Palestine Polytechnic University

College of Engineering & Technology

Electrical & Computer Engineering Department

Graduation Project

Design & Implementation of Mixing and Filling Colors Machine (MFCM)

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Abstract

This project presents Design and Implementation of Color Mixing & Filling Machine, which mixes the basic four colors with predetermined percentages in order to obtain large specter of colors at least 40 throughout applying PC interfacing panel.

The design procedure was divided into four stages: Field survey and data collection about the existence of such type machines in the industry, problem formulation, proposed design, and the last stage was optimization and calibration of mixing in filling process.

The machine prototype was tested taking into account the liquid quantity is determined based time-rate flow.

Good and accurate results were obtained.

الملخص

هذا المشروع هو تصميم وتطبيق لالة مزج وتعبئة الالوان والتي تستخدم اربعة الوان رئيسية وتقوم بمزجها بنسب مختلفة, لانتاج 40 لون على الاقل عن طريق اختيار اللون المطلوب من جهاز الحاسوب.

وقد مرت خطوات العمل باربع مراحل: الزيارات الميدانية ومن ثم مرحلة جمع المعلومات عن الالات المتواجدة بالصناعة والاطلاع على مشكلاتها ومن ثم وضع التصميم الصحيح لحل بعض هذه المشكلات التي تعاني منها هذه الالات وفي النهاية عملية التطبيق والمعايرة لعملية التعبئة والمزج.

وقد اعتمدت هذه الاله على زمن تدفق الخليط من علب الالوان . وقد كانت النتائج جيدة ومرضية.

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Introduction to Mixing and Filling Colors Machine (MFCM)

1.1 Introduction

Industrial Automation Engineering is one of the most improved sector in the field of electrical engineering due to wide spread application of industrial automated systems in the world industry.

There are three fields covered by this program:

- Electrical.
- Mechanical.
- Computer systems.

In order to implement the acquired knowledge during our studying period, a Mixing and Filling Colors Machine was implemented.

This machine mixes four main colors Red, Yellow, Blue and White (R, Y, B, W), in additional to filling the mixture in a special container (bottle). --

Project Contents: - The main components of this project are:

- Electrical driving system.
- Hydraulic system.
- Programmable logic control (PLC).
- Personal computer (PC).
- Interfacing system.
- Accessories.

1.2 Project aims.

This project aims at:

1- Strengthen our knowledge in machine mixing system and their control.

2- Implementing of a machine mixing system that could be used in automated painting systems.

3- Practically implement and calibrate the several part of the system.

4- Proposing an innovative method for colors mixing.

1.3 Subject and reasons for this study:

The mixing and filling machines are one of the most popular applied systems in food, plant, chemical and building industries…etc. Because of it's rational and economical saving, leading to reduce the cost of the product.

There are several applications, which need a combination of mixing and filling machine such car painting, building painting, drawing colors, and other applications.

Based on our survey in Hebron and Bethlehem districts, there are no machines that combine both color mixing and filling at the same time because of its high cost and complexity.

For example in car painting workshops and mini companies, they depend on preparing the required color by weighting samples manually, and mixing them together manually too. And in building construction field they depend on trailing and correction procedure to produce the required colors manually.

1.4 Literature Review:

After studying literature review of the mixing and filling machine and studying its design that almost depends on flow rate for the main tanks and controlled from PLC. These machines need a system to provide a fixed flow rate.
Also in mixing colors operation which is complex operation at control and design phases, the depending on weighting by hand, therefore.
A computerized system with a good interface is proposed with purpose to overcome these drawbacks.

1.5 project Cost / (Visible Study):

The next table shows the total cost of the project.

Table 1.1 Project cost

Equipments	Cost ($)
Motors	200
Transformer and Rectifier	150
Programmable Logic Control (PLC).	300
Programming (HW & SW)	100
Switches , Protection system	220
Valves	240
Lathe and welding the machine body	900
Stationery	70
Travel and Transport	100
Total cost	$2280

1.6 Schedule time:

The next table displays the project progress schedule through 32 weeks.

Table 1.2 Schedule time

Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Choosing project	■	■														
Collection data			■	■	■											
Data analysis						■	■									
Practical experiment on colors									■							
Machine design										■	■	■	■	■		
Writing project text															■	■

[illegible]	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
[illegible] parts design	■	■	■	■	■	■										
[illegible]							■	■								
[illegible]									■	■	■	■				
[illegible]													■	■		
[illegible] Timing															■	■

1.8 Project Parts (modules).

Three main parts:

1- Electromechanical & Interface:

Table1.3 Electromechanical & Interface devices table

Title	Aims	Controllable
Valve1	Control the Red color flow rate.	Yes
Valve2	Control the Yellow color flow rate.	Yes
Valve 3	Control the Blue color flow rate.	Yes
Valve4	Control the White color flow rate.	Yes
Motor 1	The motor used to move the empty tank to the right position under the main color tanks & mixer.	Yes
Motor2	Mixing after the filling.	Yes
Program(interfacing system)	Choose the color and send specific signals to the PLC.	Yes
Power Supply	To turn on the electrical devices.	No
Main Switch	To start for turn on the system.	No

2- Control part:

Table 1.4 Control devices table

Title	Aims
Personal Computer(PC)	Give 5 bits with a specific time to the PLC
Programmable Logic Control	Controlling driving system depending on the inputs.

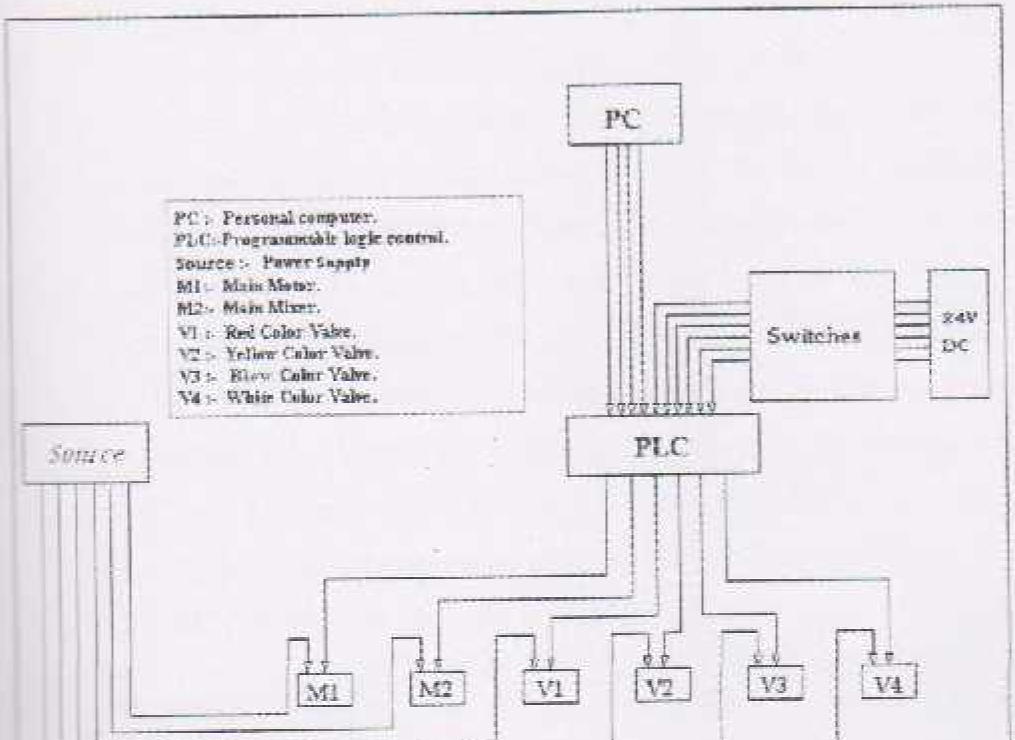


Fig 1.1 Block Diagram of the project

1.9 Project Formulating (Proposing).

Taking into account the previous studies, discussed literature review and system formulation, the following suggestions can be proposed in order to enhance the project operation and quality of the output product:

1- Adding system that support computer user interface.

2- Make a connection between PLC and the PC.

Chapter 2

Introduction to Colors and Painting

2.1 History:

The use of color as a therapy has a long history. The ancient Egyptians and ancient Greeks built healing temples of light and color. The use of color became deeply embedded in Chinese and Indian medicine, and it remains an integral part of Ayurvedic medicine.

In Europe and the U.S., interest in the therapeutic use of color developed during the second half of the 19th century. In 1878, Dr. Edwin Babbitt published "The Principles of Light and Color," in which he recommended various techniques for the use of color in healing. In 1933, a definitive work on color therapy called "The Spectro Chrometry Encyclopedia" was written by an Indian scientist Dinshah Ghadiali. This was a landmark publication and laid the foundation for most of modern color therapy. Around the same time a form of color therapy, known as "Syntonics," was developed in the U.S. by Dr. Harry Riley Spitler. He found that he could produce profound physiological and psychological changes in his patients by altering the color of light entering their eyes. [2]

Interest has grown in color therapy steadily since. Today there are hundreds of practitioners using a wide variety of color-related therapeutic techniques in the US. Today, color therapy is a well-accepted technique in complementary medicine.

2.2-Types of Painting: [7]

According to chemical composition we can classified the painting to:

2.2.1 Fresco: Buon fresco is the process of painting a water and pigment solution on a damp lime-plastered wall. Michelangelo's Sistine Ceiling was done in the buon fresco method. This meant that he had to begin and finish the area he was working on in one 24-hour period. After that the lime plaster has dried and will not accept pigment the same way. In Giotto's Lamentation we can see the areas that he worked in that one-day span.

-Fresco secco is the process of painting water and pigment of the early 20th Century used this process. This work by Diego Rivera shows a finished fresco.

-The Mexican muralists called this process mezzo fresco because they sometimes worked on both damp and dray plaster.

2.2.2- Encaustic: Is paint made of beeswax and pigment. Jasper Johns, a member of the Pop Art movement of the 1960's uses encaustic in his work.

2.2.3 Oil Paint: Is a combination of an oil (usually linseed) and pigment. Many artists prefer oils because they have a great deal of flexibility; they dry very slowly, and have a great deal of transparency.

- Glazes: Transparency allows processes like glazing that depends on the transfer of light through the layers of oil. A great example of glaze painting lies in Jan Davidz de Heem's Vase of Flowers. De Heem worked in 17th Century Netherlands where he focused on still life as his main subject. The Flemish and Dutch painters were the first to introduce oil painting (said to be invented by Jan Van Eyck) because oil was a by-product of the textile industry that flourished from the 15th Century on.

-Impasto: is a process of applying thick paint to a canvas. Anselm Kiefer uses heavily applied paint combined with other materials, such as straw, to create evocative and expressive works.

2.2.4-Tempera: Is paint made form pigment and egg yolk. Albumen a chemical in the egg yolk provides a strong and durable vehicle for the pigment. Egg tempera dates back to the ancient Egyptian culture fig.2.1 from which some paintings still survive. The Adoration of the Magi by Gentile da Fabriano, an Italian Renaissance painter, shows his unique use of tempera gilding. This work took stylistic characteristics from the North and from the Near East.

Fig.2.1 Tempera Picture [2]

2.2.5- Acrylic Paint: Is a plastic-like polymer that cleans up with water. This uses acrylic glazes in the painting process.Ralph Larmannpainting by

2.2.6- Water Color: In contemporary art language refers to aquarelle.

2.2.7- Spray Paint: Has been used in one form or another since the Paleolithic period. Contemporary street and graffiti artists utilize spray paint and spray techniques.

2.3- The Color Wheel and Color Complements: [7, 4]

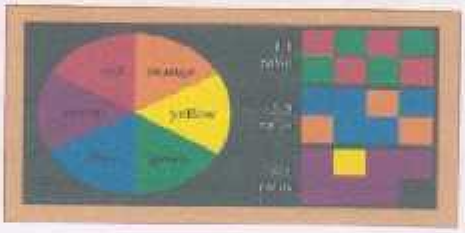


Fig.2.2 Wheel Color

The Color Wheel describes the relationships between colors. It is laid out so that any two Primary Colors (Red, Yellow, Blue) are separated by the Secondary Colors (orange, violet, and green).

Primary Colors are basic and cannot be mixed from other elements. They are to color what prime numbers are to mathematics. One can mix two primaries to get a Secondary Color. You will notice that each Secondary Color on the Color Wheel is bounded by two primaries. These are the components that one would mix to get that Secondary Color.

Color Complements are color opposites. These colors contrast each other in the most extreme way possible. They also help to make each other more active. In the Color Wheel illustration above, the complement of the color is used as text in that section. This is to illustrate the opposite character of the color. Color Complements are on opposite sides of the Color Wheel.

The ratios and illustrations on the right of the chalkboard are ideal amounts of color compliments according to Johannes Itten. He believed that equal amounts of red and green are appropriate (1:1 ratio). Blue and orange are different in value, so they their ratios need adjustment (5 blue: 3 orange ratios). The same is true of violet and yellow (6 violet: 1 yellow). These ratios were probably devised to counter the intensity of colors like yellow and orange.

Hint: All colors travel in waves within light. Color Complements have drastically different wavelengths and, consequently, cause some perception problems for a viewer if they are placed close to each other in a work of art. The cones and rods of the eye cannot handle so much information, so we sometimes detect a quivering or optical distortion when two complements are used near each other.

2.4- Updated Color Mixing In Pigment:

There have been some updates in the traditional primary/secondary color wheel. Painters have learned that red, yellow, and blue are the primary colors.

Fig.2.3 Color Mixing In Pigment

But because of research in the area of color we find that the true primary colors, those that are the basis for all others and cannot be made from mixed color, are *magenta, yellow and cyan*. From these primary colors the secondary colors *red, blue, violet and green* can be mixed from combinations of two primaries. The result when all three primaries are mixed is black. Color that we see is the result of a part of the visible spectrum that is reflected. We see yellow because only that part of the spectrum is reflected. Black occurs because all the colors of the spectrum are absorbed rather than being reflected. There is the opposite result when all primaries are mixed in light. This process is also called subtractive color mixing and it is used in pigment and in commercial printing processes

Fig.2.5 Color Mixing In Optics

This type of color mixing was practiced by the Impressionists and Postimpressionists. The best example is work by the Pointillists (Georges Seurat being the most recognizable) who laid down small dots of different colors and allowed the viewer to optically mix them. A good specific example of this is in Show.

A similar example of this process occurs in color newspaper photos. If you look at a color newspaper photograph using a magnifying glass, you will see not a solid color, but small dots which, when optically mixed, create other colors. Although this process is subtractive and the Impressionists worked additively, the visual effect is largely the same.

2.7 –Color Saturation and Intensity:

Color has value. This is the darkness or lightness of a particular color. We can divide these value changes into Shades and Tints.

Shades are the relative darkness of a color and Tints are the relative lightness of a color. These divisions are created by darkening or lightening the Pure hue. This is the base color at its full intensity.

It is important to note Intensity of a color here because a value of, lets say, red can be the same as a medium Tone of that same color. A Tone can be the same value, but can be grayed in such a way that it is not at the highest degree of Intensity. The Pure Hue has the highest Saturation of color. This is illustrated in the middle ring of the Color Wheel above. The outer ring of Tints illustrates what happens to a Pure Hue when white is added. The center section of Shades shows the effect of black on the Pure Hue.

The four graphs at the right of the chalkboard show relative values of three colors and gray. The star in each column shows the purest hue of the group. It is important to note that the pure hue changes with the relative value of that color.

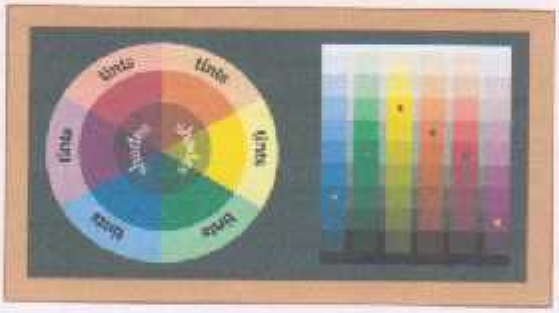


Fig.2.6 Color intensity

For example the pure hue of yellow is lighter than medium gray, whereas the pure hue of blue is much darker than middle gray.

Hint: When mixing pigment it is advisable to use a pure color rather than a mixed color to achieve highest saturation of color. When two pigments are mixed, their relative intensity decreases. Therefore it if a strong green was the intention, it may be more beneficial to get a green pigment instead of mixing blue and green. This effect seems to become more noticeable with as more pigments are added.

Table 2.1 Gray Scale:

Gray Scale Table											
[illegible]	0	1	2	3	4	5	6	7	8	9	10
[illegible]											
[illegible]	Colorless or White	Extremely light	Very light	Light	Medium light	Medium	Medium dark	Dark	Very dark	Extremely dark	Black
[illegible]	C	EX1	V1	1	M1	M	MD	D	VD	EXD	B1

Table 2.2 Color samples

Some color samples and its names and symbols. Table		
Color Samples	Name	Code
	red	R
	orangy red	oR
	red-orange or orange-red	RO/OR
	reddish orange	rO
	orange	O
	yellowish orange	yO
	orangy yellow	oY
	yellow	Y
	greenish yellow	gY
	yellow-green or green-yellow	YG/GY
	strongly yellowish green	styG
	yellowish green	yG

	slightly yellowish green	slyG
	green	G
	very slightly bluish green	vslbG
	bluish green	bG
	very strongly bluish green	vstbG
	green-blue or blue-green	GB/BG
	very strongly greenish blue	vstgB
	very slightly greenish blue	vslgB
	blue	B
	violetish blue	vB
	bluish violet	bV
	violet	V
	bluish purple	bP
	purple	P
	reddish purple	rP
	red-purple or purple-red	RP/PR
	strongly purplish red	stpR
	slightly purplish red	slpR
	red	R
	pink (exception)	Pk
	brown (exception)	Brn

2.8- Overview in Present Machine:

Taking in to account the above described colors combination, the large spectrum of color can be derived from the four main colors (R, Y, B and W), by appropriate percentage & mixing procedure.

The proposed mixing machine will deal will so called water painting each color will be reserved in one tank; these four tanks should be used in the produce procedure. The quantity of required color & combination can be controlled by PC on rate flow of the color.

Chapter 3

Electromechanical and Control Parts and elements

3.1 Introduction:

In this chapter we illustrate and explain the main electromechanical and control parts that should be used in the project, with justifications for choosing these elements.

The main parts are:

1-Electromechanical parts:

The Electromechanical part contains the motors, power system and valves.

* Power system used to energize the different parts by suitable power (voltage, current).

* Valves used to control the colors flow from the four main tanks, one valve for each tank, and double solenoid valve used to control the piston with purpose to move the mixer up and down.

2- Mechanical part: the main body and gears.

3- Control parts:

The control parts are: Personal Computer, Programmable Logic Control, Switches (Relays, Emergency, Overload, Push Button, and Fuses).

* Switches that used to set the rotation of the system in the right position and for protection system that can stop the motors and valves.

*Personal Computer (PC) used to choose the color and to control the PLC depending on specific time.

*Programmable logic Controller (PLC) receives the input signal from PC, switches then it controls the actuators (motors, valves, etc).

The electrical motors used for:

1- Mix the colors in the bottle.

2- Move the gear and the disk that carry off the bottle, in additional to calibration of the positions.

3.2 Electrical Motors:-

Electrical Motors are used to efficiently convert electrical energy into mechanical energy. Magnetism is the basis of their principles of operation. They use permanent magnets, electromagnets, and exploit the magnetic properties of materials in order to create these amazing machines.

There are several types of electric motors available today. The following outline gives an overview of several popular ones. There are two main classes of motors: AC and DC. AC motors require an alternating current or voltage source to make them work. DC motors require a direct current or voltage source to make them work. Universal motors can work on either type of power. Not only is the construction of the motors different, but the means used to control the speed and torque created by each of these motors also varies, although the principles of power conversion are common to both.

Fig 3.1: -Electrical Motors

3.2.1 Motors Types:[7]

There are several types of motors used in industrial, commercial and residential applications Fig 3.2.

