بسم الله الرحمن الرحيم

Palestine Polytechnic University

College of Engineering & Technology

Mechanical Engineering Department

Mechatronics Engineering

A robotic manipulator for elder and blind people blood finger pricking and a liquating in blood testing apparatus

Graduation Project

Project Team

Ibrahim Mansour

Abd Alkarim Abualia

Project Supervisor

Eng . Majdi Zallom

Hebron – Palestine

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ABSTRACT (English)

This project aims to design and Automation diabetes testing device to help the elder and the blind People who suffering from diabetes disease to measure the rate of glucose in the blood easily and safely.

The design and construction of this device includes several stages, starting from the mechanical design of the project and identify the mechanisms and steps of measuring the test. there are three mechanisms in the project, the first mechanism is to moves the needle forward and reveres to take a sample of blood from the finger, the second is to inserted in and out from the glucose tester, the third one is a lifting arm mechanism using for lifting up the movable arm when the person put his/her finger inside the machine. We use **CATIA** program to identify the dimensions of the mechanical parts.

The Second-stage is the electrical design include the motors and electrical components , there are three motors in the project one to rotate the roller to inserted in and out the cells from the glucose tester and the second motor using for lifting arm and the third one is to move the needle forward and reveres .

The third stage is to control the project using PIC microcontroller connected with limit switches to enable the project and to control the direction of motors. The last stage of the project is to building the mechanical and electrical structure to gets the final product.

Abstract (عربي)

يهدف هذا المشروع الى تصميم و اتمتة جهاز فحص السكري بحيث يقوم بمساعدة كبار السن والمكتوفين المصابين بمرض السكري على قياس نسبة السكر في الدم بكل سهولة وامان.

يشمل تصميم وبناء هذا الجهاز عدة مراحل تبدا من مرحلة التصميم الميكانيكي للمشروع وتحديد الاليات والخطوات اللازمة لإجراء الفحص حيث تبدأ هذه المرحلة بتصميم الية إدخال وإخراج الشرائح من جهاز فحص السكري . والالية الثانية تصميم كيفية اخذ عينة الدم من الاصبع, وفي هذا المشروع استخدم برنامج الكاتيا لرسم القطع الميكانيكية وابعاد هذه القطع.

المرحلة الثانية وهي التصميم الكهربائي للمشروع والتي تبدا من تحديد الموتورات التي تعمل على تحريك ودوران الاجزاء الموجودة في المشروع حيث يوجد في المشروع ثلاث موتورات . الموتور الاول لإدخال وإخراج الشرائح والموتور الثاني يستخدم لرفع الذراع المتحرك عن الشرائح والموتور الثالث لتحريك الابرة واخذ عينة الدم من الاصبع.

المرحلة الثالثة وهي بناء نظام للتحكم في المشروع يشمل التحكم في الابرة لاخذ عينة الدم من الاصبع والتحكم في ادخال واخراج شرائح الفحص ويتم التحكم عن طريق نظام التحكم (PIC microcontroller) . المرحلة الاخيرة في المشروع وهي تركيب الجهاز بشكل نهائي وتصميم الشكل الخارجي للمشروع.

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Chapter One

Introduction

1.1 Overview

In these days there are many blind and elder patients in the world suffering from diabetes disease, and they need to measure the glucose level continuously at home.

Diabetes is the condition that refers to the body's inability to produce enough insulin or the body's loss of capacity to respond to insulin (insulin resistance). Insulin is the hormone produced by the pancreatic islet beta-cells and prompts the fat cells (adipocytes) to store glucose from circulation reducing its blood level concentration.

The danger in the absence of sufficient insulin or insulin resistance reaching a high blood glucose levels termed hyperglycemia. Hyperglycemia leads to a chemical reaction producing gluco-toxin; which in turn leads to various physiological complications. According to the year 2000 international health organization statistics, the prevalence of thie disease was at 37-45 patients for each thousand. This means in a country such as Palestine with an approximate population of four million the number of patients would be more than a hundred and sixty thousand diabetic. The latest statistics shows that there are almost 171 million patients worldwide.

Diabetes generally can be classified in many ways. For instance medically it is classified into; Type I diabetes (juvenile diabetes), and Type II diabetes. The difference between the two types is that type I patients either have a reduction in insulin production or complete absence of the hormone. Patients diagnosed with type II have normal, other times elevated levels of insulin, yet their bodies fail to respond to it.

The one responsiveness to insulin is associated with multiple factors, some are the environmental such as life style and type of food, while another factor is genetic based that predispose part of the population more than the rest. Recent scientific studies revolutionized the definition of type I diabetes as it used to only refer to those born with insufficient insulin production, while nowadays it also include those who develop this insufficiency due to another disease such as autoimmune disorder even if it happen later in life.

1.2 Project Goal

The main purpose of this project is to design and manufacture a novel automated glucose tester, to help the blind and elder people who suffers from diabetes diseases to measure the glucose level continuously and without any help from others, since these people might not be able to visit hospitals frequently or it would be difficult for them to use the traditional machine because of its complexity to measure the test alone.

1.3 Project Importance

To understand the importance behind our project it is important for the reader to understand the complexity and disastrous health consequences behind diseases such as diabetes.

The novelty of our project provides three main objectives. The First one is the automation of measuring glucose level, and then the design that will provide the culturally relevant and patient friendly than those in the market. Finally, it will provide a prototype for a device that can also be a part of biomedical testing labs, hospitals, and doctor's private clinics.

1.4 Methodology

Since this project is a mechatronics system, which is integration between multi-disciplinary sciences, it can be represented by figure (1.1), which shows the synergistic integration of three engineering fields. This integration make our project is very useful in our society.

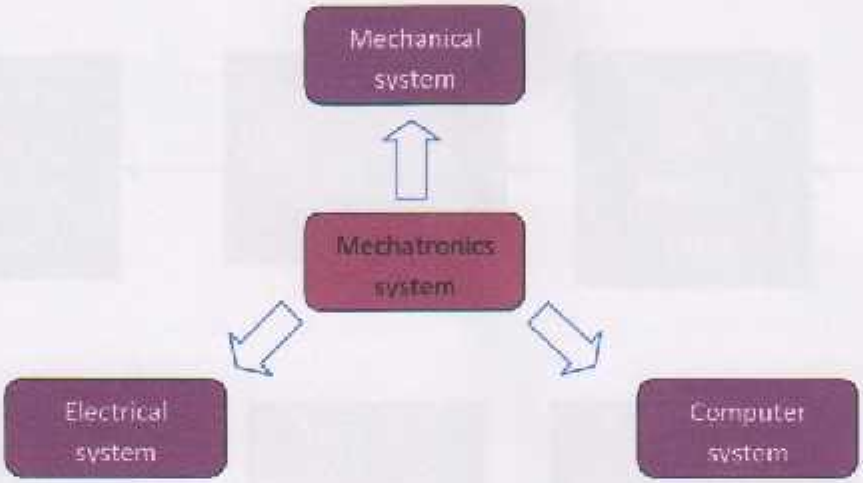


Figure (1.1) Synergistic Integration

- **Mechanical System:**

  Designing and building the mechanical structure of the project choosing the appropriate dimensions and shape in order to fit in all the internal component of the machine then designing the first mechanism to move the needle forward and reverse and the second mechanism is to insert in or insert out the test cells from the glucose tester.

- **Electrical System (Control System):**

  Implementing the motors for the movement of components, also designing the control circuit of the machine which consists of limit switches and a drive circuit to suit the application, and then implementing the transformer that supplies the motors with power.

- **Computer System:**

Implementing the micro-controller (PIC), program it with C language, to execute the test in sequential procedure.

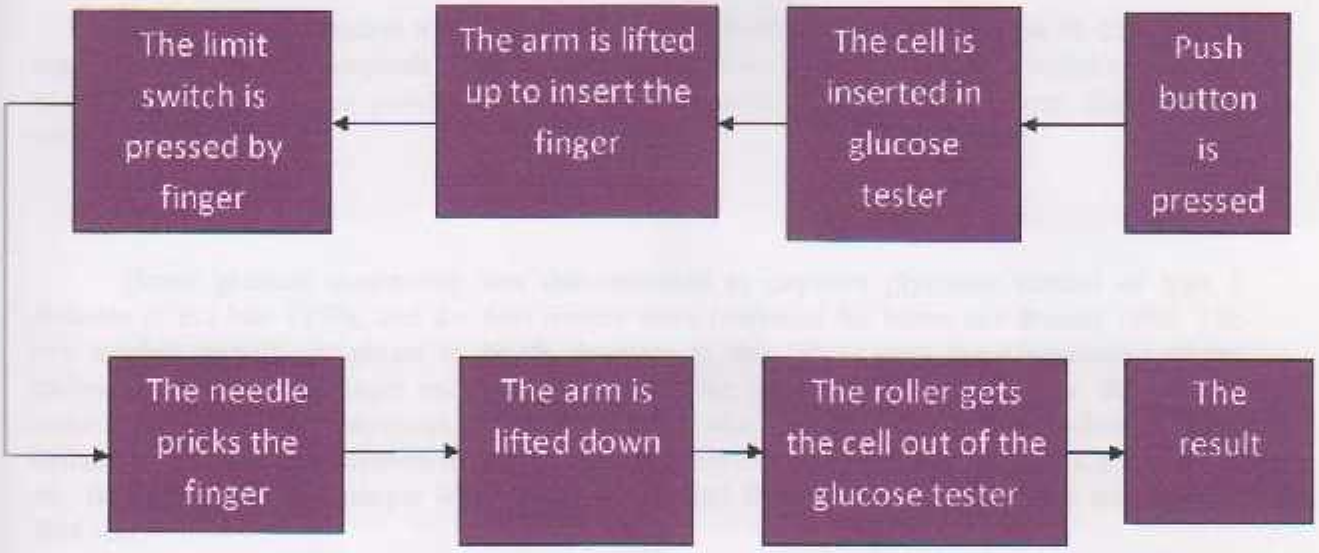


Figure 1.2 Operation of project

As shown above, figure 1.2 explains the operation of the project that will be discussed in chapter two.

1.5 Motivation

1. To help blind and elder people to measure glucose level continuously at home.
2. To improve the health life in our community.

3. Reducing the errors in measuring glucose level in blood.
4. To convoy the development of technology in the world.

1.6 Literature Review

In 1962, Clark and Lyons at the Cincinnati Children's Hospital developed the first glucose enzyme electrode. It relied on a thin layer of glucose oxidase on an oxygen electrode. The sensor worked by measuring the amount of oxygen consumed by the enzyme.

Another early glucose meter was the Ames Reflectance Meter by Anton H. Clemens. It was used in American hospitals in the 1970s. It was about 10 inches long. It needed connection to an electrical outlet for power. A moving needle indicated the blood glucose after about a minute.

Home glucose monitoring was demonstrated to improve glycemic control of type 1 diabetes in the late 1970s, and the first meters were marketed for home use around 1980. The two models initially dominant in North America in the 1980s were the Glucometer whose trademark is owned by Bayer and the Accu-chek meter (by Roche). Consequently, these brand names have become synonymous with the generic product to many health care professionals. In Britain, a health care professional or a patient may refer to "taking a BM": "Mrs X's BM is 5", etc. BM stands for Boehringer Mannheim, now called Roche, who produced test strips called 'BM-test'.

Several methods exist for measuring hemoglobin, most of which are done currently by automated machines designed to perform several different tests on blood. Within the machine, the red blood cells are broken down to get the hemoglobin into a solution. The free hemoglobin is exposed to a chemical containing cyanide which binds tightly with the hemoglobin molecule to form cyanmethemoglobin. By shining a light through the solution and measuring how much light is absorbed (specifically at a wavelength of 540 nanometers), the amount of hemoglobin can be determined.

At least in North America, hospitals resisted adoption of meter glucose measurements for inpatient diabetes care for over a decade. Managers of laboratories argued that the superior accuracy of a laboratory glucose measurement **outweighed** the advantage of immediate availability and made meter glucose measurements unacceptable for inpatient diabetes management. Patients with diabetes and their endocrinologists eventually persuaded acceptance.

Some health care policymakers still resist the idea that the society would be well advised to pay the consumables (reagents, lancets, etc.) needed.

Home glucose testing was adopted for type 2 diabetes more slowly than for type 1, and a large proportion of people with type 2 diabetes have never been instructed in home glucose testing. This has mainly come about because health authorities are reluctant to bear the cost of the test strips and lancets.

Measure tissue sugar in body tissues and not the blood sugar in blood fluid. To determine blood glucose, the measuring beam of infrared light, for example, has to penetrate the tissue for measurement of blood glucose.

It is speculated that within the next decade, meters may be replaced with continuous glucose sensors for many people with diabetes. This will likely decrease complications found in people with diabetes by limiting problems associated with hyperglycemia and hypoglycemia.

There is currently an effort to develop an integrated treatment system with a glucose meter, insulin pump, and wristop controller, as well as an effort to integrate the glucose meter and a cell phone. These glucose meter/cellular phone combinations are under testing and currently cost $149 USD retail. Testing strips are proprietary and available only through the manufacturer (no insurance availability).

These "Glugophones" are currently offered in three forms: as a dongle for the iPhone, an add-on pack for LG model UX5000, VX5200, and LX350 cell phones, as well as an add-on pack for the Motorola Razr cell phone. This limits providers to AT&T for the iPhone and Verizon for the others. Similar systems have been tested for a longer time in Finland.

1.7 Estimated Cost

The following table shows estimated hardware costs.

Item number	Item	Price
1	Mechanical Structure	300
2	Motor	100
3	PIC Microcontroller	50
4	Transformer	80
5	Boards & Integrated Circuits	300
Total (NIS)		**830**

Table 1.1 - Operating hardware costs

1.8 Project schedule

- **First semester**

Table 1.2 – project time –schedule

Process	Week															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Selected the project																
Collection the needed data for the project																
Electromechanical modeling																
Writing documentation																

- **Second semester**

Table 1.3 – project time –schedule

Process	Week															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Implementation mechanical structure																
Implementation electrical component																
Project programming																
Writing documentation																

1.8 Report Content

In report contain four chapter, which they are; introduction, mechanical part, electrical and computer system and results and recommendation.

Chapter one: introduction of the diabetes diseases and project goal, project importance, methodology, literature review, time tables, and the cost of project.

Chapter two: mechanical part, as in its name, it include the mechanical part of the project and discuss the motion of the project

Chapter three: electrical and computer system, it contain the electrical part of the project, and drive circuit for the moor.

Chapter four: result and recommendation, it include the principle of working of the project. And also including some conclusion and recommendation

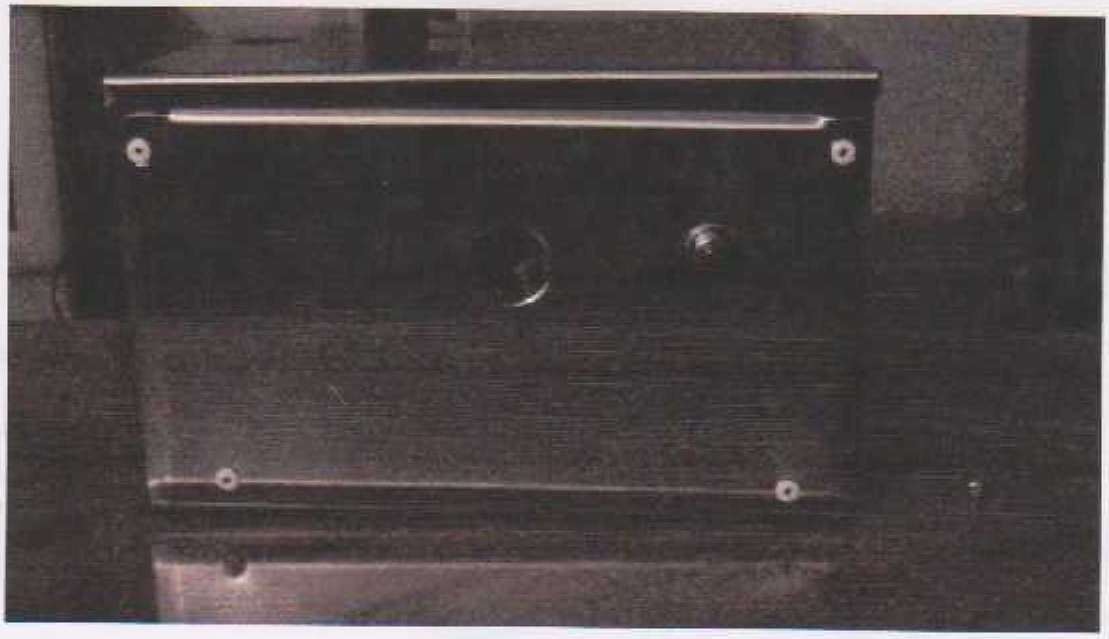


Figure 1.2 – Final product

Chapter Two

Mechanical Design and Parts

1.1 Introduction

1.2 Mechanical Part

1.3 Mechanisms

CHAPTER TWO

Mechanical Design and Parts

2.1 Introduction

In this project we designed an automated device for checking the glucose level in the blood. In order to understand the principle of the project, and to obtain the general idea about the motion we need first to understand the mechanisms. In this chapter we designed and explained the motion of each mechanism.

To obtain the needed motion, we used two mechanisms: the first one was used to move the needle to take a sample from the blood, the second one was used to insert the cell in and out the test device. Both of the two mechanisms will be discussed in the next sections.

2.2 Mechanical Parts

In this section we show and discuss the design of the main parts and mechanisms according to their functions. And these parts are:

2.2.1 Fixed Link

It is a stainless steel link, it is fixed vertically on the base, and it is connected to the movable link by a bin, and the figure below shows the fixed link. (The dimensions in mm) .

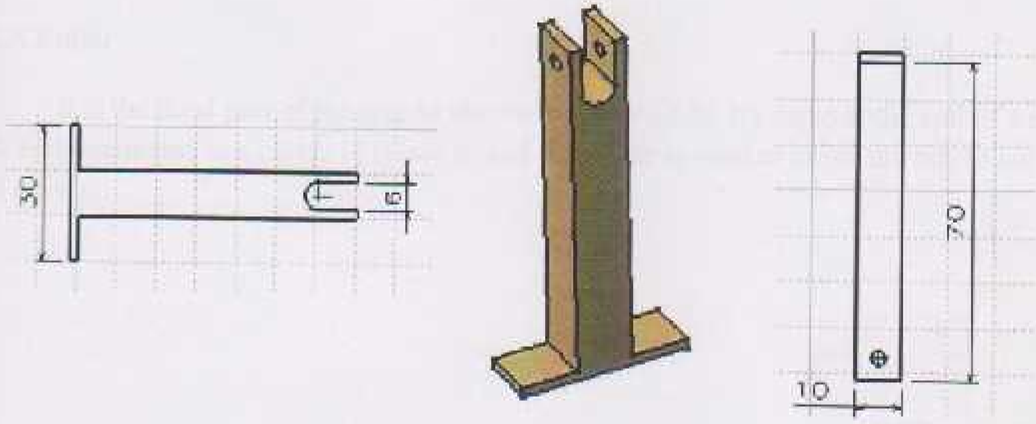


Figure 2.3 – Fixed Link

2.2.2 Movable link

It is a stainless steel link, and it's connected with the fixed link. It can be moved circularly and it's connected to the motor by a wire which lifts it. Figure (2.4) shows the movable link.

