Palestine Polytechnic University

College of Engineering & Technology

Electrical & Computer Engineering Department

Graduation Project

Design and implementation of three educational modules using PLC system

Project Team

Thaer Maher Aqeel   Ahmad Faysal Darweesh

Bashar Mohammad khalid Aljuba

Project Supervisor

Dr. Abdel-Karim Daud

Hebron-Palestine

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According to the orientations of the supervisor on the project and the examined committee is by the agreement of a staffers all, sending in this project to the electrical and computer engineering department are in the college of the engineering and the technology by the requirements of the department for the step of the bachelor's degree

Project supervisor signature

………………………………

Committee signature

………………………….. ……………….……… …………………..

Department head signature

………………………………

Dedication

We dedicate this project:

To our parents

To our brothers

To our friends

To our teachers

To our nation

To our lovely country Palestine

Acknowledgment

First and for most we should offer our thanks, obedience and gratitude to Allah.

Our appreciation to:

Palestine Polytechnic University

College of Engineering and Technology

Electrical and Computer Engineering Department

our supervisor Dr- Abder-Karim Daud for his helps and support

To Eng. Fayez S.Abu Ghalyoun

To Eng. Kareem N. Aljuneide

To any one whom helped us.

Abstract

This project stands on design and implementation of educational modules using one of the advanced control system.

The most important one is the programmable logic controller (PLC) system.

The idea comes from the needs of the university's labs to such modules to teach and train the students on it.

These modules are:-

1. Full automatic washing machine controlled by PLC system.
2. Elevator controlled by PLC system.
3. Fan system controlled by PLC system.

Where we designed the washing machine to do many tasks: filling water, heating, washing (by alternating motion), draining of water, and then drying by fast motion.

Where as we programmed the elevator which is constructed previously, by using system and study the whole construction to determine any other needs.

Finally, we designed and implementation a fan system, which constructed of two fans and one pushbutton, where we well program the system to operate the 1st fan by pushing the pushbutton, and the 2nd fan operates by the 2nd push, then the whole system stop by 3rd push.

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Chapter One

Introduction

1.1 General description

Hence the need of instruments and machines at the Palestine Polytechnic University (PPU) is still' The administration of the engineering & technology collage especially the electrical & computer engineering department head tends to a chive this goal by the department resources through the teachers technicians & students independently rather than donors and other resources. So our project the (Three in one) as a washing machine, elevator and the fan system hand serves to help students learning and understanding technical systems in the industry field. The project contains the mechanical body, electrical circuits, ac motors, and other elements, as well as control and programming.

1.2 Project Significance

- ✓ Provide a student real opportunity to deal with real machine.
- ✓ Minimize the gap between theoretical and practical.
- ✓ Improve student's ability to design machines.
- ✓ Gives experience of maintenance.
- ✓ Accepts student's skill of (PLC) programming.
- ✓ Teaches how to use ac motor and when.
- ✓ Accuracy and good timing.
- ✓ Giving opportunity to build another control system using the microprocessor or the personal computer PC.
- ✓ Advertisement to the university.
- ✓ Demonstrates the high skills and abilities of the experienced working team.

1.3 Proposal

Project: PLC modules

The goal:

- ✓ The PLC modules project aim is to build a three machine, the 1st is a full automatic washing machine, the 2nd is elevator and the 3rd is fan system that have two fans and one push button if we pressed push button on pressed the first fan is turn on and the second pressed the second fan is turned on and the third pressed the two fan turn off.
- ✓ very useful is to build the three modules
    1. Less space to occupy.
    2. Higher productivity to earn
    3. Lower price to pay.

1.4 Expectations:

A successful project like this makes the enthusiasm and confidence to the students of the collage to creative ideas resulting at a machine controlling using programmable logic controller .

1.5 Challenges:

The high sophistication of the project in both hardware and software are the main challenges of the project.

1.6 Work Plan

1st week to 8th week we studied the project and collected data from the internet and books about the project and it is components, from 8th week to 14th week we wrote some of documentation, and we made a simulation of the project, and from 16th to 30th we built the modules hardware and complete the documentation and the simulation. Table 1.1 explains the time plan.

Table 1.1: Time plan

Week #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
collection data about the project and it is components and understanding it.															
Write some of the documentation and simulating the project															
Week #	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
building hardware of the project															
Performing the simulation programs															
Experiments and testing the modules operations.															
Complete the documentation															

1.7 Finance study

The estimated cost of project listed in table 1.2

Table 1.2: The estimated cost of project

part	cost(NIS)
AC motor	470
Iron	400
Water valve	250
Heater (2)	100
Water pump	300
Washing tube	1200
Wood work	700
Fan (2)	100
Relay 24 Vdc (10)	400
Level detector	100
Switches and lamps	100
Connecting wire	100
PLC plugs	20
A.S.R	100
Another costs	400
Total cost	4740

Chapter Two

General block diagram

2.1 Washing Machine Drive System

The figure show the automatic washing machine block diagram, that is the controller is the PLC , where the machine consist of (in general) ac motor, water valve, inflection pump, and water detector.

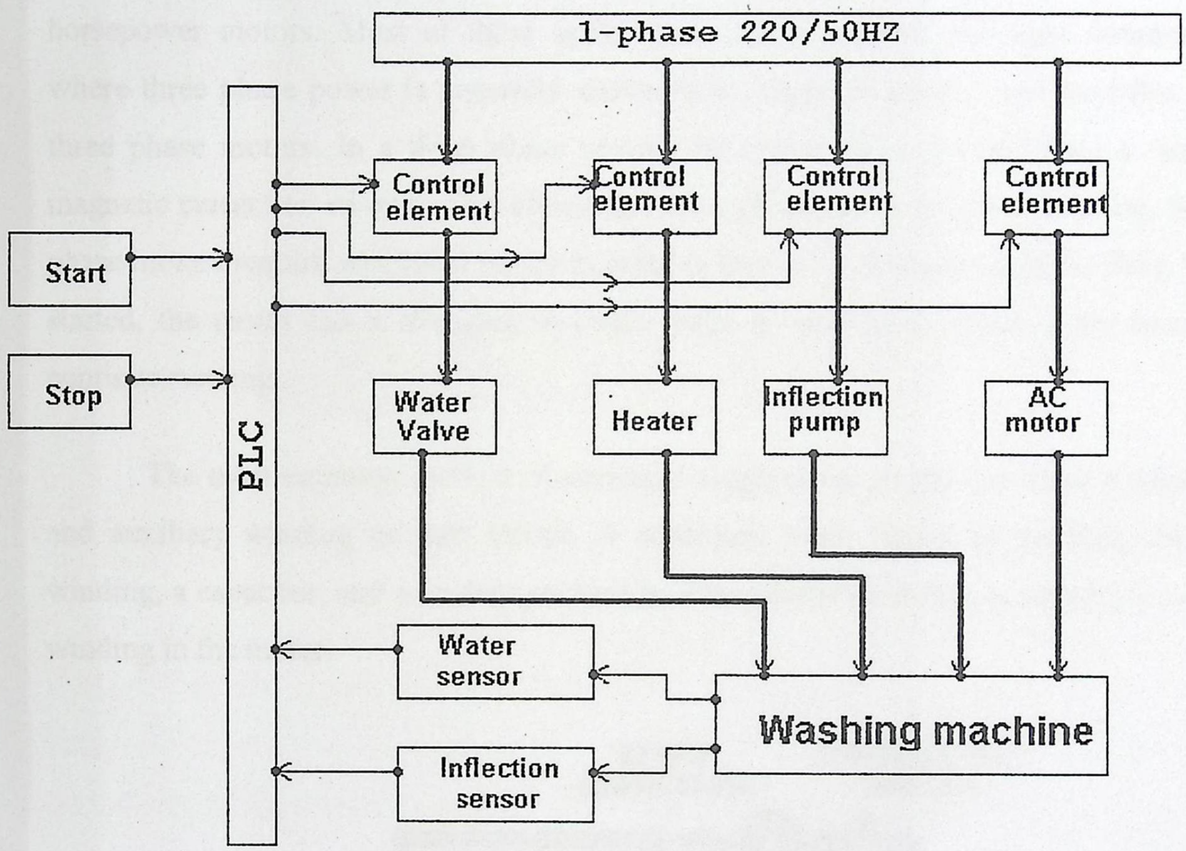


Figure 2.1: General block diagram

The components of electrical drive are explained in the following subsections:

2.1.1 AC Motor

Single-phase induction motors are widely used in sizes of 1 hp and less, less commonly in sizes up to 10 hp, and rarely above 10 hp. Compared with three-phase motors, they are hard to start, they run rough (noisy), and they are more expensive, at least in sizes above 1 hp. We use them wherever three-phase is not available, but would normally choose a three- phase motor if three-phase power is available.

There are three major types of single-phase motors, the capacitor start, the split phase, and the shaded pole. The first two require a start winding in addition to the main or run winding. The shaded pole gets its starting torque by placing a shorted single turn of copper wire around half of each stator pole. The reason for these additional parts is that a squirrel cage rotor in a single coil has no starting torque. It needs something like a second coil rotated in space, and driven by a voltage with a phase shift, to get a rotating flux to establish a starting torque.

Many motor applications use single phase power; especially for smaller horsepower motors. Most of these applications are residential and light commercial, where three phase power is generally unavailable. Single phase AC motors differ from three phase motors. In a three phase motor, the incoming power produces a rotating magnetic current on its own. This allows the three phase motor to be self starting. Single phase motors require additional power in order to produce a rotating magnetic field. Once started, the motor has a changing magnetic field at each pole, allowing the motor to continue running.

The most common method of starting a single phase motor combines a capacitor and auxiliary winding or start circuit. A schematic view shows an auxiliary starting winding, a capacitor, and a centrifugal switch. The auxiliary winding is actually a second winding in the motor.

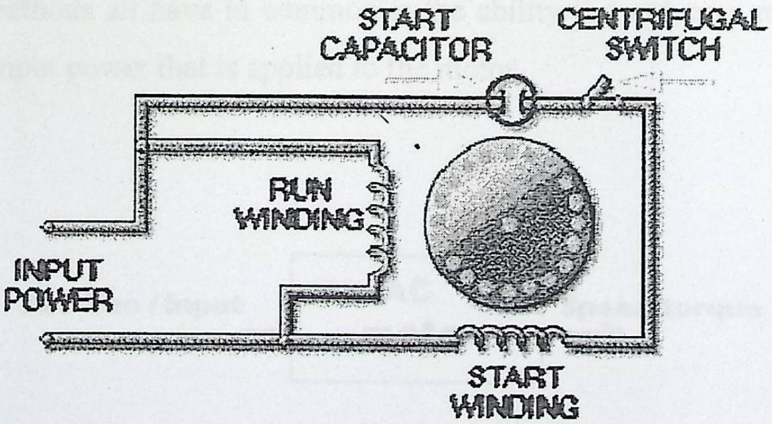


Figure 2.2:Single phase motor

When current is applied to the motor, both the run winding and the start winding produce magnetic fields. Because the start winding has a lower resistance, a stronger magnetic field is created which causes the motor to begin rotation. Once the motor reaches about 80 percent of its rated speed, a centrifugal switch disconnects the start winding. From this point on, the single phase motor can maintain enough rotating magnetic field to operate on its own. The graph shows a typical torque/speed curve for auxiliary starting on single phase motors.