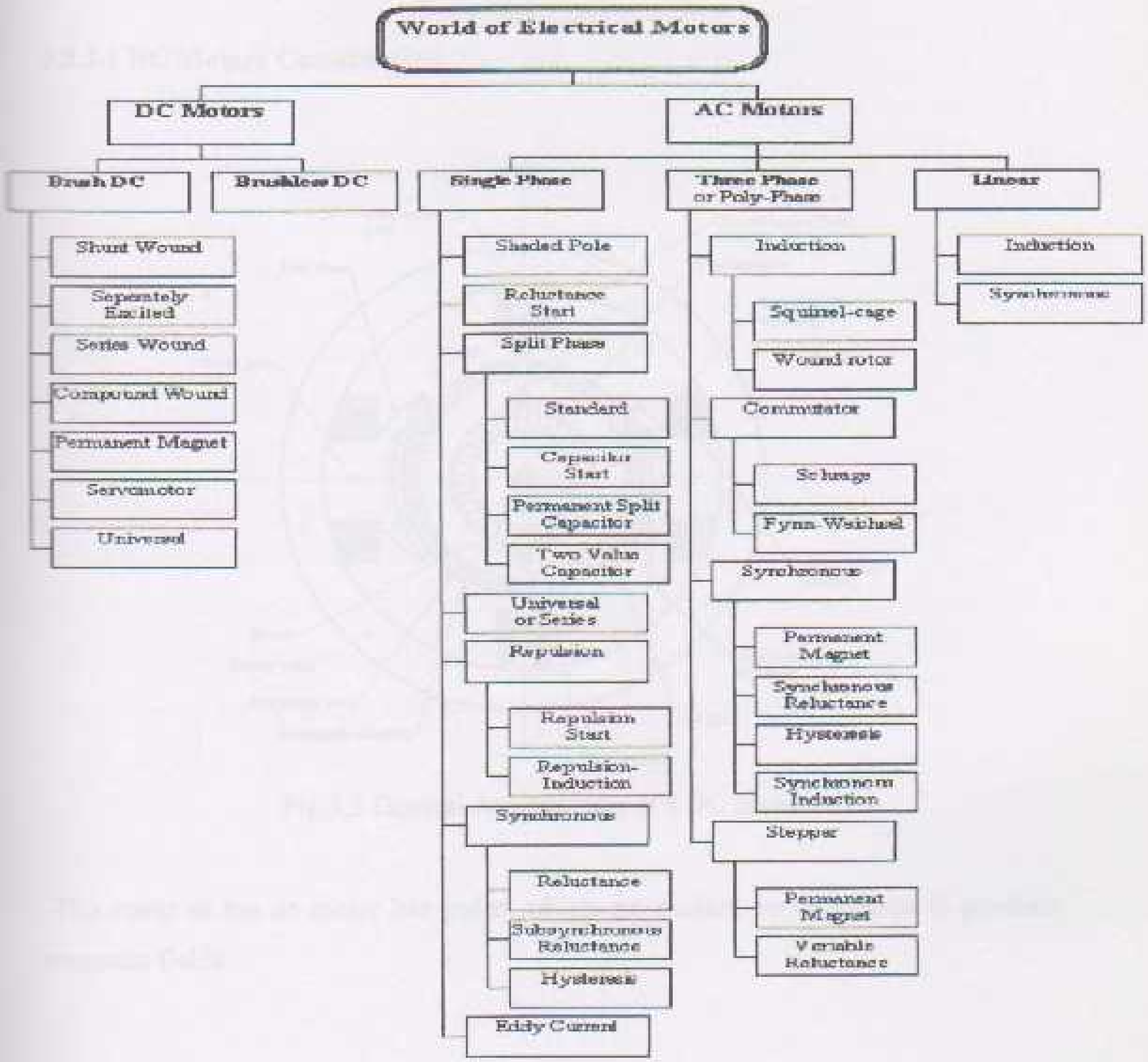


Fig 3.2:- Electrical Motors type

3.2.2 DC Motors:

DC Motors are fairly simple to understand. They are also simple to make and only require a battery or dc supply to make them run.

3.2.2.1 DC Motors Construction:

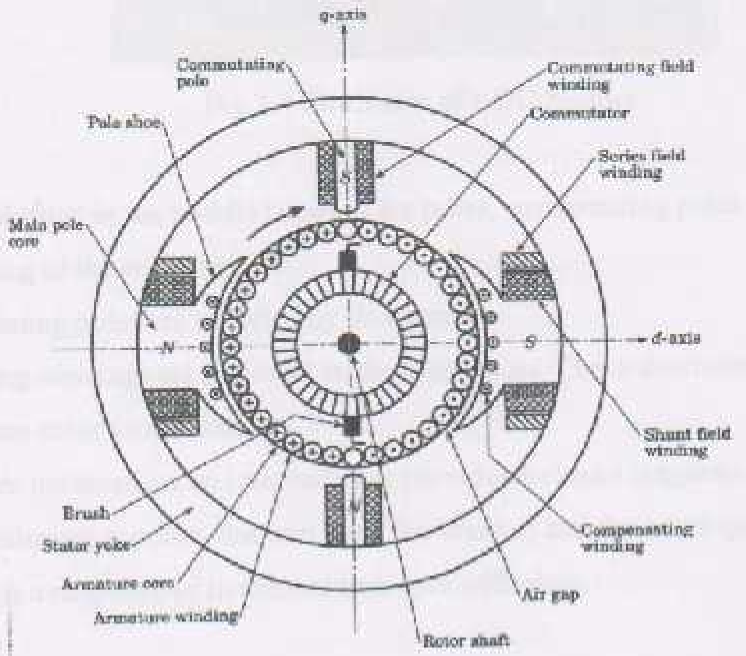


Fig.3.3 General Arrangement of a DC Motors

-The stator of the dc motor has poles, which are excited by dc current to produce magnetic fields.

Fig.3.4 The Stator of a DC Motors

-In the neutral zone, in the middle between the poles, commutating poles are placed to reduce sparking of the commutator.

-The commutating poles are supplied by dc current.

-Compensating windings are mounted on the main poles. These short-circuited windings damp rotor oscillations.

-The poles are mounted on an iron core that provides a closed magnetic circuit.

-The motor housing supports the iron core, the brushes and the bearings.

-The rotor has a ring-shaped laminated iron core with slots.

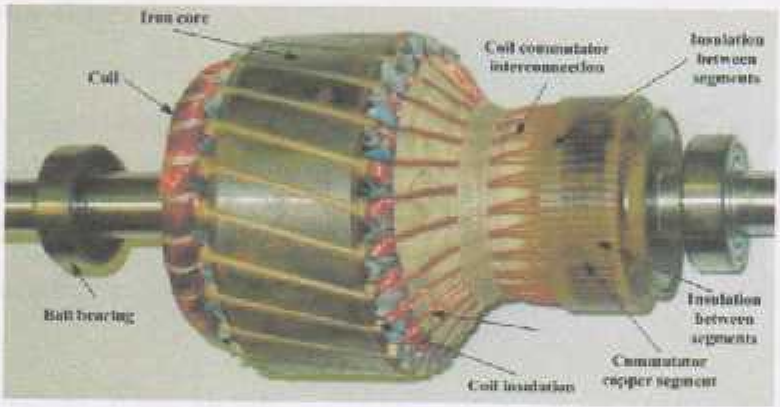


Fig.3.5 The Rotor of a DC Motors

-Coils with several turns are placed in the slots. The distance between the two legs of the coil is about 180 electric degrees.

-The coils are connected in series through the commutator segments.

-The ends of each coil are connected to a commutator segment.

-The commutator consists of insulated copper segments mounted on an insulated tube.

-Two brushes are pressed to the commutator to permit current flow.

-The brushes are placed in the neutral zone, where the magnetic field is close to zero, to reduce arcing.

-The commutator switches the current from one rotor coil to the adjacent coil.

-The switching requires the interruption of the coil current.

-The sudden interruption of an inductive current generates high voltages.

-The high voltage produces flashover and arcing between the commutator segment and the brush.

3.2.2.2 Dc Motor Operation:

There are five different methods for supplying the dc current to the motor:

1- Separate excitation.

2- Shunt connection.

3- Series connection.

4- Compound.

5- Permanent magnet (Wiper Motor).

3.2.2.3 Advantages and Disadvantages of DC Motors:

- Advantages of dc motors:

- Easy to understand design.
- Easy to control speed.
- Easy to control torque.
- Simple, cheap drive design.

- Disadvantages of dc motors:

- Expensive to produce.
- Can't reliably control at lowest speeds.
- Physically larger.
- High maintenance.

After studying the characteristics DC motors we find the motor which needed to drive the machine for each stage to fill the bottle from any colors we needed.

3.2.2.4 Wiper Motors:

Most, if not all, wipers motors now are in use are the permanent magnet motors. The drive is taken via a worm gear to increase torque and reduce speed. Three brushes may be used to allow two speed operations. The normal speed operates through two-brushes placed in the usual position opposites to each other. For a fast speed the third brush is placed closer to the earth brush. This reduces the number of armature windings between them, which reduces resistance and hence increases current and there fore speed.

Typical specifications for wiper motor speed and hence wipe frequency are 30 rev\min at normal speed and 50 rev\min at fast speed. The motor must be able to overcome the starting friction of each blade at minimum speed of 5 rev\min.

Fig 3.6:- Wiper Motor

Advantages of Wiper Motor

1. Have two speeds (low speed and high speed).
2. Low cost.
3. The range of high and low speed is suitable for our project.
4. The torque is suitable comparing with the load torque which needed.
5. Low power needed.

3.2.3 AC Motors:-

AC motors can be divided into two major categories: asynchronous and synchronous.

The induction motor is the most common form of asynchronous motor and is basically an ac transformer with a rotating secondary. The primary winding (stator) is connected to the power source, and the shorted secondary (rotor) carries the induced secondary current. Torque is produced by the action of the rotor (secondary) currents on the air gap flux.

The synchronous motor resembles a dc motor turned inside out, with the permanent magnets mounted on the rotor. As an alternative, some are constructed using a wound rotor excited by a dc voltage through slip rings. The flux created by the current-carrying conductors in the stator rotates around the inside of the stator in order to achieve motor action.

3.2.3.1Advantges and Disadvantages of AC Motors:

*** Advantages of AC Motors:**

- Variety of Mounting Styles.
- Low Cost.
- Reliable Operation.

*** Disadvantages of AC Motors:**

- Expensive speed control.
- Inability to operate at low speeds.
- Poor positioning control.

3.3 Valves:

3.3.1 Definition:

A valve is a device that regulates the flow of fluid (gases, fluidized solids, slurries, or liquids) by opening, closing, or partially obstructing various passageways. Valves are technically pipe fittings, but are usually discussed separately.

Valves are used in a variety of applications including industrial, military, commercial, residential, and transportation.

Valves may be operated manually, either by a hand wheel, lever or pedal. Valves may also be automatic, driven by changes in pressure, temperature or flow. These changes may act upon a piston witch in turn activates the valve.

3.3.2 Types of Valves:

1. Directional control valves.
2. Non-return valves.
3. Flow control valves.
4. Pressure control valves.
5. Shut-off valves.

1. Directional Control Valves:

Directional control valves are devices which influence the path taken by an air stream. Normally this involves one or all of the following: opening the passage of air and directing it to particular air lines, cancelling air signals as required by blocking their passage and/or relieving the air to atmosphere via an exhaust port.

2. Non-Return Valves:

- Check valve.
- Shuttle valve.
- Dual-pressure valve.
- Quick exhaust valve.

3. Flow Control Valves:

- Throttle valve.
- One-way flow control valve.

4. Pressure Control Valves:

- Pressure regulating valve.
- Pressure limiting valve.
- Pressure sequence valve

3.3.3 Valve Description:

The valve is described by:

1. Number of ports or openings (ways): 2-way, 3-way, 4-way, etc.
2. Number of positions: 2 positions, 3 positions, etc.
3. Methods of actuation of the valve: manually actuated, mechanically actuated, pneumatically actuated, electrically actuated.
4. Methods of return actuation: Spring return, air return, etc.

3.4:-PC (Personal Computer):-

Fig 3.7:- Personal Computer

The PC in this machine used to choose the color wanted after that sends the signals to PLC to control the other parts in the machine.

3.5:- PLC (Programmable Llogic Ccontrol):

Fig.3.8: PLC (Programmable Logic Control)

3.5.1 Introduction to PLC:

The PLC was invented in response to the needs of the American automotive industry. Before the PLC, control, sequencing, and safety interlock logic for manufacturing automobiles and trucks was accomplished using relays, timers and dedicated closed-loop controllers. The process for updating such facilities for the yearly model change-over was very time consuming and expensive, as the relay systems needed to be rewired by skilled electricians. In 1968 GM Hydromantic (the automatic transmission division of General Motors) issued a request for proposal for an electronic replacement for hard-wired relay systems.

3.5.2 Definition:

A programmable logic controller, PLC or programmable controller is a small computer used for automation of real-world processes, such as control of machinery on factory assembly lines. Where older automated systems would use hundreds or thousands of relays and cam timers, a single PLC can be programmed as a replacement.

Programmable controllers were initially adopted by the automotive manufacturing industry, where software revision replaced the re-wiring of hard-wired control panels. The PLC is a microprocessor based device with either modular or integral input/output circuitry that monitors the status of field connected "sensor" inputs and controls the attached output "actuators" (motor starters, solenoids, pilot lights/displays, speed drives, valves, etc.) according to a user-created logic program stored in the microprocessor's battery-backed RAM memory. The functionality of the PLC has evolved over the years to include capabilities beyond typical relay control; sophisticated motion control, process control, Distributed Control System and complex networking have now been added to the PLC's list of functions.

3.5.3 Basic Structure of most PLC systems:

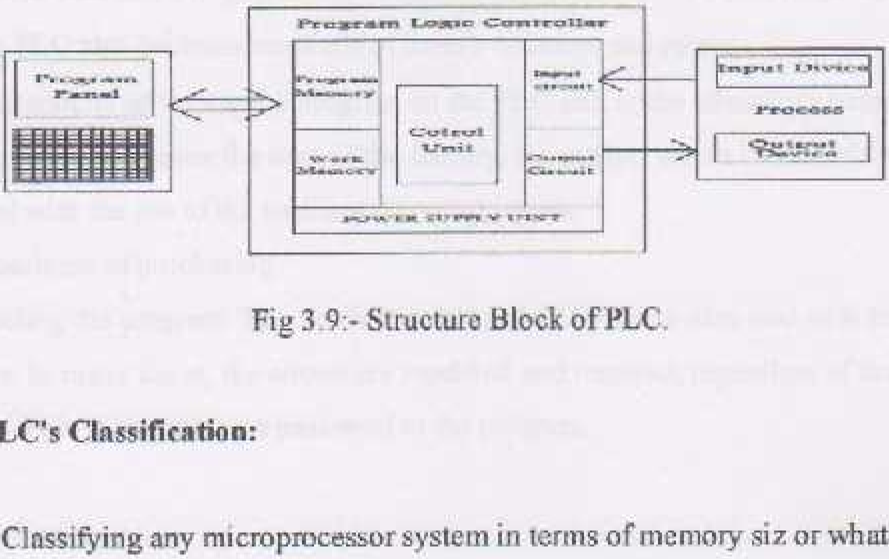


Fig 3.9:- Structure Block of PLC.

3.5.4 PLC's Classification:

Classifying any microprocessor system in terms of memory siz or whatever goes out of date the moment it's printed. As a results use the following as guide only.

Small: up to 30 I/O ports; up to 1k byte memory.

Medium: up to 100 I/O ports; up to 1k byte memory.

Large: more than 100 I/O ports; more than 10k byte RAM.

3.5.5 Advantages and Disadvantages of PLC:

a) Advantages:

1. Flexibility: namely, that the stored on programmed can be modified, therefore, adding or changing controlling steps without resorting to modify the connectors in both inputs and outputs.
2. Correcting error: modification or correcting error in the control panels, which have traditional circuit, requires a long time, but in the plc the matter is limited in modifying the program.
3. The capability of determining the troubles accurately and with extreme speed. Besides, the capability of modifying the program, while the machine continues in its normal performance until it is repaired.
4. The PLC contains a large number of connecting points. They could be switched on or off. The PLC also contains hundreds of timer's counters and relays.
5. The simplicity of testing the program on the PLC unit in the laboratory before putting it in machine. This saves the time of the factory, the matter, which is difficult to be, achieved with the use of the traditional control panels.
6. The easiness of purchasing.
7. Protecting the program. This advantage is touched by those who deal with the machine. In many times, the circuit are modified and repaired, regardless of the needed security. This is via putting a password to the program.

b) Disadvantages:

1. Presenting a new technology needs time to train people sufficiently.
2. In some applications, it with little benefits, as some faculties are not needed or used.
3. Being affected by the environmental hard conditions, as (high temperatures-violent vibrations – moisture).

3.6:- **Relays:**

The relays is a small contactor containing a number of auxiliary points whether (NO) or (NC).It doesn't have any contacts. It contains a coil working according to different voltages as other contactors. It is usually used in circuits as an auxiliary to connect or disconnect a small capacity current (say of 9 amperes for instance) from other coils or loads.

Fig 3.10:- Relay

3.7:- **Overload:-**

a) Instruction

It is composed of three thermal coils related to the motor in series. It has graduation which is adjusted to the same value of the current intensity draw by the contactor function the main function of the overload is to protect the motor from any increase in current intensity

Fig 3.11:- Overload

b) Steps of working:

when the current intensity with drawn by the motor exceeds the value on which the overload was adjusted for any reason such as an overloading or a phase disconnection etc., this excess leads to a temperature increase in the thermal coils which expand and move apiece of fiber that disconnect the (NC) inside the overload. This contact is connected in *series* to the contactors.

Coil of the motor, disconnecting its main contacts and cutting off the current. After identifying the reason why the current intensity increased and after fixing it up, we can switch on a button to close the overload contact and thus, the circuit can work once again.

3.8:-Switches:-

a switch is an electrical component that can break an electrical circuit, interrupting the current or diverting it from one conductor to another.

Fig 3.12 Switch

3.8.1 Push Buttons:-

Fig 3.13:- Push Buttons

a) Off button – Function:

Cutting off the current to the circuit so that its connecting contacts get disconnected when pressed.

b) On button- Function:

Switching on the circuit so that its disconnected contacts get connected when passed.

3.8.2 limit switches:-

An electric switch, operated by a power-driven machine or by the movement of the car which it drives, which alters or controls the electric circuit associated with the machine.

Fig 3.14 Limit Switches

Chapter Four
Design of Mixing and Filling Colors Machine

In this chapter calculations and design of the different parts in the machine were conducted. After that we will choose the suitable devices needed to build this machine such as the motors, transformers, rectifier, pulleys and other parts.

4.1 Proposed Machine Design:

Figure (4.1) illustrates the proposed overall machine view with all parts.

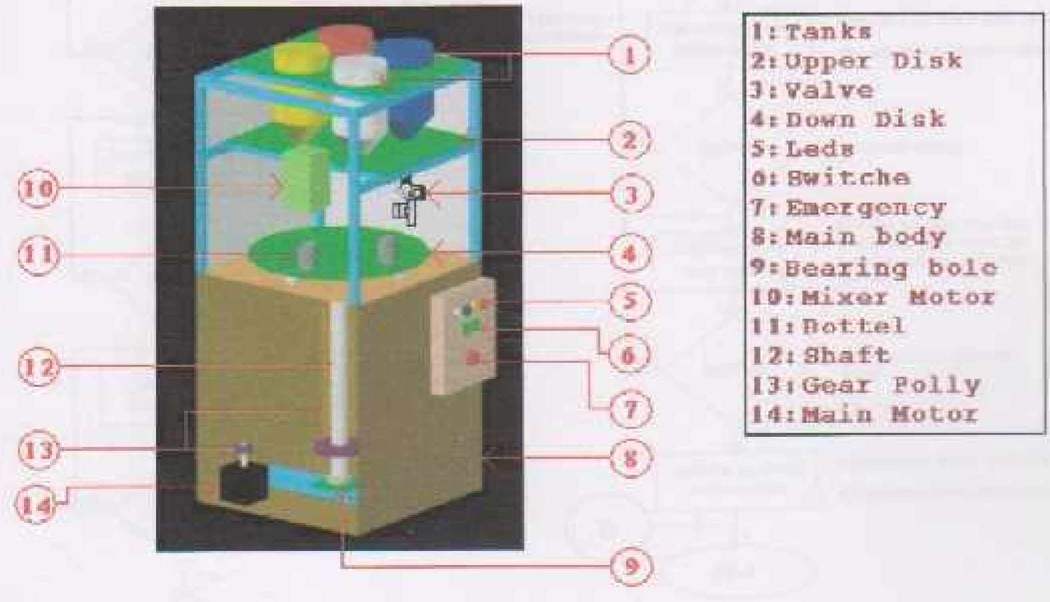


Fig 4.1 Mixing and Filing Colors Machine

4.2 Principle of operation.

This machine has the following operation sequence explains how the machine works.

