. The value of the capacitor and the resistor determine the limits of the ripple.

$$Vdc = \left(1 - \frac{1}{2fR1C1}\right)V(out). \quad \text{.......... (5.4)}$$

$$Vr(p-p) = \left(\frac{1}{FR1C1}\right)V(out). \quad \text{………. (5.5)}$$

$$RippleFactor = \frac{Vr(p-p)}{Vdc}. \quad \text{………. (5.6)}$$

2. Regulator gives well-regulated DC voltage positive or negative according to the regulator number. Such as 7812 and 7912 for 12V and -12V respectively.

The project needs 12, 5 DC voltages. Maximum DC voltage needed is 12V so the input of regulator must be greater than 12V. 220V ac to 12Vac transformer must be used.

(Vp / Vs)= 9.1 ⟶ Turn ratio between primary and secondary is about 9:1.

*Vs (p-p)= 12 ** $\sqrt{2}$*= 16.97V*

Vout (rectifier)= 16.97-1.4 =15.57V

$$Vdc = \left(1 - \frac{1}{2fRIC}\right)Voutrect$$

$$Vr(p-p) = \left(\frac{1}{FRIC}\right)Voutrect$$

$$RippleFactor = 1\% = \frac{Vr(p-p)}{Vdc}$$

$$\left(\frac{1}{FRIC}\right)Voutrect = 0.01\left(1 - \frac{1}{2fRIC}\right)Voutrect \quad \text{……….. (5.7)}$$

If we use 500µF by assumption, F is frequency equal 100Hz since full wave rectification, RL from calculation will be 1005..

Vdc = 15.66V.

Vripple = 0.15

Vin regulator [15.98, 16.31]

Rectifier should be not less than 17V.

Capacitor value is 500µF, 17V.

5.2 Inductive Proximity Sensors

The Inductive proximity sensor feedback the distance to PIC microcontroller, the supply voltage for inductive sensor up to 12 V.[10]

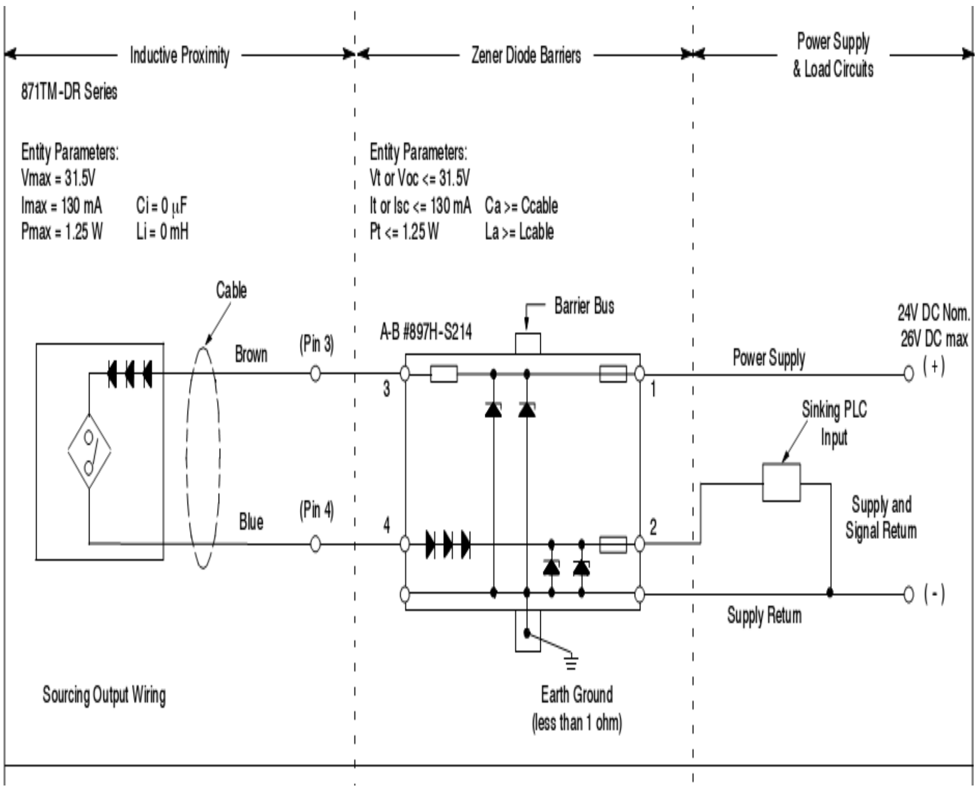

Figure 5.2: inductive proximity sensor diagram.