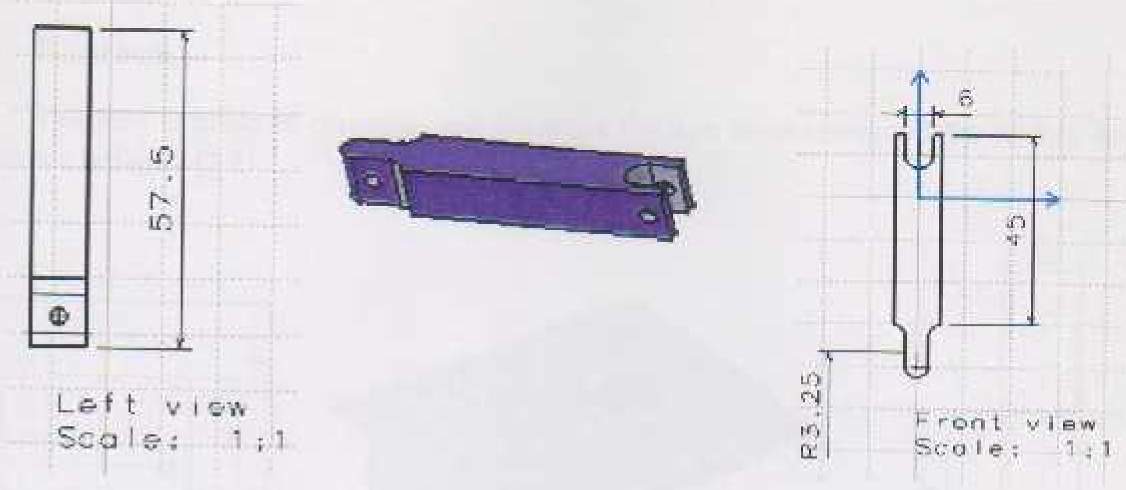


Figure 2.4 – Movable Link

2.2.3 Roller

It is the third part of the arm as shown in figure (2.5), It's fixed at the end of a movable link and connected to a motor to rotate it, and this roller is used to move the cell in and out the test device.

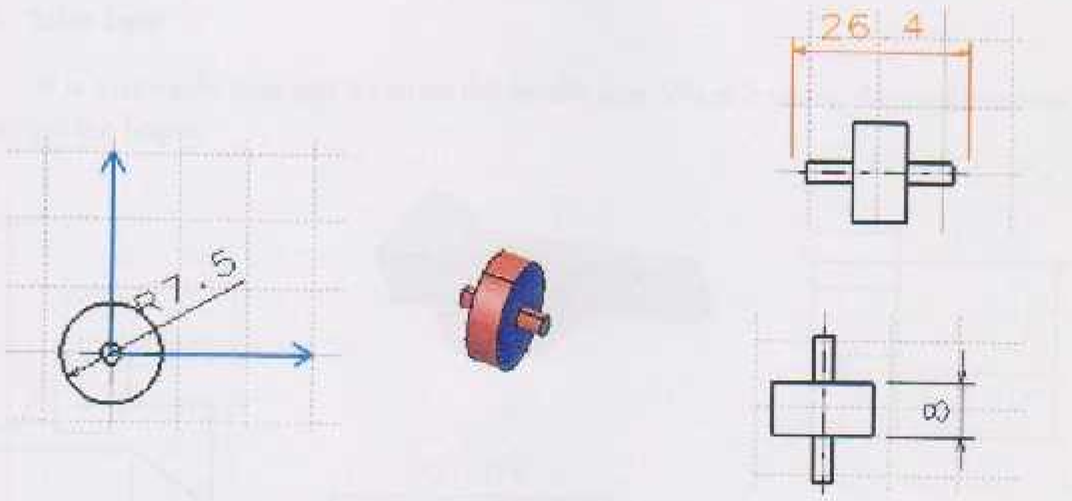


Figure 2.5- Roller

2.2.4 Fixed base

This base is made of stainless, and it carries the arm mechanism and the sliding base. Shown in figure (2.6).

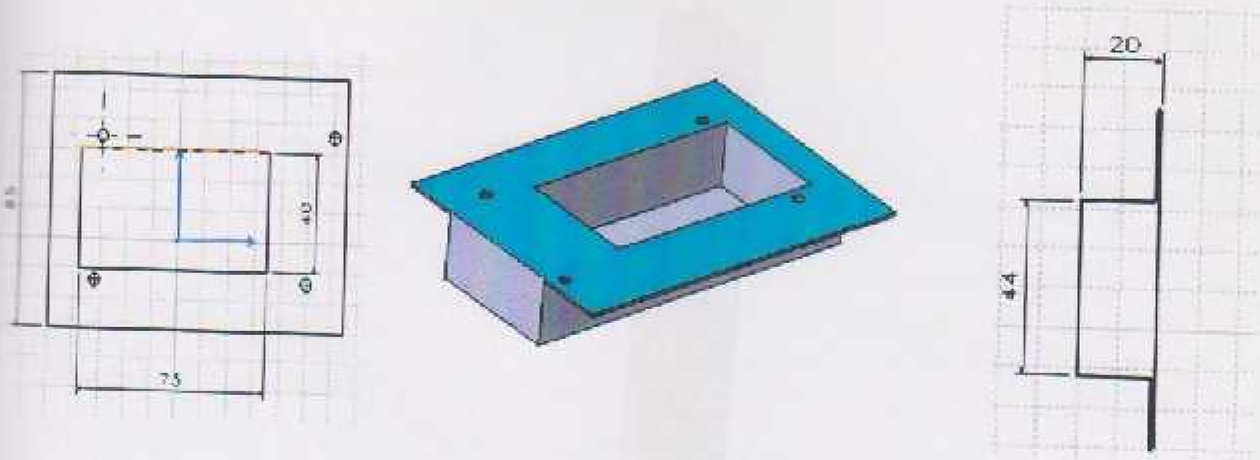


Figure 2.6- Fixed Base

2.2.5 Slide base

It is a movable base and it carries the needle arm. When it slides, the needle moves toward the finger.

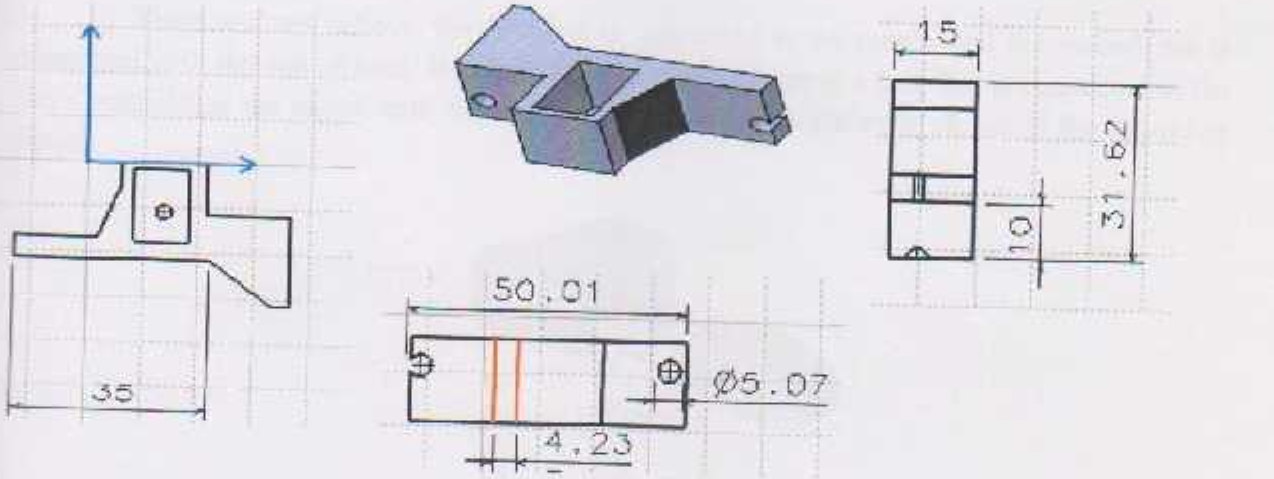


Figure 2.8 – Slide Base

2.2.6 Needle Arm

It is a stainless steel bar, and it is used to carry the needle, as shown in the figure below.

Figure 2.9 – Needle Arm

2.2.7 Pulley

There are two pulleys: the first one is connected to the motor, and the second one is connected with the end of base. Between the two pulleys there is a belt that is connected to the slide base. When the motor runs, the base starts moving. The pulley is shown in the following figure.

Figure 2.10- Pulley

2.3 Mechanisms

A mechanism is a combination of resistant bodies, and they are interconnected that by applying force or motion to one or more of those bodies, some of them cause to perform desired work accompanied by desired motions.

2.3.1 Translation Mechanism

It is the first mechanism in the project; it consists of three parts: First part is a fixed base, which is made of stainless, this base carries the arm mechanism and the sliding base. The second part of this mechanism is slid base, which is a movable base that carries the needle arm. When it slides, the needle moves toward the finger. The last part of this mechanism is a pulley. There are two pulleys: the first one is connected to the motor, the second one is connected with the end of the base. Between the two pulleys there is a belt that is connected to the slide base, and as we have mentioned above when the motor runs, the base starts moving. Figure (2.11) shows the translation mechanism and its parts.

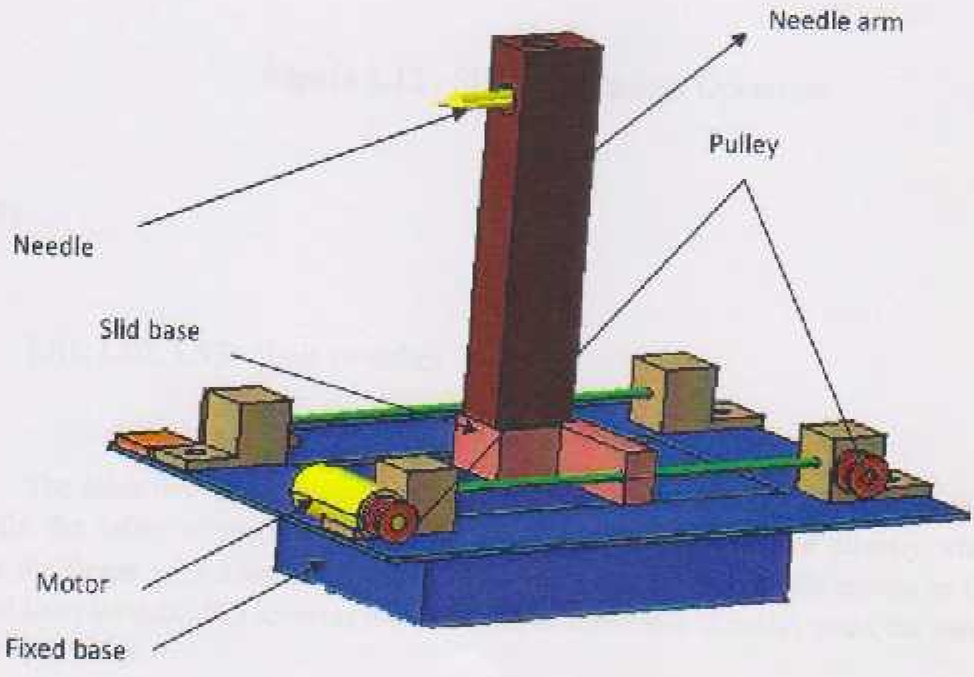


Figure 2.11 – Translation Mechanism

2.3.1.1 Principle of Operation

In addition to the mechanical part of this mechanism there are three limit switches: the first limit switch is for moving the needle forward to prick the finger. When the user inserts his/hers finger inside the machine, he/she must press on the first limit switch (LS1), which will send a command to microcontroller, and as a result the PWM will be opened to operate the motor that is connected with slid base which causes the needle to move and take a sample of the blood and measure the test. The needle can't prick the finger without pressing on the first limit switch. The figure shows the slide mechanism operation.

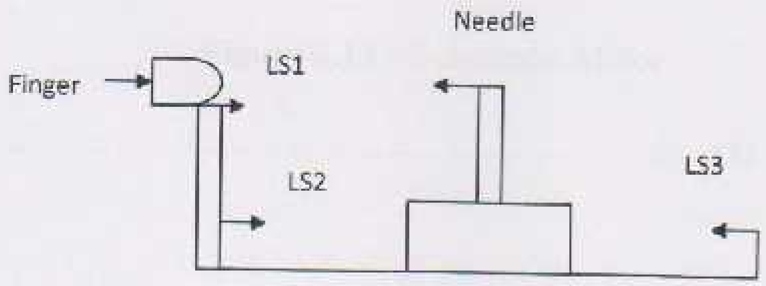


Figure 2.12 – Slide Mechanism Operation

Where:

LS1, LS2, LS3: limit switches

The other two limit switches are used to control of the direction of the motor and they are used for the safety of the operation to reverse the direction of motor directly when the needle pricks the finger with 2mm inside the finger, so that when the needle moves to the finger, the second limit switch(LS2) reverses the direction of the motor directly; since the needle enters the finger with 2mm.

The third limit switch (LS3) is used to stop the motor and the operation of the needle.

2.3.1.2 Theoretical Analysis

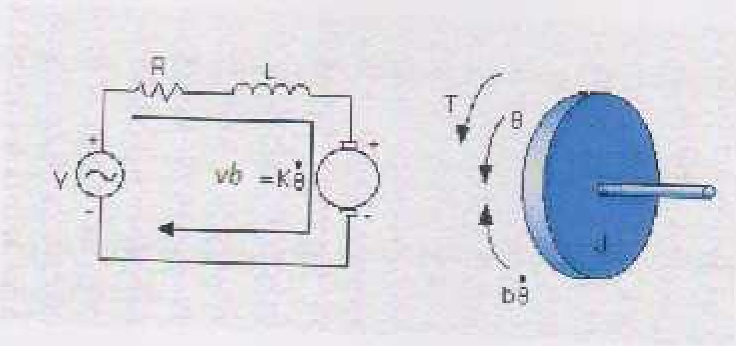


Figure 2.13 – Schematic Motor

$$vb = kb\,\frac{d\theta}{dt} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where

kb: *is the constant proportinality*

$\frac{d\theta}{dt}$: *is the angular velocity of the motor*

By writing the loop equation:

$$R_a I_a + vb = E_a(s) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

The torque developed by the motor is :

$$T_m = K_t I_a \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

K_t: *is the motor torque constant which depend on the motor and magnitic feild characteristics .*

$I_a = \frac{1}{K_t} T_m$ ....(4)

To find the transfer function of the motor we substitute equation (1) and (4) into (2), yielding

$\frac{(R_a)T_m}{K_t} + kb \frac{d\theta}{dt} = E_a(t)$ ....(5)

Now we must find T_m in the term of ω_m , the figure below shows the typical equivalent mechanical loading in the motor .

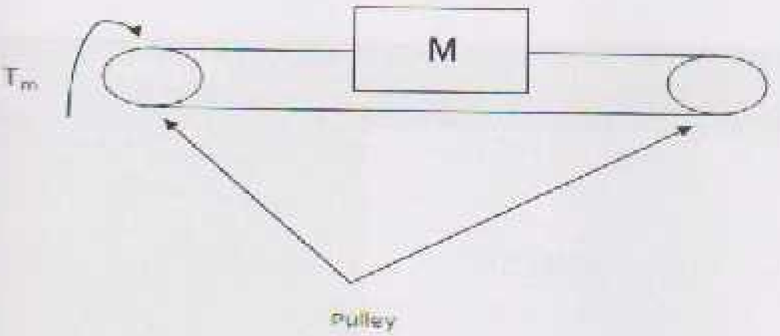


Figure 2.14 – Slide Mechanism View

$T_m = J_{eq}\ddot{\theta}$ ....(6)

$J_{eq} = Mr^2 + J_m + J_{p1} + J_{p2}$ ....(7)

Where:

J_{eq}: *the equevelent inertia of the system*

M : *mass of the slid base and needle arm and needle*

r : *the radius of the pulley* 1

J_m *is the equivalent inertia at the armeture*

J_p : *the inartia of the pulley*

$$\frac{(R_a)J_{eq}\ddot{\theta}}{K_t} + kb\,\frac{d\theta}{dt} = E_a(t) \quad \ldots\ldots(8)$$

By taking Laplace transform, the equation becomes:

$$\left(\frac{R_a J_{eq}}{K_t}s + kb\right)\omega(s) = E_a(s) \quad \ldots\ldots(9)$$

$$\frac{\omega(s)}{E_a(s)} = \frac{1}{\left(\frac{R_a J_{eq}}{K_t}s + kb\right)} \quad \ldots\ldots(10)$$

Quantity	Value
moment of inertia of the motor	3.2284E-6 kg.m^2
electromotive force constant (K=Ke=Kt)	0.0274Nm/Amp
Armature resistance Ra	4 ohm
Mass of slide base	20 gm

Table 2.1 – Quantity of the Slide Mechanism

By applied the above value in equation (7) we get

$$J_{eq} = 50 \times 10^{-3}(0.5 \times 10^{-2})^2 + 3.2284 \times 10^{-3} = 3.23 \times 10^{-6} \quad \ldots\ldots(11)$$

By applied Newton's law to find the acceleration of the slide base

$$v_2^{\,2} = v_1^{\,2} + 2ax \quad \dots\dots (12)$$

Where:

V_1 : the initial speed of the slide base

V_2: the final speed of slide base

a: the acceleration of the slide base

x : the distance that the slide base moves

$$0.1^2 = 2 \times 0.05a \quad \dots\dots (13)$$

$$a = 0.1\frac{m}{s^2} \quad \dots\dots (14)$$

$$\ddot{\theta} = \frac{a}{r} \quad \dots\dots (15)$$

where r the raduis of the pulley

$$\ddot{\theta} = \frac{0.1}{0.005} = 20\frac{rad}{s^2} \quad \dots\dots (16)$$

$$T_m = 20 \times 3.23 \times 10^{-6} = 60.46 \times 10^{-6} N.m \quad \dots\dots (17)$$

2.2.2 Arm Mechanism

The arm is the second mechanism. It consists of two links that are connected together: the first one is fixed vertically on the base, and it is connected to the movable link by a bin. The second link is a movable link that is connected with the fixed link, and it can be moved circularly, it's also connected to the motor by a wire. Beside these two links there is a roller. It's fixed at the end of the movable link and connected to a motor which rotates it, this roller is used to move the cell in and out the test device. The figure below shows the arm mechanism and its components.

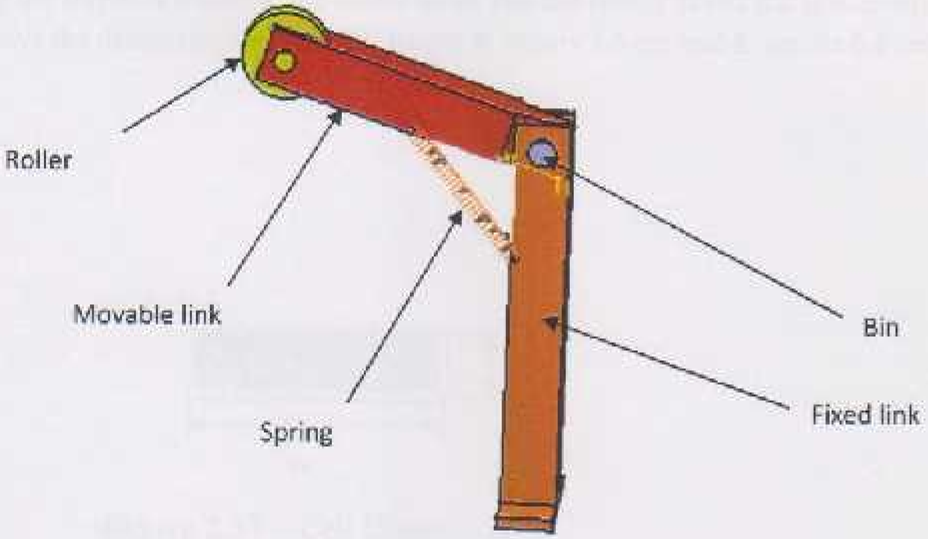


Figure 2.15 – Arm Mechanism

2.2.2.1 Principle of Operation

There are two motors connected to this mechanism: the first one is used to move the link up and down, and the second one is used to rotate the roller. At the beginning, the roller link presses on the cell through the spring that is connected to the movable arm (the dimensions of the cell is shown in figure 2.17), then when the motor receives a command from the microcontroller, the motor starts to rotate the roller so that the cell moves into the test device. The second motor is connected to the link by a wire. When the cell enters the device, the second motor runs and lifts up the link. Then when the test is finished, the two springs which are connected between the two links force the link down, and the motor reverses its direction and drives the cell out of test device.