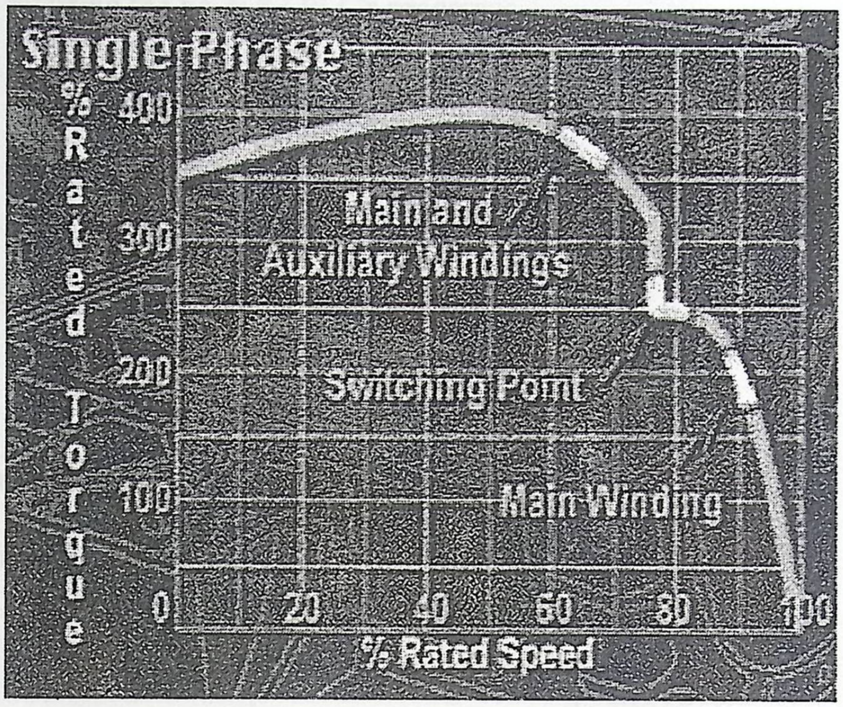


Figure 2.3: a typical torque/speed curve for auxiliary starting on single phase motors.

There are a variety of starting methods used in the different single phase motor types. These are covered in more detail in the controls drawer under "Starting." What these starting methods all have in common is the ability to produce a rotating magnetic field using the input power that is applied to the motor.

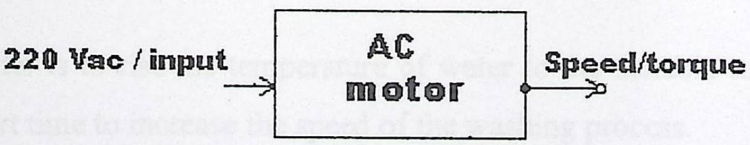


Figure 2.4: Input / Output of DC motor

2.1.2 PLC

The controlling of the machine operation would be done using the PLC this can be performed by using the S5 & S7 PLC's processor.

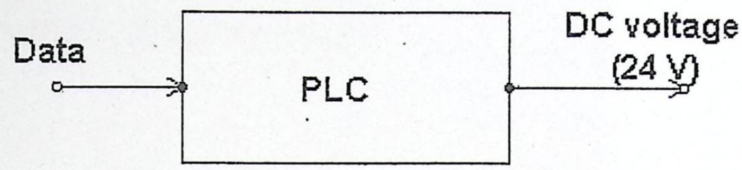


Figure 2.5: Input / Output of PLC

2.1.3 The sensors

A Sensor is a transducer , which convert a physical parameter to an electrical signal.

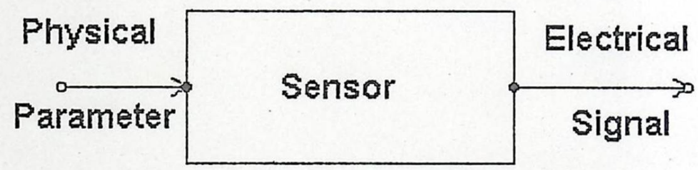


Figure 2.6: Input / Output of sensor

In our project we need four sensors situated in different locations in the machine , two of those sensors limits the level of water, the other sensor limit the process of taken triturate and the final sensor to limit the temperature pf the water.

2.1.4 The Heater

This heater is to rise the temperature of water to the suitable temperature to the washing in a short time to increase the speed of the washing process.

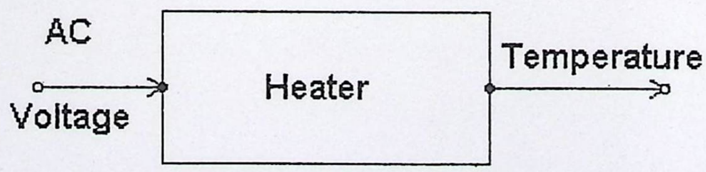


Figure2.7: Input / Output of heater

T°C water α t

T°C water = T°C heater * t

Where :

T°C water : the temperature of water that need.

T°C. heater : the temperature of heater (constant).

t : the time.

2.1.5 The Inflection Pump

The motor used in this pump is agitator motor and the calculation of this motor are mention below the block.

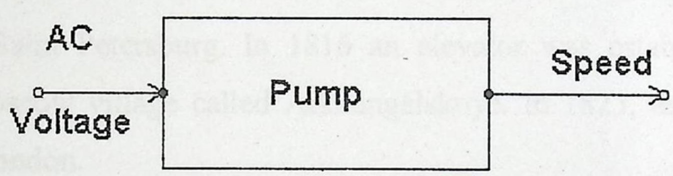


Figure 2.8: Input / Output of inflection pump

2.2 Elevator Drive system

An elevator or lift is a vertical transport vehicle that efficiently moves people or goods between floors of a building. They are powered by electric motors that either drive traction cables and counterweights a pulley

The first reference to an elevator is in the works of the Roman architect Vitruvius, who reported that Archimedes built his first elevator, probably, in 236 B.C. In some literary sources of later historical periods, elevators were mentioned as cabs on a hemp rope and powered by hand or by animals. It is supposed that elevators of this type were installed in the Sinai monastery of Egypt. In the 17th century the prototypes of elevators were located in the palace buildings of England and France.

In 1793 Ivan Kulibin created an elevator with the screw lifting mechanism for the Winter Palace of Saint Petersburg. In 1816 an elevator was established in the main building of sub Moscow village called Arkhangelskoye. In 1823, an "ascending room" made its debut in London.

In the middle 1800's, there were many types of crude elevators that carried freight. Most of them ran hydraulically. The first hydraulic elevators used a plunger below the car to raise or lower the elevator. A pump applied water pressure to a plunger, or steel column, inside a vertical cylinder. Increasing the pressure allowed the elevator to descend. The elevator also used a system of counter-balancing so that the plunger did not have to lift the entire weight of the elevator and its load. The plunger, however, was not practical for tall buildings, because it required a pit as deep below the building as the building was tall. Later a rope-geared elevator with multiple pulleys was developed.

Elevators are characterized as being extremely safe. Their safety record of moving millions of passengers every day, with extremely low rate of incident, is unsurpassed by any other vehicle system. Even so, fatalities due to malfunction have been known to occur on occasion.A certain number of passengers do die every year in elevator-related incidents. In 1998, it was reported that of the estimated 120 billion rides per year in the approximately 600,000 elevators in the United States, 10,000 people wound up in the emergency room because of elevator-related accidents.

Past problems with hydraulic elevators meant those built prior to a code change in 1972 were subject to possible catastrophic failure. The code had previously required only single-bottom hydraulic cylinders. In the event of a cylinder breach, an uncontrolled fall of the elevator might result. Because it is impossible to verify the system completely without a pressurized casing (as described below), it is necessary to remove the piston to inspect it. The cost of removing the piston is such that it makes no economic sense to re-install the old cylinder; therefore it is necessary to replace the cylinder and install a new piston Another solution to protect against a cylinder blowout is to install a "life jacket." This is a device which, in the event of an excessive downward speed, clamps onto the cylinder and stops the car. This device is also known as a Rupture Valve in some parts of the world.

In addition to the safety concerns for older hydraulic elevators, there is risk of leaking hydraulic oil into the aquifer and causing potential environmental contamination.

This has led to the introduction of PVC liners (casings) around hydraulic cylinders which can be monitored for integrity.

In the past decade, recent innovations in inverted hydraulic jacks have eliminated the costly process of drilling the ground to install a borehole jack. This also eliminates the threat of corrosion to the system and increases safety.

On traction lifts there is a device called a "Safety Gear" that is fitted to the bottom of the lift car frame. This device connects to another device commonly known as a "Overspeed Governor." There is a separate rope from the main lifting ropes that connects the safety gear to the overspeed governor. The Overspeed Governor usually has a pulley which the safety rope runs on. The overspeed governor usually has an arm type latch. If the device spins too quickly, the arm is forced out from the middle of the unit by centrifugal force. This locks the pulley, which stops the rope. Once the rope stops and the car is still moving down, the rope pulls up on the safety gear causing a wedge type friction roller or a solid plate to clamp very tightly on the lift running guides. This causes the lift to stop suddenly ("instantaneous" safety gear) or in a progressive slowing motion ("progressive" safety gear). There are many different versions of these but they all work in the same way.