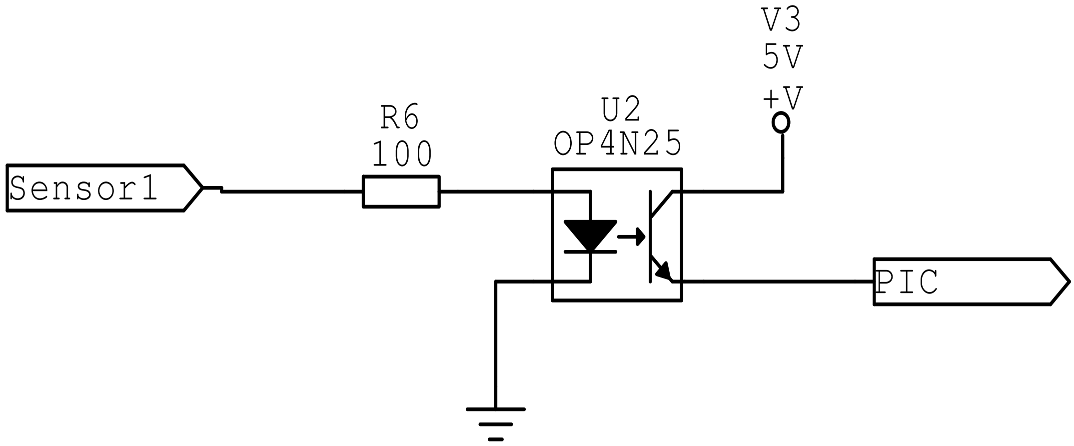

Figure 5.3: inductive proximity sensor circuit

5.3 Stepper Motor [14]

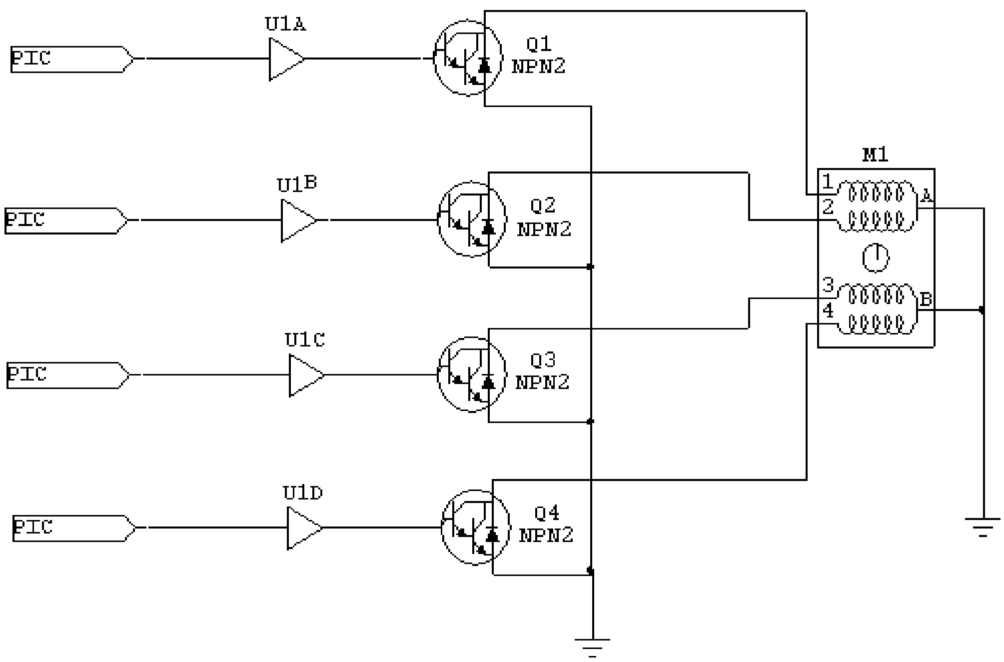

Figure 5.4: Stepper Motor Circuit

5.4 Force Calculation that Will be Using to Move the Heparin Syringe

D: big diameter for the syringe (30mm)

d: small diameter for the syringe (output) (5mm)

5.4.1 Bernoulli's equation:

By apply Bernoulli's equation for the uncompressible fluid:

$$P_1 + \frac{1}{2}\rho V_1^2 + \rho g h_1 = P_2 + \frac{1}{2}\rho V_2^2 + \rho g h_2 \text{……… } (5.8)$$

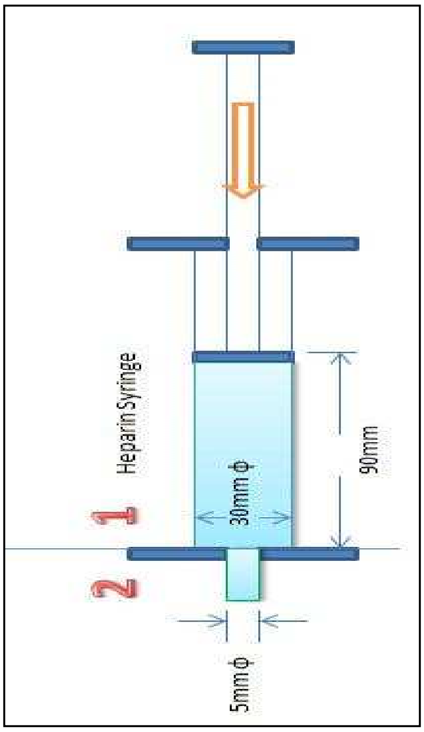

Figure 5.5: heparin syringe

Where:

P_1: Pressure inside the heparin syringe (Pa)

P_2 : outlet heparin Pressure (2000 Pa)

ρ: heparin density (we will use water $1000 kg/m^3$)

V_1: heparin flow velocity inside the heparin syringe (m/s)

V_2: outlet heparin flow velocity (m/s)

ρ gh= 0.0 because it is very small height.[3]

$$V = \frac{flow\ (\frac{m3}{h})}{Area\ (m2)} \text{…….. } (5.9)$$

Our flow is 60ml/4min = 15ml/min (ρ: heparin density)

(We will use water100kg/m³)

Outlet heparin flow = 0.0009m^3/h =0.00000025 m^3/s

$$A=\pi \frac{D2}{4} \quad \text{……… (5.10)}$$

A_1:Area inside the heparin syringe .

A_1= 0.000765 m^2

A_2:Area of outlet heparin syringe orifice .

A_2= 0.00001965 m^2

$$V1=\frac{heparin\ flow}{A1} \qquad = \mathbf{0.00026798\ m/s}$$

$$V2=\frac{heparin\ flow}{A2} \qquad = \mathbf{0.012732\ m/s}$$

Apply Bernoulli's equation

$$P_1+\frac{1}{2}\rho\,(V_1)^2 = P_2+\frac{1}{2}\rho(V_2)^2$$

ρ=100kg/m^3

V_1= 0.00026798 m/s

V_2= 0.012732 m/s

P_2= 20000 Pa

By Apply Bernoulli's equation

P_1 =20000.08102 Pa

P=$\frac{Force\ (N)}{Area\ (m2)}$……… *(5.11)*

F_h =15.3 N [4]

5.4.2 Motion Direction

There are two directions for the motion

1- During heparin injection (the load in this case are minimum because the direction of the frame body are same of gear direction)

2- During lifting the frame body and this is the maximum load can effect to the gear.

We will calculate the required power that will use to inject the heparin and to lift the frame body.

During heparin injection

Horizontal force

$\sum Fx = 0.0$, $Fs - Fgx = 0.0$, $Fs = Fgx$

$Fgx = Fg\ COS\ \theta$ ………*(5.12)*

Vertical Force

$\sum Fy = ma = zero$

There are motion but it is constant velocity that mean a=0

. $Fh-W1-Fgy-W2=0.0$ ……… *(5.13)*

Fgy= Fg SIN θ ………. *(5.14)*

Where:

m:mass

a: acceleration

Fh : back force from heparin

W1: force from Wight of beam 1

Fs: force from rack gear support

Fg: gear force.

W2: force frame Wight of beam 2

θ : pressure angel (angel for gear effect) (14.5^{o} from gear design)

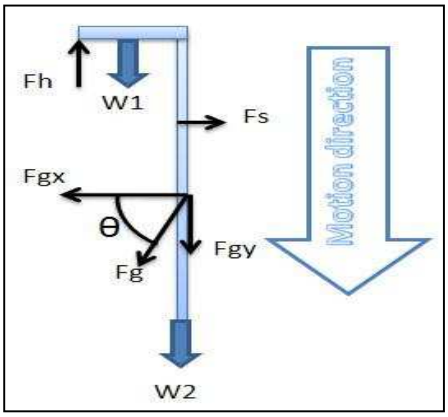

Figure5.6: Direction of force on gear(1)

During lifting the frame body

Horizontal force

∑Fx =0.0 , Fs –Fgx =0.0 , Fs =Fgx

Fgx= Fg COS θ ………. *(5.15)*

Vertical Force

$\sum Fy = ma = zero$

There are motion but it is constant velocity that mean a=0.0

Fgy - W1 -W2=0.0 ………. *(5.16)*

Fgy= Fg SIN θ ………. *(5.17)*

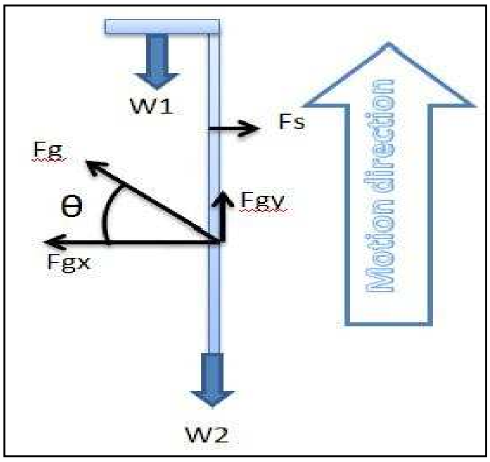

Figure5.7: Direction of force on gear(2)

We need to fined W1 and W2 which is show the effect of the weight of the parts.