As we have shown in the figure2.17, when the motor operates, it draws the link up, and when the stage of pricking the finger is finished, the motor stops and the spring draws the link down. The figure below shows the dimensions of the cell, where **w** equals **3.6** cm and **L** equals **0.6** cm.

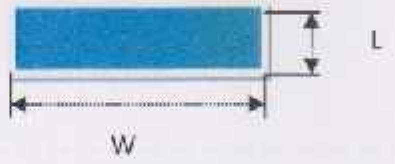


Figure 2.17 – Cell Dimension

2.2.2.2 Theoretical Analysis

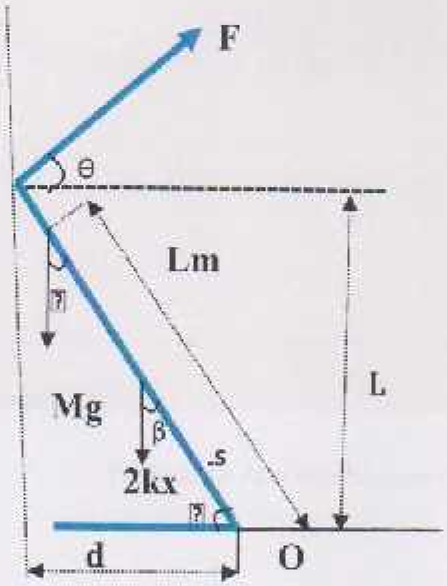


Figure 2.18 – Free Body Diagram of the Arm

$$\sum M_o = J\ddot{\emptyset} \quad (18)$$

$$Fl\cos\theta + Fd\sin\theta - mgl_m\sin\varphi - 2kxl_s\sin\beta = J\ddot{\emptyset} \quad (19)$$

Quantity	Value
M :the mass of the link	100 gm
K : stiffness of the springs	90 N/m
L	5.5 cm
Lm	4.3 cm
Ls	3 cm
D	2.4 cm

Table 2.2 – Arm Mechanism Quantity

$$F = \frac{J\ddot{\theta}+mgl_m sin\varphi+2kxl_s sin\beta}{lcos\theta+dsin\theta} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (20)$$

But we want to find the force in the term of T_m, the figure below shows the force applied on the motor.

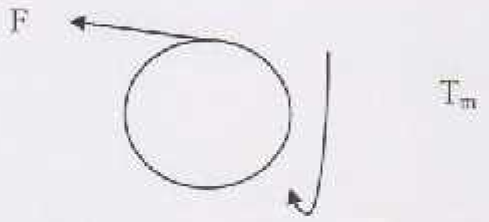


Figure 2.19 – Free Body Diagram of the Motor

$$\sum M_o = J\ddot{\emptyset} \quad (21)$$

$$T_m - FL = J_m\ddot{\emptyset} \quad (22)$$

But the inertia of the motor is very small so

$$T_m = FL \quad (23)$$

$$T_m = \frac{l(J\ddot{\emptyset} + mgl_m sin\varphi + 2kxl_s sin\beta)}{lcos\theta + dsin\theta} \quad (24)$$

Chapter Three

Electrical and Computer System

3.1 Introduction

3.2 Selection of Motors

3.3 Drive Circuit

3.4 Project Safety

Chapter Three

Electrical and Computer System

3.1 Introduction

As a mechatronics system and as provided in the title of this project, the system is powered assisted, and according to that , there will be electrical part; either provides input signal or receive output signal from the control system

Figure 3.1 –Integration between many systems that resulted in automotive mechatronics connection

This chapter will discuss the process of designing the needed electrical parts to operate the system. These parts include electrical motors, drive circuit of the project, we will discuss the control of the project by using PIC microcontroller and how the PIC microcontroller connected to electrical part using the drive circuit, and we will discuss the component of the drive circuit.

The system includes three electrical motors to provide the needed motions. the first motor is to provide rotational motion to insert in and get out the cells from the glucose tester ,second one is to provide the translational motion to move the needle forward and reverse to take a sample of blood from the finger and measure the test, the third one is to lifting the arm up and down . These motions are constrained by a group of limit switches to control the motors.

The selection of the motors will be discussed, where the torques needed to rotate, translate will be determined to select the required motors specifications.

3.2 Selection of motors

As mentioned previously, the system requires three motors, for rotation and translation. These motors will be selected according to the needed torques and speeds.

3.2.1 Translational motion motor

The translational motor used to move the needle forward and reverse throughout two slide base connected with two pulleys, these pulleys are connected with belt to move the needle, the needle carried by fix arm, and the weights of the needle arm and the needle are distributed among these two slides equally. The value of these weights is 30g for needle arm and 10g for the needle.

$$T_m = J_{eq}\ddot{\theta} \qquad (1)$$

As calculation in chapter two the needed torque for translation motor is

$$T_m = 20 \times 3.23 \times 10^{-6} = 60.46 \times 10^{-6} N.m \qquad (2)$$

A suitable dc motor for a roller is used to provide the needed torque ,and its rated input voltage is 10V . See figure (3.2).

Figure 3.2- Translation Motor

The motors needs voltage source, and is fed from the drive circuit which will be discussed later in this chapter.

3.3 Drive Circuit

It consists of multiple components for multi task operation that has been discussed in the previous section. These components are will be discussed in the coming sections.

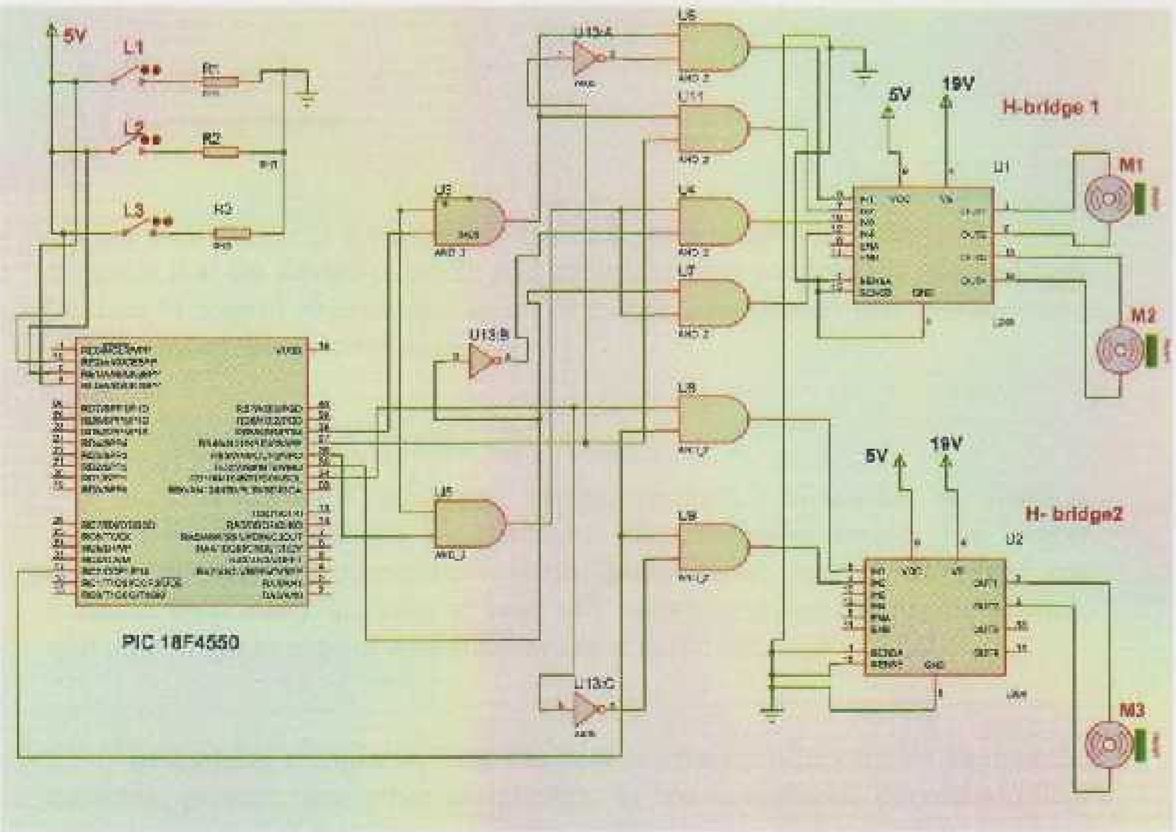


Figure 3.2 Drive Circuit of Microcontroller

Where:

M1= Needle motor
M2= Arm lifting motor
M3=Roller motor
L1, L2, L3 = limit switches

The above figure explains how the PIC microcontroller connected to the logic gates and to the electrical motors .we will discuss the drive circuit and the component of it in the coming section.

3.3.1 Microcontroller

A microcontroller is a computer-on-a-chip, or a single-chip computer. Micro suggests that the device is small, and controller tells you that the device might be used to control objects, processes, or events. Microcontrollers can be found in all kinds of things these days.

Any device that measures, stores, controls, calculates, or displays information is a candidate for putting a microcontroller inside. The largest single use for microcontrollers is in automobiles; just about every car manufactured today includes at least one microcontroller for engine control, and often more to control additional systems in the car.

In desktop computers, you can find microcontrollers inside keyboards, modems, printers, and other peripherals. In test equipment, microcontrollers make it easy to add features such as the ability to store measurements, to create and store user routines, and to display messages and waveforms. Consumer products that use microcontrollers include cameras, video recorders, compact-disk players, and ovens.
Microcontrollers have long been a convenient interface for the embedded systems; they represent the core of the control system for the electronic devices in dedicated applications.

Thus, in contrast the microprocessors that are used in general purpose applications like personal computers that need high-performance. Microcontrollers contain data and program memory, serial and parallel I/O, timers, and external and internal interrupts, and many more peripherals, made them a strong choice when implementing control systems.

PWM is an important property in the microcontroller which used her to control the voltage that drives the motor; the PWM mode produces a PWM output at 10 bit resolution. A PWM output is basically a square waveform with a specified period and duty cycle.

as shown in figure 3.4 Duty cycle describes the proportion of on time to the regular interval or period of time, a low duty cycle corresponds to low power, because the power is off for most of the time. Duty cycle is expressed in percent, 100% being fully on.

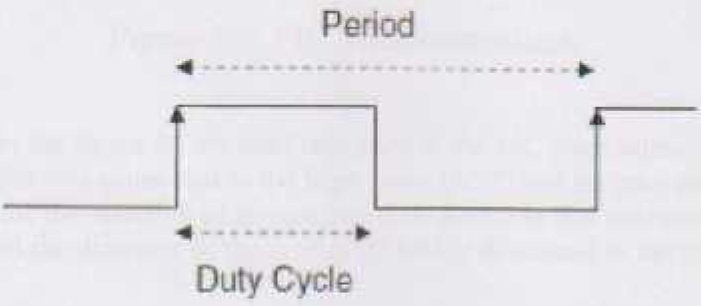


Figure 3.4- PWM shape

PWM period *formula:*

$$Period = ((1/Frequency)/4 \times (1/F_{osc}) \times Timer2\ Prescaler) - 1$$

Period = ((1/20 x 103)/4 x (1/8 x 106) x 1)-1

Period = 99 sec.

(More information about PIC 18F4550 microcontroller in appendix A)

In our project The PIC microcontroller (PIC 18F4550) from Microchip is found easily, and has a lot of ports (port A, B, C, D and E), can be programmed simply and it gives all characteristics that the project needs, the PIC 18F4550 and all of the ports shown in the drive circuit in figure 3.2

Figure 3.3- PIC Microcontrollers.

As shown in the figure 3.2 we used two ports in the PIC microcontroller the first port is port B that was connected to the logic gates (AND and inverter gates), these gates are used for the selection of motors and their direction that connected to H bridge to control the direction of the motors (H bridge discussed in the coming section).

The second port is port A that was connected to the limit switches and to the push button .In PIC 18F4550 there are two PWM (pulse with modulation) to operate the motors : the first PWD connected to the two motors (the motor of the needle and the arm lifting motor), and the second PWM connected to the motor of roller.

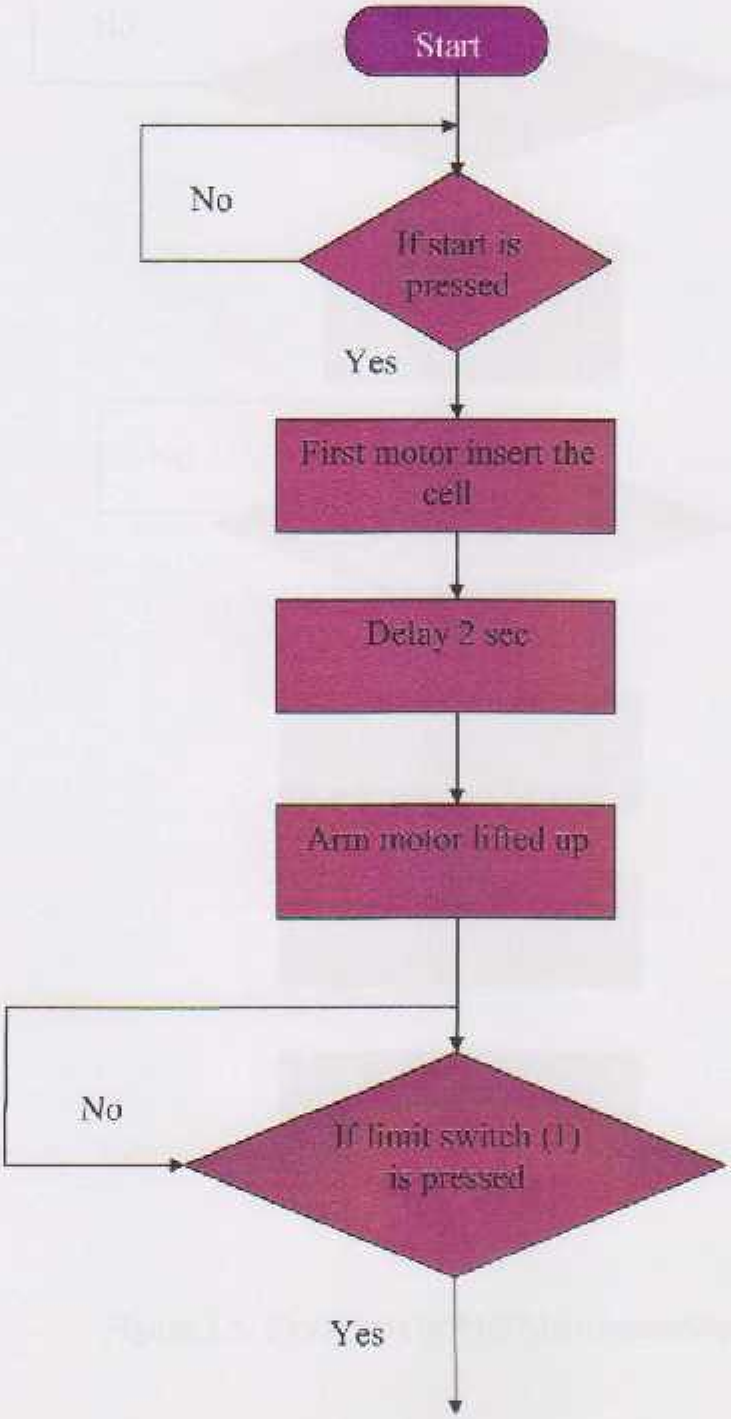
3.3.1.1 PIC programming

Programming PIC microcontrollers is done in three steps process: writing the code, compiling the code, and uploading the code into a microcontroller.

We programmed the operation of project in MPLAB IDE program, using C language (The program code of the project in the appendix A).

The First step of the program is to write the code of the roller to insert the cell in glucose tester, then the code of the arm mechanism that lifted up and down, finally we wrote the code of the needle mechanism.

The flowchart of the code that was written is shown in figure 3.5



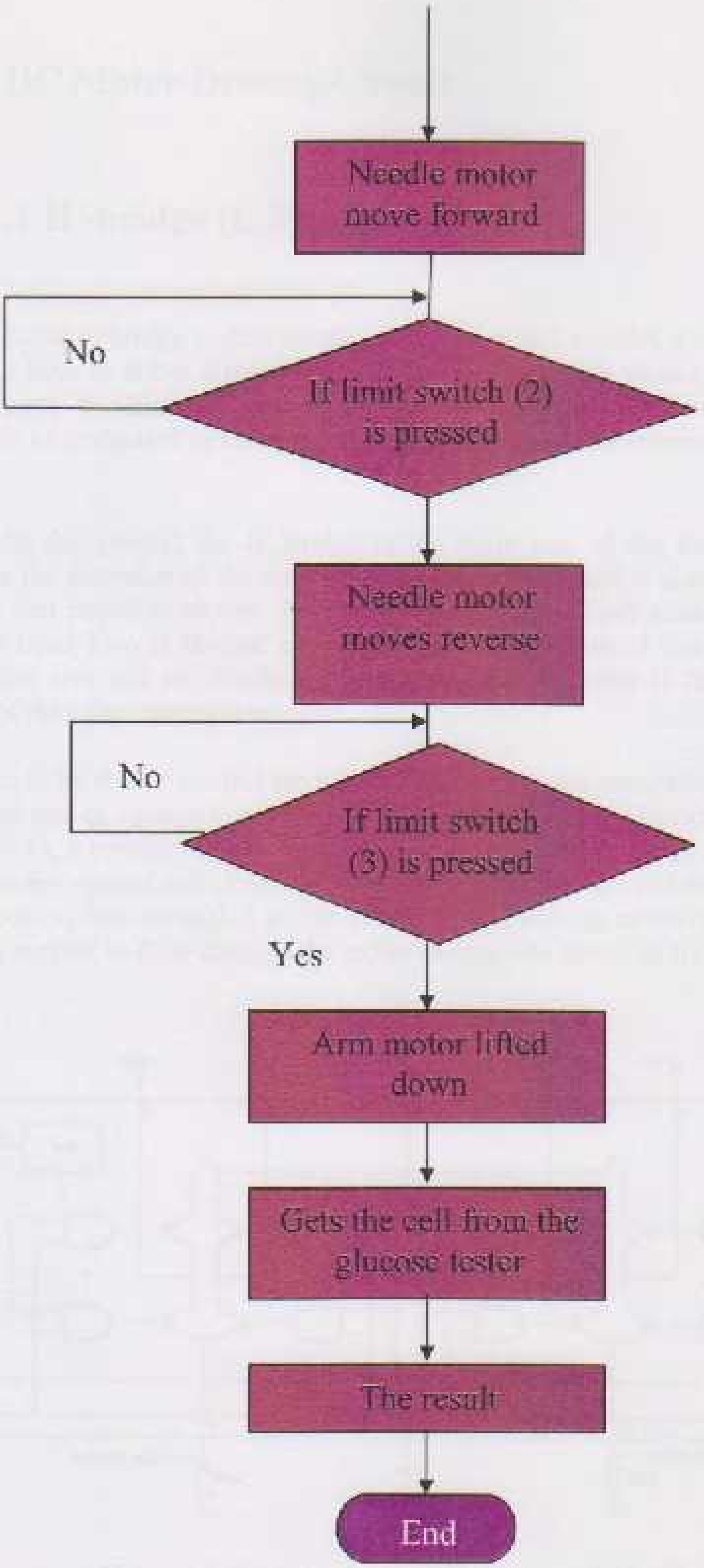


Figure 3.5- Flowchart of PIC Microcontroller Code

3.3.2 DC Motor Driving Circuit

3.3.2.1 H -bridge (L 298)

L298 H-bridge is dual electronic circuit which enables a voltage to be applied across a load in either direction. These circuits are often used in robotics and other applications to allow DC motors to run forwards and backwards. H-bridges are available as integrated circuits or can be built from discrete components.