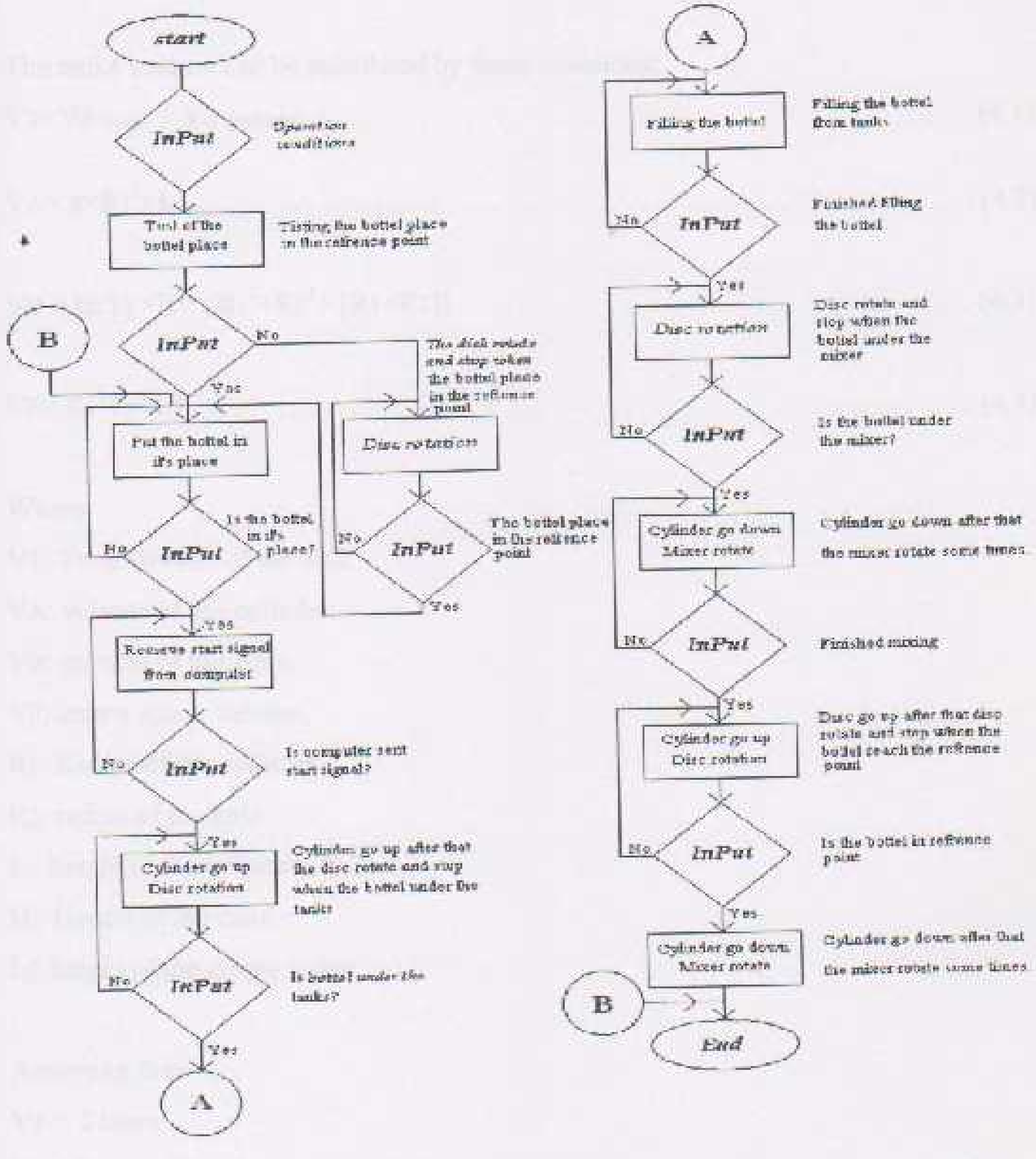


Fig 4.2: Flow Chart

4.3 The Function and calculation of the mechanical parts.

4.3.1 Main Tanks: These tanks used to carryout the main colors.

The tanks volume can be calculated by these equations:

$V_T = V_{B\,(cone)} + V_{A\,(cylinder)}$ .... (4.1).

$V_A = \pi \times R_1^2 \times L$ .... (4.2).

$V_B = (\pi/3) \times H \times \{R_1^2 + R_2^2 + [R_1 \times R_2]\}$ .... (4.3).

$V_F = R_1^2 \times \pi \times L_f$ .... (4.4).

Where:

V_T: Total volume of the tank.

V_A: volume of the cylinder.

V_B: volume of the cone.

V_F: empty space volume.

R_1: Radius of the cylinder.

R_2: radius of the hole.

L: height of the cylinder.

H: Height of the cone.

Lf: height of the empty space.

Assuming that:-

V_T = 5 liters.

R_1 = 9cm. R_2 = 1cm.

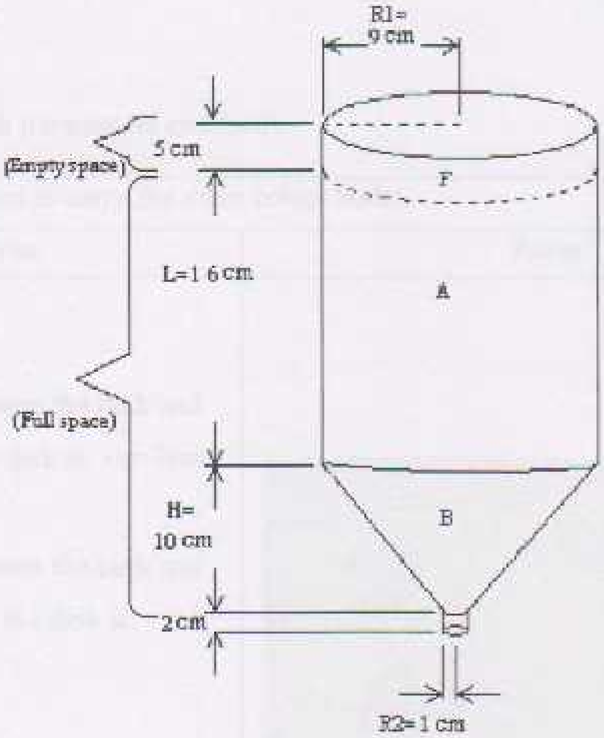


Fig 4.3:- Main Tank

Results:-

Lf = 5cm

V_A = 4.048 Litters.

V_B =0.952Litter.

V_T = 5Litters.

V_F = 1.2717 Litter.

By some calculation we conclude:

L = 16cm.

H = 10cm.

4.3.2 Upper Disk:-

Table 4.1 Upper disk parameters and form.

<table>
<tr><td colspan="2">The upper disk used to carry the main colors tanks.</td></tr>
<tr><th>Given</th><th>Form</th></tr>
<tr><td>The distance between the tank and the out side of the disk is: - a=7cm.

The distance between the tank and the other tanks on the disk is: - b= 2cm.

The radius of the hole in this disk = 5cm.

The length of the disk is: - 60 cm.

The width of this disc is: - 50cm.

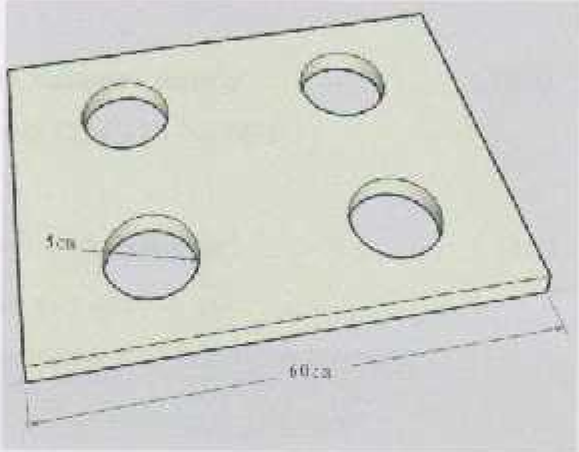
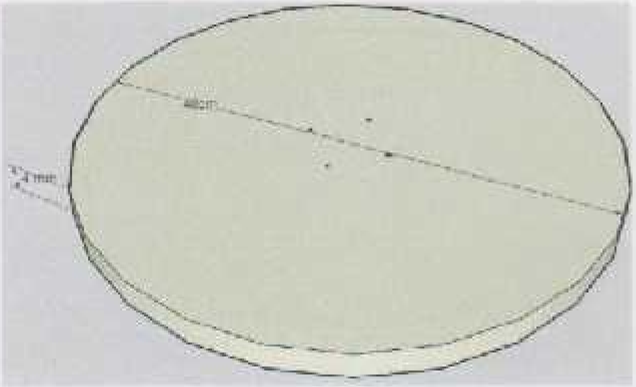
The thickness of this disk is :- 2mm.</td><td>

Fig 4.4:- Upper Disk</td></tr>
</table>

4.3.3 Down Disk:

Table 4.2 Down Disk parameters and form.

The down disc used to carry the bottle to move it under the main colors tanks and main mixer.	
Given	**Equations and Form**
* The volume of the disc is :- $V_D = 0.7234 \times 10\text{-}3\ m^3$ * The down disk radius is:- R_D= 24cm. * Thickness of this disk is 4mm. * Density= 7870 kg/m³. * The mass of this disc is:- M_D= 5.6931 kg. * The moment of inertia of the disc is:- J_D= 0.16396 kg.m²	$V_D = Radius^2 \times \Pi \times Thickness$ . . . . (4.5). $= (0.24)^2 \times \Pi \times 0.004$ M_D= Volume× density . . . . (4.6). $= 0.7234 \times 10^{-3} \times 7870$ $J_D = 0.5\ Mass \times Radius^2$ . . . . (4.7) $= 0.5 \times 5.6931 \times 0.24^2$  Fig 4.5:Lower Disc

4.3.4 Base, Shaft and Screw:

Table 4.3 Base parameters and form.

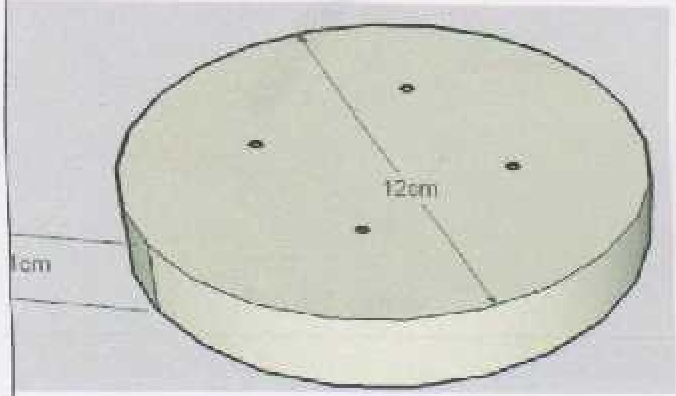
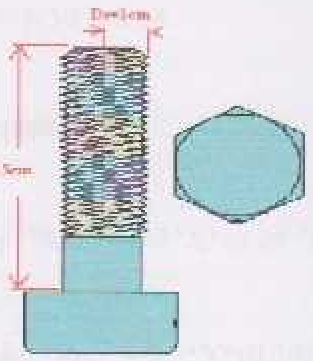
This base used to connect between the shaft and down disc.	
Given	Equations and Form
* The volume of this base is:- $V_b = 0.11304 \times 10^{-3} m^3$	By using equation 4.5 :- $V_b = R_b^2 \times \Pi \times L = (0.06)^2 \times \Pi \times 0.01$.
* The radius of the base is: - Rb= 12cm.	By using equation 4.6:- $M_b = V_b \times density = 0.11304 \times 10^{-3} \times 7870$.
* The diameter of the hole is: - c=1cm.	By using equation 4.7:- $J_b = 0.5\ M_b \times R_b^2 = 0.5 \times 0.8896 \times (0.06)^2$
*Thickness of the base Is: - L=1cm. * The mass of this base is :- Mb= 0.8896 kg * The moment of inertia of this base is :- $J_b = 1.6.13 \times 10^{-3}\ kg.m^2$	 Fig 4.6:- Lower Disk Base

Table 4.4 Shaft parameters and form

The shaft used to rotate the down disc.	
Given	**Equations and Form**
* The diameter of the shaft is: - c=30 mm. The length of the shaft is: - h=70cm. The mass of the shaft is :- Ms= 3.8921kg. The moment of inertia is: - $Js=0.43786\times10^{-3}$ kg.m^2	$Ms= (Rs^2\times\Pi\times h)\times$ density .... (4.8). $= (0.015)^2\times\Pi\times0.7\times7870$. $Rs = c/2$. By using equation 4.7:- $Js = 0.5\ Ms\times Rs^2 = 0.5\times3.8921\times(0.015)^2$.  Fig 4.7:- Shaft

Table 4.5 Screw parameters and form.

The screw used to connect between the base and the down disc.	
Given	**Form**
* The diameter is :- Ds =1cm = 10mm. * The length of the screw is: - Ls = 15mm.	 Fig 4.8:- Screw

4.3.5 Gear:

Table 4.6 Gear parameters and form.

The gear used to convert the speed by limit ratio.	
Given	Form
* The number tooth of first pulley is: N1=9. * The number tooth of second pulley is: - N2=50. * The mass of first pulley is X gm. * The mass of second pulley is Y kg. *The moment of inertia of the first pulley is :- $J_{P1} = 0.25\ X \times 10^{-3}\ kg.m^2$. *The moment of inertia of the second pulley Is: - $J_{P2} - (0.02\ Y)\ kg.m^2$.	$a = N1/N2 = 9/50 = 0.18$. By using equation 4.7:- $J_{p1} = 0.5\ M_{p1}*R_{p1}^2 = 0.5*X*(0.05^2) kg.m^2$ $J_{p2} = 0.5*M_{p2}*R_{p2}^2 = 0.5*Y*(0.20)^2$  Fig 4.9 Gear

4.4:- Main Motor.

4.4.1:- Permanent Magnet dc Motor.

In steady state performance of the permanent dc motor, suitable mounting permanent magnets on the stator obtain field excitation. Ferrites or rare earth magnets are employed. Ferrites are commonly used because of lower cost, but the machine becomes bulky due to low retentively. Rare earth because of their high retentively allows a large reduction in weight and size, but they are very expensive. The permanent magnet motors are mainly, employed in fractional horsepower range, but they are available up to 5kW rating. Use of permanent magnets for excitation eliminates field copper loss and no need for field supply.

Compared to the field wound motors, they are more efficient, reliable, steady and compact. The field flux remains constant for all loads gaining a more linear speed torque characteristic (Because of negligible effect of the armature current reaction). In a separately excited motor, failure of field supply can lead to run away condition. This dose not happens in permanent magnet motors. As the flux is constant in these motors, speed can not be controlled above base speed. The steady state equivalent circuit of armature of a dc machine is shown in Figure (4.8). Resistance Ra is the resistance of the armature circuit. For separately excited and PM motors, it is equal to the resistance of the armature winding.

Basic equations applicable to all dc motor are:-

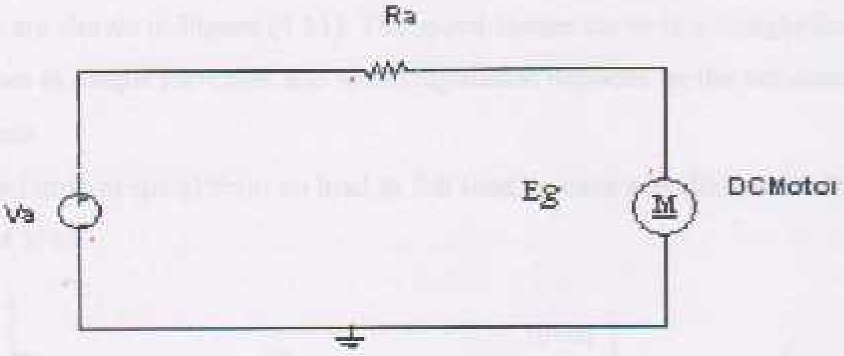


Figure 4.10: Steady State Equivalent Circuit of Armature

Permanent magnet equations [4].

$E = C.\phi \times \omega$ .... (4.9).

$Va = E + Ra \times Ia$.. .... (4.10).

$T = C.\phi \times Ia$ .... (4.11).

Where: ϕ: flux per pole.

Ia: armature current, Ampare.

Va: armature voltage, volt.

Ra: resistance of the armature circuit, ohms.

ωm: speed of armature, Rad/sec.

T: torque developed by motor, N.m.

Cϕ: motor constant

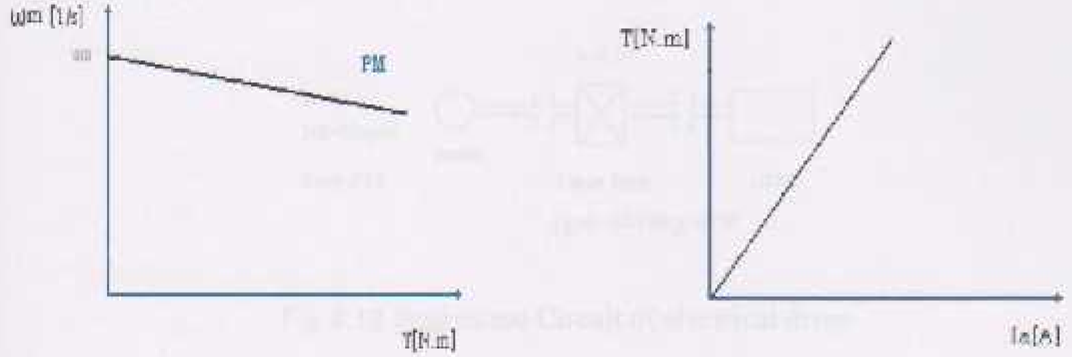
From Equation (4.9 – 4.11) the mechanical angular frequency could be represented as:

$$\varpi = \frac{Va}{C.\phi} - \frac{Ra.Ia}{C.\phi} \quad \text{........................ (4.12).}$$

$$\varpi = \frac{Va}{C.\phi} - \frac{Ra.T}{(C.\phi)^2} \quad \text{........................ (4.13).}$$

The speed-torque and torque- current characteristics of a PM dc motor for rated terminal voltage are shown in Figure (4.11). The speed-torque curve is a straight line. Speed decreases as torque increases and speed regulation depends on the armature circuit resistance.

The used drop in speed from no load to full load, in case a medium size motor is of the order of 5%.



(A) Speed-Torque Performance (B) Torque-current Performance

Figure 4.11: Performances of dc motors

The maximum current that can be communicated without sparking limits the maximum current that a dc motor can safely carry during starting. For normally designed machines twice the rated current can be allowed to flow and for specially designed machines it can be 3.5 times.

At stand still, back EMF is zero and the only resistance opposing flow of the current is the armature circuit resistance, which quite small for all types of dc motors. If a dc motor is started with full supply voltage across its terminals a very high current will flow, which may damage the motor due to the heavy sparking at commutator and heating of the winding.

Therefore, it is necessary to limit the current to a safe value during starting. When motor speed is controlled by armature voltage control (dc chopper) the controller which controls the speed can also be used for limiting motor current during starting to a safe value.

4.4.2:- Motor calculations [5].

A rotating disk has 24cm radius and thickness 4mm is driven by 12V dc motor with a pulley moving it with speed of 6rpm as shown in Figure (4.9).

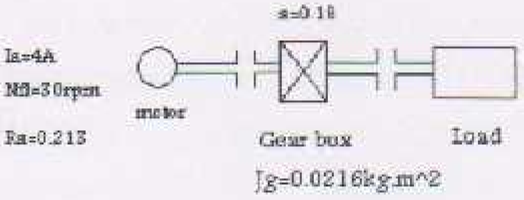


Fig 4.12 Equivalent Circuit of electrical drive

The parameters of this drive system are defined as flow:

By using eq (4.9) and (4.10) we conclude:-

$$C\phi = \frac{Va - Ia * Ra}{\omega} \qquad (4.14)$$

$C\phi = 3.54 web$

$$Tm = C.\phi \times Ia \qquad (4.15)$$

Tm =3.54*4 = 14.2N.m

Tn=m*g *Rp2*a/μ = ...(4.16)

=15*9.81*0.1*0.18/0.65 = 4.08N.m.