We chose Stainless steel 316 L rack gear and push arm rack gear dimension 127X20X20 mm push arm dimension 78X7X20 mm stainless steel density =7.715 g/cm³

W1 = mg

Mass (m)= Stainless steel density X volume……….*(5.18)*

= 7.715 g/cm³ X 78 X 7 X 20mm

=0.084 kg

W1= 0.084 kg X 9.81

W1=0.827 N

$W2 = mg$

Mass (m)= Stainless steel density X volume

= 7.715 g/cm³ X 127 X 20 X 20mm

=0.392 kg

W2= 0.392 kg X 9.81

W2=3.85 N

During heparin injection

By apply W1 and W2 in Eq. *(5.13)*

Fh-W1-Fgy-W2=0.0

Fgy = 15.3 – 0.827 – 3.85

Fgy= 10.623 N

By apply Fgy in Eq. *(5.14)*

Fgy= Fg SIN θ

$$Fg = \frac{10.623}{\sin 14.5}$$

Fg = 42.43 N Gear force.

By apply Fgy in Eq. *(5.12)*

Fgx= Fg COS θ

Fgx = 42.43 COS 14.5

Fgx = 41.08 N

During lifting the frame body

By apply W1 and W2 in Eq.*(5.16)*

Fgy - W1 -W2=0.0

Fgy = 4.667 N

Fgy= Fg SIN θ   Eq.*(5.17)*

Fg = $\frac{4.667}{\sin 14.5}$

Fg = 18.64N

Calculation result

Table below shows the calculation result for the two Direction of motion and summarize the required stepper motor power.

Table 5.1: Calculations results

Direction of motion	**Gear force Fg (N)**	**Work W=Force x moving Distance (J)**	**POWER P=W/TIME (W)**
During heparin injection	42.43	3.18	0.01325
During lifting the frame body	18.64	1.68	0.007

When we compare the value of power for Two direction of the moving we found the necessary power in the during heparin injection so the stepper motor power should be at least 1watt.

Note: Moving Distance = 9cm (the distance watch the rack gear and the syringe punch will move it)

Time = 4min = 240sec

5.5 Gear Speed

To calculate the speed for the rack.

$\mathbf{V}_{rack} = \frac{Moving\ Distance}{TIME\ of\ moving}$……… *(5.19)*

Moving distance = 9cm

Time of moving = 4 min

$\mathbf{V}_{rack}$ = 0.0225 m/min

$\mathbf{d}_{pinion}$ =25.4 mm

So. ω pinion= 1.8 rpm

6

Software

To control the previous described project we must used a programmed PIC microcontroller, so this chapter will express the following:

6.1 Flow Charts

6.1.1 Program Flowchart

6.2 Software needed for the project

Chapter Six
Software

6.1 Flow Charts

A flow chart illustrates the steps of the process by visualizing the processes.

6.1.1 Program Flow Chart

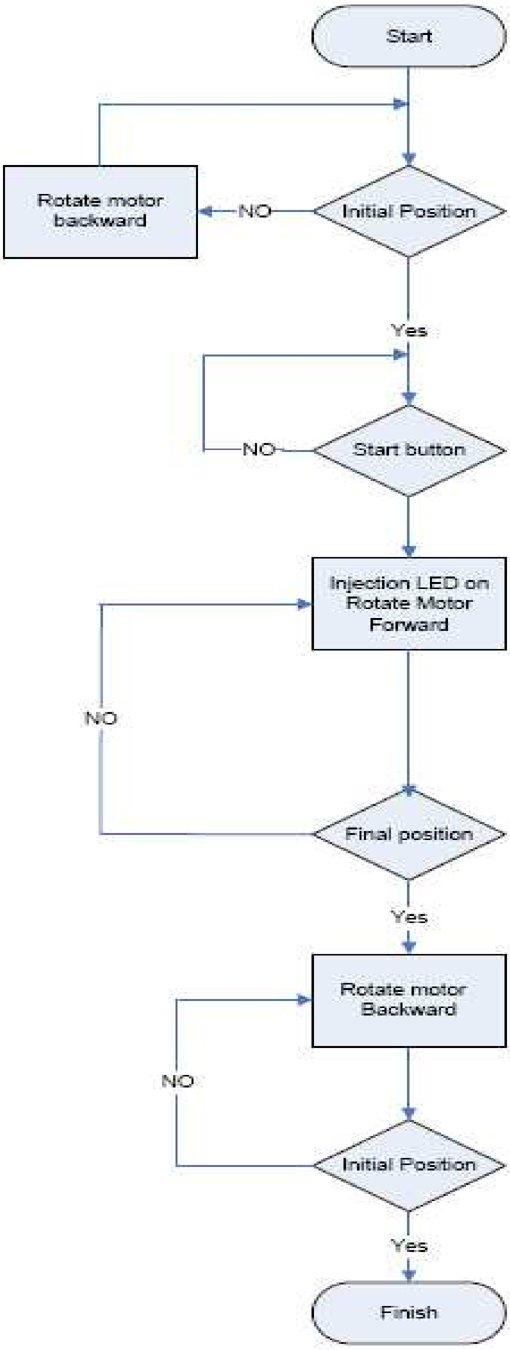

Figure 6.1: Program Flowchart

6.2 Software Needed for the Project

In our project described earlier we will use C-language to program the PIC microcontroller so that it controls the whole system of Heparin pump.