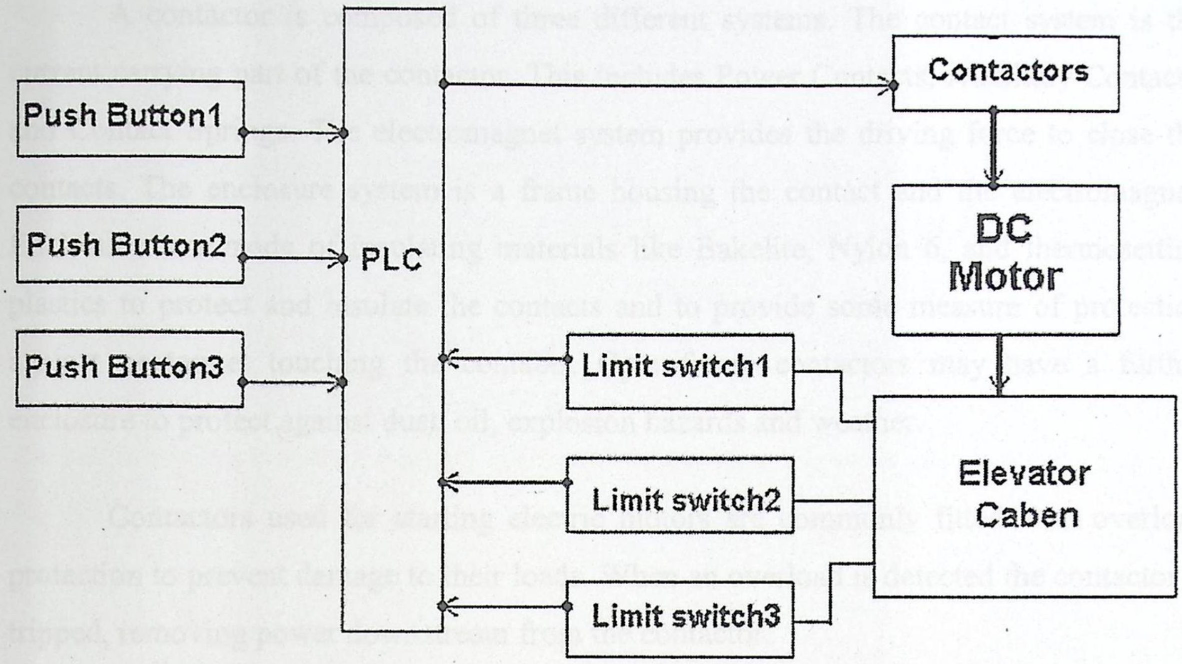


Figure 2.9: Elevator Drive System

2.2.1 Limit switch

A limit switch is used to stop the motion of a machine slide or element once it reaches a fixed point. An example of limit switch use is in machining components on automatic machine tools like lathes and special purpose machines. Attributes like holes, bores, etc. have a fixed depth. Once the cutting tool has to cut through the required depth, the slide must be stopped or else it will dash against the component sides.

In this elevator we have a three limit switch used to limit the level of working.

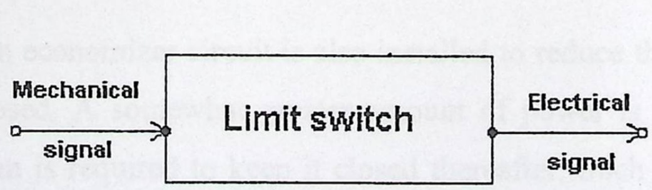


Figure2.10: Input / Output of limit switch

2.2.2 Contactors

2.2.2.1 Construction of contactors

A contactor is composed of three different systems. The contact system is the current carrying part of the contactor. This includes Power Contacts, Auxiliary Contacts, and Contact Springs. The electromagnet system provides the driving force to close the contacts. The enclosure system is a frame housing the contact and the electromagnet. Enclosures are made of insulating materials like Bakelite, Nylon 6, and thermosetting plastics to protect and insulate the contacts and to provide some measure of protection against personnel touching the contacts. Open-frame contactors may have a further enclosure to protect against dust, oil, explosion hazards and weather.

Contactors used for starting electric motors are commonly fitted with overload protection to prevent damage to their loads. When an overload is detected the contactor is tripped, removing power downstream from the contactor.

High voltage contactors (greater than 1000 volts) often have arc suppression systems fitted (such as a vacuum or an inert gas surrounding the contacts).

Magnetic blowouts are sometimes used to increase the amount of current a contactor can successfully break. The magnetic field produced by the blowout coils force the electric arc to lengthen and move away from the contacts. This is especially useful in contactors used in DC power circuits; AC arcs have periods of low current, during which the arc can be extinguished with relative ease, but DC arcs have continuous high current, so blowing them out requires the arc to be stretched further than an AC arc of the same current. The magnetic blowouts in the pictured Albright contactor (which is designed for DC currents) more than double the current it can break, increasing it from 600 amps to 1500 amps.

Sometimes an economizer circuit is also installed to reduce the power required to keep a contactor closed. A somewhat greater amount of power is required to initially close a contactor than is required to keep it closed thereafter. Such a circuit can save a substantial amount of power and allow the energized coil to stay cooler. Economizer circuits are nearly always applied on direct-current contactor coils and on large alternating current contactor coils.

Contactors are often used to provide central control of large lighting installations, such as an office building or retail building. To reduce power consumption in the contactor coils, latching contactors are used, which have two operating coils. One coil, momentarily energized, closes the power circuit contacts, which are then mechanically held closed; the second coil opens the contacts.

A basic contactor will have a coil input (which may be driven by either an AC or DC supply depending on the contactor design). The coil may be energized at the same voltage as the motor, or may be separately controlled with a lower coil voltage better suited to control by programmable controllers and lower-voltage pilot devices. Certain contactors have series coils connected in the motor circuit; these are used, for example, for automatic acceleration control, where the next stage of resistance is not cut out until the motor current has dropped.

2.2.2.2 Operating Principle

Unlike general-purpose relays, contactors are designed to be directly connected to high-current load devices. Relays tend to be of lower capacity and are usually designed for both Normally Closed and Normally Open applications. Devices switching more than 15 amperes or in circuits rated more than a few kilowatts are usually called contactors. Apart from optional auxiliary low current contacts, contactors are almost exclusively fitted with Normally Open contacts. Unlike relays, contactors are designed with features to control and suppress the arc produced when interrupting heavy motor currents.

When current passes through the electromagnet, a magnetic field is produced which attracts ferrous objects, in this case the moving core of the contactor is attracted to the stationary core. Since there is an air gap initially, the electromagnet coil draws more current initially until the cores meet and redacts the gap, increasing the inductive impedance of the circuit. The moving contact is propelled by the moving core; the force developed by the electromagnet holds the moving and fixed contacts together. When the contactor coil is de-energized, gravity or a spring returns the electromagnet core to its initial position and opens the contacts.

For contactors energized with alternating current, a small part of the core is surrounded with a shading coil, which slightly delays the magnetic flux in the core. The effect is to average out the alternating pull of the magnetic field and so prevent the core from buzzing at twice line frequency.

Most motor control contactors at low voltages (600 volts and less) are "air break" contactors, since ordinary air surrounds the contacts and extinguishes the arc when interrupting the circuit. Modern medium-voltage motor controllers use vacuum contactors.

Motor control contactors can be fitted with short-circuit protection (fuses or circuit breakers), disconnecting means, overload relays and an enclosure to make a combination starter. In large industrial plants many contactors may be assembled in motor control centers.

We have two contactors in the elevator.

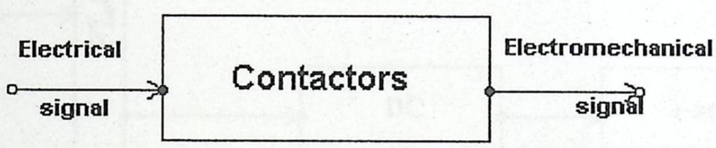


Figure 2.11: Input / Output of contactor

2.3 Fan System Electric Drive

Our fan technology is used in engine cooling plants and in the heating and air conditioning systems of modern vehicles. Electric cooling fans which can be controlled as required and are integrated in the engine management system are a good way of providing the cooling capacity actually required for a combustion engine. Increasingly, they are also taking over the function of the viscofan and the additional air conditioning fan driven by the combustion engine. Our modules are distinguished by their compact design and are manufactured in many customer-specific variants

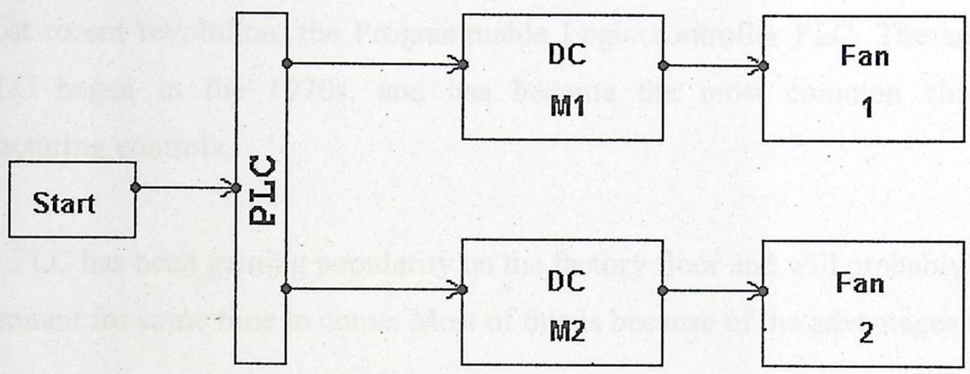


Figure 2.12: Fan system Electric Drive

2.3.1 Brushless DC Motor

A brushless DC motor (BLDC) is a synchronous electric motor which is powered by direct-current electricity (DC) and which has an electronically controlled commutation system, instead of a mechanical commutation system based on brushes. In such motors, current and torque, voltage and rpm are linearly related.

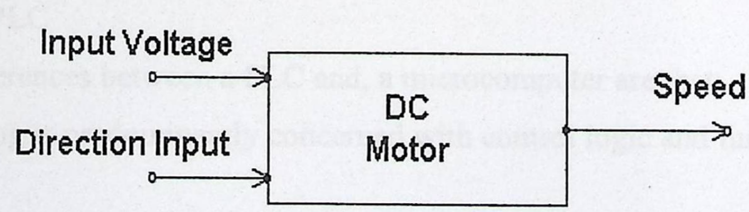


Figure 2.13: Input / Output of DC motor

Chapter Three

PLC

3.1 INTRODUCTION

Control engineering as evolved over time. In the past humans were the main methods for controlling a system. More recently electricity has been used for control and early electrical control was based on relays. These relays allow power to be switched on and off without a mechanical switch. It is common to use relays to make simple logical control decisions. The development of low cost computer has brought the most recent revolution, the Programmable Logic controller PLC. The advent of the PLC began in the 1970s, and has become the most common choice for manufacturing controls.

PLC has been gaining popularity on the factory floor and will probably remain Predominant for some time to come. Most of this is because of the advantages they offer.

- Cost effective for controlling complex systems.
- Flexible and can be reapplied to control other systems quickly and easily.
- Computational abilities allow more sophisticated control.
- Trouble shooting aids make programming easier and reduce downtime.
- Reliable components make these likely to operate for years before failure.

3.2 Controller selection

* Why using PLC

The main differences between a PLC and, a microcomputer are that:

1. Programming is predominantly concerned with control logic and function block operation.
2. Interfacing circuit is integral to the controller.
3. PLC's are rugged, being packaged to withstand, temperature, humidity and noise.