Where:-
Tm:-Motor Torque.
Tn: - Weight Torque
Tw: -Friction torque.
Tacc: - Acceleration torque.
Tl: - Load Torque.
Pout:-Output power.

$T_w = 0.3T_L$ .... (4.17).

$T_{acc} = J_{p1} * \alpha$ .... (4.18).

$T_L = T_m + T_n + T_w$ .... (4.19).

$T_L = 4.08 + 14.2 + 0.3T_L$

$0.7\ T_L = 18.28$

$T_L = 26.1 N.m$

$P_{out} = T_L * \omega_m =$ .... (4.20).

$=26.1 * 2*3.14 *30/60 = 82W.$

4.4.3:- Wiper motors:

After the calculations we choose the wiper motor with data sheet since it suitable to drive the rotating disk in our machine.

The Specifications for wiper motor we will use in the present machine:

a) DC: 12V
b) Low speed: 45rpm
c) High speed: 60rpm
d) Power: 100W

Fig 4.13:- Wiper Motor

4.5: Transformer design:

A transformer is a device that transfers electrical energy from one circuit to another through inductively coupled electrical conductors. A changing current in the first circuit (the primary) creates a changing magnetic field. This changing magnetic field induces a changing voltage in the second circuit (the secondary). This effect is called mutual induction.

If a load is connected to the secondary circuit, electric charge will flow in the secondary winding of the transformer and transfer energy from the primary circuit to the load. In an ideal transformer, the induced voltage in the secondary winding (V_S) is a fraction of the primary voltage (V_P) and is given by the ratio of the number of secondary turns to the number of primary turns.

By appropriate selection of the numbers of turns, a transformer thus allows an alternating voltage to be stepped up — by making N_S more than N_P — or stepped down, by making it less.

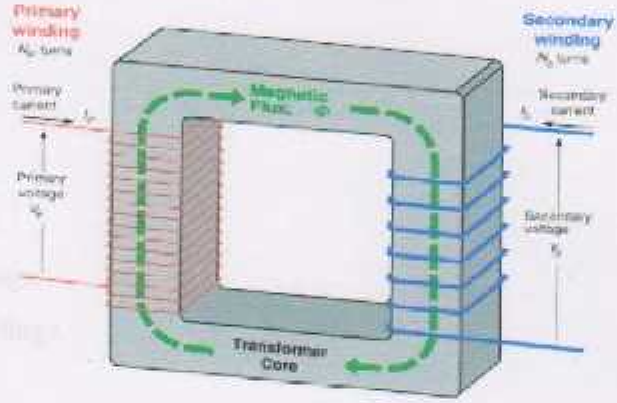


Figure 4.14: Transformer

Transformer equations [4].

$$S = Vs \times Is \quad \text{.......... (4.21)}$$

$$Afe = 1.14\sqrt{KVA[VA]} \quad \text{.......... (4.22)}$$

$$Np = \frac{K}{Afe} \quad \text{.......... (4.23)}$$

$$Ns = \frac{K}{a \times fe} \quad \text{.......... (4.24)}$$

$$Ip = \frac{K \times Va}{Vs} \quad \text{.......... (4.25)}$$

$$Is = \frac{K \times Va}{Vs} \quad \text{.......... (4.26)}$$

$$Ap = \frac{Ip}{J} \quad \text{.......... (4.27)}$$

$$dp = \sqrt{\frac{Ap(mm)}{0.785}} \quad \text{.......... (4.28)}$$

$$ds = \sqrt{\frac{As(mm)}{0.785}} \quad \text{.......... (4.29)}$$

$$FF = \frac{Np \times dp + Ns \times ds}{1083} \times 100\% \quad \text{.......... (4.30)}$$

$$Np = 2.056 \times Vs \quad \text{.......... (4.31)}$$

$$Ns = 2.174 \times Vs \quad \text{.......... (4.32)}$$

Where:

S : Power factor.

Vp: Primary voltage.

Vs: secondary voltage.

F : Frequency.

J : Current density.

Afe: Core area.

Np : Number of turns for the primary.

Ns : Number of turns for the secondary.

Ip : Primary current.

Is : Secondary current.

Ap: Primary conductor area.

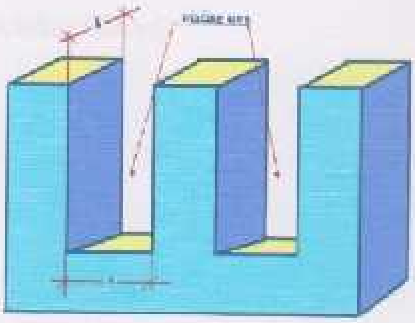
As: Secondary conductor area.

dp: Primary conductor diameter.

ds : Secondary conductor diameter.

FF: Filling factor.

Table 4.7 Transformer parameters

Given Parameters	**Calculations**
Vp= 220 V.	
Vs= 13.75V.	Afe= 10.9mm^2.
F= 50 Hz.	Ip=0.417A.
S= 91.7VA.	Is= 6.67 A.
From table(A.1) we get :	Ap= 0.139mm^2.
J= 3 A/mm^2.	As= 2.223mm^2.
Np= 2.857Vp=628 Turn.	dp= 0.42mm^2.
Ns = 2.174Vs=42 Turn.	ds= 1.683mm^2.
Length X Width=a X b=2.9X4.6.	FF=29.78%
Number of sheet =92sheet.	 Figure 4.15 Transformer Core

4.6: AC to DC converter (Rectifier):

Because of practical electrical circuit need DC power supply and adding energy converter to a system is used.

These converters are used to convert AC to DC voltage, the input ac voltage into output DC voltage with predetermined DC value and ripples ratio.

These circuit compound combined diodes, filters and transformer as well shown in figure 4.16.

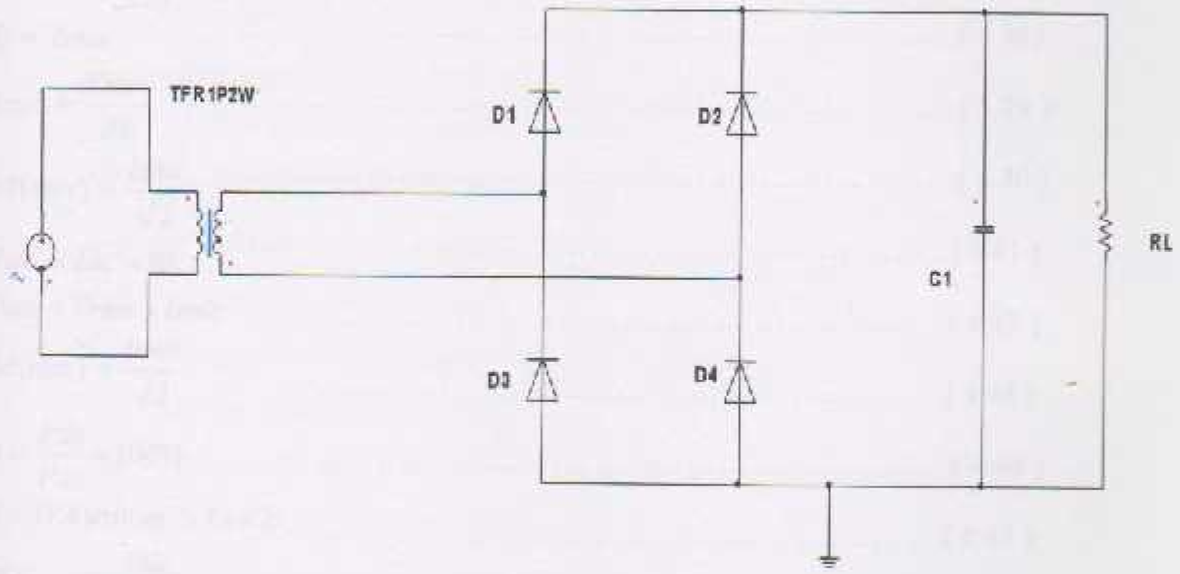


Figure 4.16 Rectifier Circuit

4.6.1 The rectifier parameters:

Output parameters:

Vdc = 12 .38V.

Idc = 6 A.

Pdc = 74.28Watt

RFI = 4%.

The main equations [3].

$$Vm = \sqrt{2} \times Vs \quad \text{.......(4.33)}$$

$$Vrms = Vs \quad \text{.......(4.34)}$$

$$Vdc = \frac{2}{\pi} \times Vm \quad \text{.......(4.35)}$$

$$RL = \frac{Vdc}{Idc} \quad \text{.......(4.36)}$$

$$Id(avr) = \frac{Vdc}{2RL} \quad \text{.......(4.37)}$$

$$Is = Irms \quad \text{.......(4.38)}$$

$$Irms = \frac{Vrms}{RL} \quad \text{.......(4.39)}$$

$$Id(rms) = \frac{Irms}{\sqrt{2}} \quad \text{.......(4.40)}$$

$$Pdc = Idc^2 \times RL \quad \text{.......(4.41)}$$

$$Pac = Vrms \times Irms \quad \text{.......(4.42)}$$

$$Id(rms) = \frac{Irms}{\sqrt{2}} \quad \text{.......(4.43)}$$

$$\eta = \frac{Pdc}{Pac} \times 100\% \quad \text{.......(4.44)}$$

$$S = (VA)rating = Vs \times Is \quad \text{.......(4.45)}$$

$$TUF = \frac{Pdc}{(VA)rating} \quad \text{.......(4.46)}$$

$$PIV = Vs \times \sqrt{2} \quad \text{.......(4.47)}$$

$$FF = \frac{Vrms}{Vdc} \quad \text{.......(4.48)}$$

$$RF = \sqrt{FF^2 - 1} \quad \text{.......(4.49)}$$

$$PF = \frac{Pac}{S} \quad \text{.......(4.50)}$$

$$CF = \frac{Is(peak)}{Is} \quad \text{.......(4.51)}$$

$$FFI = \frac{Irms}{Idc} \qquad (4.51)$$

$$RFI = \sqrt{FFI^2 - 1} \qquad (4.52)$$

$$RF = \frac{1/\sqrt{2}}{4f \times R \times C - 1} \qquad (4.53)$$

Where:

- Vp : Primary voltage.
- Vs : Secondary voltage.
- $Vrms$: Effective output voltage.
- $Irms$: Effective output current.
- $Id(avr)$: Average diode current.
- $Id(rms)$: Effective diode current.
- Vdc : Average rectifier voltage.
- Idc : Average rectifier current.
- Pdc : Output average load power.
- Pac : Output effective load power.
- TUF : Transformer utilization factor.
- $(VA)rating$: Transformer apparent power.
- PIV : Peak inverse voltage.
- FF : Form factor.
- η : Rectification efficiency.
- RF : Ripple factor.

Table 4.8 Rectifier parameters

Given parameters	From equations (4.33 -4.53) we get these results
V_p =220V V_s=13.75V V_{dc} =12.38V I_{dc} =6A	$Vrms = Vs = 13.75V$ RL=2.06 ohm $Id(avr) = 3A$ $Irms = 6.67A$ $Id(rms) = 4.86A$ $(VA)rating = 91.53VA$ $TUF = 0.80$ $Pdc = 74.28$watt $Pac = 94.53$watt $\eta = 80.1\%$ $PIV = 19.44V$ $FF = 1.11$ $RF = 48.55\%$ CF=1.41 $a = 16$ FFI=1.112 RFI=4% C=3mF

4.6.2 Rectifier simulation using Simplorer program.

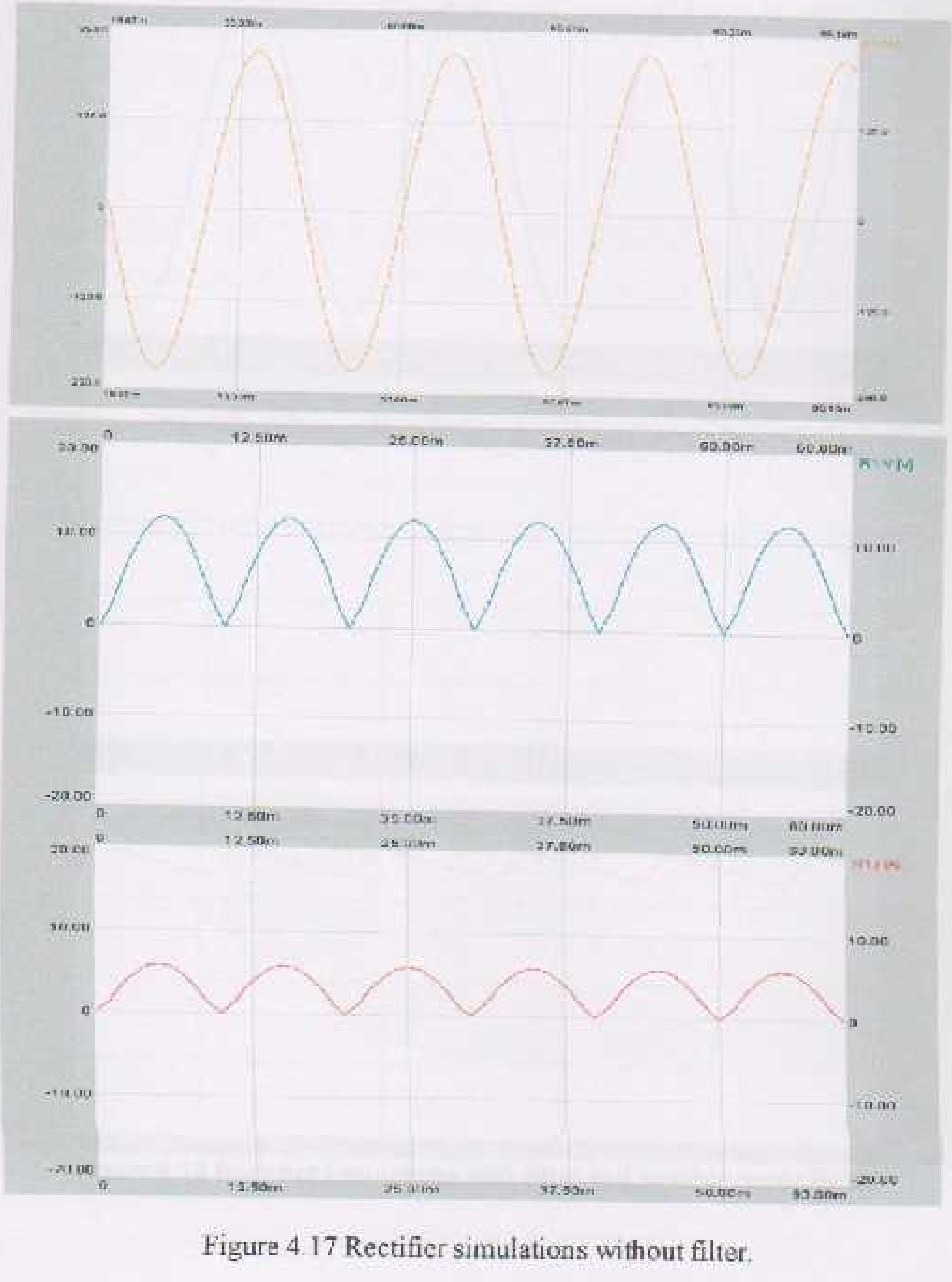


Figure 4 17 Rectifier simulations without filter.

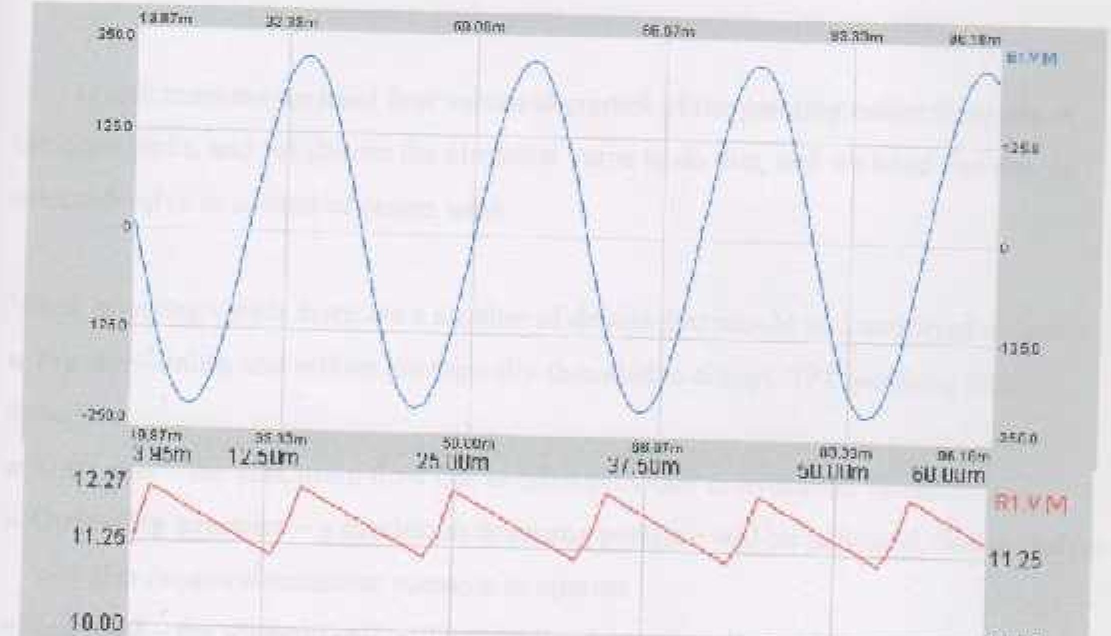


Figure 4.18 Rectifier simulations with filter and suitable ripple factor.

4.7:- Valves.

In this machine we need four valves to control of the painting colors flow rate in the main tanks, and we choose the electrical valve to do that, and we need one double solenoid valve to control of piston work.

When selecting valves there are a number of details that should be considered as listed:

- **Pip size** – inlets and outlets are typically threaded to accept NPT (national pipe thread).
- **Flow rate** – the maximum flow rate is often provided to hydraulic valves.
- **Operating pressure** – a maximum operating pressure will be indicated. Some valves will also require a minimum pressure to operate.
- **Electrical** – the solenoid coil will have a fixed supply voltage (AC or DC) and current.
- Response time – this is the time for the valve to fully open/close. Typical times for valves range from 5ms to 150ms.

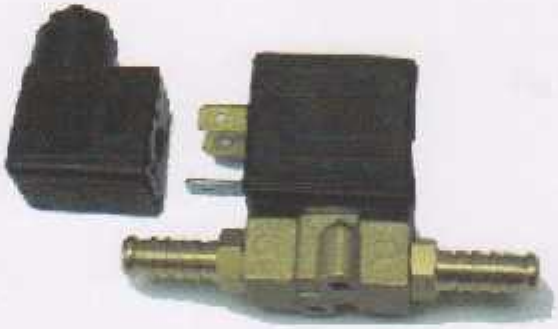


Fig 4.19:- Valve

We used valves its outlet diameter is small, for a high efficiency control to the colors flow.

4.8:-Mixing motors.

We need 5 motors in mixing tanks (4 for main color tanks & 1 for mixing tank).

- Features
  - DC motor
  - 150 rpm
  - 12 volt
  - Current 0.8

Fig 4.20:- Mixer motor.

4.9:- Circuit breaker:

240 Volt

10Ampere

Fig 4.21:- Circuit breaker.

4.10:- Relay.

24V DC

(1- 2.5) Ampere

Fig 4.22-Relay

4.11 Fuses.

a: Two fuses 1A for PLC.

b: One fuse for main motor.

Fig 4.23:- Fuse

4.12:- PLC (Programmable Logic Controller).

4.12.1:- PLC Type.