In this project the H Bridge is the main part of the drive circuit where it controls the direction of the motors in both directions, and it also controls the rate of voltage that passes to motors. In order to operate the overall system at the same time, we will need Two H Bridge: one to control the direction of two motors (motors for lifting the arm and the needle mechanisms), and the other H Bridge to control the motor of the roller mechanism.

And to be able to control the direction of each motor separately (cw or ccw) and rate of voltage transmitted to each motor, LM298 H-bridge is used, see figure (3.6), it consists of four switches connected in the topology of H. Where all switches are opened and closed so as to put a voltage of one polarity across the motor for current to flow through it in one direction, or a voltage of the opposite direction, causing current to flow through the motor in opposite direction for reverse rotation.

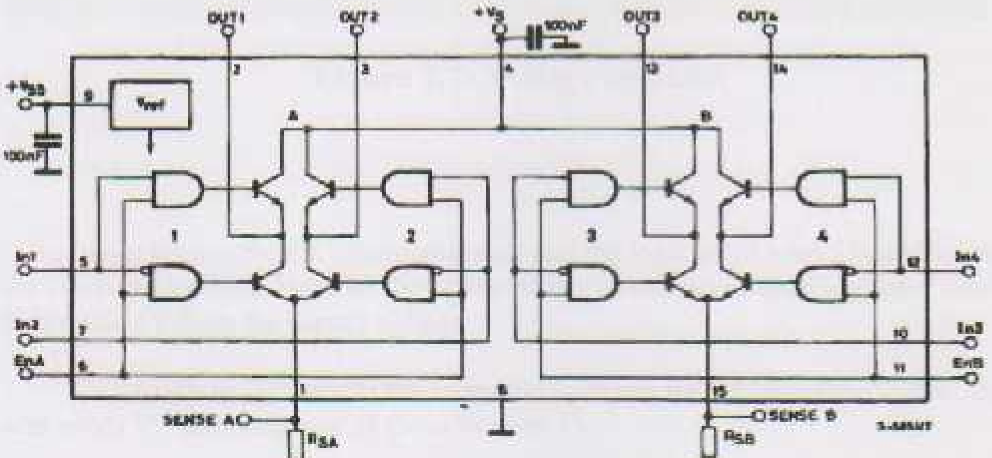


Figure 3.6 - Connection Diagram of H –Bridge

The H-bridge is supplied with two voltages, one is 5v used to run the H-bridge and the other is19 v used to supply voltage for the motors, and also it has an enable signal that enables or disables it.

3.3.3 Voltage Regulator:

A voltage regulator is an electrical component designed to automatically maintain a constant voltage level.

It may be used in electromechanical mechanism, or passive and active electronic components. Depending on the design, it may be used to regulate DC voltages.

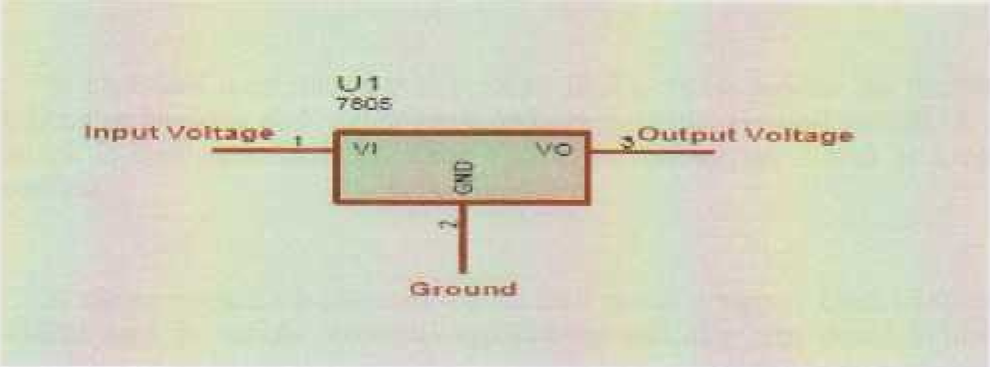


Figure 3.7- Voltage regulator

In our project the PIC microcontroller and the logic gates need 5V, and to enable the H Bridge we need 5V from the power supply so that the voltage regulator needed to provide 5V from the supply voltage.

We have three DC motors with variable voltages: the motors of the needle, the arm needs 9V and the motor of the cells need 5V.

Since the supply voltage provides 19V and the motors need 9V and 5V so that the regulator is required to reduce the voltage. There are two types of regulator, the first is constant (5V) and the other is variable. We chose (E7805CV) regulator with constant 5V, whereas the voltage of the other motors is controlled by the microcontroller.

Features:

- Output current up to 1.5 A
- Output voltages of 5; 6; 8; 8.5; 9; 12; 15; 18;24 V
- Short circuit protection

(More information about regulator in appendix B)

3.3.4 Limit Switches:

Switches are commonly employed as input devices to indicate the presence or absence of a particular condition in a system or process that is being monitored and/or controlled.

In motorized electromechanical systems, limit switches provide the function of making or breaking electrical contacts and consequently electrical circuits. A limit switch is configured to detect when a system's element has moved to a certain position.

A system operation is triggered when a limit switch is tripped. Limit switches are widely used in various industrial applications, and they can detect a limit of movement of an article and passage of an article by displacement of an actuating part such as a pivotally supported arm or a linear plunger. The limit switches are designed to control the movement of a mechanical part. Limit switches are typically utilized in industrial control applications to automatically monitor and indicate whether the travel limits of a particular device have been exceeded.

In our project as we discussed in chapter two there are three limit switches to control the machine: one to enable the motor of the needle and the second limit switch to reverse the direction of the motor when the needle pricks the finger to take a sample of blood to measure the test. The Third one is to stop the motor.

Figure 3.8 - Limit Switch

3.3.5 Power supply (19V)

A device or system that supplies electrical or other types of energy to an output load or group of loads is called a **power supply unit** or **PSU**. The term is most commonly applied to electrical energy supplies, less often to mechanical ones, and rarely to others.

Figure 3.9- Supply voltage

3.3.6 Logic gates:

We used two logic gates to connect the circuit to the PIC microcontroller ,these logic gates consist of two IC's, the first one is 7408 AND gate and the second is 7404 INVERTER gate, where the AND gate receives the PWM and direction signals from the PIC and passes them to the H-bridge.

The AND gate is an electronic circuit that gives a **high** output (1) only if **all its inputs** are high.

Figure 3.10 - AND gate

Figure 3.11- Inverter gate

(Information about AND gate and inverter gate in appendix C)

3.4 project safety

As mentioned in chapter one, the project purpose is to help the elder and blind people to measure the glucose level in a blood, so that the project is medical project that interact with human so that the safety is an important field in the project. In this section we discuss many sides of safety for the users in the project.

After the user presses on the push button, the needle can't prick the finger before the user press on the limit switch, and the finger placed on the suitable place. When the needle pricks the finger, the other limit switch reverses the direction of the needle motor directly when the needle is 2mm inside the finger, the directly of reversing the direction of motor is one of example of safety on the mechanism of needle. The other side of safety is to overcome the inertia of needle motor by placing the limit switch on distance of 2mm from the finger, this distance is enough to prevent the effect of inertia on the finger. As we see in figure 3.12.

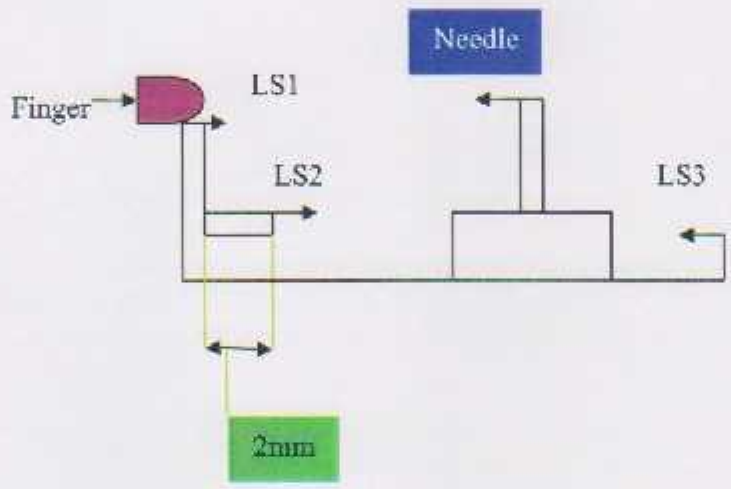


Figure 3.12- Needle mechanism

Where:

LS1, LS2, LS3 = limit switches

As shown in the above figure, the distance between the finger and the limit switch (LS2) is 2mm, so that we make sure that there is no effect from the inertia of motor on the finger. This is another side of safety in the project and it is considered the most important part that we have covered.

Chapter Four

Results and Recommendations

4.1 Introduction

This chapter contains the results that are obtained from making experiment for a person that uses the machine to measure the glucose level, this experiment was done to verify the designs and implementation of mechanical, electrical, and control design.

A group of recommendations are provided to enhance the performance of the project. Also the problems that faced the working team will be discussed.

4.2 Practical results

4.1.1 Practical mechanical structure

As discussed in chapter two the mechanical parts that are designed to be used in building the system are completely formed and used as it's designed. The following figures show practical pictures for mechanical parts, which are used in the mechanisms of the project.

The roller and lifting arm motors shown in figure (4.1) where the roller connected to the movable arm uses to insert the cell inside the glucose tester, when the operation completed the roller uses to draw the cell out side the glucose tester.

Figure 4.1 – Roller and Movable Arm

As shown in figure (4.1) the arm lifting up after the cell inserted in the glucose tester Until the person put his finger inside the machine as shown in figure (4.2)

Figure 4.2 – Needle Pricks the Finger

The needle mechanism shown in figure (4.2) when the person put his finger, the needle move with high speed and pricks the finger to take a sample of blood on the cell and measure the glucose level. As said above the roller draw the cell after completed the test.

4.1.2 Practical electrical structure

After finishing the assembly of mechanical parts, the electrical parts are provide the safety factor to the system and to operate and control the motors.

As discussed in chapter three, there are three motors to move and rotate the mechanisms, motor of lifting arm, needle motor, and the motor for the roller. The three motors shown in the figures in section 3.2.

There are three limit switches to control the system, as shown in the figure 4.2

As we discussed in chapter two the first limit switch using for moving the needle mechanism and the others limit switches use to control the direction of the motor.

4.1.3 Electronic circuit implementation

The figure (4.3) shown the PIC microcontroller connected to the drive circuit . As discussed in chapter three and shown in figure (4.5) the PIC microcontroller connected with logic gates , H-bridge, regulators, and power supply. These components were discussed in chapter three.

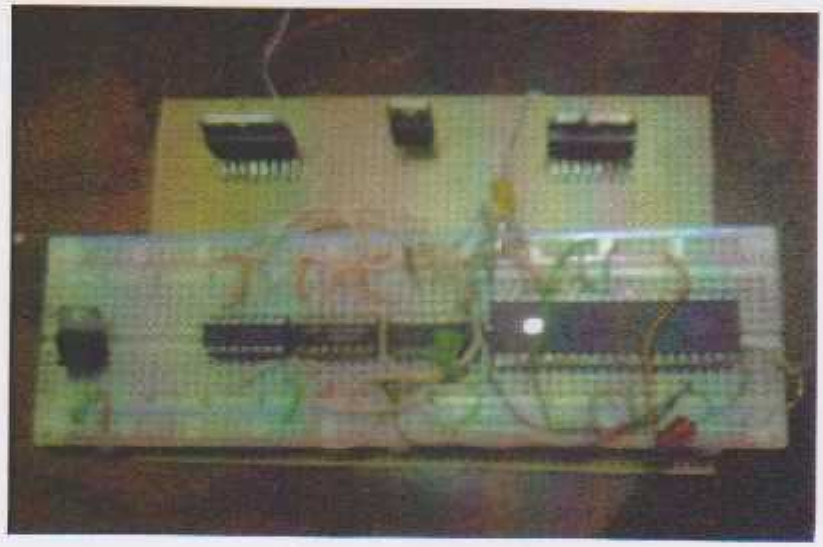


Figure 4.3 – Electrical Circuit

4.3 problems and recommendations

During the practical working, a lot of problems faced the working team throughout all the project stages. The first problem was in building the structure and designing the mechanical components because of the dimensions of the mechanical parts were very small such as the cells container.

The second problem was uncontrolling the cells when they were inserted in the glucose tester using the logic control (limit switch) because of the complexity of the internal structure of the glucose tester, and there was no full information about the glucose tester.

We recommend developing the system to be fully controlled and using position control to control the needle when it moves to pricks the finger since this control is used to improve the safety in the project. And we recommend using the machine in hospitals not just at home.

Appendix A

PIC18F4550 Microcontroller

Datasheet & C Code

MICROCHIP PIC18F2455/2550/4455/4550

28/40/44-Pin, High-Performance, Enhanced Flash, USB Microcontrollers with nanoWatt Technology

Universal Serial Bus Features:

- USB V2.0 Compliant
- Low Speed (1.5 Mb/s) and Full Speed (12 Mb/s)
- Supports Control, Interrupt, Isochronous and Bulk Transfers
- Supports up to 32 Endpoints (16 bidirectional)
- 1-Kbyte Dual Access RAM for USB
- On-Chip USB Transceiver with On-Chip Voltage Regulator
- Interface for Off-Chip USB Transceiver
- Streaming Parallel Port (SPP) for USB streaming transfers (40/44-pin devices only)

Power-Managed Modes:

- Run: CPU on, peripherals on
- Idle: CPU off, peripherals on
- Sleep: CPU off, peripherals off
- Idle mode currents down to 5.8 µA typical
- Sleep mode currents down to 0.1 µA typical
- Timer1 Oscillator: 1.1 µA typical, 32 kHz, 2V
- Watchdog Timer: 2.1 µA typical
- Two-Speed Oscillator Start-up

Flexible Oscillator Structure:

- Four Crystal modes, including High Precision PLL for USB
- Two External Clock modes, up to 48 MHz
- Internal Oscillator Block:
  - 8 user-selectable frequencies, from 31 kHz to 8 MHz
  - User-tunable to compensate for frequency drift
- Secondary Oscillator using Timer1 @ 32 kHz
- Dual Oscillator options allow microcontroller and USB module to run at different clock speeds
- Fail-Safe Clock Monitor:
  - Allows for safe shutdown if any clock stops

Peripheral Highlights:

- High-Current Sink/Source: 25 mA/25 mA
- Three External Interrupts
- Four Timer modules (Timer0 to Timer3)
- Up to 2 Capture/Compare/PWM (CCP) modules:
  - Capture is 16-bit, max. resolution 5.2 ns ($T_{CY}/16$)
  - Compare is 16-bit, max. resolution 83.3 ns (T_{CY})
  - PWM output: PWM resolution is 1 to 10-bit
- Enhanced Capture/Compare/PWM (ECCP) module:
  - Multiple output modes
  - Selectable polarity
  - Programmable dead time
  - Auto-shutdown and auto-restart
- Enhanced USART module:
  - LIN bus support
- Master Synchronous Serial Port (MSSP) module supporting 3-wire SPI (all 4 modes) and I²C™ Master and Slave modes
- 10-bit, up to 13-channel Analog-to-Digital Converter module (A/D) with Programmable Acquisition Time
- Dual Analog Comparators with Input Multiplexing

Special Microcontroller Features:

- C Compiler Optimized Architecture with optional Extended Instruction Set
- 100,000 Erase/Write Cycle Enhanced Flash Program Memory typical
- 1,000,000 Erase/Write Cycle Data EEPROM Memory typical
- Flash/Data EEPROM Retention: > 40 years
- Self-Programmable under Software Control
- Priority Levels for Interrupts
- 8 x 8 Single-Cycle Hardware Multiplier
- Extended Watchdog Timer (WDT):
  - Programmable period from 41 ms to 131s
- Programmable Code Protection
- Single-Supply 5V In-Circuit Serial Programming™ (ICSP™) via two pins
- In-Circuit Debug (ICD) via two pins
- Optional dedicated ICD/ICSP port (44-pin devices only)
- Wide Operating Voltage Range (2.0V to 5.5V)

Device	Program Memory		Data Memory		I/O	10-Bit A/D (ch)	CCP/ECCP (PWM)	SPP	MSSP		EAUSART	Comparators	Timers 8/16-Bit
	Flash (bytes)	# Single-Word Instructions	SRAM (bytes)	EEPROM (bytes)					SPI	Master I²C™			
PIC18F2455	24K	12288	2048	256	24	10	2/0	No	Y	Y	1	2	1/3
PIC18F2550	32K	16384	2048	256	24	10	2/0	No	Y	Y	1	2	1/3
PIC18F4455	24K	12288	2048	256	35	13	1/1	Yes	Y	Y	1	2	1/3
PIC18F4550	32K	16384	2048	256	35	13	1/1	Yes	Y	Y	1	2	1/3

TABLE 1-3: PIC18F4455/4550 PINOUT I/O DESCRIPTIONS

Pin Name	Pin Number			Pin Type	Buffer Type	Description
	PDIP	QFN	TQFP			
$\overline{MCLR}$/VPP/RE3	1	18	18			Master Clear (input) or programming voltage (input).
$\overline{MCLR}$				I	ST	Master Clear (Reset) input. This pin is an active-low Reset to the device.
VPP				P		Programming voltage input.
RE3				I	ST	Digital input.
OSC1/CLKI	13	32	30			Oscillator crystal or external clock input.
OSC1				I	Analog	Oscillator crystal input or external clock source input.
CLKI				I	Analog	External clock source input. Always associated with pin function OSC1. (See OSC2/CLKO pin.)
OSC2/CLKO/RA6	14	33	31			Oscillator crystal or clock output.
OSC2				O	—	Oscillator crystal output. Connects to crystal or resonator in Crystal Oscillator mode.
CLKO				O	—	In RC mode, OSC2 pin outputs CLKO which has 1/4 the frequency of OSC1 and denotes the instruction cycle rate.
RA6				I/O	TTL	General purpose I/O pin.

Legend: TTL = TTL compatible input; CMOS = CMOS compatible input or output; ST = Schmitt Trigger input with CMOS levels; I = Input; O = Output; P = Power

Note 1: Alternate assignment for CCP2 when CCP2MX Configuration bit is cleared.
2: Default assignment for CCP2 when CCP2MX Configuration bit is set.
3: These pins are No Connect unless the $\overline{ICPRT}$ Configuration bit is set. For NC/ICPORTS, the pin is No Connect unless ICPRT is set and the $\overline{DEBUG}$ Configuration bit is cleared.