There are many points that must be considered when choosing the PLC.

The most important 10 points are:

1. The processor type.

2. The size of RAM, measured in MB, or the number of statements that can be stored.

3. The number of input and output channels and modules, and characteristics.

4. The number of flags and markers available.

5. The number of timers available.

6. The number of counters available.

7. The number of function blocks available.

8. The availability of a Real time clock (RTC).

9. The type of memory sub modules (external memory) EPROM, EEPROM.

10. The type and characteristics of electrical power supply(AC, DC).

The PLC available in our college (Siemens\simatic-25-100u) contains

1. 16 timers, of 5 different types: pulse, extended pulse, on-delay, off_ delay and stored on-delay timer.

2. 16 counters ,up/down.

3.A(1 k B) RAM.

4. 16 input channels.

5. 16 output channels.

6. 256 flags.

7. 256 function Blocks.

These tools available in the PLC are enough and fulfill the requirements of our project

3.3 PLC Hardware

The configuration of the PLC refers to the packaging of the components. Typical Configurations are listed below from largest to smallest as shown in Figure(3.1).

* Rack - A rack is often large and can hold multiple cards.
when necessary ,multiple racks can be connected together .The set end to be the highest cost, but also the most flexible and easy to maintain.

* **Mini** - These are smaller than full sized PLC racks, but can have the same I/o Capacity.

* **Micro** - These units can quantities of I/O and be as small as a deck of cards. limited abilities, but costs will They tend to have fixed be the lowest.

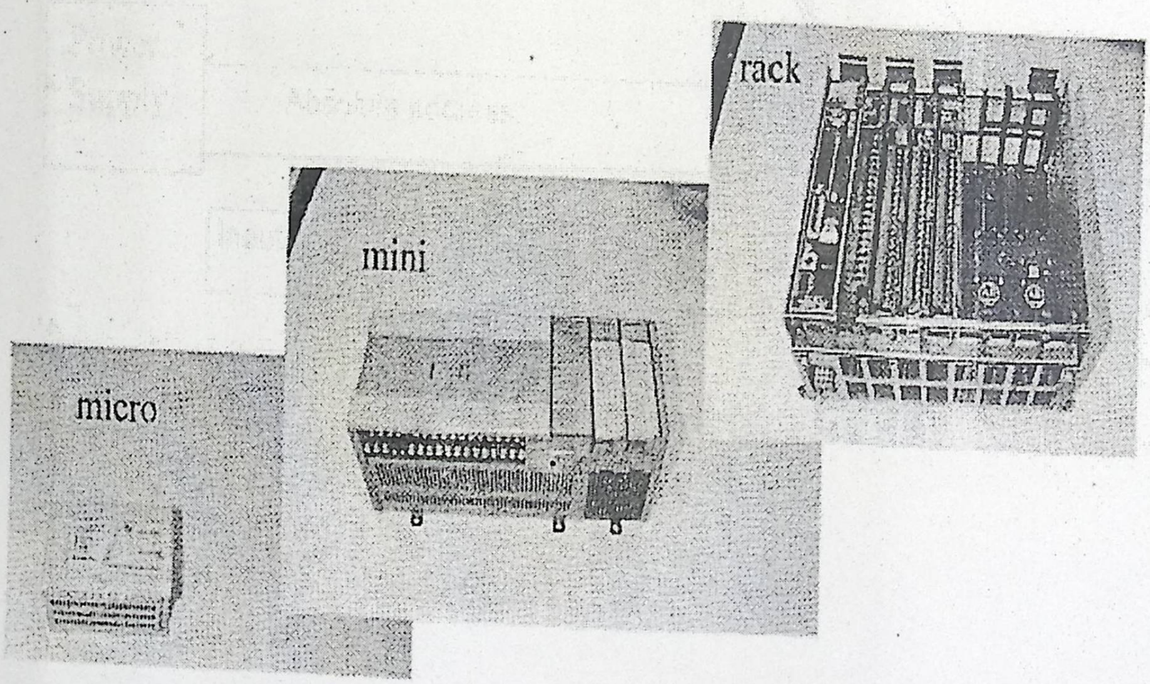


Figure 3.1: Typical configuration of PLC

Many PLC configurations are available, even from a single vendor. But in each of these there are common components and concepts .The most essential components are :shown in Figure (3.2) and wiring in Figure (3.3).

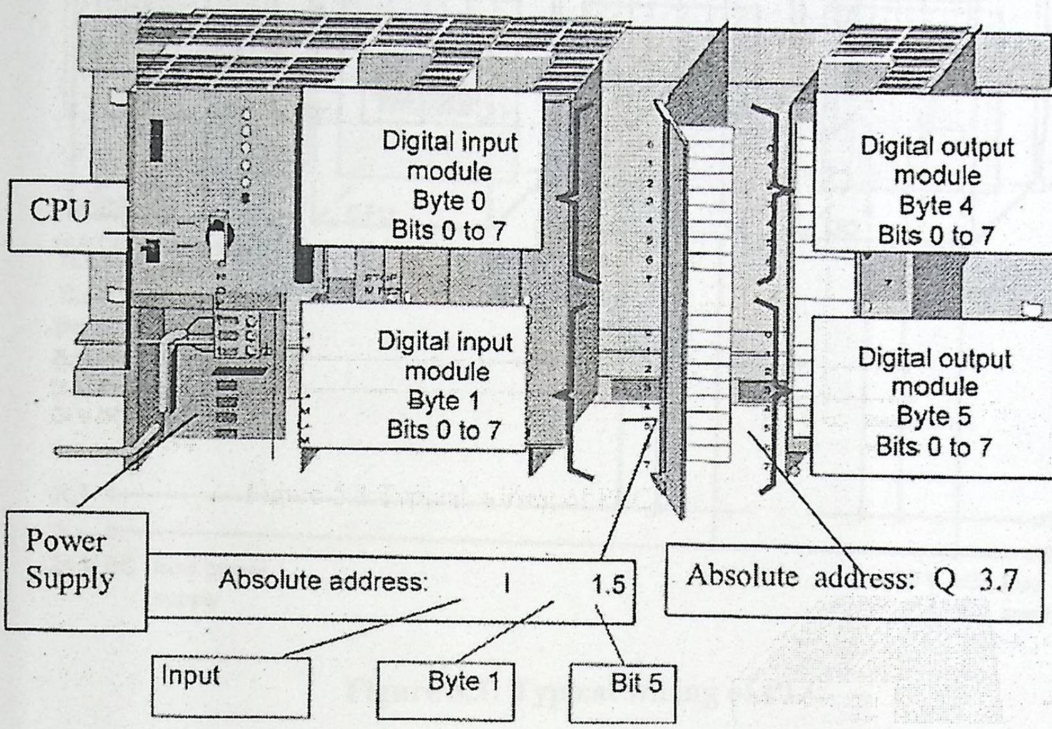


Figure 3.2: Typical components of PLC

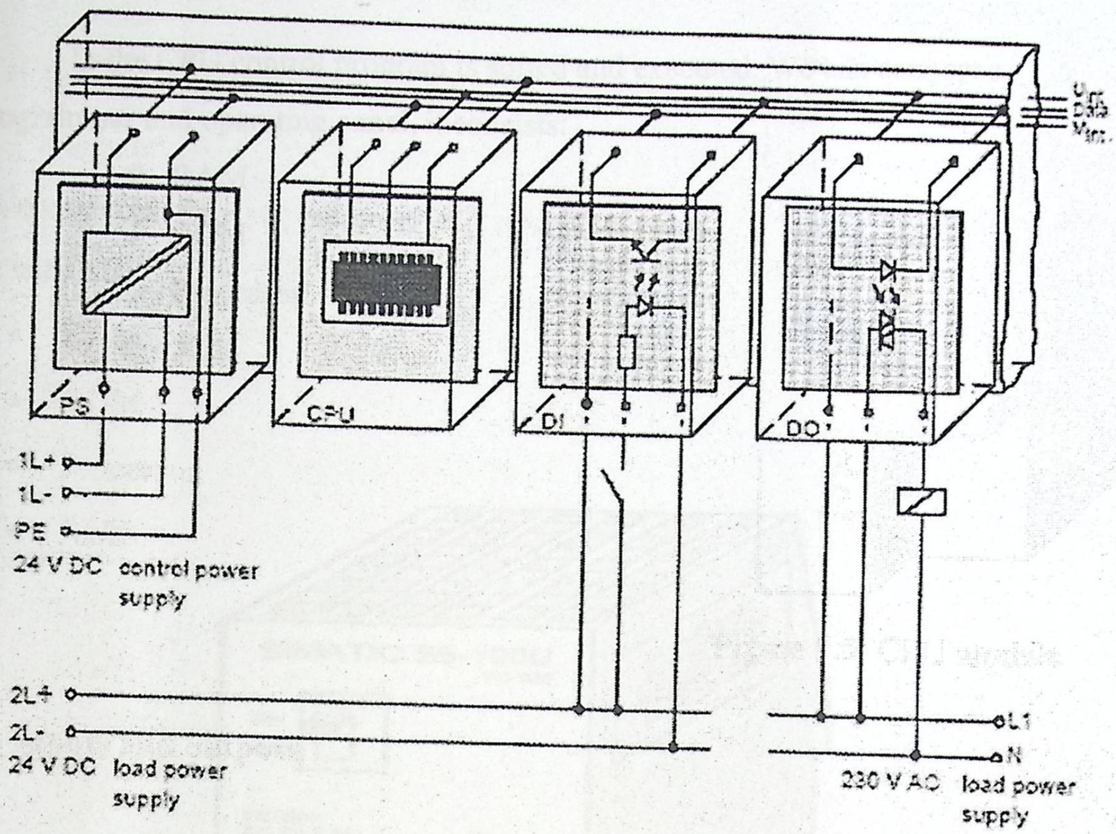


Figure 3.3: Typical wiring of PLC

3.3.1 Power supply

The power supply can be built into the PLC or be an external unit. Common voltage levels required by the PLC (with and without the power supply) are 24Vdc,l20Vac, 220Vac.