Siminse, S200, S7

14/10 input, output

Fig 4.24:-PLC

4.12.2 PLC Input and Outputs

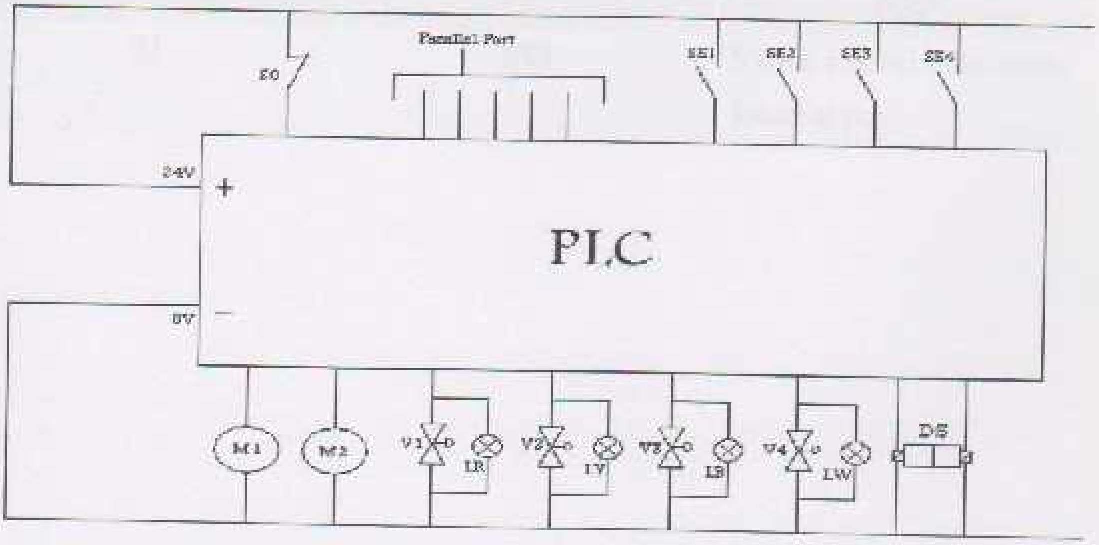


Figure 4.25 PLC circuit

Table 4.9:- Input to PLC.

#	Input	Comment
1	S0	Start operation switch
2,3,4,5,6	Parallel Port	5 bits received from the computer
7	SE1	Switch to limit the initial position
8	SE2	Switch to limit the position under the tanks
9	SE3	Switch to limit the position under the mixer
10	SE4	Switch for safety in the door
11	SE5	Switch to limit if the bottle found or not

Table 4.10:- Output from PLC.

#	Output	Comment
1	M1	Start & stop the main motor
2	M1	Reverse the main motor
3	M2	Start & stop the main mixer
4	V1	Open & close the first valve
5	V2	Open & close the second valve
6	V3	Open & close the third valve
7	V4	Open & close the forth valve
8	DS,L	Activate the left side of double solenoid valve
9	DS,R	Activate the right side of double solenoid valve

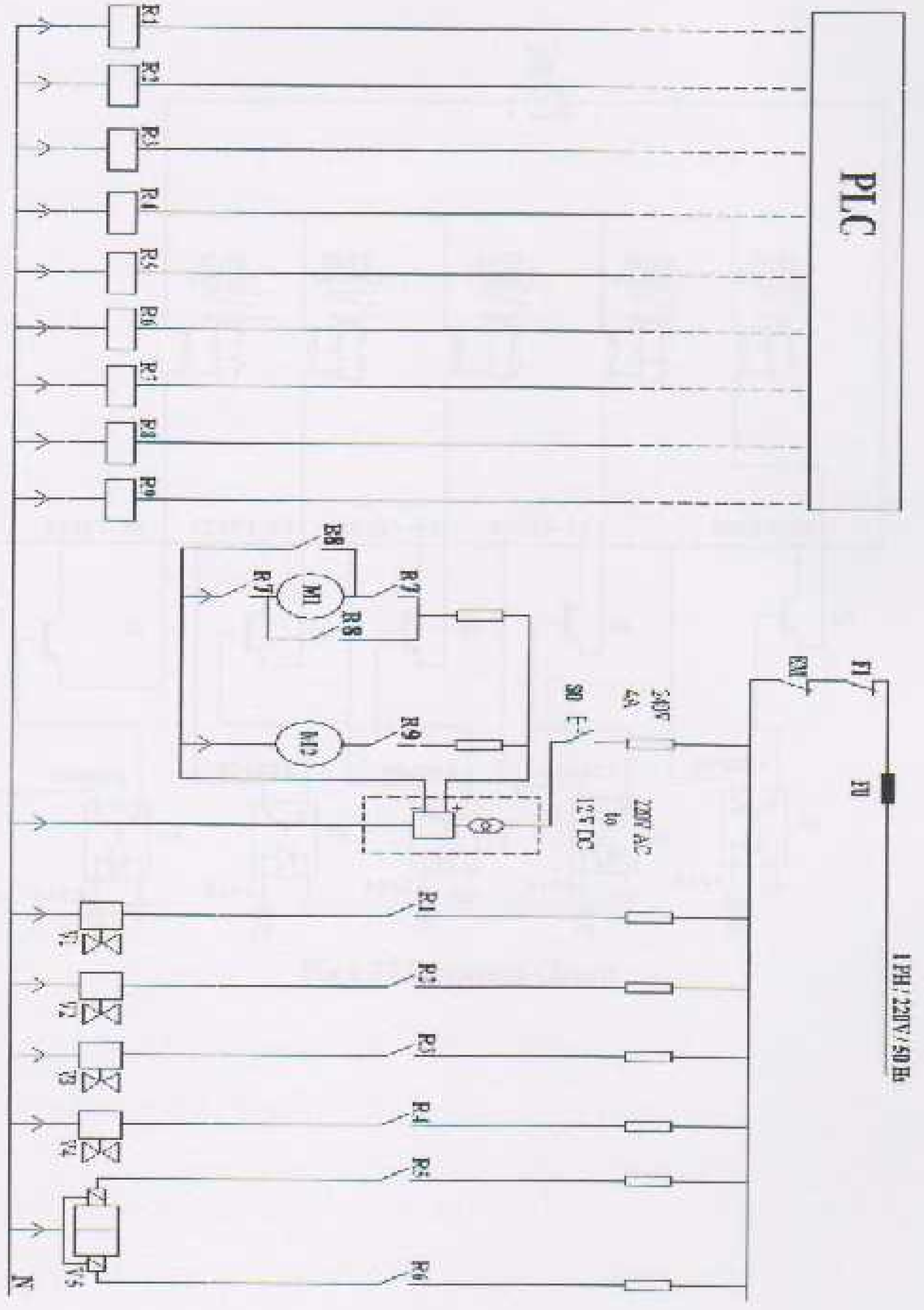


Figure 4.26: Electrical Circuit Map.

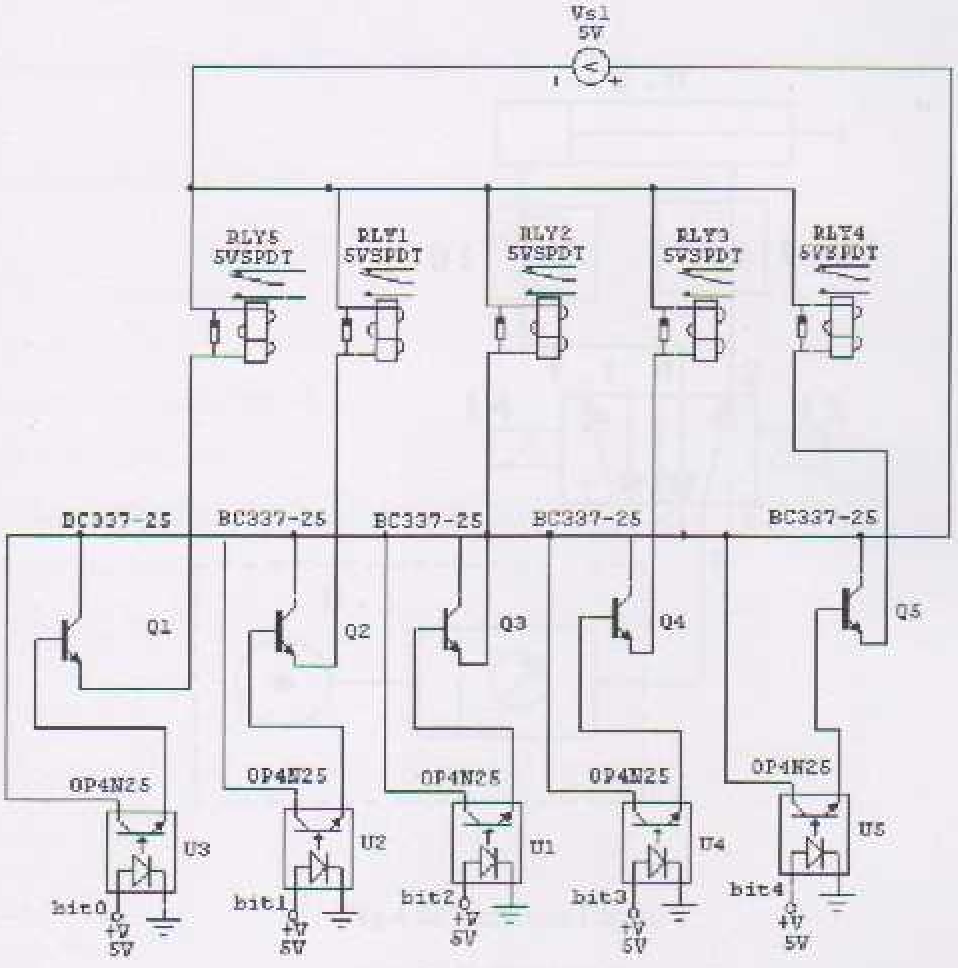


Fig 4.27 Electronic Circuit

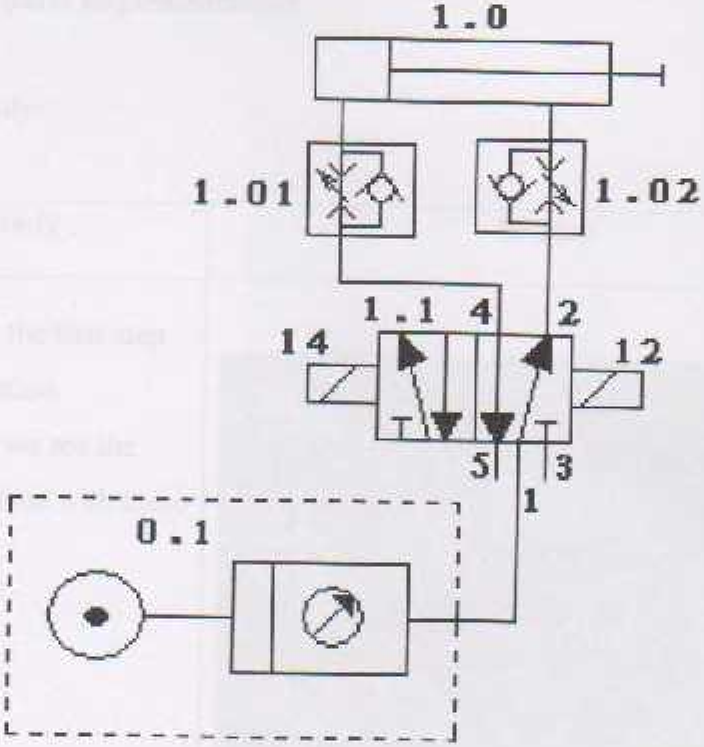


Fig 4.28Hydraulic Circuit

4.12 Overview for this chapter:

After finishing these calculations an previous design we expect a good result in implementation.

Chapter 5
Implementation of mixing and filling colors machine

5.1: mechanical parts implementation:

5.1.1 Outside body:

Main body	Picture
The main body is the first step of the implementation. From this picture we see the body for our machine with these dimensions: Length= 60 cm Wide=82 cm Height= 160	 Figure (5.1): main body

5.1.2: Upper tanks base

Upper tanks base	Pictures
The main function of this base to put the tanks between them which keep tanks in its place without any rotation.	 Figure (5.2): upper tanks base

5.1.3 Down Disk

Down disk	Pictures
The main function of the down disk is to start with a bottle from a reference point and rotate under the tanks and mixer then goes back to the reference point. This disk rotates only if the main motor rotates.	 Figure (5.3): down disk

5.1.4 Down disk base

<table>
<tr><th>Down disk base</th><th>Pictures</th></tr>
<tr><td>This base connect between the rod and the down disk

Radius= 6 cm.</td><td>
Figure (5.4): down disk base</td></tr>
</table>

5.1.5 Colors tanks.

Tanks used in our machine	Pictures
Number of color tanks = 4. Size of the tanks = 5 litters. Each tank contains one main color (red, yellow, blue, white)	 Figure (5.5): Tanks

5.1.6 Gears

Gears	Pictures
The gears which used have these characteristics : Numbers of tooth's of small gear=9 Numbers of tooth's for large gear=50 We choose these ratios because of the motor speed 30rpm and the speed needed 6rpm. Ratio =9/50=0.18.	 Figure (5.6): Gears

5.2- Electrical part Implementation:

5.2.1 Motors.

Main motor & Mixer	Pictures
We use two motors : 1. Wiper DC motor as a main motor which rotate the down disk. 2. DC motor which mixes the colors in the bottle Parameters of mixing motor: Voltage=12V Current=0.8A Power= 9.6w Main motor type: wiper motor Parameters of main motor: Voltage=12V Current= 6A Power=72w	 Figure (5.7): main motor  Figure (5.8): mixer motor.

5.2.2 Relays

Relays	Pictures
We use 9 relays as outputs & 5 relays as inputs : **Outputs relays :** 1-We use 4 relays 24V DC as outputs for valves. 2- We use 2 relays as outputs for double solenoid valve (up and down). 3- We use three relays as outputs for motors. **Inputs relays:** We use five relays 5V DC as inputs for PLC device.	 Figure (5.9): relay

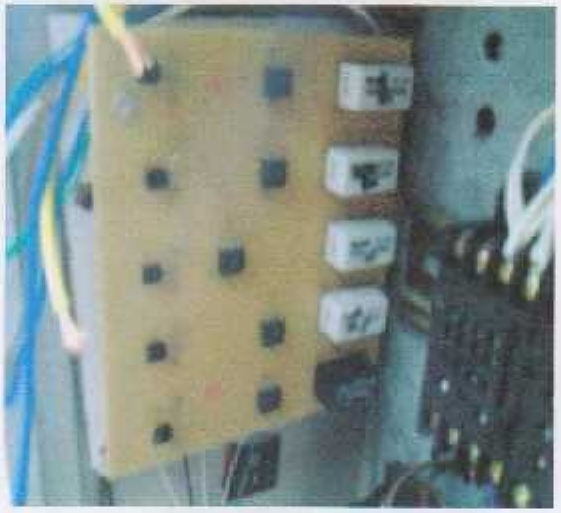
5.2.3 Fuses and circuit breaker.

Fuses & circuit breakers	Pictures
We use three fuses & main circuit breaker in our machine to protect the motors and PLC device. Two fuses protect the PLC with same rated current: 2A. And one fuses to protect the main motor with rated current: 6A. We use one circuit breaker to protect the machine from high current with rated current: 10A.	 Figure (5.10): fuses & circuit breakers

5.2.4 Power supply

Power supply	Pictures
We use in our machine two power supplies : 1. 12V DC as main power supply for feeding the motors (main motor and mixer motor). 2. 24V DC as additional power supply for feeding the outputs of PLC device. 3. And 220 V AC as main input for machine.	 Figure (5.11): Power supply 24V  Figure (5.12): Power supply 12V

5.2.5 Electronic circuit.

Applied Electronic circuit	Pictures
We built the electronic circuit because of the current flow from parallel port cant turn on the coils of relays. **Components it:** 1. Five relays 5V, 2A. 2. Five transistors Tr-222. 3. Five auto couplers **2N25.** 4. External power supply 5V. 5. Weirs. From outputs of relays, we take it to PLC device as input switches.	 Figure (5.13): electronic circuit

5.3 - Hydraulic part implementation:

Valves, regulators and piston.	Pictures
We used four valves in our machine Types: single solenoid valve Pip size: 0.5" Electrical: 220V AC, 38mA. Response time: 5ms to 150ms.	 Figure (5.14): piston
2.sector Double solenoid valve 220V AC.	 Figure (5.15): selector
3.regulator Maximum pressure 8bar. Minimum pressure 0bar.	 Figure (5.16): Valve
4. piston: Stroke: 10 cm. Pressure: 1bar.	 Figure (5.17) Regulator

5.4- Control part implementation:

5.4.1 Interfacing program

<table>
<tr><th>Interfacing program</th><th>Pictures</th></tr>
<tr><td>

*At the first of starting the program we make a welcome screen to define the operation of the machine and who design the system.

*And then we defined a constant time that make a ratios between colors which process in the program and defined as over all time of the flow rate of the valves

</td><td>

Figure (5.18): Program interface

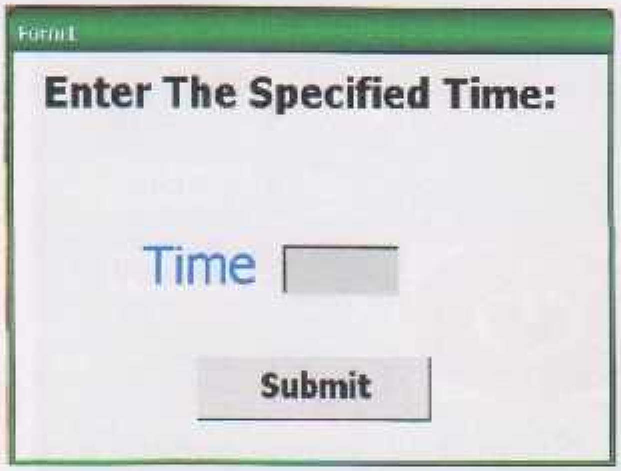


Figure (5.19): Program time interface

</td></tr>
</table>

* This interface for the almost used colors in area which you can choose any of these colors.

* Also you can return back to the previous slide by using home button or stop the process by using power button or close the program by using end button.

* If you want to produce a new color you can choose the advance button which you can inter the ratios of the basic colors and the volume of bottle and the system will simulate the values to produce the new color

Figure (5.20): program colors interface

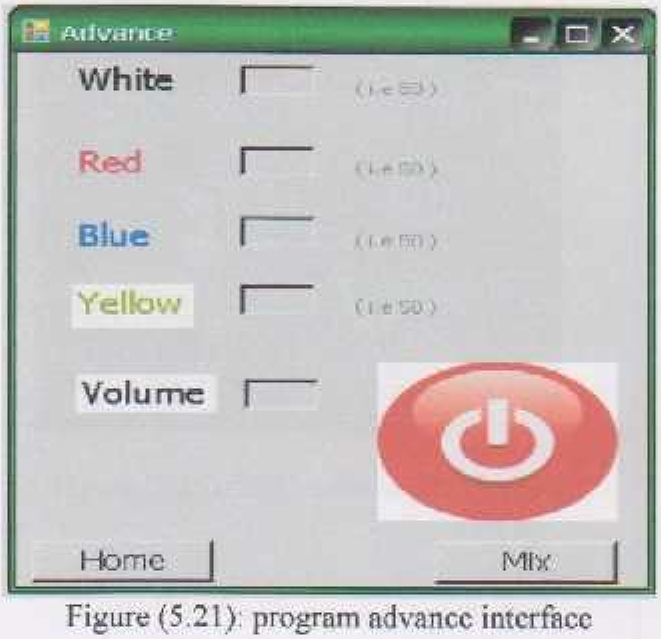


Figure (5.21): program advance interface

5.4.2 PLC Device

PLC device	Pictures
We used S200 Siemens with 10 input & 9 output . This PLC used to control in any operation automatically in our machine.	 Figure (5.22): PLC  Figure (5.23): PLC with in & out pins

5.5 - Out side machine:

It's important to give a good look for the machine which give a good expression for the user and this proposed machine.

Figure (5.24): machine out side

5.6 Actual cost for our machine

Table 5.1 Actual cost

Item	Price (NIS)	Student contribution	University contribution
Main body	1500	yes	No
Motors	150	yes	No
gears	100	yes	No
Lathe	1000	yes	No
Relays	300	yes	No
Fuses & circuit breaker	100	yes	No
Switches	450	No	No
Electronic elements	150	No	No
Electrical bored	100	yes	No
Electrical weirs	100	No	No
Paints	100	No	No
Valves	1000	No	No
PLC device	1000	No	yes
Pump	500	No	yes
Main colors	100	No	No
Our Expenses	1000	yes	No
	Total cost	7650 NIS	

All the elements from our university contribution available in the lab and return back to the lab.