This is the program code

```
#include<p18f452.h>
#include<delays.h>

#pragma config WDT = OFF
#pragma config LVP = OFF
#pragma config OSC = HS

/******************declarations****************

Input:
Position sensor(initial position) : RB0.
Position sensor(final position) : RB1.
Start button: RB2.

Outputs:
Motor coil 1: RC0.
Motor coil 2: RC1.
Motor coil 3: RC2.
Motor coil 4: RC3.
Ready LED: RC4.
Injecting LED: RC5.
Remove injection LED: RC6
************************************/

void main(void)
          {
          // ports (B,C,D,E) declaration
           TRISB=0xFF; // Input
           TRISC= 00; // Output
           PORTC= 00; //coils off
          While(1)
           {
           while (PORTBbits.RB3==1)
                     PORTCbits.RC6=1;          //remove injection LED on
           PORTCbits.RC6=0;                    //remove injection LED off
           while (PORTBbits.RB0==0)
                   {
```

```
                    PORTCbits.RC0=1;
                    Delay10TCYx( 500 );
                    PORTCbits.RC1=1;
                    Delay10TCYx( 500 );
                    PORTCbits.RC0=0;
                    Delay10TCYx( 500 );
                    PORTCbits.RC2=1;
                    Delay10TCYx( 500 );
                    PORTCbits.RC1=0;
                    Delay10TCYx( 500 );
                    PORTCbits.RC3=1;
                    Delay10TCYx( 500 );
                    PORTCbits.RC2=0;
                    Delay10TCYx( 500 );
                    PORTCbits.RC0=1;
                    Delay10TCYx( 500 );
                    PORTCbits.RC3=0;

        }
PORTCbits.RC0=0; //All coils are off
PORTCbits.RC1=0;
PORTCbits.RC2=0;
PORTCbits.RC3=0;

while (PORTBbits.RB3==0)
        PORTCbits.RC7=1;                //load injection LED on
PORTCbits.RC7=0;                        //load injection LED off
if (PORTBbits.RB0==1)
        PORTCbits.RC4=1;                //ready LED on
while (PORTBbits.RB2==1)                //start button.
        PORTCbits.RC4=1;                //ready LED on
PORTCbits.RC4=0;                        //ready LED off
PORTCbits.RC5=1;                        //injecting LED on
while (PORTBbits.RB1==0)
{
                PORTCbits.RC0=1;
                Delay10TCYx( 500 );
                PORTCbits.RC3=1;
                Delay10TCYx( 500 );
                PORTCbits.RC0=0;
                Delay10TCYx( 500 );
                PORTCbits.RC2=1;
                Delay10TCYx( 500 );
                PORTCbits.RC3=0;
                Delay10TCYx( 500 );
                PORTCbits.RC1=1;
```

```
                Delay10TCYx( 500 );
                PORTCbits.RC2=0;
                Delay10TCYx( 500 );
                PORTCbits.RC0=1;
                Delay10TCYx( 500 );
                PORTCbits.RC1=0;
        }
PORTCbits.RC0=0;                // All coils are off
PORTCbits.RC1=0;
PORTCbits.RC2=0;
PORTCbits.RC3=0;
}
```

7

System Implementation and Testing

This chapter demonstrates the methods and procedures used to implement, test, and examine the system operation and behavior. System testing is an important step in implementing whole system.

Chapter Seven

System Implementation and Testing

System implementation and testing are performed on subsystems and all system. These subsystems are:

7.1 Mechanical system implementation and testing

The mechanical system implementation and testing includes the rack, pinion, stepper motor and syringe. The following picture shows mechanical system implementation.

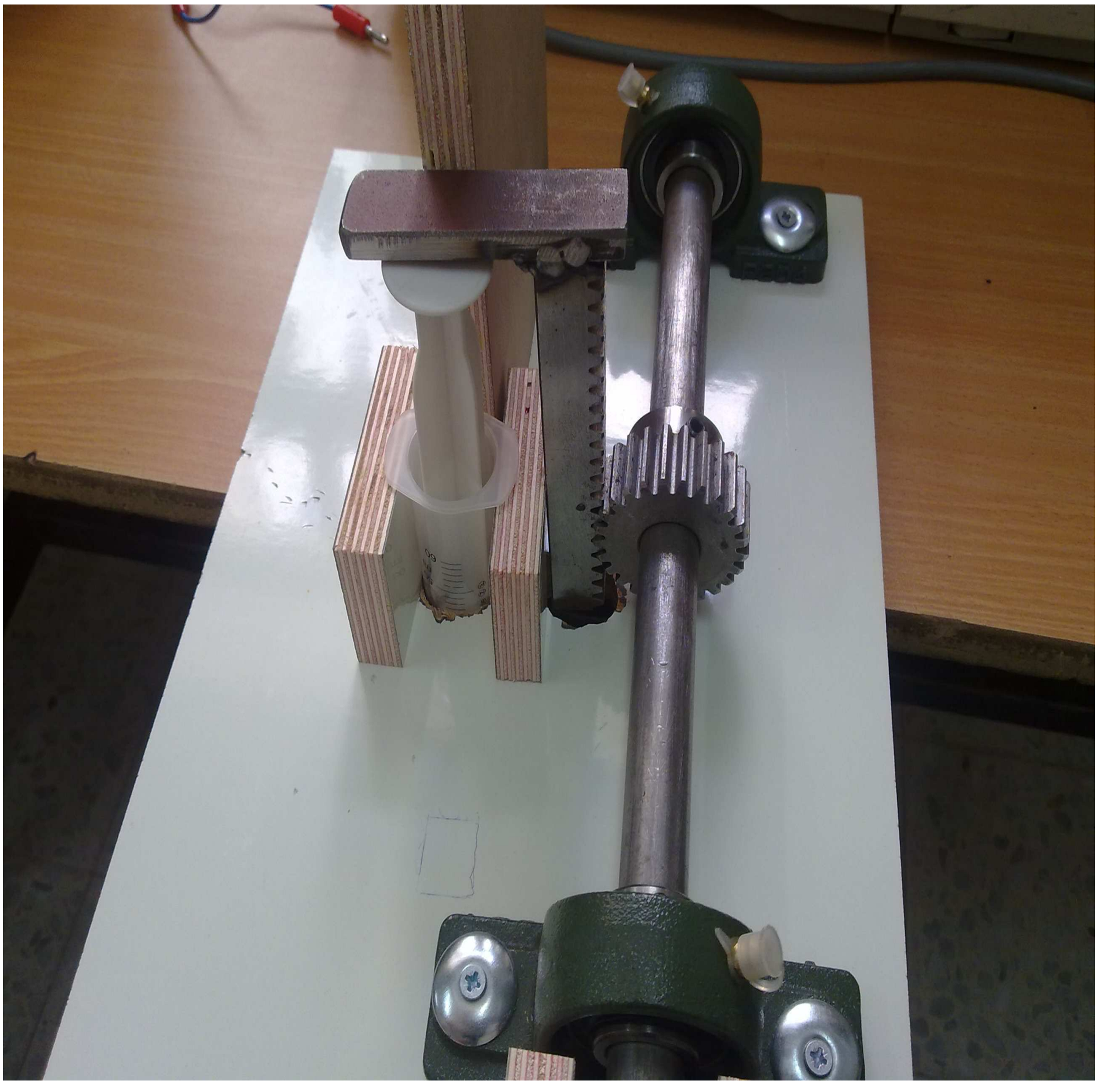

Figure 7.1: Mechanical system

After building the mechanical system we tested it manually, by rotating the pinion to move the rack to start heparin injection

7.2 Electrical and electronic subsystems implementation and testing

1. Stepper motor circuit

Stepper motor circuit implemented by using buffer and Darlington transistor to activate one stepper motor coil at a time.

Stepper motor control circuit was tested by applying an external Vcc and we get the required output (5v) to activate stepper motor coil. The following figure shows the implementation of Stepper motor control circuits.