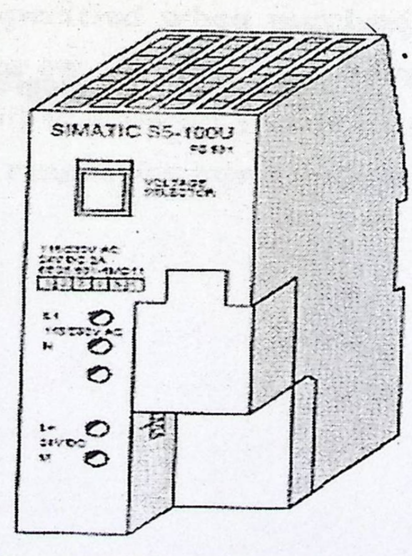


Figure 3.4: Power supply

3.3.2 CPU (Central Processing Unit)

In the CPU control program is sorted and executed. We can connect a progralnmer and operating panel, it consists:

- RAM
- ROM
- Processor
- ALU

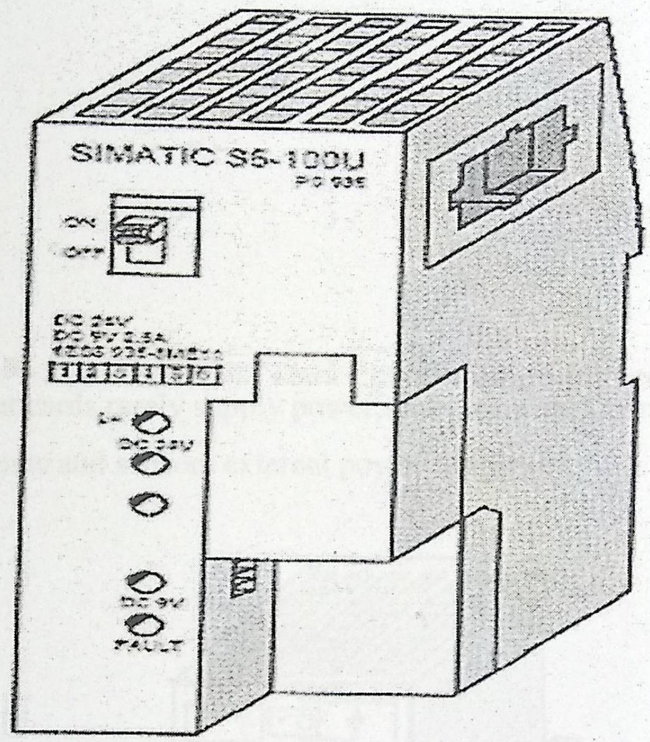


Figure 3.5:CPU module

3.3.3 Inputs and outputs

Inputs modules

In smaller PLCs the inputs are normally built in and are specified when purchasing the PLC' For larger PLCs the inputs are purchased as modules, or cards, with g or 16 inputs of the same type on each card. For discussion purposes we will discuss all inputs as if they have been purchased as cards. The list below shows typical ranges for input voltages, and is roughly in order of popularity.

12-24Vdc

48 Vdc

5 Vdc (TTL)

10-60 Vdc

100-120 Vac

12-24 Vac/dc

200-240Vac

24 Vac

PLC input cards rarely supply power, this means that an needed to supply power for the inputs and sensors external power supply is

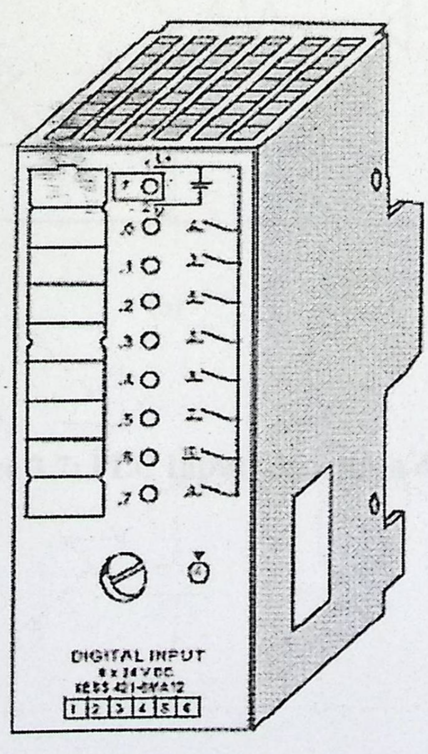
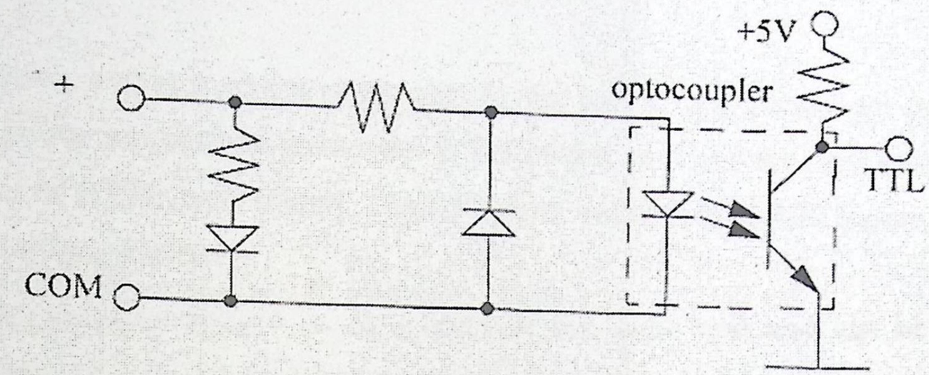
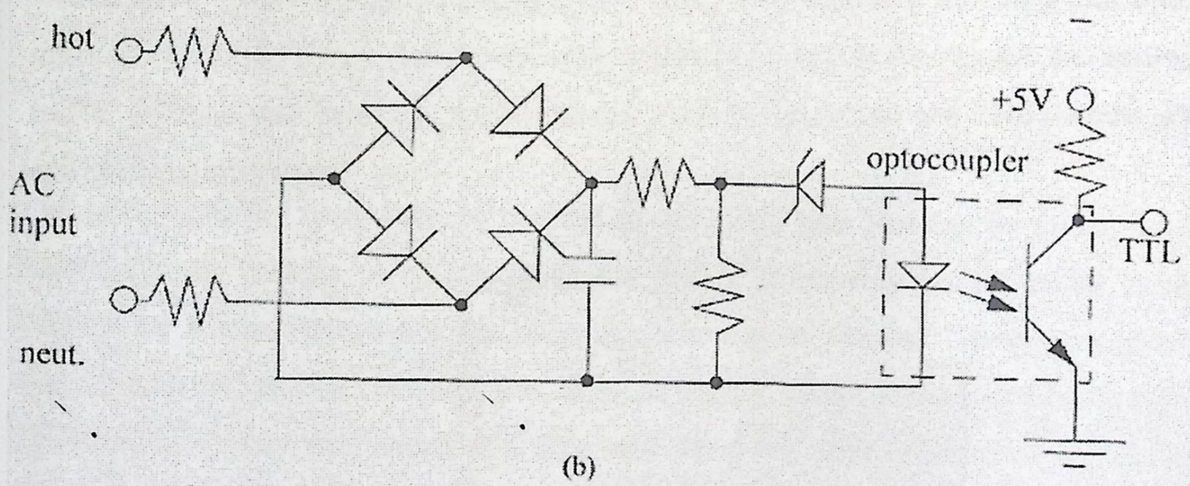


Figure 3.6: an 8x24Y DC Input Card and adder Logic for Siemens

PLC inputs must convert a variety of logic levels to the 5Vdc logic levels used on the data bus. This can be done with circuits similar to those shown below. Basically the circuits condition the input to drive an optocoupler. This electrically isolatest he external electrical circuitry from the internal circuitry. Other circuit components are used to guard against excess or reversed voltage polarity.



(a)



(b)

Figure 3.7: PLC Input Circuits (a & b)

Outputs modules

As with input modules, output modules rarely supply any power, but instead act as switches. External power supplies are connected to the output card and the card will switch the power on or off for each output. Typical output voltages are listed below, and roughly ordered bypopularity.

120 Vac

24 Vdc

5 Vdc (TTL)

12-48 Vdc

12-48Vac

230Vac

These cards typically have 8 to 16 outputs of the same type and can be purchased with different current ratings. A common choice when purchasing output cards is relays transistors or triacs. Relays are the most flexible output devices. They are capable of switching both AC and DC outputs. But, they are slower (about 10ms switching is typical), they are bulkier, they cost more, and they will wear out after millions of cycles. Relay outputs are often called dry contacts. Transistors are limited to DC outputs, and triacs are limited to AC outputs. Transistor and triac outputs are called switched outputs

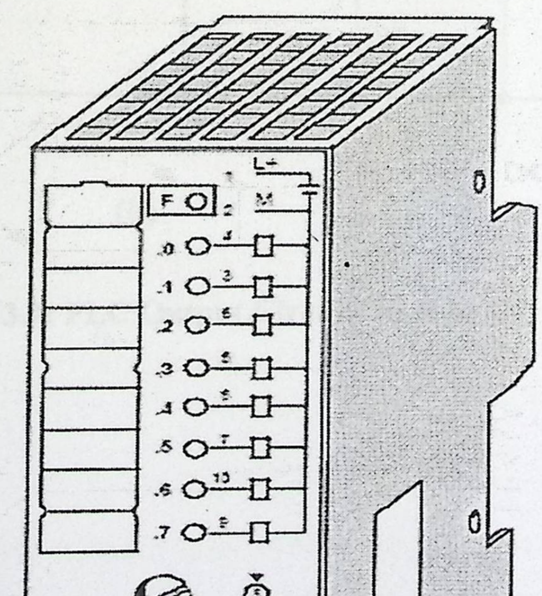


Figure 3.8: An 8x24Y DC output card and Ladder Logic for siemens

PLC outputs must convert the 5Vdc logic levels on the PLC data bus to external voltage levels. This can be done with circuits similar to those shown in Figure (3.9). Basically the sircuits use an optocoupler to switch external circuitry. This electrically isolates the external electrical circuitry from the internal circuitry. Other circuit components are used to guard against excess or reversed voltage polarity.