5.7 Recommendation & suggestions:

1-We suggest to add a balance to the machine for obtain more accuracy on the produced colors because of depending on the time is not give us accuracy comparing with balance accuracy.

2- Changing the tanks which used in implementation machine and replace it in tanks designed in chapter four.

3- We suggest using a position sensor which determined the scale of colors in tanks.

5.8 Conclusion:

1-This machine increase our knowledge in the electrical and mechanical elements and how we can use them.

2- Innovation of new machine that can be used in local market

3- This machine increases our knowledge in computer programming by using the parallel port to control the time rate.

4. Our project opens for us many hopes for the future work in the local industry.

Error

Subsystem: JPEG

Error: Error Code 0xa9

Operator: SetBrushSource

Position: 12743

[illegible]

5.6 Actual cost for our machine

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2- Innovation of new machine that can be used in local market

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Appendix

A: Parallel port
B: Optocoupler
C: PLC Program
D: Transformer design
E: Visual studio
F: Limit switch

Appendix A

Parallel port

Introduction

PC parallel port can be very useful I/O channel for connecting your own circuits to PC. The PC's parallel port can be used to perform some very amusing hardware interfacing experiments. The port is very easy to use when you first understand some basic tricks. This document tries to show those tricks in easy to understand way.

WARNING: PC parallel port can be damaged quite easily if you make mistakes in the circuits you connect to it. If the parallel port is integrated to the motherboard (like in many new computers) repairing damaged parallel port may be expensive (in many cases it it is cheaper to replace the whole motherborard than repair that port). Safest bet is to buy an inexpensive I/O card which has an extra parallel port and use it for your experiment. If you manage to damage the parallel port on that card, replacing it is easy and inexpensive.

NOTE: The I/O port level controlling details here has proven to work well with parallel ports on the PC motherboard and expansion cards connected to ISA bus. The programming examples might not work with PCI bus based I/O cards (they can use different hardware and/or I/O addresses, their drivers make they just look like parallel ports to "normal" applications). The programming examples do not work with USB to parallel port adapters (they use entirely different hardware, their drivers make them to look like normal parallel port to operating system "normal" applications).

DISCLAIMER: Every reasonable care has been taken in producing this information. However, the author can accept no responsibility for any effect that this information has on your equipment or any results of the use of this information. It is the responsibly of the end user to determine fitness for use for any particular purpose. The circuits and software shown here are for non commercial use without consent from the author.

How to connect circuits to parallel port

PC parallel port is 25 pin D-shaped female connector in the back of the computer. It is normally used for connecting computer to printer, but many other types of hardware for that port is available today.

Not all 25 are needed always. Usually you can easily do with only 8 output pins (data lines) and signal ground. I have presented those pins in the table below. Those output pins are adequate for many purposes.

```
pin function
 2    D0
 3    D1
 4    D2
 5    D3
 6    D4
 7    D5
 8    D6
```

9   D7

Pins 18,19,20,21,22,23,24 and 25 are all ground pins.

Those datapins are TTL level output pins. This means that they put out ideally 0V when they are in low logic level (0) and +5V when they are in high logic level (1). In real world the voltages can be something different from ideal when the circuit is loaded. The output current capacity of the parallel port is limited to only few milliamperes.

Here is a simple idea how you can connect load to a PC parallel port data pins.

```
        Dn Out ------+
                     |+
 Sourcing          Load (up to 2.6 mA @ 2.4 v)
                     |-
        Ground ------+
```

This is not the only way to connect things to a parallel port.

The parallel port data pins are TTL outputs, that can both sink and source current. In ordinary parallel port implementations the data outputs are 74LS374 IC totem-pole TTL outputs which can source 2.6 mA and sink 24 mA.

Regular TTL outputs basically consist of a two "stacked" transistor in series between +5 volts and ground, with the output coming from the connection between them. This is called a "totem pole output". At any given time one of these transistors is conducting and the other is not. To pull the output "high", the transistor from +5 to the output conducts (H), which "sources" positive current from the output to ground (that is, an external device between the output and ground will get power). To pull the output low, only the lower transistor (L) conducts, "sinking" current to ground; an external device between +5 volts and the output can be energized.

```
       +5
       /  |
   ---H on  V
       \      -->
        |________          TTL output on = 1 = high, "sourcing"
current
        |  out  \
       /        / |
   ---L off     \ V
       \________/
       Gnd


      +5________
       /        \
   ---H off     / |
       \        \ V
        |_______/          TTL output off = 0 = low, "sinking" current
           <-- out
       /
      L on |
       \   V
      Gnd
```

The outputs are designed so that they give at least 2.4V at 2.6 mA load. This 2.6 mA figure is for ordinary LS-TLL circuits used, the LSI implementations used in many computers can give more or less. For example quite popular (few years ago) UM82C11-C parallel port chip can only source 2 mA.

Simple current sinking load connection:

```
          Dn Out ------+
                       |+
 Sourcing            Load (up to 2.6 mA @ 2.4 v)
                       |-
          Ground ------+
```

When taking current from PC parallel port, keep the load low, only up to few milliamperes. Trying to toke too much current (for example shorting pins to ground) can fry the parallel port. I have not killed any parallel port (yet) in this method, but I have had in cases where too much load has made the parallel port IC very hot. Be careful.

If you have an external +5 volt supply, you have another option for connection: use the Data Out pins to sink up to 24 mA from your +5 volt supply. This can be made with a circuit like this:

```
                       +------------------------------ (+5 v)
                       |+
  Sinking            Load (up to 24 mA @ 4.2v)
                       |-             Power Supply
          Dn Out ------+

          Ground ---------------------------------------- (Gnd)
```

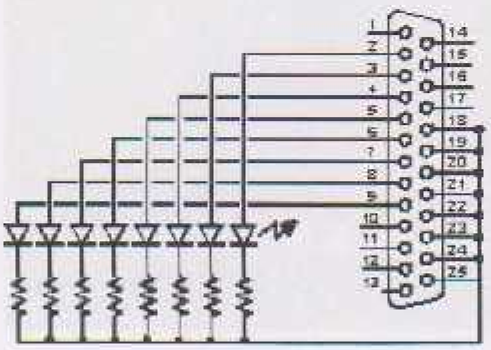
The load gets power then you have external +5V on and the printer port data pin set to 0. This circuit gives you capability of of driving more current than the "sinking" approach. You need to be careful with this circuit, because with this circuit you can easily fry the parallel port if you do things wrong. My advice is to be very careful with this type of circuit and make sure that the external +5V power supply gets turned off when computer gets turned off (all printer ports might not like getting +5V though the load to printer port when they are not powere). The most convient source "external +5V" might be from same other port on your PC (USB, joystick, keyboard/mouse etc. port).

I have used mostly "sinking" type circuits and this article is concentrated on using them.

Simple LED driving circuits

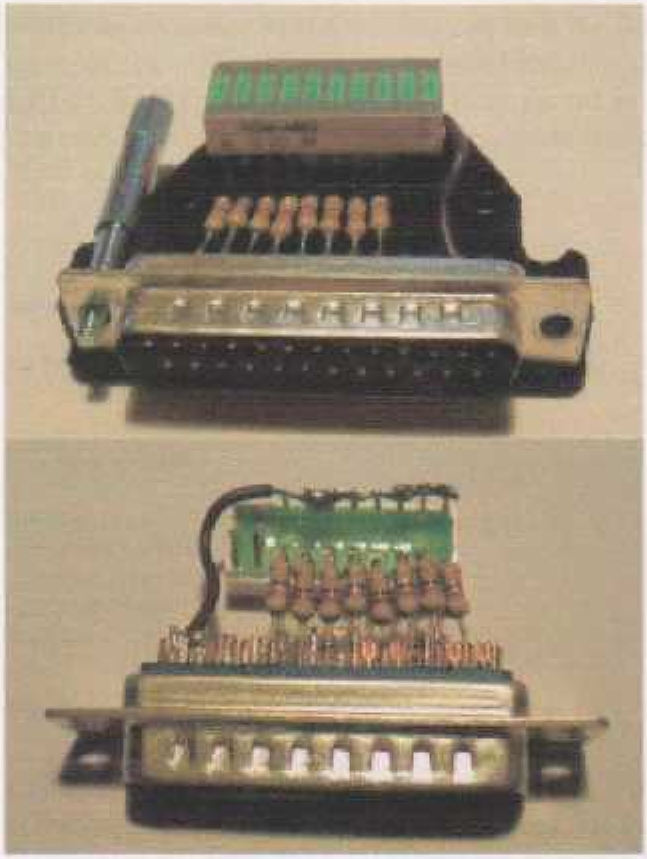
You can make simple circuit for driving a small led through PC parallel port. The only components needed are one LED and one 470 ohm resistors. You simply connect the diode and resistor in series. The resistors is needed to limit the current taken from parallel port to a value which light up acceptably normal LEDs and is still safe value (not overloading the parallel port chip). In practical case the output current will be few milliampres for the LED, which will cause a typical LED to somewhat light up visibly, but not get the full brigtness.

Then you connect the circuit to the parallel port so that one end of the circuit goes to one data pin (that one you with to use for controlling that LED) and another one goes to any of the ground pins. Be sure to fit the circuit so that the LED positive lead (the longer one) goes to the datapin. If you put the led in the wrong way, it will not light in any condition. You can connect one circuit to each of the parallel port data pins. In this way you get eight software controllable LEDs.



The software controlling is easy. When you send out 1 to the datapin where the LED is connected, that LED will light. When you send 0 to that same pin, the LED will no longer light.

Here are two photos of circuit above I have built:



Pn those circuits I have wired the ground wire only to one ground pin (it works also well, you can use any of the ground pins).

Technical specifications of parallel port pins

The IBM specifications says accoding http://www.epanorama.net/counter.php?url=http://www.linux.com/howtos/IO-Port-Programming-6.shtml the following: The data output pins (pins 2-9) sink 24 mA, source 15 mA, and their high-level output is min. 2.4 V. The low state for both is max. 0.5 V. Pins 1, 14, 16, and 17 (the control outputs) have open collector drivers pulled to 5 V through 4.7 kiloohm resistors (sink 20 mA, source 0.55 mA, high-level output 5.0 V minus pullup). Non-IBM parallel ports probably deviate from this standard.

Warning: Be careful with grounding. You can break parallel ports by connecting devices to them when PC is powered on. It is not a good idea to short the pins to ground or +5V, this can damage the port. It might be a good thing to use a parallel port not integrated on the motherboard for things like this. (You can usually get a second parallel port for your machine with a cheap standard `multi-I/O' card)

Control program for DOS (and Win9x)

The following program is an example how to control parallel port LPT1 data pins from your software. This example directly controls the parallel port registers, so it does not work under some multitasking operating system which does not allow that. It works nicely under MSDOS. You can look the Borland Pascal 7.0 code (should compile also with earlier versions also) and then download the compiled program LPTOUT.EXE. This has worked nicely for me in DOS systems and Windows 95/98 systems. On recent testings this program has worked unreliably on some Windoes 2000 systems.

```
Program lpt1_output;

Uses Dos;

Var
   addr:word;
   data:byte;
   e:integer;

Begin
   addr:=MemW[$0040:$0008];
  Val(ParamStr(1),data,e);
   Port[addr]:=data;
End.
```

How to use the program

LPTOUT.EXE is very easy to use program. The program takes one parameter, which is the data value to send to the parallel port. That value must be integer in decimal format (for example 255). Hexadecimal numbers can also be used, but they must be preceded by $ mark (for example $FF). The program hoes not have any type of error checking to keep it simple. If your number is not in correct format, the program will send some strange value to the port.

NOTE: I have found out that this program does not work reliably on some Windows 2000 systems I have tested on this. I don't know what is causing this specific problem (other than you should not try to access hardware directly on Windows NT based system..). I have not tested this program with Windows XP.

Example how to use the program

LPTOUT 0
Set all datapins to low level.

LPTOUT 255
Set all datapins to high level.

LPTOUT 1
Set datapin D0 to high level and all other datapins to low level.

How to calculate your own values to send to program

You have to think the value you give to the program as a binary number. Every bit of the binary number control one output bit. The following table describes the relation of the bits, parallel port output pins and the value of those bits.

```
Pin      2   3   4   5   6   7   8   9
Bit      D0  D1  D2  D3  D4  D5  D6  D7
Value    1   2   4   8   16  32  64  128
```

For example if you want to set pins 2 and 3 to logic 1 (led on) then you have to output value 1+2=3. If you want to set on pins 3,5 and 6 then you need to output value 2+8+16=26. In this way you can calculate the value for any bit combination you want to output.

Making changes to source code

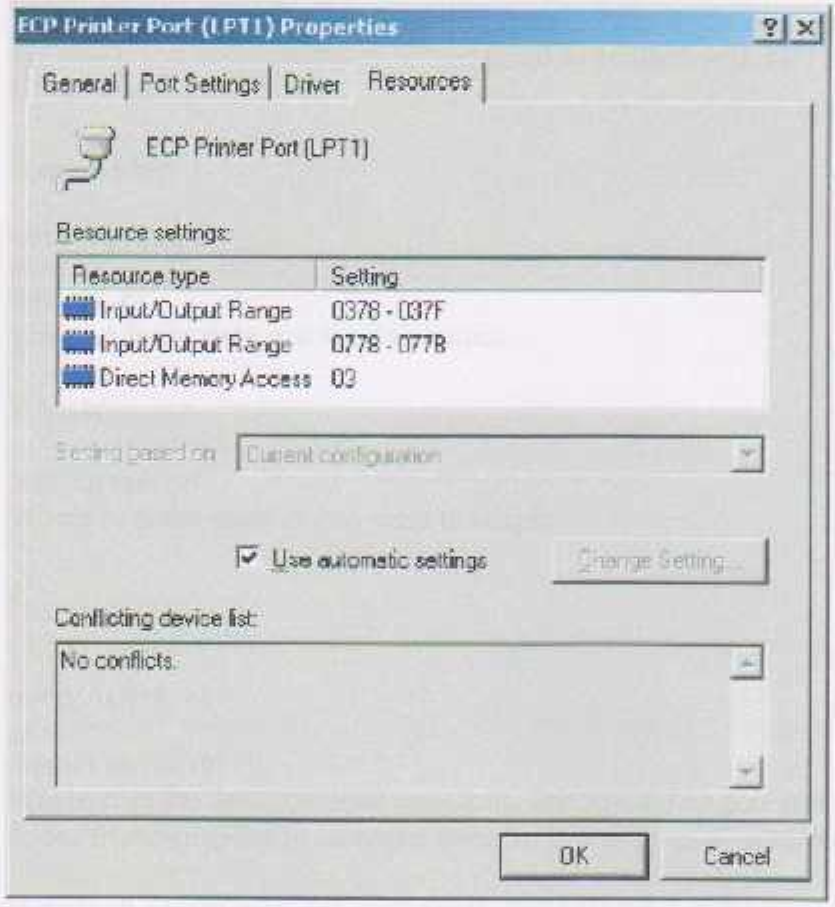
You can easily change te parallel port number int the source code by just changing the memory address where the program read the parallel port address. For more information, check the following table.

```
Format of BIOS Data Segment at segment 40h:
Offset  Size    Description
 08h    WORD    Base I/O address of 1st parallel I/O port, zero if
none
 0Ah    WORD    Base I/O address of 2nd parallel I/O port, zero if
none
 0Ch    WORD    Base I/O address of 3rd parallel I/O port, zero if
none
 0Eh    WORD    [non-PS] Base I/O address of 4th parallel I/O port,
zero if none
```

For example change the line **addr:=MemW[$0040:$0008];** in the source code to **addr:=MemW[$0040:$000A];** if you want to output to LPT2.

Instead of trying to read the address from the DOS information data block you can always use the I/O address fixed to source code. The LPT1 port is typically at I/O-address 378h or 3BCh.

To get to know the port address to use you can use for example the method: On modern Windows systems (I tested in Windows 2000) you can get to know the parallel port I/O addrss through device manager. First open the device manager (start - settings - control panel - system - hardware - device manager). Then select there the parallel port you are interrested from Ports (COM & LPT) section. With mouse right button you can get menu where you select Properties. From there select Resources where you should see a screen like this:



The details in this image are from the parallel port built into the motherboard of my PC.

Parallelport programming in DOS

The following examples are short code examples how to write to I/O ports using different languages. In the examples I have used I/O address 378h which is one of the addresses where parallel port can be.

The typical parallel port I/O addess configurations seen on PCs with ISA bus:

- LPT1: 3BCh, LPT2: 378h, LPT3: 278h
- LPT1: 378h, LPT2: 278h
- LPT1: 378h

Those are the typical I/O addresses used in ISA bus based systems. In PCI bus based systems the LPT1 port on motherboard is typically at I/O-address 378h or 3BCh. If the systems has extra LPT ports on multi-IO card in PCI bus, those extra LPT ports work differently than the "normal parallel port" described in this document, and the same control methods can't be applied to them (they are on different I/O addresses and could use different control register system that could be card specific, the driver software that comes with the card makes them to look like LPT ports for the applications using standard operating system printing routines).

The following examples are for DOS system (they might or might not work on other systems). The code examples are designed to be used with LPT1 port that resides in I/O address 378h.

Assembler

```
MOV DX,0378H
MOV AL,n
OUT DX,AL
```

Where n is the data you want to output.

BASIC

```
OUT &H378, N
```

Where N is the number you want to output.

C

```
outp(0x378,n);
or
outportb(0x378,n);
```

Where N is the data you want to output. The actual I/O port controlling command varies from compiler to compiler because it is not part of standardized C libraries.

Here is an example source code for Borland C++ 3.1 compiler:

```
#include <stdio.h>
#include <dos.h>
#include <conio.h>

/********************************************/
/*This program set the parallel port outputs*/
/********************************************/

void main (void)
{
clrscr();              /* clear screen */
outportb(0x378,0xff); /* output the data to parallel port */
getch();               /* wait for keypress before exiting */
}
```

Using DOS debug to access parallel port

DOS program Debug is a simple 8088 assembler that comes with DOS operating system (comes with DOS utilities on most modern WIndows systems as well). Debug allows debugging of simple 16-bit DOS applications (not useful to modern 32-bit Windows programs). Debug program has several built-in debugging tool commands, including commands to read and write I/O ports.

```
o- writes one byte of dat to the specified I/O port
SYNTAX o port value
port - specifies the port address. The port address can be an 8 or a
16 bit value.
```

```
value - specified the value to write to this I/O-port. This value is
8 bit value.
```

```
i- reads one byte of data from the specified I/O port
SYNTAX i port
port - specifies the port address. The port address can be an 8 or a
16 bit value.
```

Examples:

```
If you type

o 3bc ff

debug will output value ff (hex) to port 3bc (hex).

If you type

i 3bc

debug will display 1 byte of data from the parallel port.
```

Parallel port controlling in Windows programs

Writing programs to talk with parallel port was pretty easy in old DOS days and in Win95/98 too. We can use Inporb and outportb or _inp() or _Outp functions in our program without any problem if we are running the program on Dos or WIN95/98. But entering to the new era of NT clone operating systems like WIN NT4, WIN2000, WINXP, all this simplicity goes away.

Direct parallel port controlling in possible under Windows 3.x and Windows 95 directly from 16 bit application programs and DLL libraries. So you can use the C example above in Windows 3.x and Windows 95 if you make your program 16 bit application. If you want to control parallel port from Visual Basic or Delphi then take a look at the libraries at Parallel Port Central at http://www.epanorama.net/counter.php?url=http://www.lvr.com/parport.htm.

Direct port controlling from application is not possible under Windows NT and to be ale to control the parallel port directly you will need to write some kind of device driver to do this. You can find also this kind of drivers from Parallel Port Central and Inpout32.dll for WIN NT/2000/XP.

Driverlinx PortIO at http://www.epanorama.net/counter.php?url=http://www.driverlinx.com/DownLoad/DlPortIO.htm is a worth to check driver for accessing I/O ports directly under Windows 95/NT (works also well with Windows 2000). This free software comes with example programs (both executable and source code available) how to access I/O ports from Visual Basic and Microsoft Visual C programs.