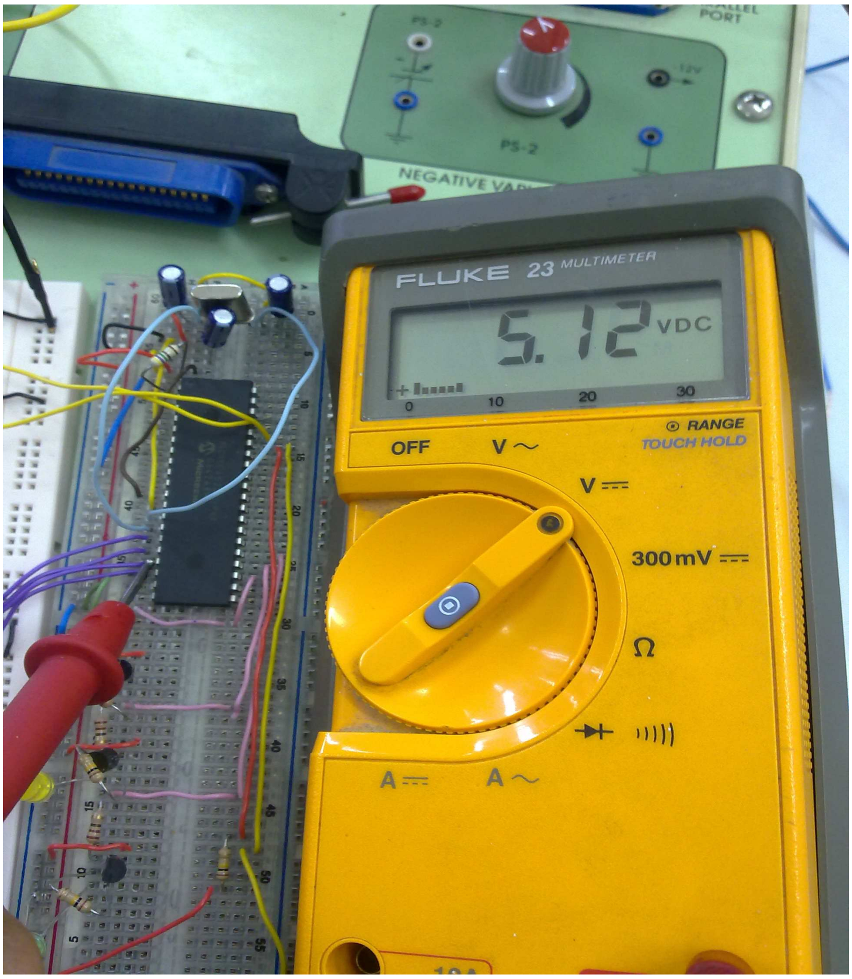

Figure 7.2: Stepper motor control board

2. Sensor circuit

Sensor circuit implemented by using opt coupler to send the signal to the PIC to do the required action.

Sensor control circuit was tested by checking the output signal when the rack moving in front of the sensor. The following figure shows the implementation of sensor control circuits.

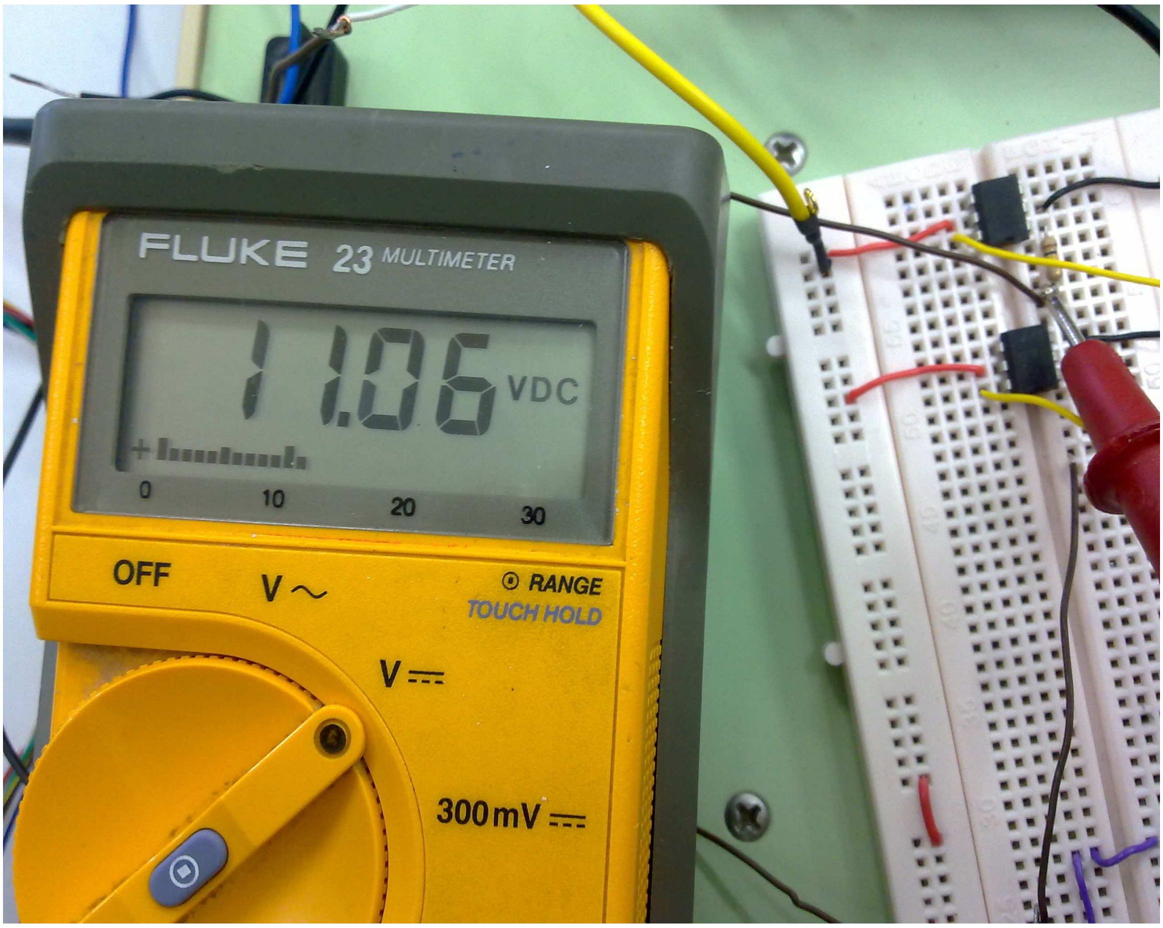

Figure 7.3: Sensor control board

3. LED circuit

LED circuit implemented by using transistor and connected to the PIC to show us the project work status.

LED control circuit was tested by applying external Vcc to check the output. The following figure shows the implementation of sensor control circuits.