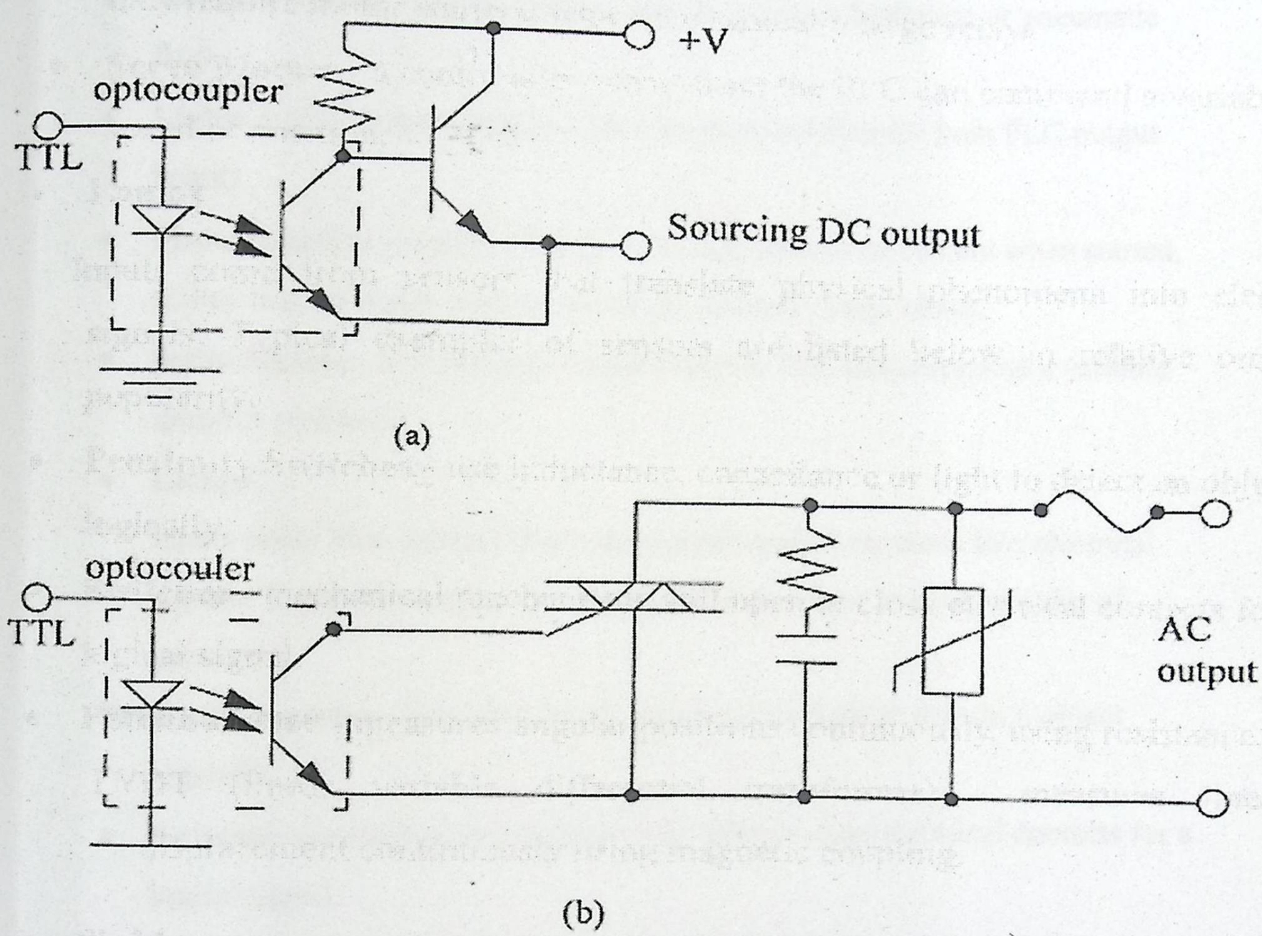


Figure 3.9: PLC Output Circuits (a & b)

3.4 Inputs and outputs equipment

Inputs to, and outputs from, a PLC are necessary to monitor and control a process.outputs to actuators allow a PLC to cause something to happen in a process. A short list of popular actuators is given below in order of relative popularity.

- **Relay** – logical outputs that can operate three phase motors and others.
- **Solenoid Valves** - logical outputs that can switch a hydraulic or pneumatic flow.
- **Lights**-logical outputs that can often be powered directly from PLC output boards
- **Motor Starters** - motors often draw a large amount of cument when started, sothey require motor starters, which are basically large relays.
- **Servo Motors** - a continuous output from the PLC can command a variable speed or position.
- **Lamps**

  Inputs come from sensors that translate physical phenomena into electrical signals. Typical examples of sensors are listed below in relative order of popularity.

Proximity Switches- usei nductancec, apacitancoer light to detecta n object logically.

- **Switches**- mechanical mechanisms will open or close electrical contacts for a logical signal.
- **Potentiometer**- measures angular positions continuously, using resistance. LVDT (linear variable differential transformer) - measures linear displacemenct continuously using magnetic coupling.
- **Sinking**

  lnputs for a PLC come in a few basic varieties, the simplest are AC and DC inputs. Sourcing and sinking inputs are also popular. This output method dictates that a device does not supply any power. lnstead, the device only switches current on or off, like a simple switch.

3.5 Programming

The first PLCs were programmed with a technique that was based on relay logic wiring schematics. This eliminated the need to teach the electricians, technicians and engineers how to program a computer but this method has stuck and it is the most common technique for programming PLCs today.

programming language

It enables the first-time user to become quickly familiar with PLC technology. The PLC's can be programmed using language.

Methods of representation

- Ladder diagram (LAD)
- Function block diagram (FBD)
- Statement list (STL)

The statement list uses mnemonics for statements. The control system flowchart is ideal for those who prefer the logic representation of machine functions and processes. If you are accustomed to working with circuit diagrams, the use of the ladder diagram is recommendable.

3.5.l Ladder Logic (LAD)

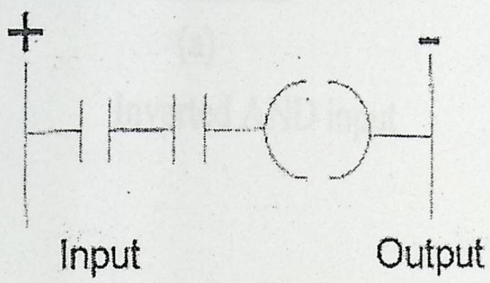
Bit logic instructions work with two digits, I and 0. These two digits form the base of a number system called the binary system. The two digits 1 and 0 are called binary digits or bits. In the world of contacts and coils, a I indicates activated or energized, and a 0 Indicates not activated or not energized.

The bit logic instructions interpret signal states of I and 0 and combine them according to Boolean logic. These combinations produce a result of I or 0 that is called the" result of Iogic operation" (RLO).

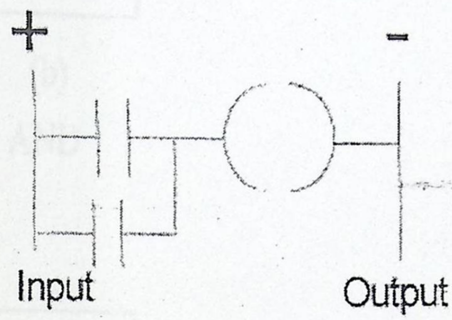
The logic operations that are triggered by the bit logic instructions perform a variety of functions.

There are bit logic instructions to perform the following functions:

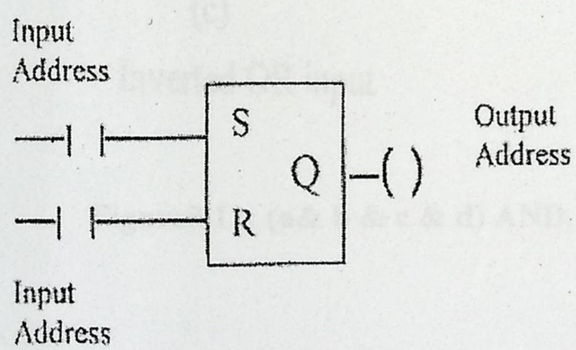
Normally Closed Contact	----| / |----
Normally Open Contact (Address)	----| |----
Bit exclusive OR	XOR
Output Coil	----( )----
Set-Reset flip flop	SR
Reset-Set flip flop	RS



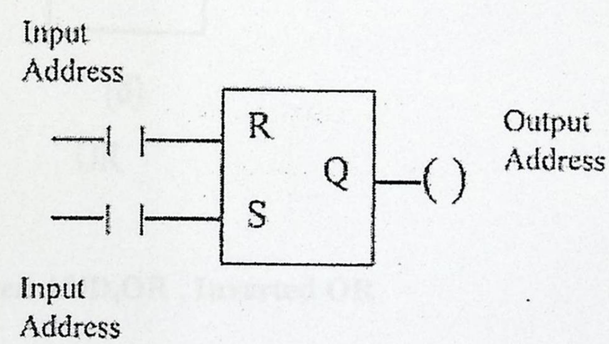
(a) AND Operation



(b) OR Operation



(c) SR



(d) RS

Figure 3.1.0: (a &b & c & d) AND, OR, SR,RS.

3.5.2 Function block diagrams (FBD)

Function block diagrams (FBD) are another method of programming. The primary concept behind the FBD is data flow. In these types of programs the values flow from the inputs to the outputs, through function blocks.

The simples using for that as shown in Figure(3.11) .

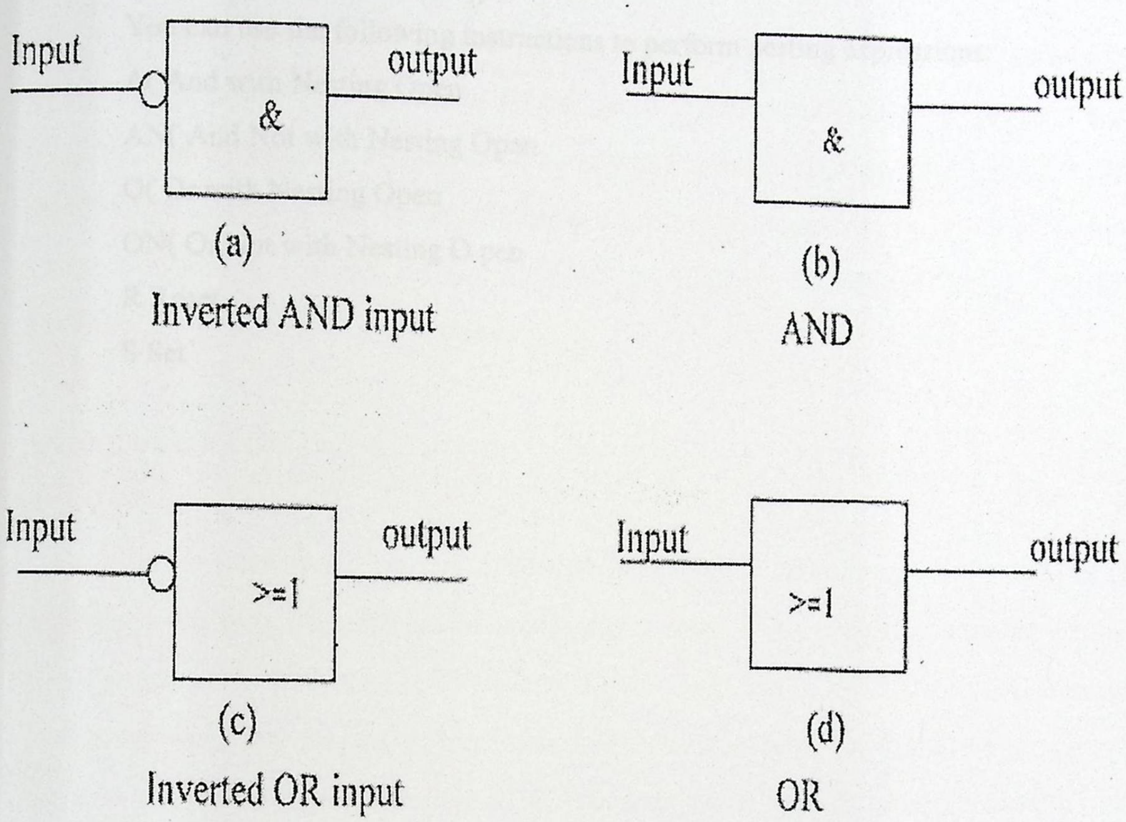


Figure3.11: (a& b & c & d) AND, Inverted AND,OR , Inverted OR

3.5.3 Statement list (STL) Programming

Boolean bit logic applies to the following basic instructions:

A And

AN And Not

O Or

ON Or Not

You can use the following instructions to perform nesting expressions:

A(And with Nesting Open

AN(And Not with Nesting Open

O(Or with Nesting Open

ON(Or Not with Nesting O pen

R Reset

S Set

Chapter four

Elements selection and calculations

4.1 Motor selection

4.1.1 Introduction

Direct current dc motor have variable characteristics and are used in applications requiring adjustable speed, good speed regulation and frequent starling, braking and reversing' Dc motor can provide a high starting torque and it is also possible to obtain speed control over a wide range. Controlling position is difficult using permanent magnet dc motor (PM dc motors). Recently, stepper motor has become popular for position control.