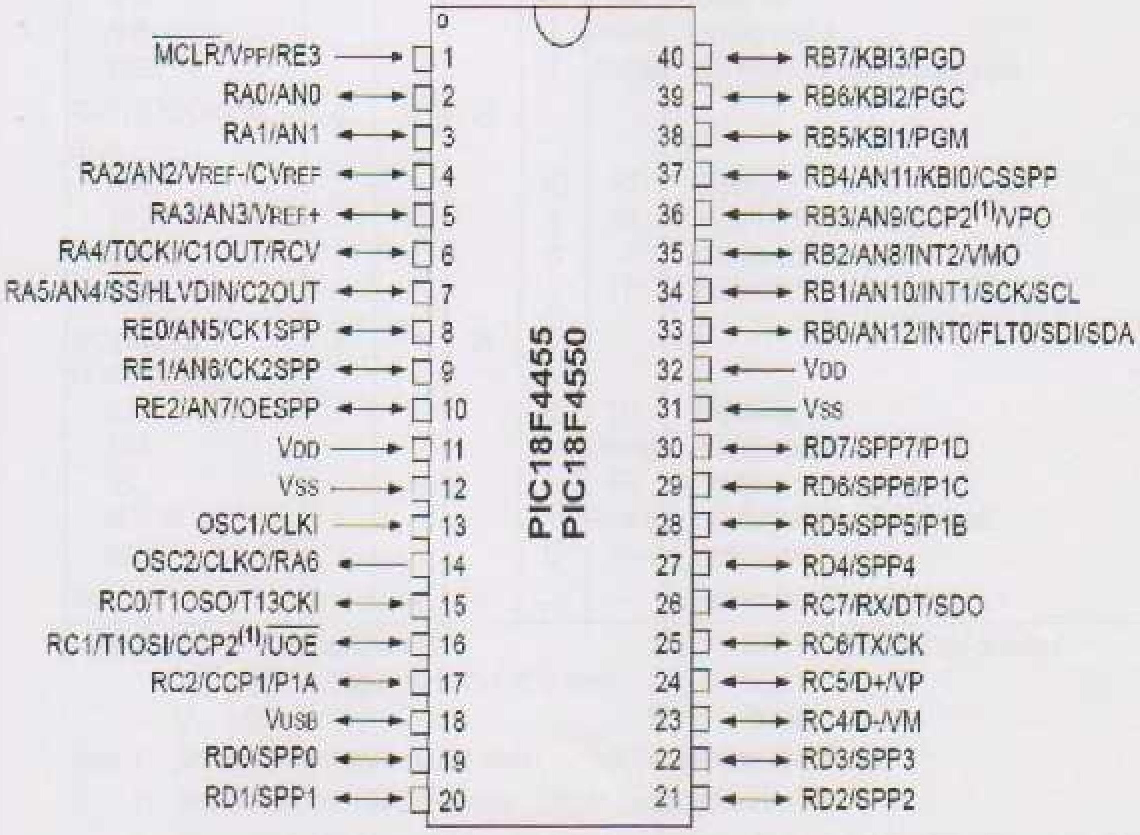


TABLE 1-3: PIC18F4455/4550 PINOUT I/O DESCRIPTIONS (CONTINUED)

Pin Name	Pin Number			Pin Type	Buffer Type	Description
	PDIP	QFN	TQFP			
						PORTA is a bidirectional I/O port.
RA0/AN0	2	19	19			
RA0				I/O	TTL	Digital I/O.
AN0				I	Analog	Analog input 0.
RA1/AN1	3	20	20			
RA1				I/O	TTL	Digital I/O.
AN1				I	Analog	Analog input 1.
RA2/AN2/VREF-/CVREF	4	21	21			
RA2				I/O	TTL	Digital I/O.
AN2				I	Analog	Analog input 2.
VREF-				I	Analog	A/D reference voltage (low) input.
CVREF				O	Analog	Analog comparator reference output.
RA3/AN3/VREF+	5	22	22			
RA3				I/O	TTL	Digital I/O.
AN3				I	Analog	Analog input 3.
VREF+				I	Analog	A/D reference voltage (high) input.
RA4/T0CKI/C1OUT/RCV	6	23	23			
RA4				I/O	ST	Digital I/O.
T0CKI				I	ST	Timer0 external clock input.
C1OUT				O	—	Comparator 1 output.
RCV				I	TTL	External USB transceiver RCV input.
RA5/AN4/$\overline{SS}$/HLVDIN/C2OUT	7	24	24			
RA5				I/O	TTL	Digital I/O.
AN4				I	Analog	Analog input 4.
$\overline{SS}$				I	TTL	SPI slave select input.
HLVDIN				I	Analog	High/Low-Voltage Detect input.
C2OUT				O	—	Comparator 2 output.
RA6	—	—	—	—	—	See the OSC2/CLKO/RA6 pin.

Legend: TTL = TTL compatible input; CMOS = CMOS compatible input or output; ST = Schmitt Trigger input with CMOS levels; I = Input; O = Output; P = Power

Note 1: Alternate assignment for CCP2 when CCP2MX Configuration bit is cleared.

2: Default assignment for CCP2 when CCP2MX Configuration bit is set.

3: These pins are No Connect unless the ICPRT Configuration bit is set. For NC/ICPORTS, the pin is No Connect unless ICPRT is set and the $\overline{DEBUG}$ Configuration bit is cleared.

TABLE 1-3: PIC18F4455/4550 PINOUT I/O DESCRIPTIONS (CONTINUED)

Pin Name	Pin Number			Pin Type	Buffer Type	Description
	PDIP	QFN	TQFP			
						PORTB is a bidirectional I/O port. PORTB can be software programmed for internal weak pull-ups on all inputs.
RB0/AN12/INT0/FLT0/SDI/SDA	33	9	8			
RB0				I/O	TTL	Digital I/O.
AN12				I	Analog	Analog input 12.
INT0				I	ST	External interrupt 0.
FLT0				I	ST	Enhanced PWM Fault input (ECCP1 module).
SDI				I	ST	SPI data in.
SDA				I/O	ST	I^2C™ data I/O.
RB1/AN10/INT1/SCK/SCL	34	10	9			
RB1				I/O	TTL	Digital I/O.
AN10				I	Analog	Analog input 10.
INT1				I	ST	External interrupt 1.
SCK				I/O	ST	Synchronous serial clock input/output for SPI mode.
SCL				I/O	ST	Synchronous serial clock input/output for I^2C mode.
RB2/AN8/INT2/VMO	35	11	10			
RB2				I/O	TTL	Digital I/O.
AN8				I	Analog	Analog input 8.
INT2				I	ST	External interrupt 2.
VMO				O	—	External USB transceiver VMO output.
RB3/AN9/CCP2/VPO	36	12	11			
RB3				I/O	TTL	Digital I/O.
AN9				I	Analog	Analog input 9.
CCP2(1)				I/O	ST	Capture 2 input/Compare 2 output/PWM 2 output.
VPO				O	—	External USB transceiver VPO output.
RB4/AN11/KBI0/CSSPP	37	14	14			
RB4				I/O	TTL	Digital I/O.
AN11				I	Analog	Analog input 11.
KBI0				I	TTL	Interrupt-on-change pin.
CSSPP				O	—	SPP chip select control output.
RB5/KBI1/PGM	38	15	15			
RB5				I/O	TTL	Digital I/O.
KBI1				I	TTL	Interrupt-on-change pin.
PGM				I/O	ST	Low-Voltage ICSP™ Programming enable pin.
RB6/KBI2/PGC	39	16	16			
RB6				I/O	TTL	Digital I/O.
KBI2				I	TTL	Interrupt-on-change pin.
PGC				I/O	ST	In-Circuit Debugger and ICSP programming clock pin.
RB7/KBI3/PGD	40	17	17			
RB7				I/O	TTL	Digital I/O.
KBI3				I	TTL	Interrupt-on-change pin.
PGD				I/O	ST	In-Circuit Debugger and ICSP programming data pin.

Legend: TTL = TTL compatible input; CMOS = CMOS compatible input or output; ST = Schmitt Trigger input with CMOS levels; I = Input; O = Output; P = Power

Note 1: Alternate assignment for CCP2 when CCP2MX Configuration bit is cleared.

2: Default assignment for CCP2 when CCP2MX Configuration bit is set.

3: These pins are No Connect unless the ICPRT Configuration bit is set. For NC/ICPORTS, the pin is No Connect unless ICPRT is set and the $\overline{DEBUG}$ Configuration bit is cleared.

TABLE 1-3: PIC18F4455/4550 PINOUT I/O DESCRIPTIONS (CONTINUED)

Pin Name	Pin Number			Pin Type	Buffer Type	Description
	PDIP	QFN	TQFP			
						PORTD is a bidirectional I/O port or a Streaming Parallel Port (SPP). These pins have TTL input buffers when the SPP module is enabled.
RD0/SPP0	19	38	38			
RD0				I/O	ST	Digital I/O.
SPP0				I/O	TTL	Streaming Parallel Port data
RD1/SPP1	20	39	39			
RD1				I/O	ST	Digital I/O.
SPP1				I/O	TTL	Streaming Parallel Port data
RD2/SPP2	21	40	40			
RD2				I/O	ST	Digital I/O.
SPP2				I/O	TTL	Streaming Parallel Port data.
RD3/SPP3	22	41	41			
RD3				I/O	ST	Digital I/O.
SPP3				I/O	TTL	Streaming Parallel Port data.
RD4/SPP4	27	2	2			
RD4				I/O	ST	Digital I/O.
SPP4				I/O	TTL	Streaming Parallel Port data.
RD5/SPP5/P1B	28	3	3			
RD5				I/O	ST	Digital I/O.
SPP5				I/O	TTL	Streaming Parallel Port data.
P1B				O	—	Enhanced CCP1 PWM output, channel B.
RD6/SPP6/P1C	29	4	4			
RD6				I/O	ST	Digital I/O.
SPP6				I/O	TTL	Streaming Parallel Port data.
P1C				O	—	Enhanced CCP1 PWM output, channel C.
RD7/SPP7/P1D	30	5	5			
RD7				I/O	ST	Digital I/O.
SPP7				I/O	TTL	Streaming Parallel Port data.
P1D				O	—	Enhanced CCP1 PWM output, channel D.

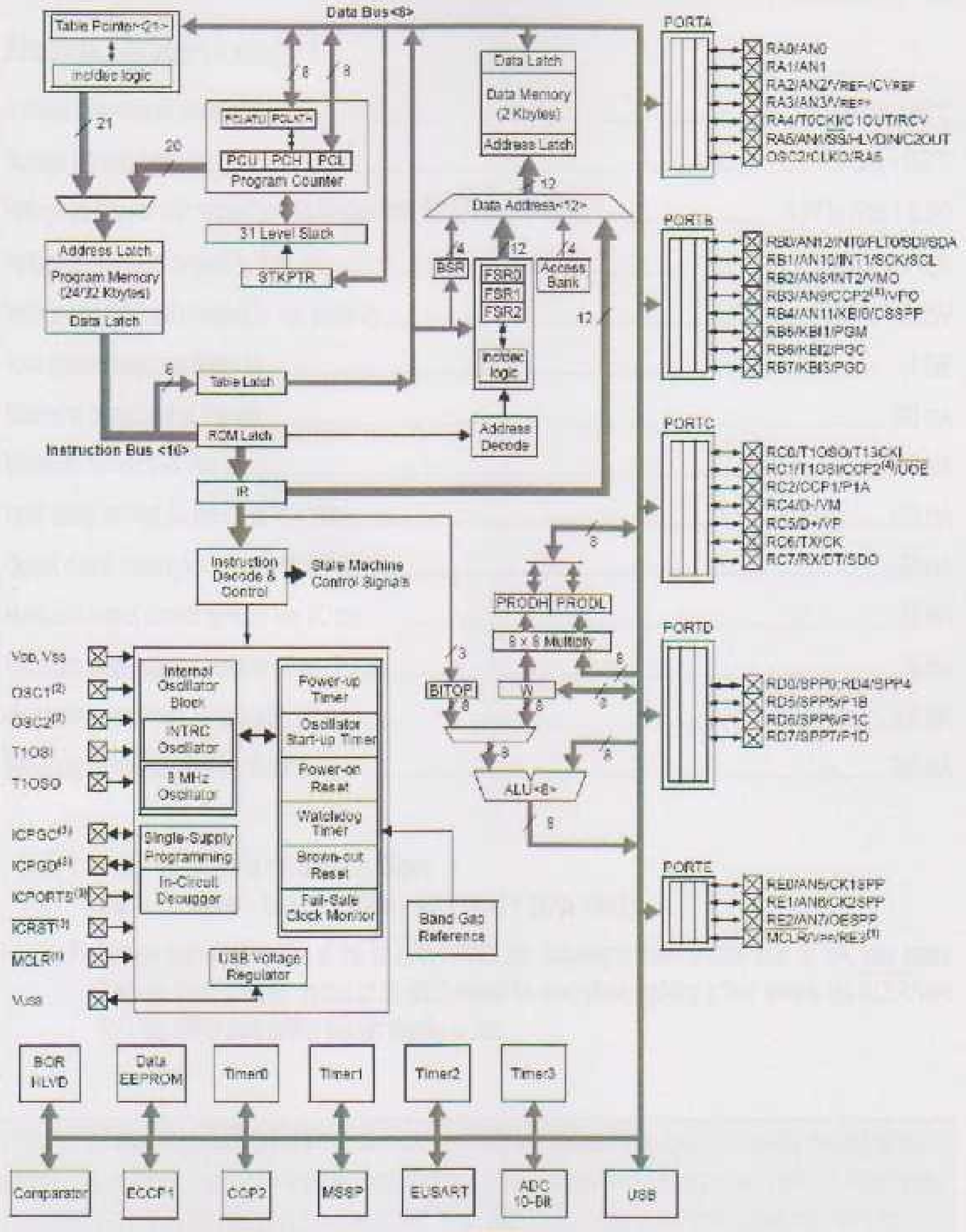
Legend: TTL = TTL compatible input; CMOS = CMOS compatible input or output; ST = Schmitt Trigger input with CMOS levels; I = Input; O = Output; P = Power

Note 1: Alternate assignment for CCP2 when CCP2MX Configuration bit is cleared.

2: Default assignment for CCP2 when CCP2MX Configuration bit is set.

3: These pins are No Connect unless the ICPRT Configuration bit is set. For NC/ICPORTS, the pin is No Connect unless ICPRT is set and the DEBUG Configuration bit is cleared.

FIGURE 1-2: PIC18F4455/4550 (40/44-PIN) BLOCK DIAGRAM



Note 1: RE3 is multiplexed with $\overline{MCLR}$ and is only available when the $\overline{MCLR}$ Resets are disabled.

2: OSC1/CLKI and OSC2/CLKO are only available in select oscillator modes and when these pins are not being used as digital I/O. Refer to **Section 2.0 "Oscillator Configurations"** for additional information.

3: These pins are only available on 44-pin TQFP packages under certain conditions. Refer to **Section 25.9 "Special ICPORT Features (Designated Packages Only)"** for additional information.

4: RE3 is the alternate pin for CCP2 multiplexing.

28.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings(†)

Ambient temperature under bias	-40°C to +85°C
Storage temperature	-65°C to +150°C
Voltage on any pin with respect to V_{SS} (except V_{DD}, $\overline{MCLR}$ and RA4)	-0.3V to (V_{DD} + 0.3V)
Voltage on V_{DD} with respect to V_{SS}	-0.3V to +7.5V
Voltage on $\overline{MCLR}$ with respect to V_{SS} **(Note 2)**	0V to +13.25V
Total power dissipation **(Note 1)**	1.0W
Maximum current out of V_{SS} pin	300 mA
Maximum current into V_{DD} pin	250 mA
Input clamp current, I_{IK} ($V_I < 0$ or $V_I > V_{DD}$)	±20 mA
Output clamp current, I_{OK} ($V_O < 0$ or $V_O > V_{DD}$)	±20 mA
Maximum output current sunk by any I/O pin	25 mA
Maximum output current sourced by any I/O pin	25 mA
Maximum current sunk by all ports	200 mA
Maximum current sourced by all ports	200 mA

Note 1: Power dissipation is calculated as follows:
$P_{dis} = V_{DD} \times \{I_{DD} - \sum I_{OH}\} + \sum \{(V_{DD} - V_{OH}) \times I_{OH}\} + \sum(V_{OL} \times I_{OL})$

2: Voltage spikes below V_{SS} at the $\overline{MCLR}$/V_{PP}/RE3 pin, inducing currents greater than 80 mA, may cause latch-up. Thus, a series resistor of 50-100Ω should be used when applying a "low" level to the $\overline{MCLR}$/V_{PP}/RE3 pin, rather than pulling this pin directly to V_{SS}.

† **NOTICE:** Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress rating only and functional operation of the device at those or any other conditions above those indicated in the operation listings of this specification is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.