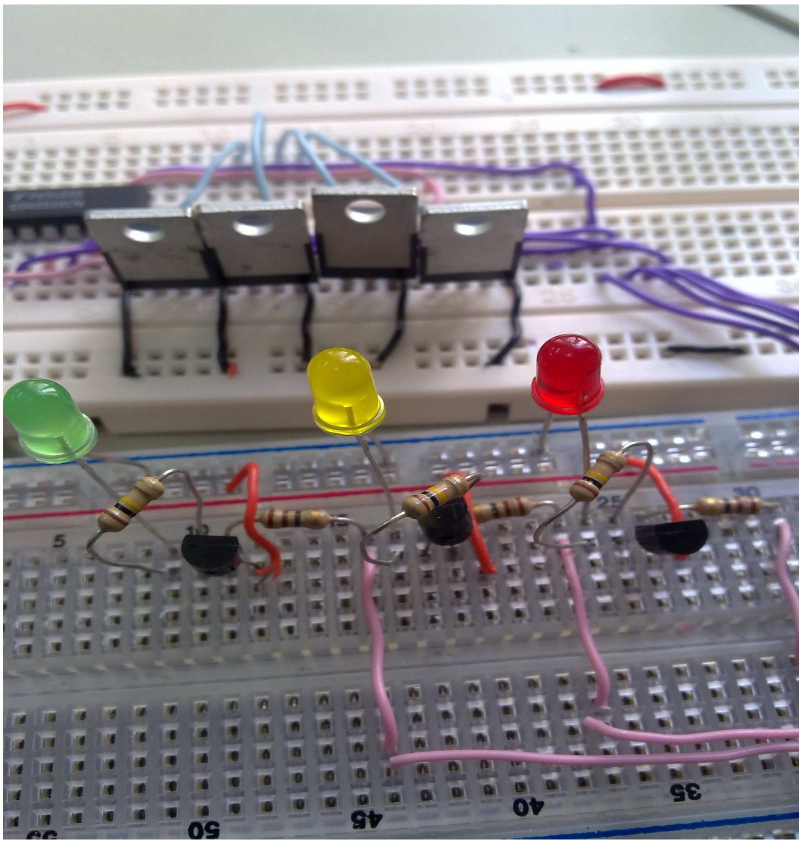

Figure 7.4: LED control board

4. PIC microcontroller and its circuits.

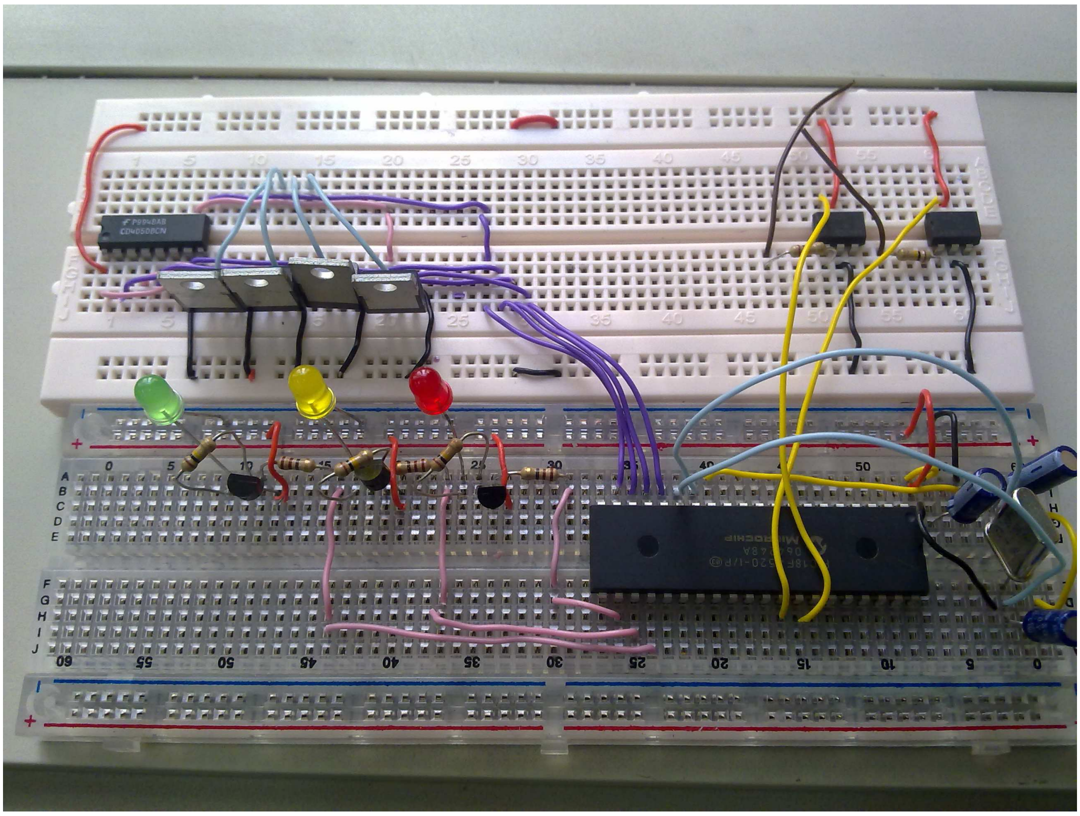

Figure 7.5: Main PIC board

PIC microcontroller is the main circuit and contain

• PIC microcontroller.

Connect PIC microcontroller IC with board and connect needed supply voltage

Chapter Eight
Conclusion and Future Work

8.1 Conclusions

1. Our project will deliver the heparin to the patient in limited quantity at time of need by stepper motor controlling.

2. This project is microcontroller based, which control the whole processes in the device.

3. The Heparin is very important to prevent the blood clotting, during right quantity injection into the blood.

8.2 Recommendations

Future modifications can be carried out so system performance and efficiency is improved, these modifications include:

1. Implementation the system by using other types of sensors.

2. Improve the system by adding LCD to display the amount of heparin injected during the time .

3. Adding printer to print a report about heparin delivery.

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Appendix

Datasheets

Inductance Type Proximity Switch LM18

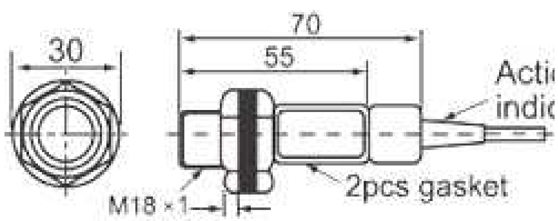
Main features:

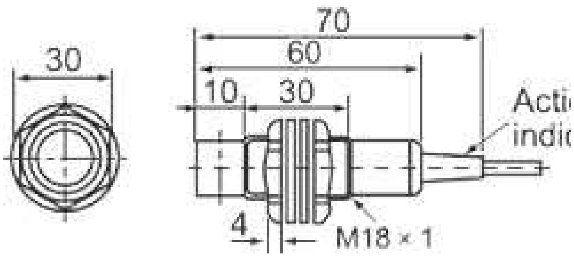
- ●Compact volume
- ●high precision of repeated location
- ●Diversified exterior structures
- ●Good performance of anti-interference.
- ●Many output forms
- ●High on-off frequency.
- ●Wide voltage range
- ●Dust proof,vibration proof,water proof and oil proof.
- ●With short-circuit protection and inverted connecting protection.
- ●Long service life

Technical Parameters:

Model NO.	Detection distance	Working voltage	Output		Flush
			Form	State	
LM18-3005NA	5mm	DC6-36V	NPN	NO	Flush
LM18-3005NB	5mm	DC6-36V	NPN	NC	Flush
LM18-3005NC	5mm	DC6-36V	NPN	NO+NC	Flush
LM18-3005PA	5mm	DC6-36V	PNP	NO	Flush
LM18-3005PB	5mm	DC6-36V	PNP	NO	Flush
LM18-3005PC	5mm	DC6-36V	PNP	NO+NC	Flush
LM18-3005LA	5mm	DC6-36V	Two wire system	NO	Flush