4.1.2 Status of DC and AC drives

In the past induction and synchronous motor drives were mainly used in fixed speed applications variable speed applications were dominated by dc motor drives. Emergence of thyristors in 1957 lead to the development of variable speed induction motor drives in late sixties which were efficient and could match the performance of dc drives. Consequently, because of the advantages of squirrel-cage induction motors over dc motors, it was predicted that induction motor drives will replace dc drives in variable speed applications. However" following hurdles for bided for the prediction to come true:

i) Although squirrel-cage induction motor was cheaper than dc motor, the converter and control circuit of an induction motor drive was very expensive compared to those for a dc drive' Therefore, total cost of an induction motor drive was significantly higher than that of a dc drive.

ii) While the technology o f dc drives was well established that of ac was new.

iii) AC drives were not as reliable as dc.

iv) Developments in linear and digital ICs. And very large scale integration VLSI5 were helpful in improving the performance and reliability of ac drives. But then these improvements also led to similar improvements in dc drives. Improvement in thyristor capabilities, availability of power transistors in early seventies and that of GTos and IGBTs in late seventies and late eighties respectively; reduction in cost of thyristors, power transistors and GTOs; developments of VLSIs and microprocessors; and improvement in control techniques of converters have resulted into reduction in cost, simple controllers, and improvement in performance and reliability for ac drives. Although even now majority of variable speed applications employ dc drives, the ac are preferred over dc in a number of applications with the result, ac drive applications are growing. Induction motor drives find applications in low considered for replacing dc servo motors for fractional range. As the trend exists applications of ac drives will continue to grow. However, dc drives will also continue to be used for quite some time.

4.1.3 Permanent magnet dc motor

In steady state performance of the permanent dc motors, suitable mounting permanent magnets on the stator obtain field excitation. Ferrites or rare earth (Cobalt Samarium and NdFeB) magnets are employed. Ferrites are commonly used because of lower cost, but the machine becomes bulky due to low retentively. Rare earth such as NdFeB , because of their high retentively allow 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 5 kW 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 does not happen 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 machines shown in Figure(4.1). 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 equation applicable to all dc motor are:-

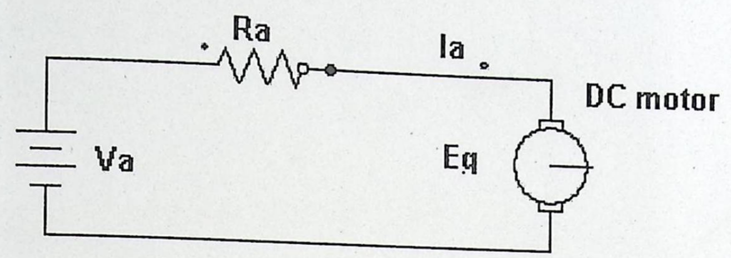


Figure4 .1: steady state equivalent circuit of armature

$$E = C\phi * W_m \qquad (4.1)$$

$$V_a = E + R_a I_a \qquad (4.2)$$

$$T = C\phi * I_a \qquad (4.3)$$

Where:

ϕ :flux per pole

Ia : armature current, Amp.

Va : armature voltage, Volt.

Ra : resistance of the armature circuit, Ohms.

Wm : speed of armature, Rad,/Sec.

T : torque developed by the motor, Nm.

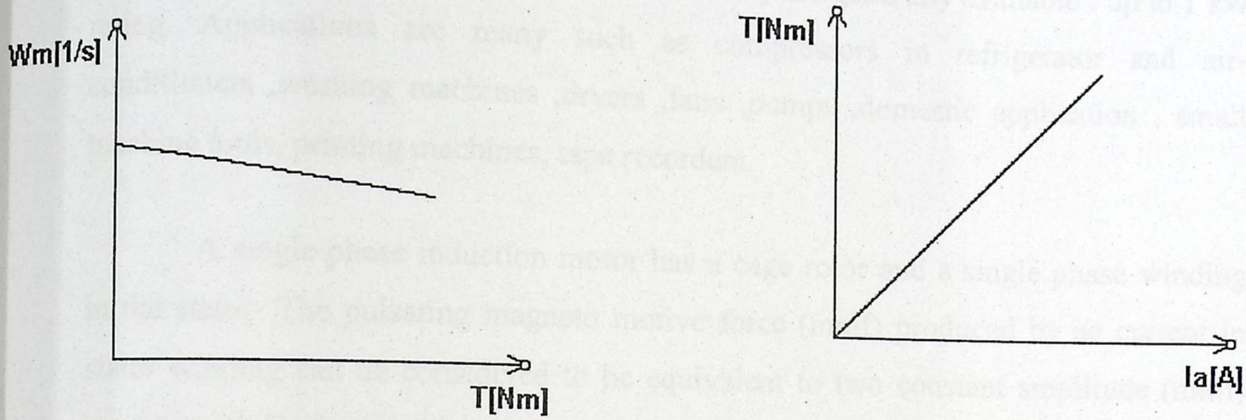
$C\phi$: motor constant.

From Equation(4.1-4.3) the mechanical angular frequency could be represented as:

$$W_m = \frac{V_a}{C\phi} - \frac{R_a}{C\phi} I_a \qquad (4.4)$$

$$W_m = \frac{V_a}{C\phi} - \frac{R_a}{C\phi^2} T \qquad (4.5)$$

The speed-torque and torque-current characteristics of a PM dc motor for rated terminal voltage are shown in Figure(4.2). 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 curve **B)Torque curve current**

Figure 4.2: performance curve 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 stands till, 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.

4.2 Single-phase induction motors

Single-phase induction motors are inferior in performance and larger in weight and volume compared to three-phase motors of the same rating However, they are simple, robust, reliable and less expensive for small ratings. They are employed in low power drives in small industries and domestic and commercial applications ,where only single-phase supply is available .They are generally available . up to 1 kw rating. Applications are many such as compressors in refrigerator and air-conditioners ,washing machines ,dryers ,fans ,pumps ,domestic application , small machine tools, printing machines, tape recorders.

A single-phase induction motor has a cage rotor and a single phase winding in the stator- The pulsating magneto motive force (mmf) produced by ac current in stator winding can be considered to be equivalent to two constant amplitude (mmf) waves revolving in opposite directions at synchronous speed, Each of these revolving mmf wave induces its own rotor current and produces induction motor action just as in a 3-phase motor. Fig. 4.3 shows torques produced by the two revolving fields and also net torque produced by the motor. When the rotor is stationary, it reacts equally to both waves, and no torque is developed. Therefore, a single-phase induction motor with single stator winding inherently

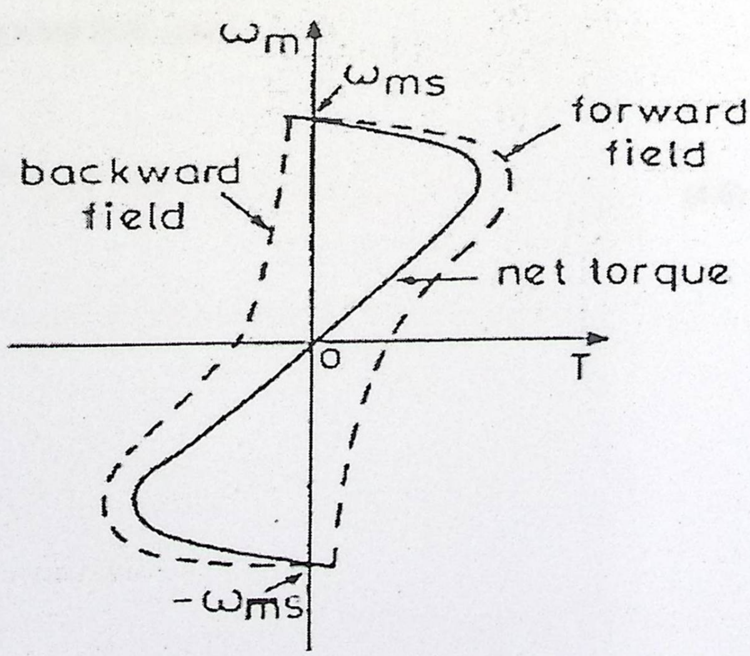


Figure 4.3: Speed- torque characteristics of a single-phase Induction motor

Has no starting torque .But if started by auxiliary means ,it will develop torque and continue to run .When the rotor is running , induced rotor currents are such that their (mmf) opposes the reverse stator (mmf) to a greater extent than they oppose the forward stator (mmf). Result is that the forward flux wave, which develops forward torque is bigger than the reverse flux wave which develops reverse torque. Net torque (difference between the forward and reverse torques) produced maintains the motion .As the speed increases forward torque increases and reverse torque decreases .Therefore, net torque progressively increases with speed. When started from its zero speed, first it builds up slowly but later accelerates fast to a speed near synchronous .Backward rotating field increases the full load slip and therefore reduces efficiency and power factor. Interactions between forward rotating field and rotor currents induced due to reverse rotating field, and reverse rotating field and rotor currents induced due to forward rotating field produce second harmonic torque pulsations which cause vibrations and noise.