Control PIC Code Developed In C Programming Language

```
#include<p18f4550.h>
#include<timers.h>
#include<delays.h>
#include<pwm.h>

void main(void)
{
unsigned char state=0;
TRISBbits.TRISB0=0;// enable to arm H bridge
PORTBbits.RB0=1;
TRISBbits.TRISB1=1;//start push button
TRISBbits.TRISB2=0; // direction selection of arm motor(PWM2)
TRISBbits.TRISB3=0; // motor selection of arm motor (RB5=0)(PWM2)
PORTBbits.RB3=0;
TRISBbits.TRISB4=0;// motor direction selection of needle motor(PWM2)
TRISBbits.TRISB5=0;// motor selection of needle motor(RB3=0)(PWM2)
PORTBbits.RB5=0;
TRISBbits.TRISB6=0;// direction selection of wheel motor (PWM1)
TRISAbits.TRISA0=1;// LS1 (finger limit switch )
TRISAbits.TRISA1=1;// LS2
TRISAbits.TRISA2=1;// LS3
OpenTimer2( TIMER_INT_OFF &
T2_PS_1_1 &
T2_POST_1_1 );
OpenPWM1(99);
OpenPWM2(99);
SetDCPWM1(0);
SetDCPWM2(0);// all motors are in brake
while(1)
{
switch(state)
{
case 0:
PORTBbits.RB0=1;
SetDCPWM1(0);
SetDCPWM2(0);
while(PORTBbits.RB1==1);
while(PORTBbits.RB1==0);
state=1;
break;
case 1:
SetDCPWM1(200);// al SHAREHA motor
SetDCPWM2(0);// the other two motors is in brake
PORTBbits.RB6=1;//forward
Delay10KTCYx(200);//delay 1sec
state=2;
break;
```

```
case 2:
PORTBbits.RB0=1;//enable the arm H bridge
SetDCPWM1(0);
SetDCPWM2(200); //arm motor forward
PORTBbits.RB3=1;
PORTBbits.RB5=0;
PORTBbits.RB2=1;
Delay10KTCYx(200);//delay one second
state=3;
break;
case 3:
SetDCPWM1(0);
SetDCPWM2(0);// all motors are in brake
while(PORTAbits.RA0==1); //wait untill the user enters his/her finger
SetDCPWM2(200); //needle motor forward
PORTBbits.RB3=0;
PORTBbits.RB5=1;
PORTBbits.RB4=1;
while(PORTAbits.RA1==1);
PORTBbits.RB4=0;// revers needle
while(PORTAbits.RA2==1);
state =4;
break;
case 4:
SetDCPWM1(0);
SetDCPWM2(0);// all motors are in brake
PORTBbits.RB0=0;// disable the arm motor H bridge
Delay10KTCYx(200);//delay one second
SetDCPWM1(200);// al SHAREHA motor
SetDCPWM2(0);// the other two motors is in brake
PORTBbits.RB6=0;//revers
Delay10KTCYx(200);//delay 1sec
state=0;
break;
}
}

}
```

Appendix B

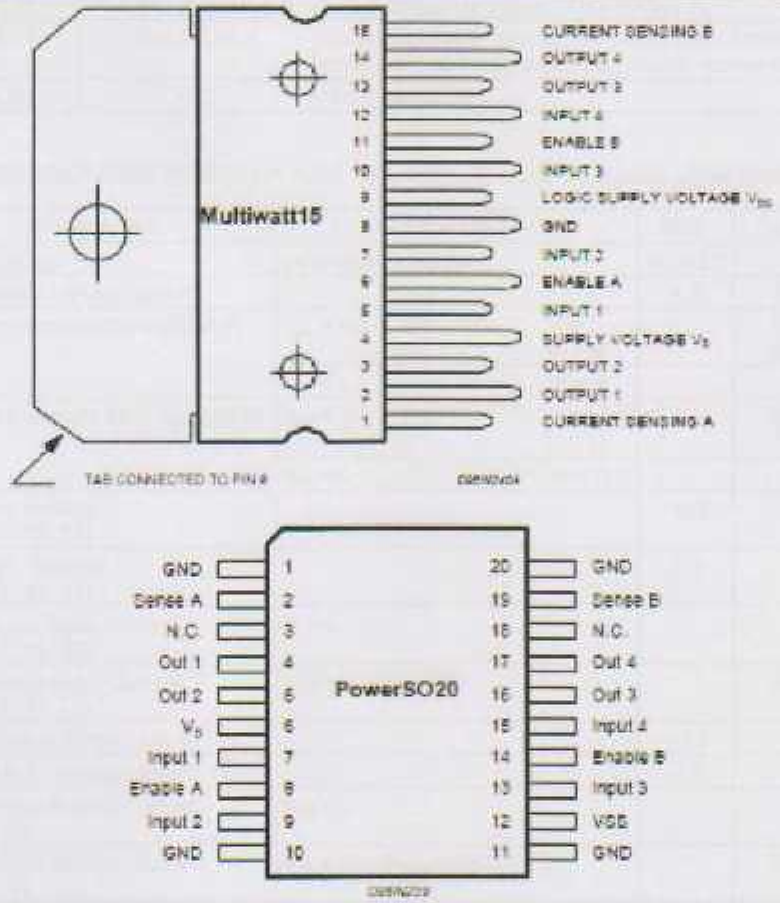
H – Bridge L298

Regulator KA7805

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_S	Power Supply	50	V
V_{SS}	Logic Supply Voltage	7	V
V_I, V_{en}	Input and Enable Voltage	–0.3 to 7	V
I_O	Peak Output Current (each Channel) – Non Repetitive (t = 100μs) –Repetitive (80% on –20% off; t_{on} = 10ms) –DC Operation	 3 2.5 2	 A A A
V_{sens}	Sensing Voltage	–1 to 2.3	V
P_{tot}	Total Power Dissipation (T_{case} = 75°C)	25	W
T_{op}	Junction Operating Temperature	–25 to 130	°C
T_{stg}, T_j	Storage and Junction Temperature	–40 to 150	°C

PIN CONNECTIONS (top view)



THERMAL DATA

Symbol	Parameter		PowerSO20	Multiwatt15	Unit
$R_{th\ j\text{-}case}$	Thermal Resistance Junction-case	Max.	–	3	°C/W
$R_{th\ j\text{-}amb}$	Thermal Resistance Junction-ambient	Max.	13 (*)	35	°C/W

(*) Mounted on aluminum substrate

PIN FUNCTIONS (refer to the block diagram)

MW.15	PowerSO	Name	Function
1;15	2;19	Sense A; Sense B	Between this pin and ground is connected the sense resistor to control the current of the load.
2;3	4;5	Out 1; Out 2	Outputs of the Bridge A; the current that flows through the load connected between these two pins is monitored at pin 1.
4	6	V_S	Supply Voltage for the Power Output Stages. A non-inductive 100nF capacitor must be connected between this pin and ground.
5;7	7;9	Input 1; Input 2	TTL Compatible Inputs of the Bridge A.
6;11	8;14	Enable A; Enable B	TTL Compatible Enable Input: the L state disables the bridge A (enable A) and/or the bridge B (enable B).
8	1,10,11,20	GND	Ground.
9	12	VSS	Supply Voltage for the Logic Blocks. A100nF capacitor must be connected between this pin and ground.
10; 12	13;15	Input 3; Input 4	TTL Compatible Inputs of the Bridge B.
13; 14	16;17	Out 3; Out 4	Outputs of the Bridge B. The current that flows through the load connected between these two pins is monitored at pin 15.
–	3;18	N.C.	Not Connected

ELECTRICAL CHARACTERISTICS (V_S = 42V; V_{SS} = 5V, T_j = 25°C; unless otherwise specified)

Symbol	Parameter	Test Conditions		Min.	Typ.	Max.	Unit
V_S	Supply Voltage (pin 4)	Operative Condition		V_{IH} +2.5		46	V
V_{SS}	Logic Supply Voltage (pin 9)			4.5	5	7	V
I_S	Quiescent Supply Current (pin 4)	V_{en} = H; I_L = 0	V_i = L V_i = H		13 50	22 70	mA mA
		V_{en} = L	V_i = X			4	mA
I_{SS}	Quiescent Current from V_{SS} (pin 9)	V_{en} = H; I_L = 0	V_i = L V_i = H		24 7	36 12	mA mA
		V_{en} = L	V_i = X			6	mA
V_{iL}	Input Low Voltage (pins 5, 7, 10, 12)			–0.3		1.5	V
V_{iH}	Input High Voltage (pins 5, 7, 10, 12)			2.3		VSS	V
I_{iL}	Low Voltage Input Current (pins 5, 7, 10, 12)	V_i = L				–10	µA
I_{iH}	High Voltage Input Current (pins 5, 7, 10, 12)	Vi = H ≤ V_{SS} –0.6V			30	100	µA
V_{en} = L	Enable Low Voltage (pins 6, 11)			–0.3		1.5	V
V_{en} = H	Enable High Voltage (pins 6, 11)			2.3		V_{SS}	V
I_{en} = L	Low Voltage Enable Current (pins 6, 11)	V_{en} = L				–10	µA
I_{en} = H	High Voltage Enable Current (pins 6, 11)	V_{en} = H ≤ V_{SS} –0.6V			30	100	µA
$V_{CEsat(H)}$	Source Saturation Voltage	I_L = 1A I_L = 2A		0.95	1.35 2	1.7 2.7	V V
$V_{CEsat(L)}$	Sink Saturation Voltage	I_L = 1A (5) I_L = 2A (5)		0.85	1.2 1.7	1.6 2.3	V V
V_{CEsat}	Total Drop	I_L = 1A (5) I_L = 2A (5)		1.80		3.2 4.9	V V
V_{sens}	Sensing Voltage (pins 1, 15)			–1 (1)		2	V

ELECTRICAL CHARACTERISTICS (continued)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
T_1 (V_i)	Source Current Turn-off Delay	0.5 V_i to 0.9 I_L (2); (4)		1.5		μs
T_2 (V_i)	Source Current Fall Time	0.9 I_L to 0.1 I_L (2); (4)		0.2		μs
T_3 (V_i)	Source Current Turn-on Delay	0.5 V_i to 0.1 I_L (2); (4)		2		μs
T_4 (V_i)	Source Current Rise Time	0.1 I_L to 0.9 I_L (2); (4)		0.7		μs
T_5 (V_i)	Sink Current Turn-off Delay	0.5 V_i to 0.9 I_L (3); (4)		0.7		μs
T_6 (V_i)	Sink Current Fall Time	0.9 I_L to 0.1 I_L (3); (4)		0.25		μs
T_7 (V_i)	Sink Current Turn-on Delay	0.5 V_i to 0.9 I_L (3); (4)		1.6		μs
T_8 (V_i)	Sink Current Rise Time	0.1 I_L to 0.9 I_L (3); (4)		0.2		μs
fc (V_i)	Commutation Frequency	I_L = 2A		25	40	KHz
T_1 (V_{en})	Source Current Turn-off Delay	0.5 V_{en} to 0.9 I_L (2); (4)		3		μs
T_2 (V_{en})	Source Current Fall Time	0.9 I_L to 0.1 I_L (2); (4)		1		μs
T_3 (V_{en})	Source Current Turn-on Delay	0.5 V_{en} to 0.1 I_L (2); (4)		0.3		μs
T_4 (V_{en})	Source Current Rise Time	0.1 I_L to 0.9 I_L (2); (4)		0.4		μs
T_5 (V_{en})	Sink Current Turn-off Delay	0.5 V_{en} to 0.9 I_L (3); (4)		2.2		μs
T_6 (V_{en})	Sink Current Fall Time	0.9 I_L to 0.1 I_L (3); (4)		0.35		μs
T_7 (V_{en})	Sink Current Turn-on Delay	0.5 V_{en} to 0.9 I_L (3); (4)		0.25		μs
T_8 (V_{en})	Sink Current Rise Time	0.1 I_L to 0.9 I_L (3); (4)		0.1		μs

1) 1)Sensing voltage can be –1 V for t ≤ 50 μsec; in steady state V_{sens} min ≥ – 0.5 V.
2) See fig. 2.
3) See fig. 4.
4) The load must be a pure resistor.

Figure 1 : Typical Saturation Voltage vs. Output Current.

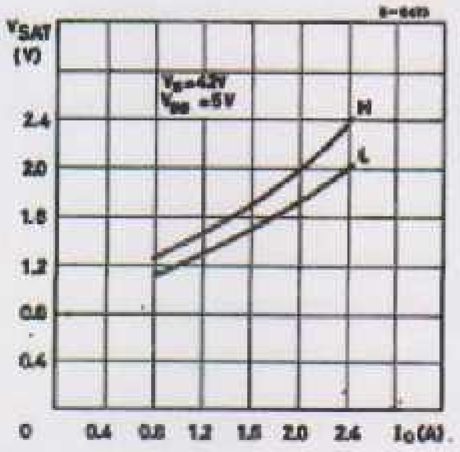
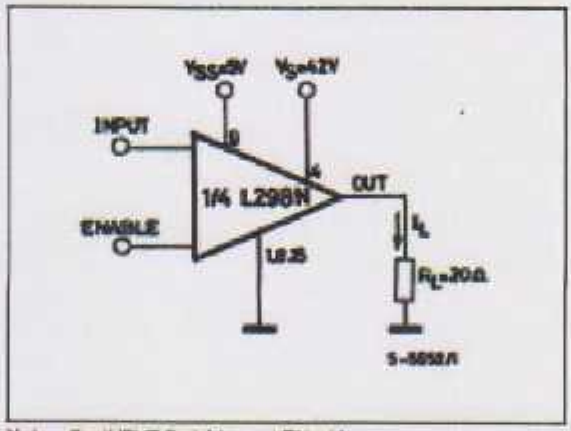


Figure 2 : Switching Times Test Circuits.



Note : For INPUT Switching, set EN = H
For ENABLE Switching, set IN = H

Figure 3 : Source Current Delay Times vs. Input or Enable Switching.

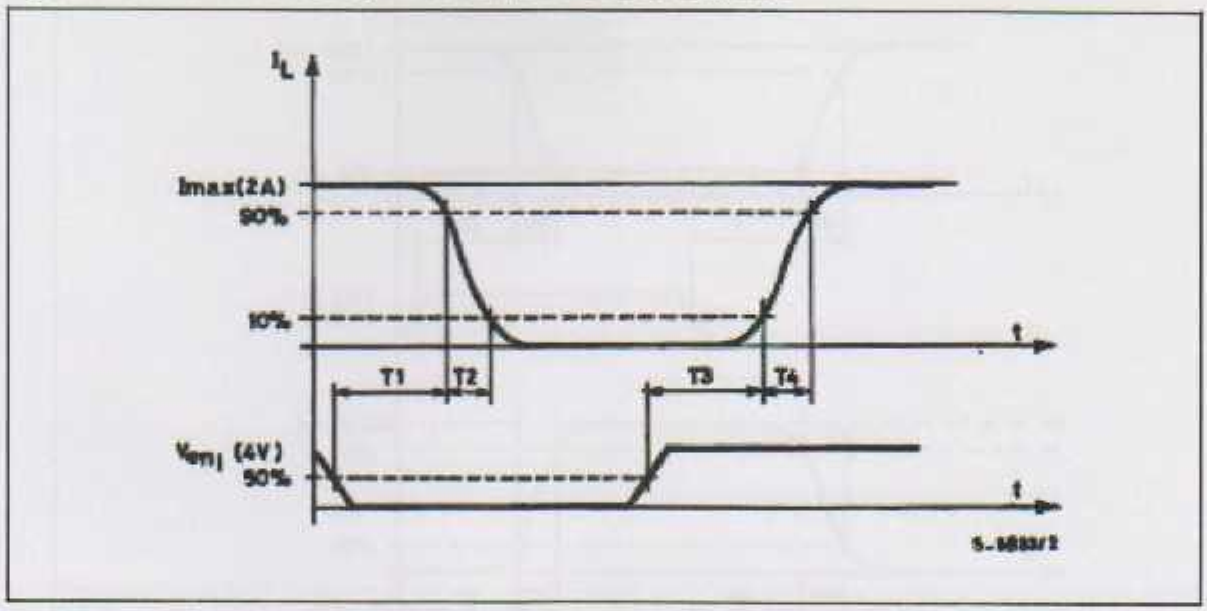
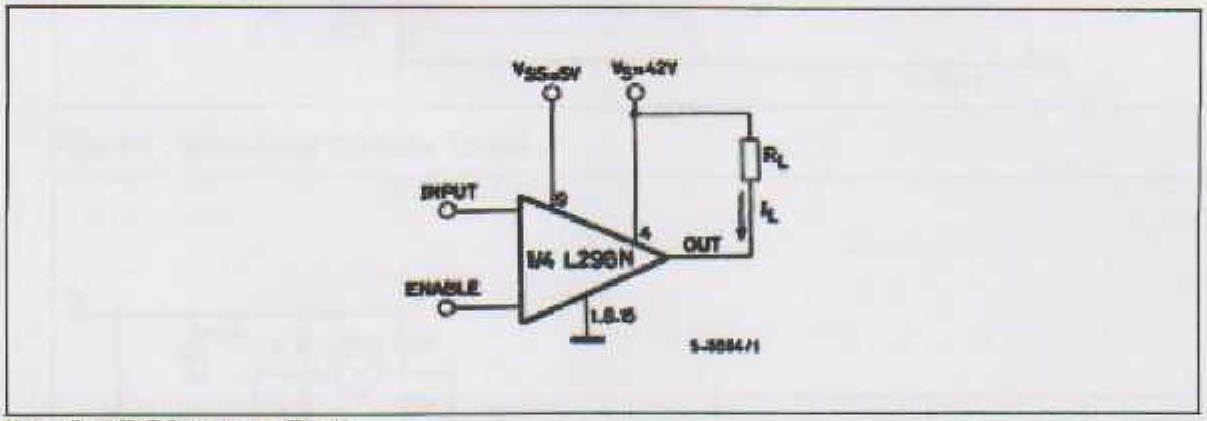


Figure 4 : Switching Times Test Circuits.



Note : For INPUT Switching, set EN = H
For ENABLE Switching, set IN = L

Figure 5 : Sink Current Delay Times vs. Input 0 V Enable Switching.

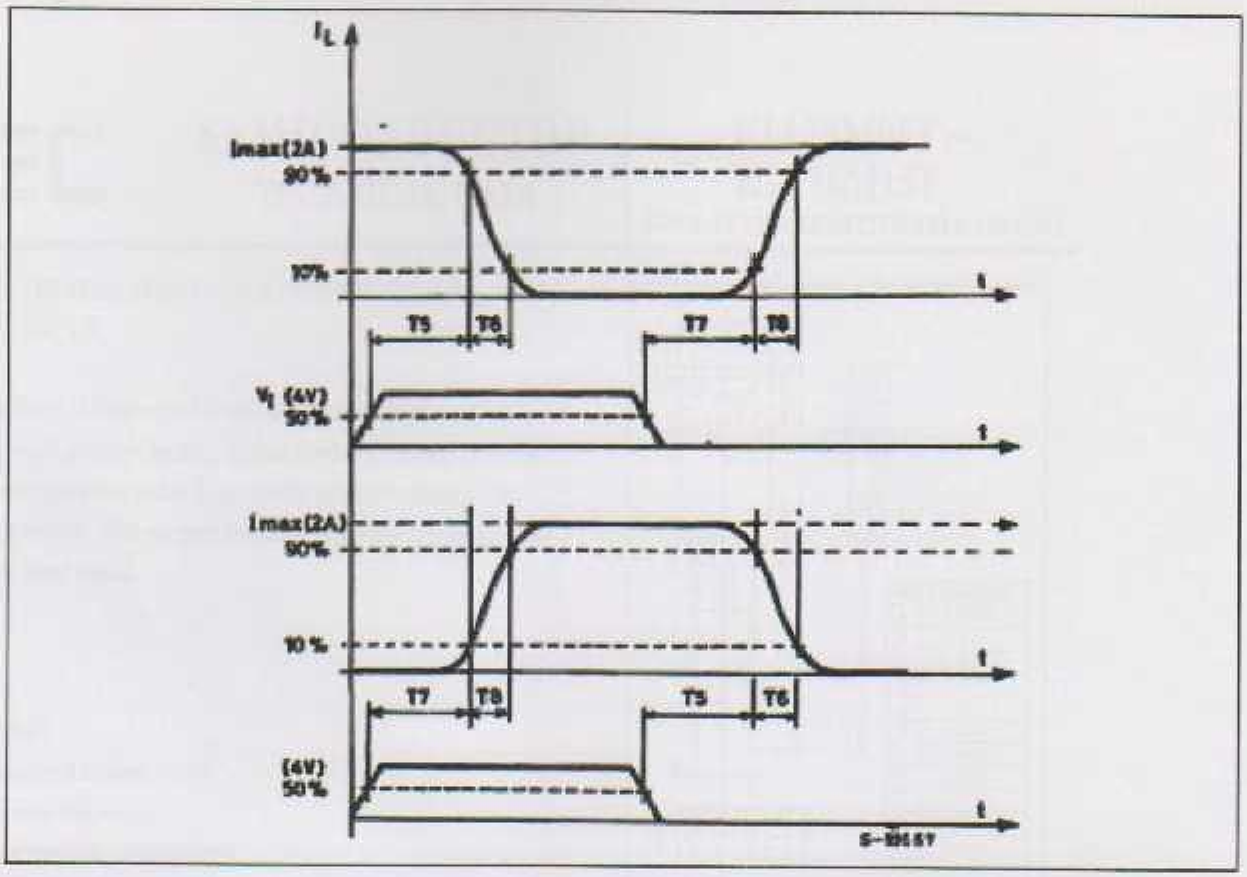
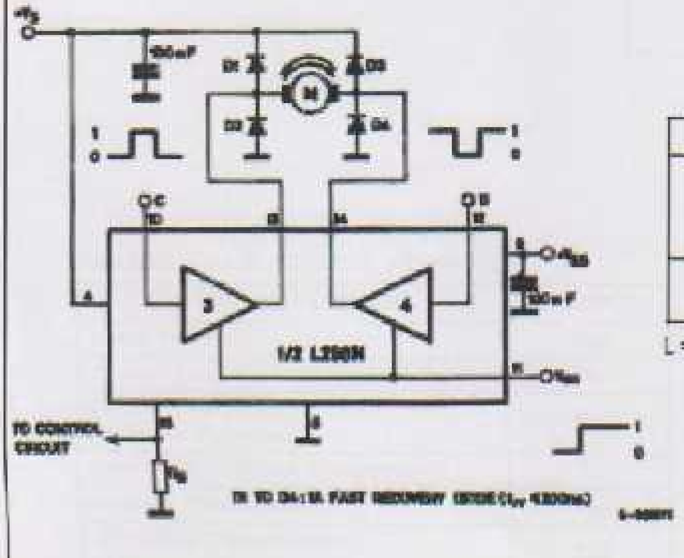


Figure 6 : Bidirectional DC Motor Control.