LM18 -3005LB	5mm	DC6-36V	Two wire system	NC	Flush
LM18 -2005A	5mm	AC90-250V	SCR Control label silicon	NO	Flush
LM18-2005B	5mm	AC90 -250A	SCR Control label silicon	NC	Flush
LM18 -2005C	5mm	AC90 -250A	SCR Control label silicon	NO+NC	Flush
LM18-3008NA	8mm	DC6-36V	NPN	NO	Non-flush
LM18-3008NB	8mm	DC6-36V	NPN	NC	Non-flush
LM18-3008NC	8mm	DC6-36V	NPN	NO+NC	Non-flush
LM18-3008PA	8mm	DC6-36V	PNP	NO	Non-flush
LM18-3008PB	8mm	DC6-36V	PNP	NC	Non-flush
LM18-3008PC	8mm	DC6-36V	PNP	NO+NC	Non-Flush
LM18-3008LA	8mm	DC6-36V	Two wire system	NO	Non-flush
LM18 -3008LB	8mm	DC6-36V	Two wire system	NC	Non-flush
LM18 -2008A	8mm	AC90-250V	SCR Control label silicon	NO	Non-flush
LM18-2008B	8mm	AC90-250V	SCR Control label silicon	NC	Non-flush
LM18 -2008C	8mm	AC90-250V	SCR Control label silicon	NO+NC	Non-flush





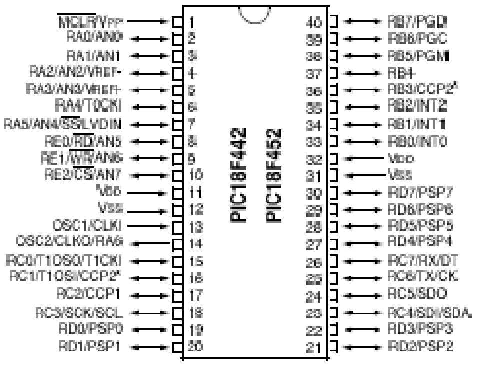
PIC18FXX2
Data Sheet

High-Performance, Enhanced Flash Microcontrollers with 10-Bit A/D

 DS39564C

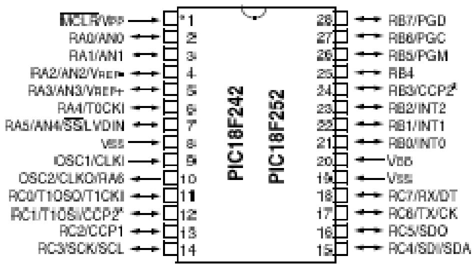
Pin Diagrams (Cont.'d)

DIP



Note: Pin compatible with 40-pin PIC16C7X devices.

DIP, SOIC



* RB3 is the alternate pin for the CCP2 pin multiplexing.

1.0 DEVICE OVERVIEW

This document contains device specific information for the following devices:

- PIC18F242
- PIC18F252
- PIC18F442
- PIC18F452

These devices come in 28-pin and 40/44-pin packages. The 28-pin devices do not have a Parallel Slave Port (PSP) implemented and the number of Analog-to-Digital (A/D) converter input channels is reduced to 5. An overview of features is shown in Table 1-1.

The following two figures are device block diagrams sorted by pin count: 28-pin for Figure 1-1 and 40/44-pin for Figure 1-2. The 28-pin and 40/44-pin pinouts are listed in Table 1-2 and Table 1-3, respectively.

TABLE 1-1: DEVICE FEATURES

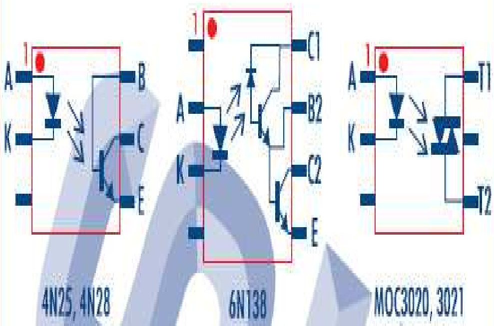
Features	PIC18F242	PIC18F252	PIC18F442	PIC18F452
Operating Frequency	DC - 40 MHz	DC - 40 MHz	DC - 40 MHz	DC - 40 MHz
Program Memory (Bytes)	16K	32K	16K	32K
Program Memory (Instructions)	8192	16384	8192	16384
Data Memory (Bytes)	768	1536	768	1536
Data EEPROM Memory (Bytes)	256	256	256	256
Interrupt Sources	17	17	18	18
I/O Ports	Ports A, B, C	Ports A, B, C	Ports A, B, C, D, E	Ports A, B, C, D, E
Timers	4	4	4	4
Capture/Compare/PWM Modules	2	2	2	2
Serial Communications	MSSP, Addressable USART	MSSP, Addressable USART	MSSP, Addressable USART	MSSP, Addressable USART
Parallel Communications	—	—	PSP	PSP
10-bit Analog-to-Digital Module	5 input channels	5 input channels	8 input channels	8 input channels
RESETS (and Delays)	POR, BOR, RESET Instruction, Stack Full, Stack Underflow (PWRT, OST)	POR, BOR, RESET Instruction, Stack Full, Stack Underflow (PWRT, OST)	POR, BOR, RESET Instruction, Stack Full, Stack Underflow (PWRT, OST)	POR, BOR, RESET Instruction, Stack Full, Stack Underflow (PWRT, OST)
Programmable Low Voltage Detect	Yes	Yes	Yes	Yes
Programmable Brown-out Reset	Yes	Yes	Yes	Yes
Instruction Set	75 Instructions	75 Instructions	75 Instructions	75 Instructions
Packages	28-pin DIP 28-pin SOIC	28-pin DIP 28-pin SOIC	40-pin DIP 44-pin PLCC 44-pin TQFP	40-pin DIP 44-pin PLCC 44-pin TQFP

The other main type of optocoupler you'll tend to encounter is the type having an output diac or bilateral switch, and intended for use in driving a triac or SCR. Examples of these are the MOC3020 and MOC3021. Here the output side of the optocoupler is designed to be connected directly into the triggering circuit of the triac (Fig.8), where it's operating from and floating at full AC mains potential.

As you'd expect the output diac is connected into the triac gate triggering circuit in much the same way as a discrete diac. You need a filter/delay circuit before the diac (R1-2 and C1) and the usual snubber circuit across the triac (Rs, Cs) to ensure correct triggering with inductive loads. Normally you'd also need at least an RFI suppressor choke LRFI as well, plus a suitable capacitor across the load.

Basic performance specs for the optocouplers stocked by Electus Distribution are shown in the table at right, while their pin connections are shown at top right.