The I/O Control Using Using Visual Basic web page at http://www.epanorama.net/counter.php?url=http://www.southwest.com.au/~jfuller/vb/vbout.htm describes how to make a simple Visual Basic application that controls PC parallel port.

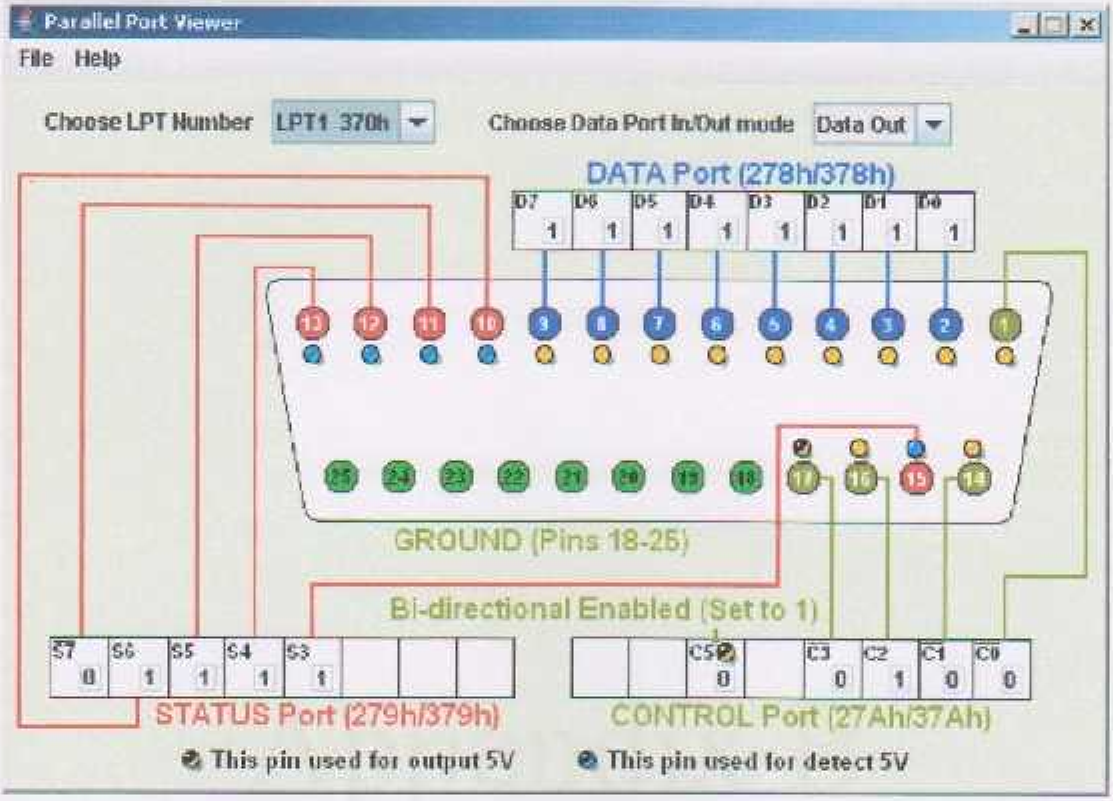
If you are looking for a ready made software, then take a look at Kemo M125 kit web page at http://www.epanorama.net/counter.php?url=http://www.kemo-electronic.com/en/module/m125/. Kemo relay module M125 is designed for switching up to 8 different appliances, lamps or motors according to a computer program (up to 40V and loads up to 0,4A DC or 0,2A AC). The module is operated at the printer port LPT1 in the same way as my parallel port controlling circuit examples (in this module there is one solid state relay connected for each of those 8 data output pin on parallel port). Kemo M125 kit information page has control software available for download. Those software allows controlling of outputs manually and timed operation. Windows software runs in WIN9x, WIN2K and WINXP. There is also programming C source code example available.

Parallel port relay relay board kit described at http://www.epanorama.net/counter.php?url=http://electronickits.com/kit/complete/elec/ck1601.htm comes with Windows and DOS control software that can be downloaded at the kit page. This software runs at Windows 9x/2000/ME/XP. Information on DOS utilities can be found at http://www.epanorama.net/counter.php?url=http://www.qkits.com/serv/qkits/diy/pages/QK74.asp

Parallel port monitors page at http://www.epanorama.net/counter.php?url=http://neil.fraser.name/software/lpt/ has programs that allow you to set and monitor parallel port pin states. The software is available for few different versions that work on Windows 98 / ME / NT / 2000 / XP and DOS / Windows 3.1 / 95 / 98 / ME systems. The software is written using Visual Basic and Euphoria programming languages and comes with source code.

Beyond Design PC Serial and Parallel Port Software and Interfaces software VBPortTest at http://www.epanorama.net/counter.php?url=http://www.beyond-designs.com/PC_ports.htm is an useful utility. VBPortTest parallel port utility is designed to help test and debug parallel port interfaces. Allows access to the three registers (data, status, and control) associated with the PC standard parallel port (SPP). The user can read and write the data and control registers. The program continually reads the status register (the status register is read-only) . Individual register bits are displayed on LEDs along with the hex value for the entire data register. In write mode, the user can toggle individual bits by clicking on the corresponding LED. Hex values can be entered on the keyboard. Bit, byte and strobed byte write modes are possible. Online Help with useful parallel port reference material includes signal descriptions and Centronics handshake timing waveform. VBPortTest is available for download as freeware. Windows 98, ME, and XP compatible.

If you want to do programming of parallel port in Windows with C/C++ then one way to go is to use using the inpout32.dll and the free borland C compiler. For more info, you can check out http://hytherion.com/beattidp/comput/pport.htm and http://csjava.occ.cccd.edu/~gilberts/bcc55.html. The second link was a very nice, step by step guide as to how to do things


Parallel Port Viewer
File Help
Choose LPT Number LPT1 378h
Choose Data Port In/Out mode Data Out
DATA Port (278h/378h)
D7 D6 D5 D4 D3 D2 D1 D0
1 1 1 1 1 1 1 1
GROUND (Pins 18-25)
Bi-directional Enabled (Set to 1)
S7 S6 S5 S4 S3
0 1 1 1 1
C5 C3 C2 C1 C0
0 0 1 0 0
STATUS Port (279h/379h)
CONTROL Port (27Ah/37Ah)
This pin used for output 5V
This pin used for detect 5V

Appendix B

Using an optocoupler

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Dr Nathan Scott & Dr Hiroyuki Kagawa - July 2002

The world is a dangerous place for sensitive electronic circuits such as the AVR. We have to protect the AVR from damage caused by high voltages and voltage spikes called transients. It is very common to use a device called an optocoupler to protect the AVR from transients on input digital lines.

Optocouplers

An optocoupler is actually two devices in one package:

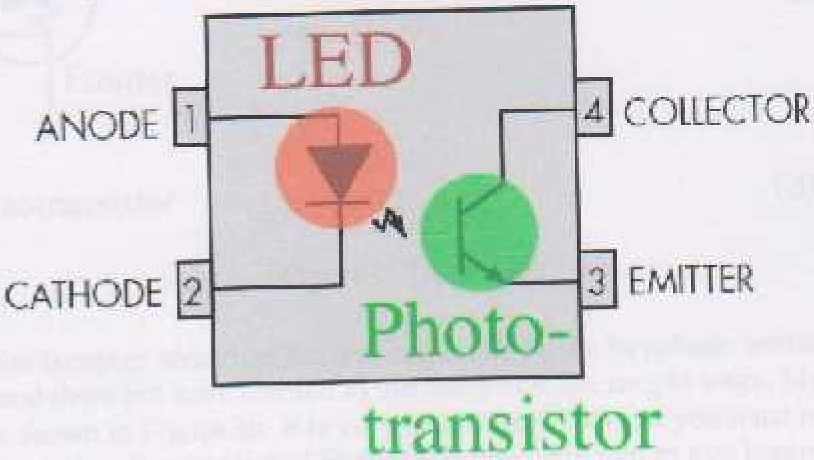

Figure 1: schematic of a typical optocoupler, from a Fairchild brochure.

You are already familiar with the LED part, it is like a small light which comes on if current passes through it. The other side (coloured green in Figure 1) is a phototransistor. Actually all transistors are phototransistors but usually they are in opaque packages that do not allow light to penetrate.

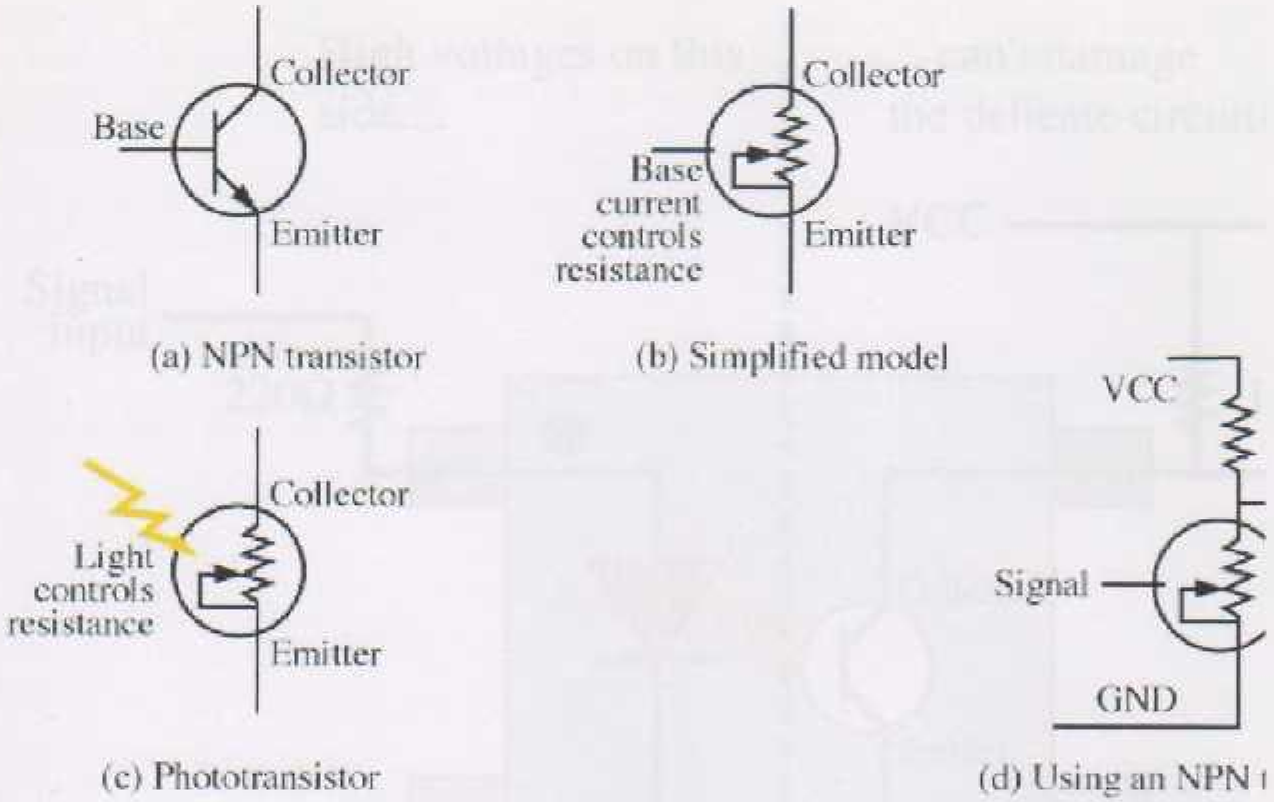

Figure 2: Transistors

Transistors are quite complex electrical devices and many books have been written about them. I do not really understand them but have learned to use them in some simple ways. My concept of how a transistor works is shown in Figure 2b. It is very much simplified and you must not think that this is what is really going on inside a transistor! However it may help you as you begin to use them. The simplified model shows that the base current controls the resistance from the collector to the emitter. It is important to understand that a **high** base current causes a **low** resistance. Now consider Figure 2d. If the signal is driven high, resistance R2 will become low and the output voltage will become close to GND (0V). If the signal is driven low, the output voltage will tend to go to VCC. A single transistor used this way is a bit like an inverting amplifier.

The signal in Figure 2d is a voltage in the case of a normal transistor. In the case of a phototransistor (Figure 2c) it is a beam of light. We can now understand how to use the optocoupler:

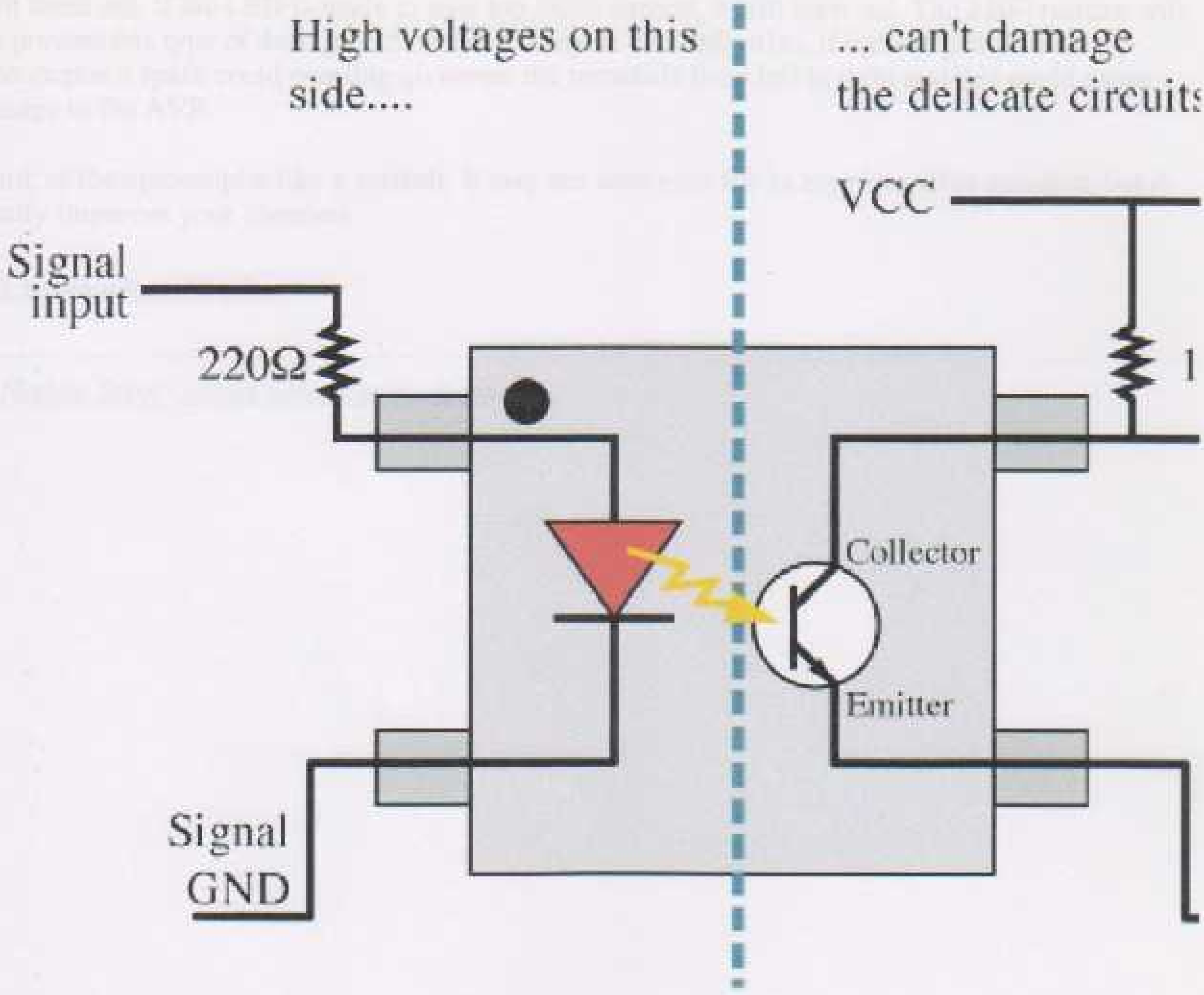

Figure 3: Using an optocoupler

It is most important to note that there is no direct electrical connection between the left side of the optocoupler and the right side. The left side is the connection to the outside world. Anything could happen on that side. For example some confused person could connect the signal with the wrong polarity, or could accidentally put 100V AC on the Signal GND line. The right side is the delicate internal workings of our device including our AVR.

- Start with the hardware set up as for the int0 project
- Set up an optocoupler as the input to the AVR instead of the 74LS14.
- Does the LED count properly?
- Now try the optocoupler AND the 74LD14. Does it count properly?
- Does the count happen when you drive the input LOW or when you drive it HIGH? Can you explain why it works the way it does? Can you change it so it works the other way?

How safe is it?

The optocoupler will help prevent some kinds of electrical damage to the AVR. However, as with any engineering object, it has its limits. The LED part of the optocoupler is very much like the LEDs that you are familiar with. LEDs are tough and not easily damaged, however it is possible to burn them out. If the LED is made to pass too much current, it will burn out. The 220Ω resistor will not prevent this type of damage if the input voltage is too high. Also, if lightning strikes the optocoupler a spark could possibly go across the terminals from left to right and this could cause damage to the AVR.

Think of the optocoupler like a seatbelt. It may not save your life in every possible accident, but it greatly improves your chances!