Inputs		Function
V_{en} = H	C = H ; D = L	Forward
	C = L ; D = H	Reverse
	C = D	Fast Motor Stop
V_{en} = L	C = X ; D = X	Free Running Motor Stop

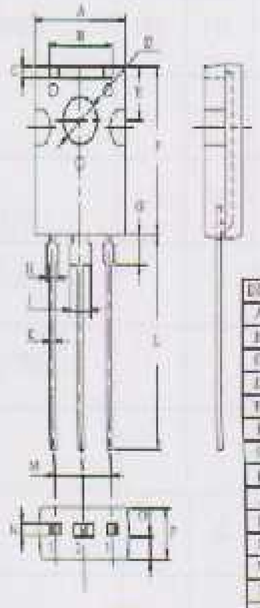
L = Low H = High X = Don't care

KEC SEMICONDUCTOR
TECHNICAL DATA

KIA78M05T ~ KIA78M15T
BIPOLAR LINEAR INTEGRATED CIRCUIT

THREE TERMINAL POSITIVE VOLTAGE REGULATORS
5V, 8V, 12V, 15V.

KIA78M × × Series of three-terminal positive voltage regulators employ built-in current limiting, thermal shutdown, and safe-operating area protection which makes them virtually immune to damage from output overloads. With adequate heatsinking, they can deliver in excess of 0.5A output current.



DIM	MILLIMETERS
A	[illegible] MAX
B	[illegible]
C	[illegible]
D	[illegible]
E	[illegible]
F	[illegible]
G	[illegible] MAX
H	[illegible] MAX
J	[illegible] MAX
K	[illegible]
L	[illegible] MIN
M	[illegible]
N	[illegible]
O	[illegible]
P	[illegible] MAX

TO-126

FEATURES

- Output current in excess of 0.5A.
- No external components.
- Internal thermal overload protection.
- Internal short circuit current limiting.
- Output transistor safe-area compensation.
- Available in TO-126 package.

MAXIMUM RATINGS (Ta=25℃)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Input Voltage	V_{IN}	35	V
Power Dissipation (Tc=25℃)	P_D	15	W
Power Dissipation (Without Heatsink)	P_D	1.5	W
Operating Junction Temperature	T_j	-40 ~ 150	℃
Storage Temperature	T_{stg}	-55 ~ 150	℃
Soldering Temperature (10 seconds)	T_{sol}	260	℃

ELECTRICAL CHARACTERISTICS

KIA78M05T

(unless otherwise specified : V_{IN}=10V, I_O=350mA, C_{IN}=0.33μF, Co=0.1μF)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Output Voltage	V_{OUT}	T_j=25℃	4.8	5.0	5.2	V
		5mA ≤ I_{OUT} ≤ 350mA P_D ≤ 7.5W, 7.5V ≤ V_{IN} ≤ 20V	4.75	5.0	5.25	
Line Regulation	Reg Line	8V ≤ V_{IN} ≤ 25V, I_{OUT}=200mA	-	-	50	mV
		7.2V ≤ V_{IN} ≤ 25V, I_{OUT}=200mA	-	-	100	
Load Regulation	Reg Load	5mA ≤ I_{OUT} ≤ 500mA	-	-	100	mV
Quiescent Current	I_B	T_j=25℃	-	4	6	mA
Quiescent Current Change	ΔI_B	5mA ≤ I_{OUT} ≤ 350mA	-	-	0.5	mA
		7.5V ≤ V_{IN} ≤ 25V, I_{OUT}=200mA	-	-	1.0	mA
Output Noise Voltage	V_{NO}	f=10Hz ~ 100kHz	-	40	-	μV
Ripple Rejection	R · R	f=120Hz, 8V ≤ V_{IN} ≤ 18V I_{OUT}=300mA	62	78	-	dB
Dropout Voltage	V_D	I_{OUT}=500mA	-	2.0	-	V
Short Circuit Current	I_{SC}	V_{IN}=35V	-	300	-	mA
Output Voltage Drift	$\Delta V_{OUT}/\Delta T$	I_{OUT}=5mA, T_j=0 ~ 125℃	-	-0.5	-	mV/℃

Appendix c

Logic gates

AND Gate (7405)

Inverter gate (7404)

FAIRCHILD
SEMICONDUCTOR ™

March 1998

DM7408 Quad 2-Input AND Gates

General Description

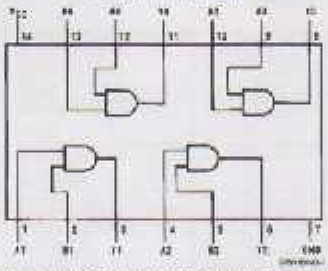
This device contains four independent gates each of which performs the logic AND function.

Features

- Alternate Military/Aerospace device (5408) is available. Contact a Fairchild Semiconductor Sales Office/Distributor for specifications.

Connection Diagram

Dual-In-Line Package



Order Number 5408DMQB, 5408FMQB, DM5408J, DM5408W or DM7408N
See Package Number J14A, N14A or W14B

Function Table

$Y = AB$

Inputs		Output
A	B	Y
L	L	L
L	H	L
H	L	L
H	H	H

H = High Logic Level
L = Low Logic Level

Absolute Maximum Ratings (Note 1)

Supply Voltage	7V	DM54 and 54	−55°C to +125°C
Input Voltage	5.5V	DM74	0°C to +70°C
Operating Free Air Temperature Range		Storage Temperature Range	−65°C to +150°C

Recommended Operating Conditions

Symbol	Parameter	DM5400			DM7400			Units
		Min	Nom	Max	Min	Nom	Max	
V_{CC}	Supply Voltage	4.5	5	5.5	4.75	5	5.25	V
V_{IH}	High Level Input Voltage	2			2			V
V_{IL}	Low Level Input Voltage			0.8			0.8	V
I_{OH}	High Level Output Current			−0.4			−0.4	mA
I_{OL}	Low Level Output Current			16			16	mA
T_A	Free Air Operating Temperature	−55		125	0		70	°C

Note 1: The "Absolute Maximum Ratings" are those values beyond which the safety of the device cannot be guaranteed. The device should not be operated at these limits. The parametric values defined in the "Electrical Characteristics" table are not guaranteed at the absolute maximum ratings. The "Recommended Operating Conditions" table will define the conditions for actual device operation.

Electrical Characteristics

over recommended operating free air temperature range (unless otherwise noted)

Symbol	Parameter	Conditions		Min	Typ (Note 2)	Max	Units
V_I	Input Clamp Voltage	V_{CC} = Min, I_I = −12 mA				−1.5	V
V_{OH}	High Level Output Voltage	V_{CC} = Min, I_{OH} = Max, V_{IL} = Max		2.4	3.4		V
V_{OL}	Low Level Output Voltage	V_{CC} = Min, I_{OL} = Max, V_{IH} = Min			0.2	0.4	V
I_I	Input Current @ Max Input Voltage	V_{CC} = Max, V_I = 5.5V				1	mA
I_{IH}	High Level Input Current	V_{CC} = Max, V_I = 2.4V				40	μA
I_{IL}	Low Level Input Current	V_{CC} = Max, V_I = 0.4V				−1.6	mA
I_{OS}	Short Circuit Output Current	V_{CC} = Max (Note 3)	DM54	−20		−55	mA
			DM74	−18		−55	
I_{CCH}	Supply Current with Outputs High	V_{CC} = Max			11	21	mA
I_{CCL}	Supply Current with Outputs Low	V_{CC} = Max			20	33	mA

Switching Characteristics

at V_{CC} = 5V and T_A = 25°C (See Section 1 for Test Waveforms and Output Load)

Symbol	Parameter	Conditions	Min	Max	Units
t_{PLH}	Propagation Delay Time Low to High Level Output	C_L = 15 pF, R_L = 400Ω		22	ns
t_{PHL}	Propagation Delay Time High to Low Level Output			19	ns

Note 2: All typicals are at V_{CC} = 5V, T_A = 25°C.

Note 3: Not more than one output should be shorted at a time.

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

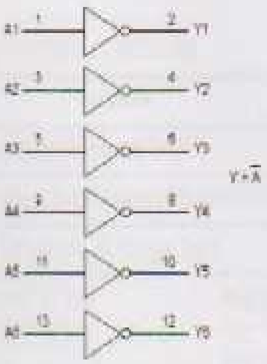
Hex Inverter
High–Performance Silicon–Gate CMOS

The MC54/74HC04A is identical in pinout to the LS04 and the MC14069. The device inputs are compatible with Standard CMOS outputs; with pullup resistors, they are compatible with LSTTL outputs.

The device consists of six three–stage inverters.

- Output Drive Capability: 10 LSTTL Loads
- Outputs Directly Interface to CMOS, NMOS and TTL
- Operating Voltage Range: 2 to 6V
- Low Input Current: 1μA
- High Noise Immunity Characteristic of CMOS Devices
- In Compliance With the JEDEC Standard No. 7A Requirements
- Chip Complexity: 36 FETs or 9 Equivalent Gates

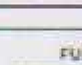
LOGIC DIAGRAM



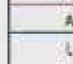
MC54/74HC04A

J SUFFIX
CERAMIC PACKAGE
CASE 632–08

N SUFFIX
PLASTIC PACKAGE
CASE 646–06



D SUFFIX
SOIC PACKAGE
CASE 751A–03



DT SUFFIX
TSSOP PACKAGE
CASE 948G–01

ORDERING INFORMATION

MC54HCXXAJ	Ceramic
MC74HCXXAN	Plastic
MC74HCXXAD	SOIC
MC74HCXXADT	TSSOP

FUNCTION TABLE

Inputs	Outputs
A	Y
L	H
H	L

MAXIMUM RATINGS*

Symbol	Parameter	Value	Unit
V_{CC}	DC Supply Voltage (Referenced to GND)	– 0.5 to + 7.0	V
V_{in}	DC Input Voltage (Referenced to GND)	– 0.5 to V_{CC} + 0.5	V
V_{out}	DC Output Voltage (Referenced to GND)	– 0.5 to V_{CC} + 0.5	V
I_{in}	DC Input Current, per Pin	± 20	mA
I_{out}	DC Output Current, per Pin	± 25	mA
I_{CC}	DC Supply Current, V_{CC} and GND Pins	± 50	mA
P_D	Power Dissipation in Still Air, Plastic or Ceramic DIP† SOIC Package† TSSOP Package†	750 500 450	mW
T_{stg}	Storage Temperature	– 65 to + 150	°C
T_L	Lead Temperature, 1 mm from Case for 10 Seconds Plastic DIP, SOIC or TSSOP Package Ceramic DIP	 260 300	°C

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high–impedance circuit. For proper operation, V_{in} and V_{out} should be constrained to the range GND ≤ (V_{in} or V_{out}) ≤ V_{CC}.

Unused inputs must always be tied to an appropriate logic voltage level (e.g., either GND or V_{CC}). Unused outputs must be left open.

* Maximum Ratings are those values beyond which damage to the device may occur.
Functional operation should be restricted to the Recommended Operating Conditions.

†Derating — Plastic DIP: – 10 mW/°C from 65° to 125°C
Ceramic DIP: – 10 mW/°C from 100° to 125°C
SOIC Package: – 7 mW/°C from 65° to 125°C
TSSOP Package: – 6.1 mW/°C from 65° to 125°C

For high frequency or heavy load considerations, see Chapter 2 of the Motorola High–Speed CMOS Data Book (DL129/D).

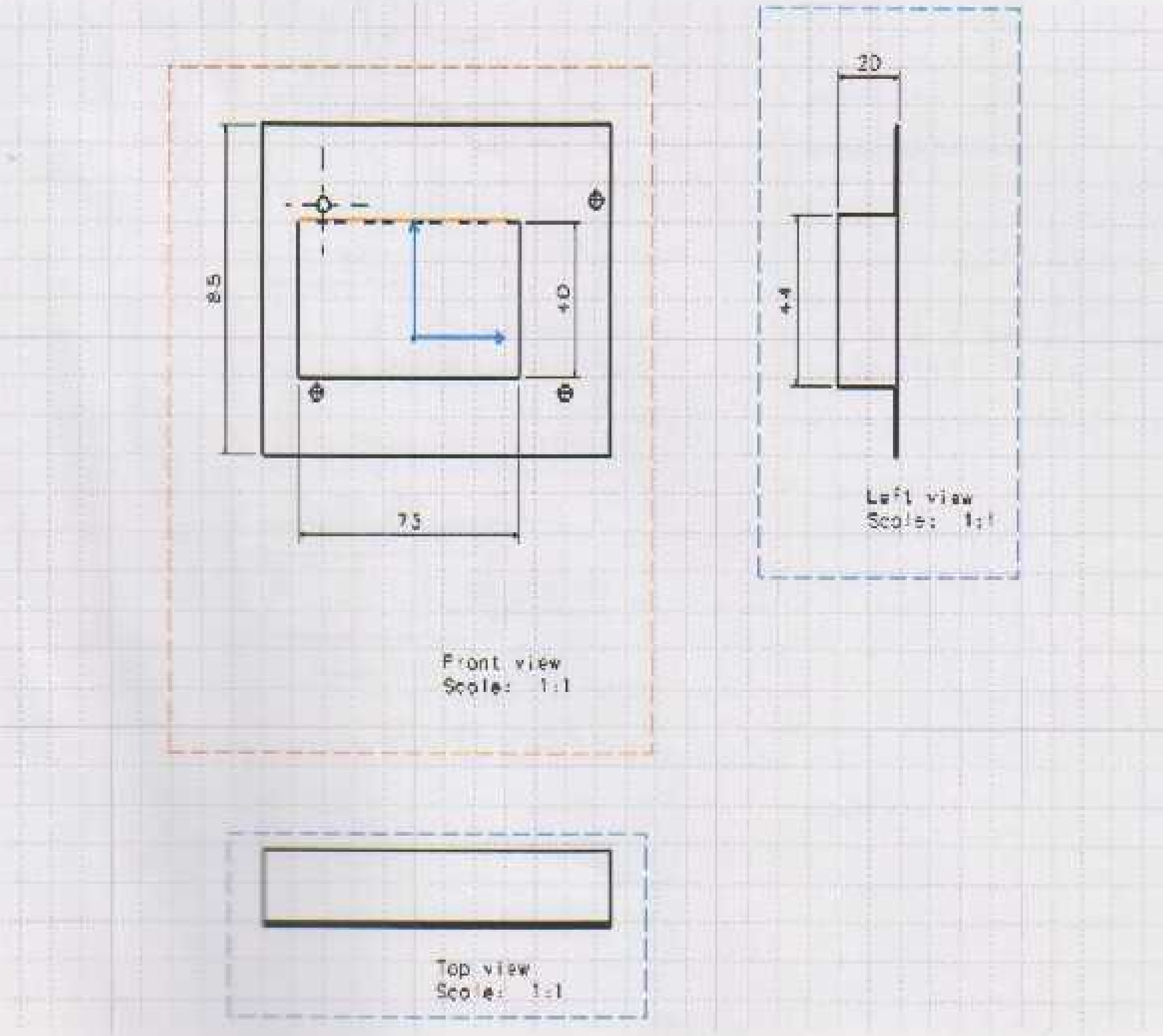
RECOMMENDED OPERATING CONDITIONS

Symbol	Parameter		Min	Max	Unit
V_{CC}	DC Supply Voltage (Referenced to GND)		2.0	6.0	V
V_{in}, V_{out}	DC Input Voltage, Output Voltage (Referenced to GND)		0	V_{CC}	V
T_A	Operating Temperature, All Package Types		– 55	+ 125	°C
t_r, t_f	Input Rise and Fall Time (Figure 1)	V_{CC} = 2.0 V V_{CC} = 4.5 V V_{CC} = 6.0 V	0 0 0	1000 500 400	ns