Common Optocoupler Connections and Basic Specs



TYPE	ISOLATION (V_{ISO})	INPUT LED $I_{F(max)}$	OUTPUT $V_{CE(max)}$	CTRmin (@ IF)	BANDWIDTH (kHz)
4N25	5300Vrms	80mA	7V	20% (10mA)	300
4N28	5300Vrms	80mA	7V	10% (10mA)	300
6N138	2500Vrms	20mA	7V	300% (1.6mA)	~20
MOC3020	7500Vpk	50mA	Voff = 400V	(Trig. @ 30mA)	—
MOC3021	7500Vpk	50mA	Voff = 400V	(Trig. @ 15mA)	—

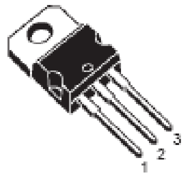
BDX33B BDX33C
BDX34B BDX34C

COMPLEMENTARY SILICON POWER DARLINGTON TRANSISTORS

DESCRIPTION

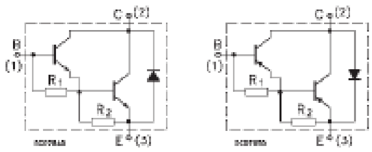
The BDX33B and BDX33C are silicon Epitaxial-Base NPN power transistors in monolithic Darlington configuration mounted in Jedec TO-220 plastic package. They are intented for use in power linear and switching applications.

The complementary PNP types are BDX34B and BDX34C respectively.



TO-220

INTERNAL SCHEMATIC DIAGRAM



R_1 Typ. = 10 KΩ R_2 Typ. = 150 Ω

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter				Unit
		NPN	BDX33B	BDX33C	
		PNP	BDX34B	BDX34C	
V_{CBO}	Collector-Base Voltage (I_E = 0)		80	100	V
V_{CEO}	Collector-Emitter Voltage (I_B = 0)		80	100	V
I_C	Collector Current		10		A
I_{CM}	Collector Peak Current		15		A
I_B	Base Current		0.25		A
P_{tot}	Total Dissipation at $T_c \leq 25$ °C		70		W
T_{stg}	Storage Temperature		-65 to 150		°C
T_j	Max. Operating Junction Temperature		150		°C

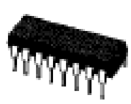
For PNP types voltage and current values are negative.

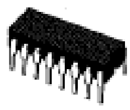
SGS-THOMSON MICROELECTRONICS

M54/74HC4049
M54/74HC4050

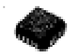
HC4049 HEX BUFFER/CONVERTER (INVERTER)
HC4050 HEX BUFFER/CONVERTER

- HIGH SPEED
  t_{PD} = 9 ns (TYP.) AT V_{CC} = 5 V
- LOW POWER DISSIPATION
  I_{CC} = 1 μA (MAX.) AT T_A = 25 °C
- HIGH NOISE IMMUNITY
  V_{NIH} = V_{NIL} = 28 % V_{CC} (MIN.)
- OUTPUT DRIVE CAPABILITY
  15 LSTTL LOADS
- SYMMETRICAL OUTPUT IMPEDANCE
  $|I_{OH}|$ = I_{OL} = 6 mA (MIN.)
- BALANCED PROPAGATION DELAYS
  t_{PLH} = t_{PHL}
- WIDE OPERATING VOLTAGE RANGE
  V_{CC} (OPR) = 2 V TO 6 V
- PIN AND FUNCTION COMPATIBLE
  WITH 4049B/4050B


B1R
(Plastic Package)


F1R
(Ceramic Package)

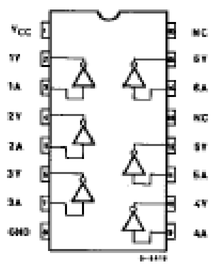

M1R
(Micro Package)


C1R
(Chip Carrier)

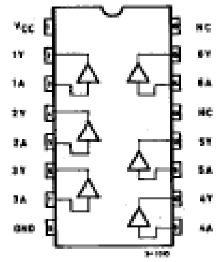
ORDER CODES :
M54HCXXXXF1R M74HCXXXXM1R
M74HCXXXXB1R M74HCXXXXC1R

PIN CONNECTIONS (top view)

HC4049



HC4050



NC =
No Internal
Connection

DESCRIPTION

The M54/74HC4049 and the M54/74HC4050 are high speed CMOS HEX BUFFER fabricated in silicon gate C^2MOS technology.

They have the same high speed performance of LSTTL combined with true CMOS low power consumption.

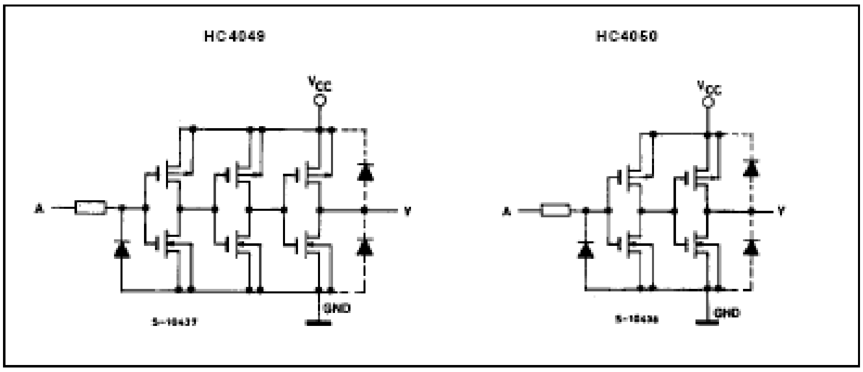
The M54/75HC4049 is an inverting buffer, while the M54/74HC4050 is a non-inverting buffer.

The internal circuit is composed of 3 stage or 2-stage inverters, which provides high noise immunity and a stable output.

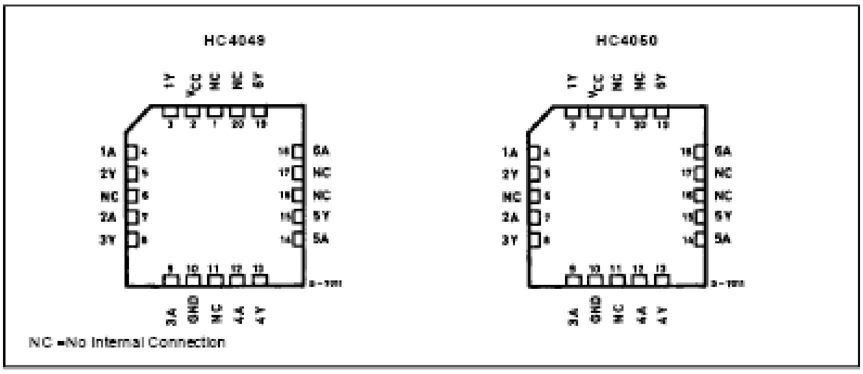
Input protection circuits are different from those of the high speed CMOS IC's.

The VCC side diodes are designed to allow logic-level convertion from high-level voltages (up to 15 V) to low-level voltages.

CIRCUIT SCHEMATIC (Per Gate)



CHIP CARRIER



TRUTH TABLE (HC4049)

INPUT	OUTPUT
nA	n$\overline{Y}$
L	H
H	L

TRUTH TABLE (HC4050)

INPUT	OUTPUT
nA	nY
L	L
H	H