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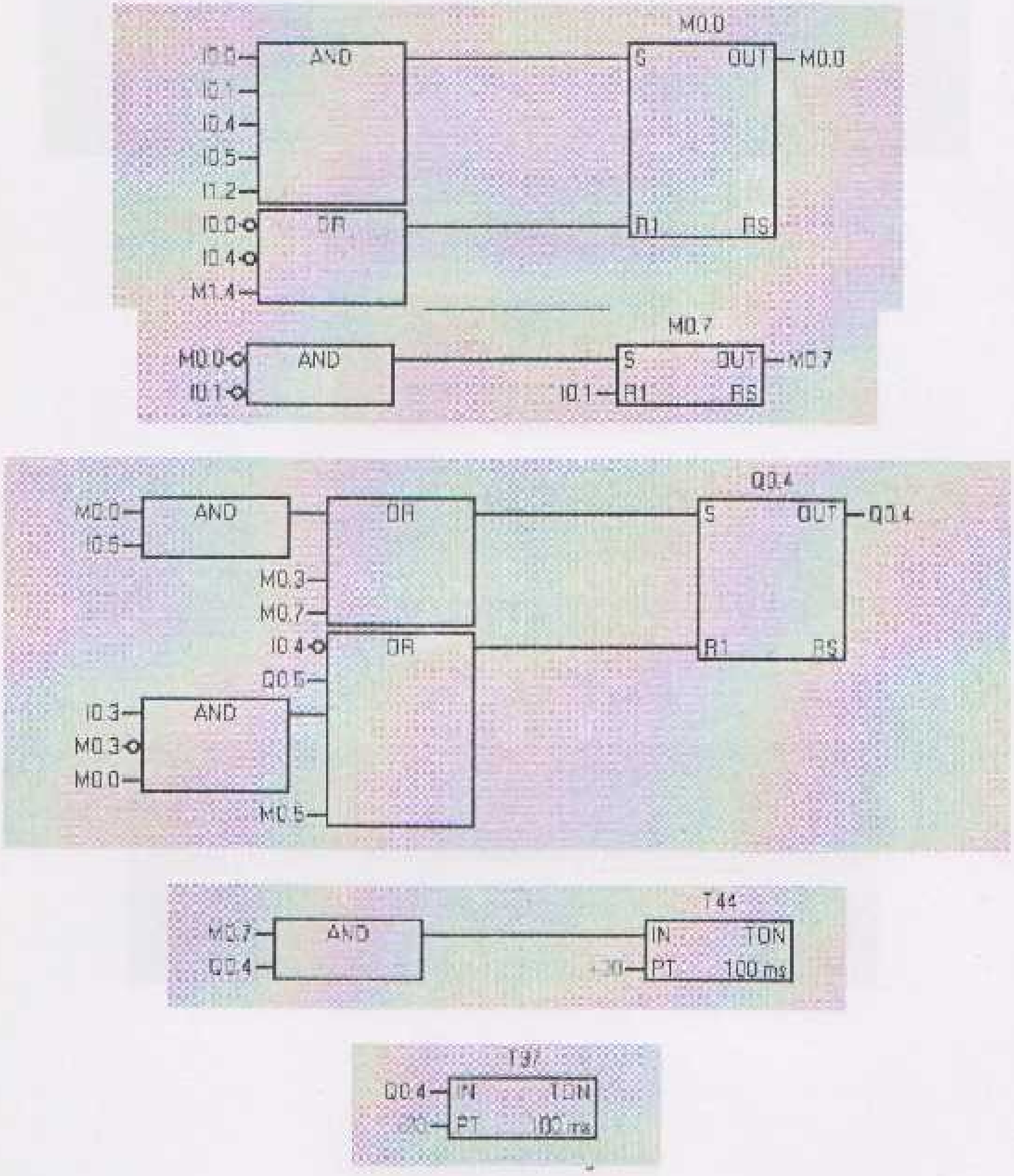
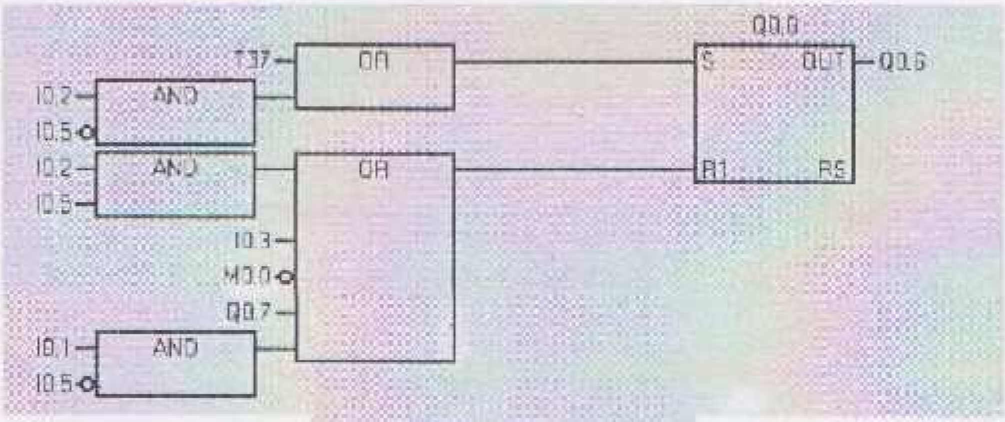
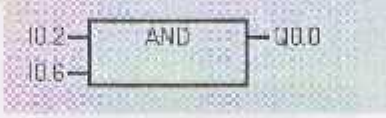
Appendix C

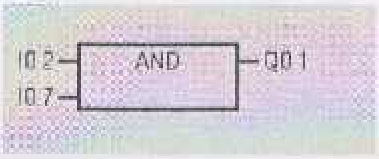
PLC Program



M0.0
I0.0
I0.1
I0.4
I0.5
I1.2
AND
I0.0
I0.4
M1.4
OR
S
OUT
M0.0
R1
RS
M0.7
M0.0
I0.1
AND
S
OUT
M0.7
I0.1
R1
RS
Q0.4
M0.0
I0.5
AND
OR
M0.3
M0.7
I0.4
Q0.5
OR
I0.3
M0.3
M0.0
AND
M0.5
S
OUT
Q0.4
R1
RS
T44
M0.7
Q0.4
AND
IN
TON
PT
100 ms
Q0.4
IN
TON
PT
100 ms

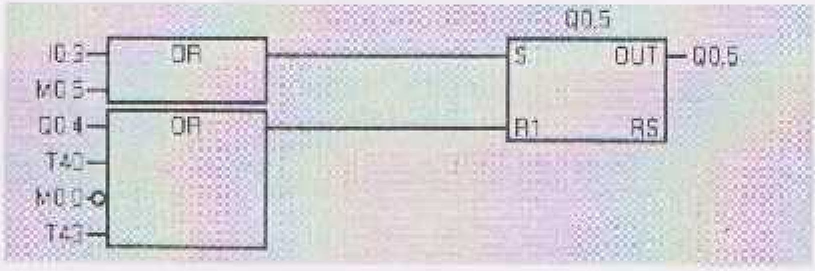

Q0.0
T37
OR
S
OUT
Q0.6
I0.2
AND
I0.5
I0.2
AND
I0.5
OR
R1
RS
I0.3
M3.0
Q0.7
I0.1
AND
I0.5

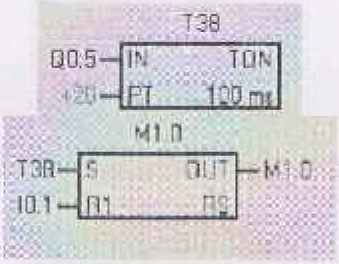

I0.2
AND
Q0.0
I0.6

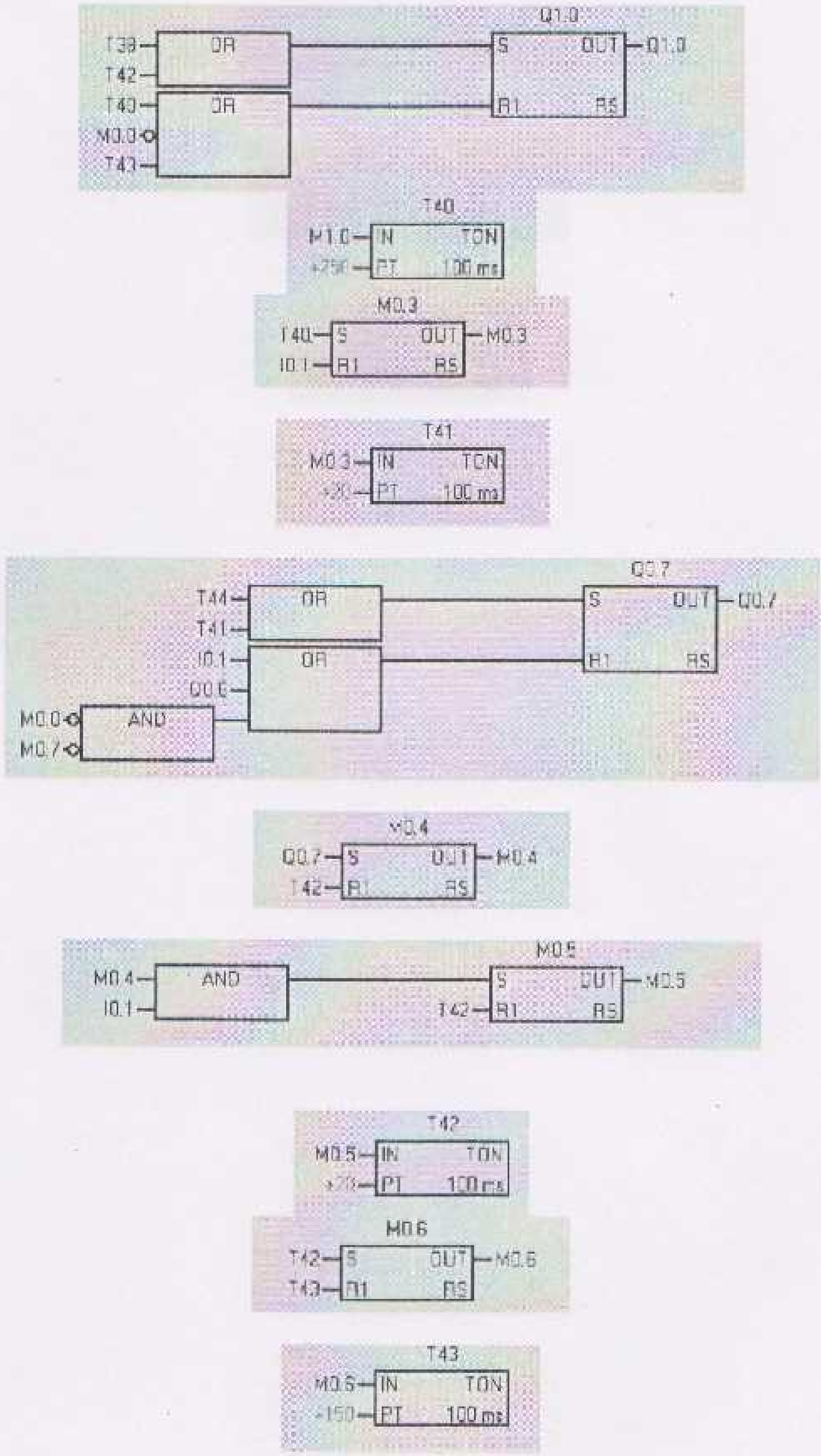

I0.2
AND
Q0.1
I0.7


I0.2
AND
Q0.2
I1.0


AND
Q0.3

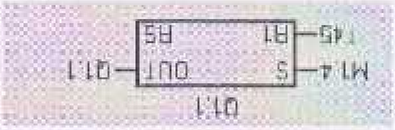

Q0.5
I0.3
OR
S
OUT
Q0.5
M0.5
Q0.4
OR
R1
RS
T40
M0.0
T43


T38
Q0.5
IN
TON
PT
100 ms
M1.0
T38
S
OUT
M1.0
I0.1
R1



Q1.0
T38
T42
T40
M0.0
T43
OR
OR
S
OUT
R1
RS
Q1.0
T40
M1.0
+250
IN
PT
TON
100 ms
M0.3
T40
I0.1
S
R1
OUT
RS
M0.3
T41
M0.3
+20
IN
PT
TON
100 ms
Q0.7
T44
T41
I0.1
Q0.6
M0.0
M0.7
AND
OR
OR
S
R1
OUT
RS
Q0.7
M0.4
Q0.7
T42
S
R1
OUT
RS
M0.4
M0.5
M0.4
I0.1
AND
T42
S
R1
OUT
RS
M0.5
T42
M0.5
+20
IN
PT
TON
100 ms
M0.6
T42
T43
S
R1
OUT
RS
M0.6
T43
M0.6
+150
IN
PT
TON
100 ms

Appendix D



Appendix D

SINGLE PHASE TRANSFORMER CALCULATIONS AND DESIGN

1. Transformer data :

Given :

Transformer voltage	**Vp, Vs**
Transformer power	**KVA**
Transformer class of temperature	**Class of temperature (some times it's recommended by the designer**

2. Calculation Procedure:

The following presents the steps realized calculation process :

1. For a given / predetermined transformer power , KVA, we determined the core area AFe by the following equation , or directly from the table for KVA we found AFe.

1. The Core Area

$$AFe = 1.14\sqrt{KVA[VA]} \text{ ,} mm^2$$

2. Number of tr-r turns for primary and secondary , we found the number of turns per volt for primary and secondary : Npe, Nse. After that total number of turns can be determined by multiplying (Nep* Vp) and (Nes*Vs).

2. The turns per volt (primary)

$$Nep = K/_{AFe}$$

3. The turns per volt (Secondary)

$$Nes = K/_{AFe}$$

3. The conductor area of both primary and secondary can be found as follow: primary conductor Ip ⟶ Ad ⟶ dp; Is ⟶ Ad' ⟶ ds;

4. The current density:
J=2.5..3.5,...... A/mm²

5. The primary current:
$Ip = KVA/_{Vp}, A$

6. The secondary current :
$Is = KVA/_{Vs}, A$

4. After determining the conductor diameter, the second step is to choose standard isolated value" conductor' for a given class of temperature. Choosing conductors with high class of temperature, it's diameter will be great, because the thickness of isolated layer will be large.

7. The conductor area :
$Ad = Ip/_J, mm; \quad Ad' = Is/_J, mm$

8. The conductor diameter
$dp = \sqrt{Ad[mm]/_{0.785}}, mm, ...$

9. The conductor diameter
$ds = \sqrt{Ad'[mm]/_{0.785}}, mm,$

4. Verifying the conductor size and placing are:
After determining the standard diameter, and number of turns of both primary and secondary , the total winding area **Aw** , and the core area where the windings are placed is calculated **Acore**. Good designed tr-r can be verified by calculating the filling factor **FF** presents the ratio between Aw and Acore, and will be less than 56%, otherwise we it's impossible to place these winding in the core space.

10. The isolated conductor:
For obtained **d,** return back to the conductor's data sheet, we determine the standard isolated diameter for given class of temperature. There're 6 standard values for temperature class:

Class	A	E	B	F	H	C
C°	105	120	130	155	180	210

11. The windings area:
$Aw = Ap + As = \frac{\pi}{4} Np * dpi^2 + \frac{\pi}{4} Ns * dsi^2,$

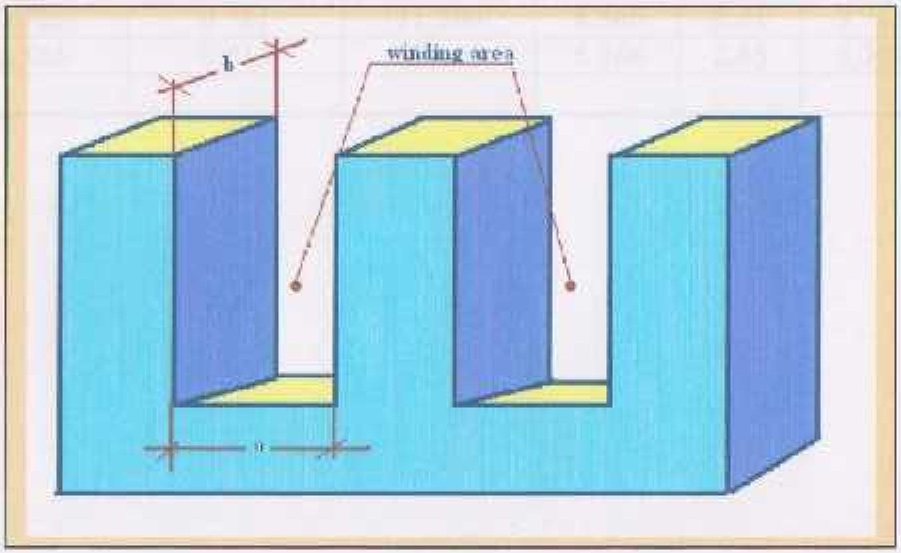
12. The core area:
$Acore = AFe = axb$, where a, b : core width, and high respectively as well shown on the figure below.

13. The filling factor FF:
The filling factor FF<56%, otherwise it's impossible to place the windings in the predetermine core space.

$$FF\% = \frac{Aw}{Acore} * 100 .$$

Where: K: voltage constant has the following value:
K=46 for power $S \leq 25VA$
K=42 for power $S \leq 100VA$
K=40 for power $S > 100VA$

Trnasformer Core:



3. Table of calculations, and tr-r data:

Table A1

Power, VA	Mag. Core (Length x Width)	Core Area AFe., cm²	Number of Sheets	Turns/Volt (Primary) Nep	Turns/Volt (Secondary) Nes	Ip, A (at Vp=220V)	The conductor area and diameter at Vp=220V					
							J=2.5A/mm²		J=3A/mm²		J=3.5A/mm²	
							Ad, mm	d[mm]	Ad, mm	d[mm]	Ad, mm	d[mm]
25	2.0 x 2.8	5.6	56	6.786	7.5	0.114	0.046	0.24	0.038	0.22	0.33	0.21
50	2.0 x 3.7	7.4	74	5.135	5.676	0.227	0.091	0.34	0.076	0.34	0.065	0.29
70	2.3 x 4.0	9.2	80	4.130	4.565	0.318	0.127	0.4	0.106	0.37	0.091	0.34
140	2.9 x 4.6	13.3	92	2.857	3.008	0.636	0.254	0.57	0.212	0.54	0.182	0.48
250	3.4 x 5.4	18.4	108	2.065	2.174	1.136	0.454	0.76	0.379	0.70	0.325	0.64
350	4.0 x 5.2	20.8	104	1.827	1.923	1.591	0.636	0.90	0.530	0.82	0.455	0.76
500	4.0 x 6.2	24.8	124	1.532	1.613	2.273	0.909	1.08	0.758	0.99	0.649	0.91
700	4.5 x 6.7	30.1	134	1.262	1.329	3.182	1.273	1.27	1.061	1.10	0.909	1.09
900	4.5 x 7.5	33.7	150	1.128	1.187	4.091	1.636	1.44	1.364	1.32	1.169	1.22
1200	5.5 x 7.1	39.1	142	0.972	1.023	5.455	2.182	1.67	1.818	1.52	1.559	1.41
2000	5.5 x 8.6	47.3	172	0.803	0.846	9.091	3.636	2.15	3.030	1.97	2.597	1.92
2500	6.5 x 8.1	52.6	162	0.722	0.761	11.364	4.546	2.41	3.788	2.20	3.247	2.03
3500	6.5 x 10	65.0	200	0.585	0.615	15.909	6.364	2.85	5.303	2.60	4.545	2.41

Appendix E

Microsoft Visual Studio is an Integrated Development Environment (IDE) from Microsoft. It can be used to develop console and graphical user interface applications along with Windows Forms applications, web sites, web applications, and web services in both native code together with managed code for all platforms supported by Microsoft Windows, Windows Mobile, Windows CE, .NET Framework, .NET Compact Framework and Microsoft Silverlight.

Visual Studio includes a code editor supporting IntelliSense as well as code refactoring. The integrated debugger works both as a source-level debugger and a machine-level debugger. Other built-in tools include a forms designer for building GUI applications, web designer, class designer, and database schema designer. It allows plug-ins to be added that enhance the functionality at almost every level - including adding support for source control systems (like Subversion and Visual SourceSafe) to adding new toolsets like editors and visual designers for domain-specific languages or toolsets for other aspects of the software development lifecycle (like the Team Foundation Server client: Team Explorer).

Visual Studio supports languages by means of language services, which allow any programming language to be supported (to varying degrees) by the code editor and debugger, provided a language-specific service has been authored. Built-in languages include C/C++ (via Visual C++), VB.NET (via Visual Basic .NET), and C# (via Visual C#). Support for other languages such as Chrome, F#, Python, and Ruby among others has been made available via language services which are to be installed separately. It also supports XML/XSLT, HTML/XHTML, JavaScript and CSS. Language-specific versions of Visual Studio also exist which provide more limited language services to the user. These individual packages are called Microsoft Visual Basic, Visual J#, Visual C#, and Visual C++.

Currently, Visual Studio 2008 and 2005 Professional Editions, along with language-specific versions (Visual Basic, C++, C#, J#) of Visual Studio 2005 are available for free to students as downloads via Microsoft's DreamSpark program. Visual Studio 2010 is currently in development.

Appendix F

PC in CONTROL

Up

Limit Switches

The switch, which is one of the most basic of all sensors, comes in two types? normally open and normally closed. Prior to advances in sensor technology, mechanical switches were used extensively in control applications. Due to improved reliability and performance, mechanical switches are still used for this purpose, but they are primarily used where switch actuation and wear are minimal. The standard limit switch is a mechanical device that uses physical contact to detect the target. A typical limit switch consists of a switch body and an operating head.

The switch body contains electrical contacts to energize or de-energize a circuit operating head incorporates a lever arm or plunger. This is also called an actuator actuator rotates when the target applies force. This movement changes the sta contacts within the switch body. Several types of actuators are available...

The roller type actuator is most suited to applications where a sliding contact ca the rotary part to rotate would otherwise cause contact wear to take place over a p of time.

The fork-style actuator must be physically reset after each operation and is su for critical stop applications in movement control. i.e. where a limit of movemer been exceeded and a manual reset is required following an emergency stop.

Flexible loop and spring rod actuators can be actuated from all directions, making them suitable for applications where the direction of approach is constantly changing.

Plunger-type actuators are ideal where short, controlled machine movements are present, or where space or mounting does not permit a lever-type actuator. The plunger can be activated in the direction of plunger stroke, or at a right angle to its axis.

All switches use the following common definitions of contact type....

Single Pole, Single Throw (SPST)
A switch that makes or breaks the connection of a single conductor in a single branc circuit. This switch typically has two terminals. It is commonly referred to as a "Sing Pole" Switch.

Single Pole, Double Throw (SPDT)
A switch that makes or breaks the connection of a single conductor with either of tv other single conductors. This switch typically has 3 terminals, and is commonly used pairs and called a "Three-Way" switch.

Double Pole, Single Throw (DPST)
A switch that makes or breaks the connection of two circuit conductors in a single b circuit. This switch typically has four terminals.

Double Pole, Double Throw (DPDT)
A switch that makes or breaks the connection of two conductors to two separate cir This switch typically has six terminals and is available in both momentary and maint contact versions.