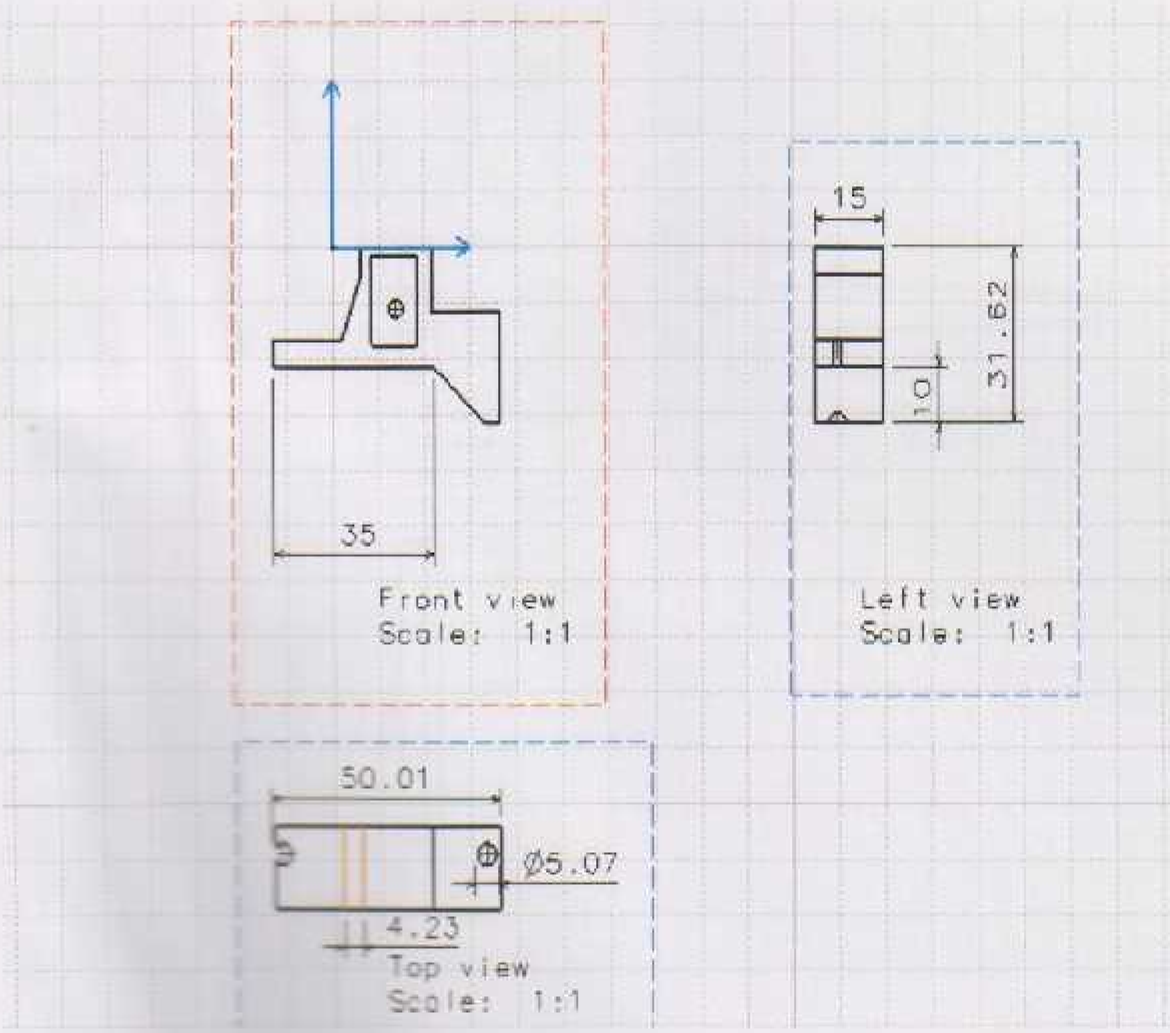
Appendix D

Drafting

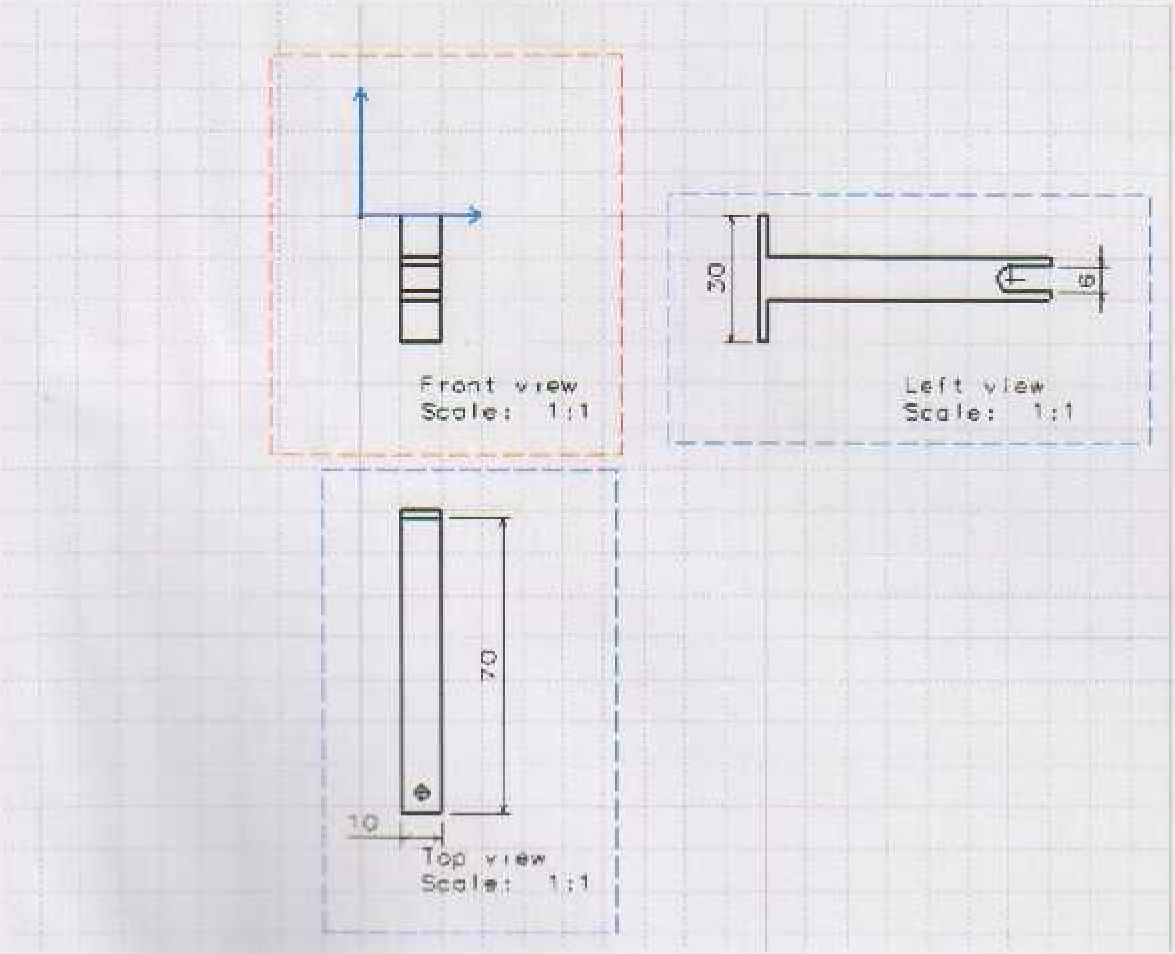
Fixed base


20
44
85
40
73
Left view
Scale: 1:1
Front view
Scale: 1:1
Top view
Scale: 1:1

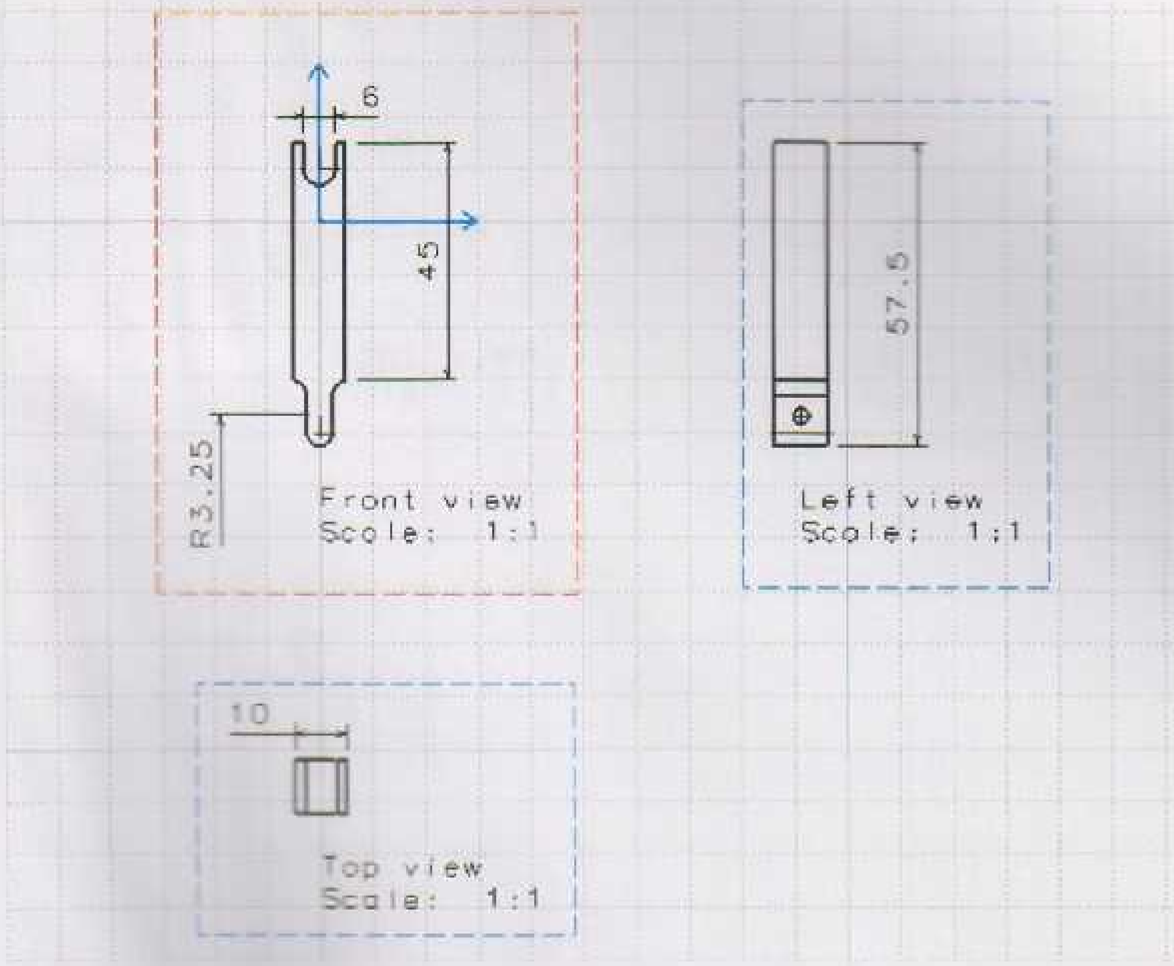
Slide Base


35
Front view
Scale: 1:1
15
31.62
10
Left view
Scale: 1:1
50.01
Ø5.07
4.23
Top view
Scale: 1:1

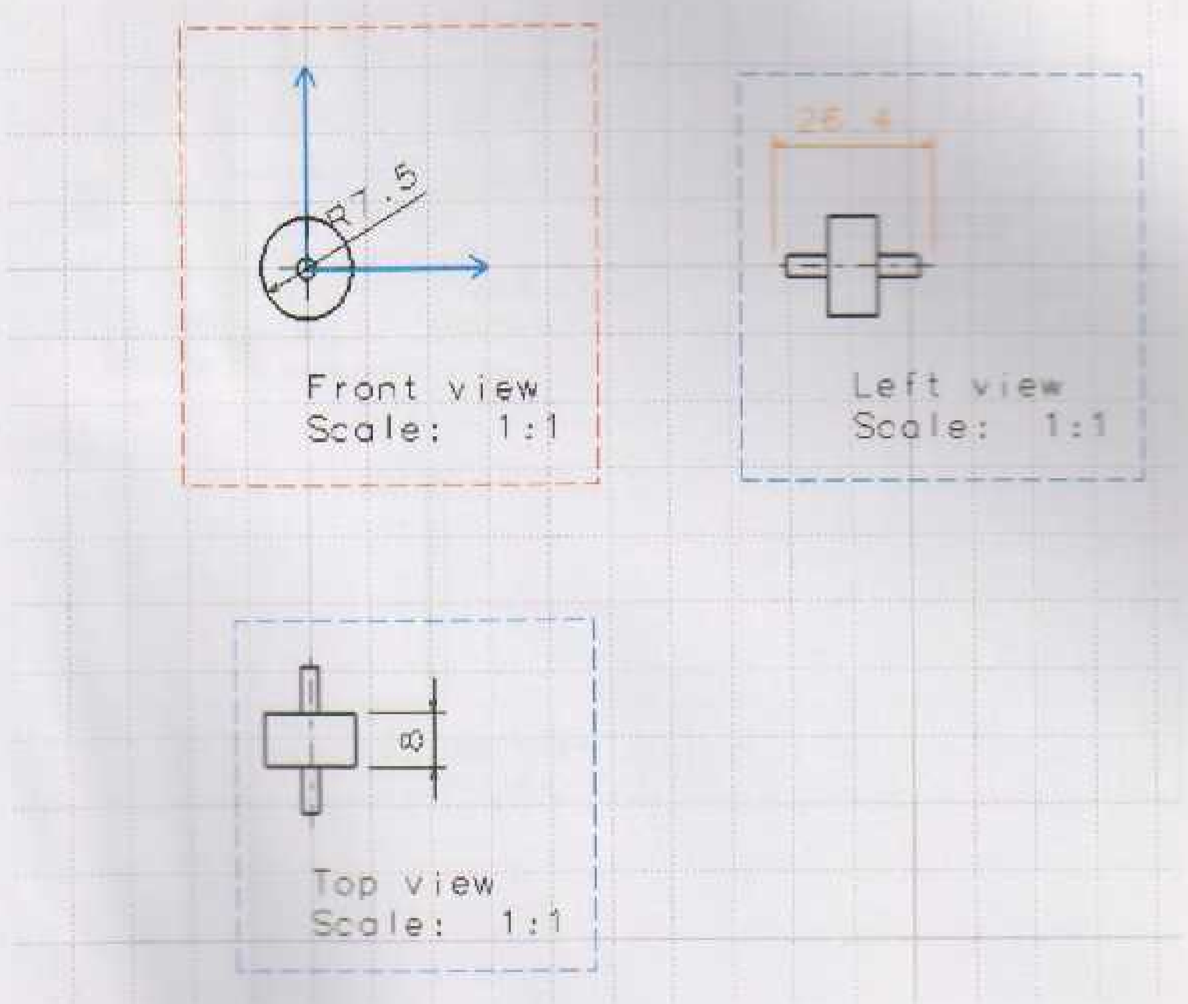
Fixed Link


30
6
Front view
Scale: 1:1
Left view
Scale: 1:1
70
10
Top view
Scale: 1:1

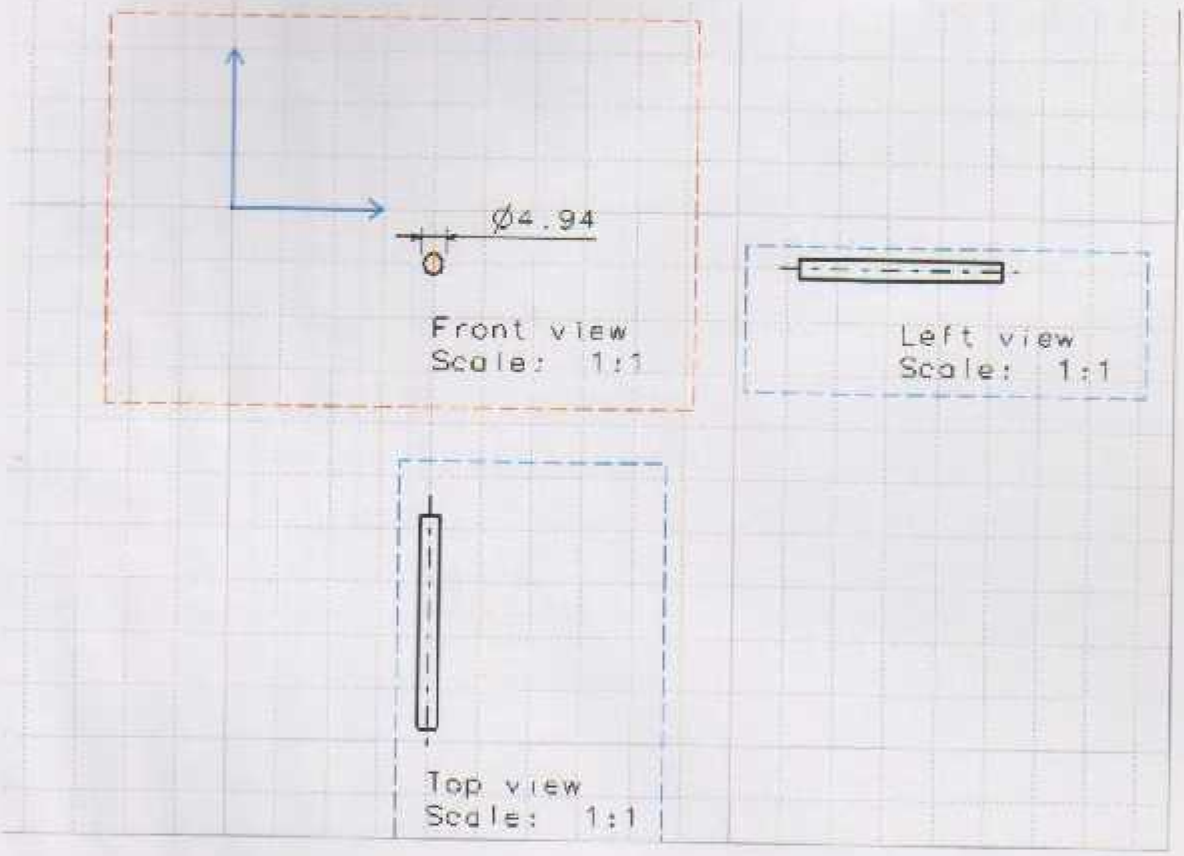
Movable Link

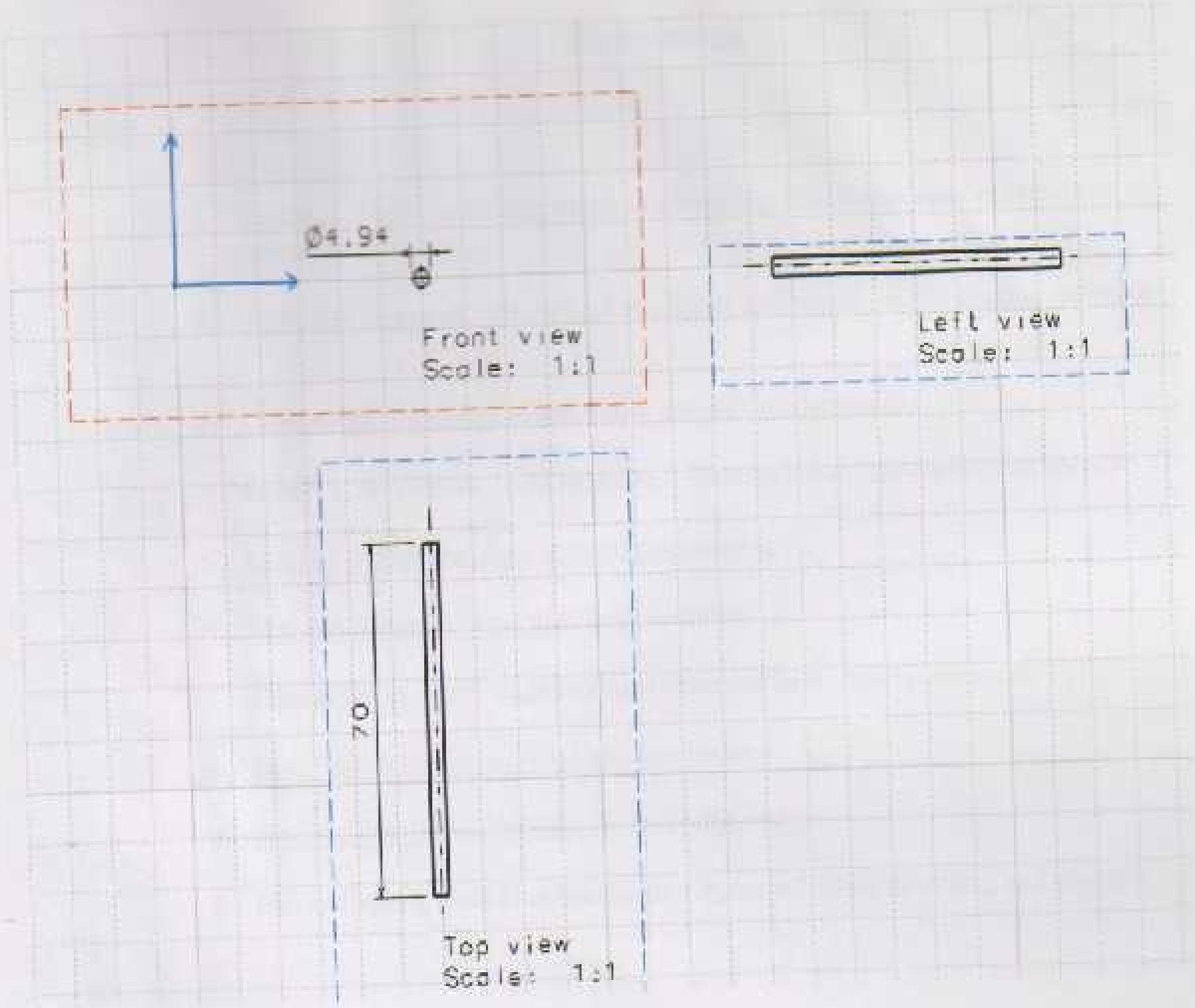


Roller


R7.5
Front view
Scale: 1:1
26.4
Left view
Scale: 1:1
8
Top view
Scale: 1:1

Left Bar (The Slide Base Move on it)




Ø4.94
Front view
Scale: 1:1
Left view
Scale: 1:1
70
Top view
Scale: 1:1

References

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