Figure 4.4 shows equivalent circuit of a single winding single-phase induction motor . Rotor equivalent circuits accounting for the forward and backward rotating fields arc indicated in the figure. When rotor moves in forward direction with a slip s (with respect to forward rotating field) then the slip Sn (with respect to backward field) will be

$$Sn = \frac{\text{backward field speed} + \text{Rotor speed}}{\text{backward field speed}}$$

$$= \frac{\omega_{ms} + (1-s)\omega_{ms}}{\omega_{ms}} = (2-s) \qquad \textbf{(4.6)}$$

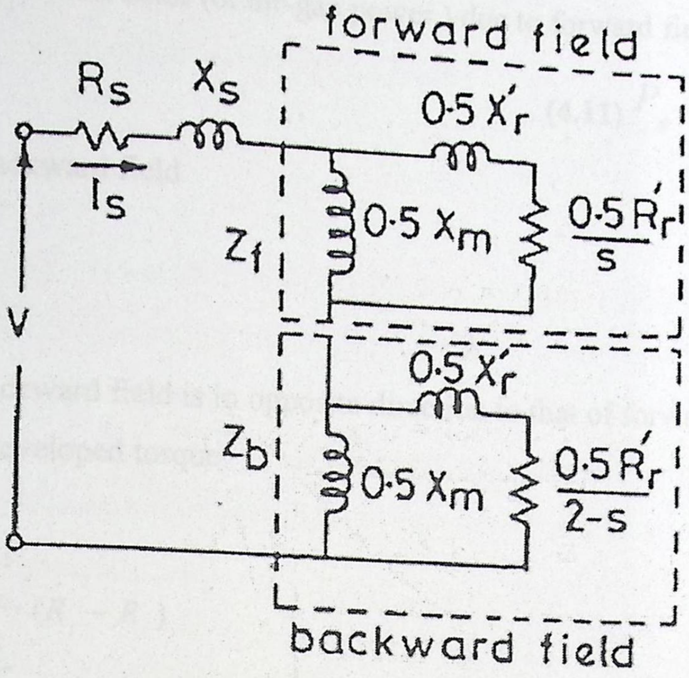


Figure 4.4: Equivalent circuit of a single-phase induction motor

Hence for backward field the rotor resistance has been divided by (2 - s) in the equivalent circuit from which stator current I_s, can be computed for any assumed value of slip when the motor impedances and applied voltage are known. Let

$$R_f + jX_f = (\frac{0.5R_r'}{s} + j\,0.5X_r') \text{in parallel with } 0.5X_m \quad \textbf{(4.7)}$$

and

$$R_b + jX_b = (\frac{0.5R_r'}{2-s} + j\,0.5X_r') \text{in parallel with } 0.5X_m \quad \textbf{(4.8)}$$

Power transferred to the rotor (or air-gap power) due to forward field

$$P_{gf} = I_s^2 R_f \quad \textbf{(4.9)}$$

Torque due to forward field

$$T_f = \frac{1}{\omega_{ms}} I_s^2 R_f \quad \textbf{(4.10)}$$

Power transferred to the rotor (or air-gap power) due to forward field

$$P_{gb} = I_s^2 R_b \quad (4.11)$$

Torque due to backward field

$$T_b = \frac{1}{\omega_{ms}} I_s^2 R_b \quad (4.12)$$

Torque of the backward field is in opposite direction to that of forward field. Therefore , net developed torque

$$T = T_f - T_b = \frac{I_s^2}{\omega_{ms}} (R_f - R_b) \quad (4.13)$$

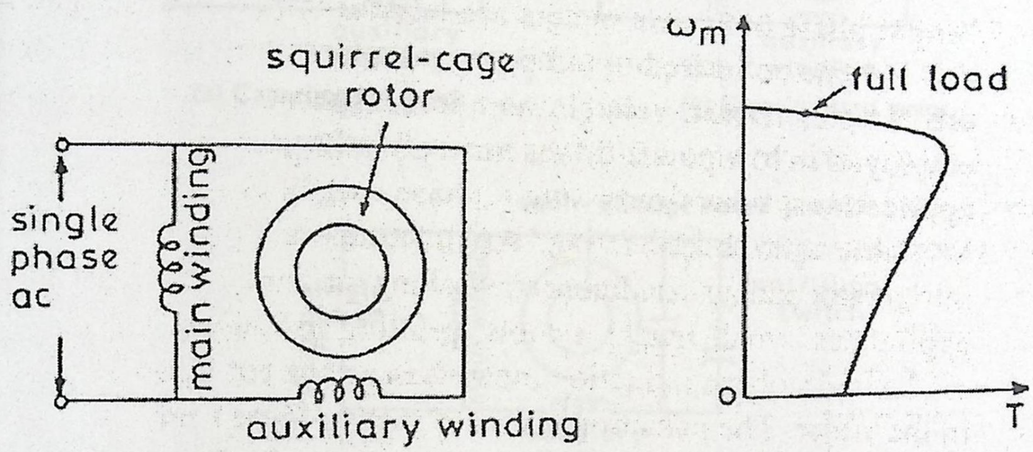
4.3 Starting methods and types of single-phase induction motors

As far as normal running is concerned, a single winding is sufficient .But all motors must be self start. The auxiliary winding is provided to produce finite torque at standstill and is displaced in space with respect to the main winding. current in second winding is supplied from same single-phase source as the main winding , but is caused to have a phase difference by various methods which are discussed later .The combination of a space displacement between the two windings together with a time displacement between the currents, produces a machine which has a finite torque at standstill and therefore it can self start .Such a motor can be reversed by changing the phase sequence which
requires that polarity of one of the windings be reversed .
Earlier it was a common practice to use the auxiliary .winding only during start and run-up .It used to be disconnected with the help of a centrifugal switch ,or relay once the motor speed reaches a round 75% of the full speed In such an arrangement auxiliary winding can have lower rating and its parameters can be chosen to improve the starting performance .But then switching
Arrangement is a disadvantage Present practice is to use auxiliary winding all the time but then its parameters are to be chosen to provide a compromise between starting and running performance and its rating has to be chosen on continuous basis.

Single-phase induction motor are classifications based on starting arrangement .Some commonly used motors are described below

4.3.1 Split-phase Motors

In these main winding is made of thick wire and large turns resulting in low resistance and high reactance .Since auxiliary winding is made of fewer turns of thin wire, it has high resistance and low reactance .Two windings are connected in parallel across the source(Fig.4.5(a)).The necessary phase shift between main and auxiliary winding currents is obtained because of the difference between their impedance angles (around 15 to 30°). As stated earlier, the



(a) Winding connection

(b) Speed-torque characteristic

Figure 4.5: Single-phase split-phase motor

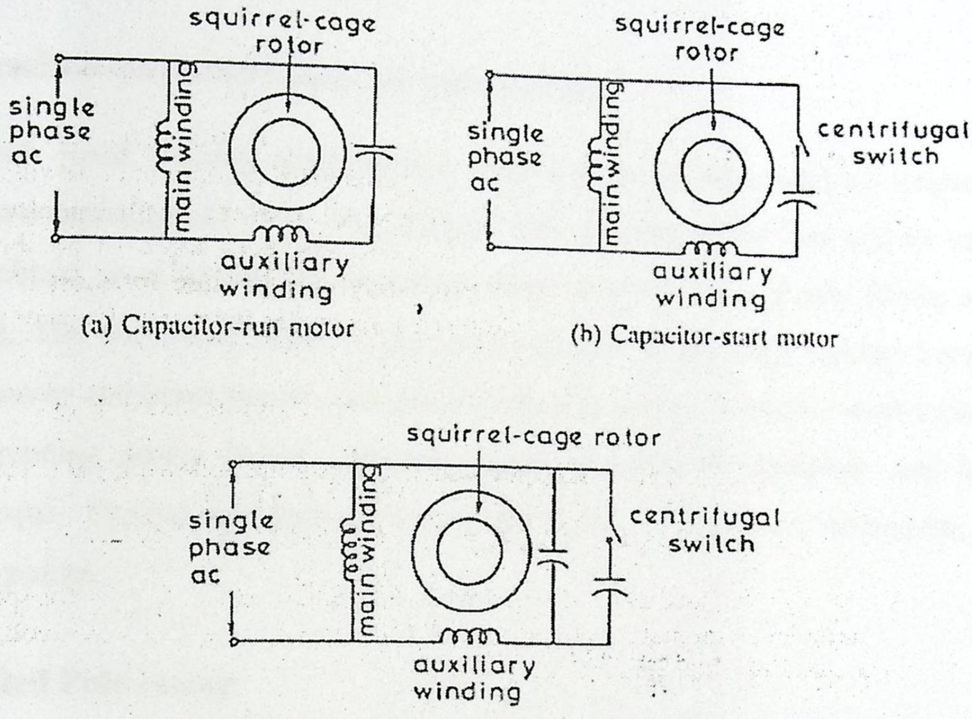
direction of rotation can be changed by reversing the auxiliary winding connection. In some motors, the auxiliary winding is used only during start and run-up and disconnected by a centrifugal switch or relay around 75%of full-load speed. Then the auxiliary winding is also called start winding .

The nature of speed-torque characteristic is shown in Fig. 4.5 (b). Starting torque is approximately 150 to 200% of full-load torque and starting current high-six to eight times the full-load current.

Split phase motors are suitable for low inertia loads, specially where starting torque is not very high. They are employed in fractional horse power ratings for fans, grinders, blowers, saws , centrifugal pumps, office equipment washing machines.

4.3.2 Capacitor-run Motors

These have two windings-main and auxiliary .A capacitor is connected in series with the auxiliary winding to provide phase-shift between the currents of auxiliary and main windings (Fig. 4.6(a)).Since the capacitor is used all the time (both during starting and normal running such motors are called capacitor run motors Capacitor value is chosen to obtain nearly 90° phase shift between



(a) Capacitor-run motor

(b) Capacitor-start motor

(c) Capacitor-start capacitor-run motor

Figure 4.6: Single-phase capacitor motors

the currents of main and auxiliary windings around full-load speed. Motor works as a balanced two-phase motor eliminating backward rotating field and second harmonic torques. Therefore, motor has good running power factor, efficiency, and quiet and smooth operation

Since capacitor value is much lower than that required to obtain good starting performance, capacitor run motor is suitable for applications requiring low starting torque ,c .g. in fans ,blowers , office machinery.

4.3.3 Capacitor-start Motors

In these also a capacitor is used in series with the auxiliary winding during start and run-up(Fig.4.6(b))At around75% of full-load speed ,the capacitor and auxiliary winding are disconnected using a centrifugal switch or relay .Hence ,the performance is identical to single winding machine, which is interior compared to the performance of capacitor – run motor .Since capacitor is used only during starting ,its value can be chosen to obtain high starting torque (3-4 times full-load torque). Because of high starting torque ,these motors find applications in loads that are difficult to start . such applications include refrigerator , compressor , air condition , conveyers and some machine tools.

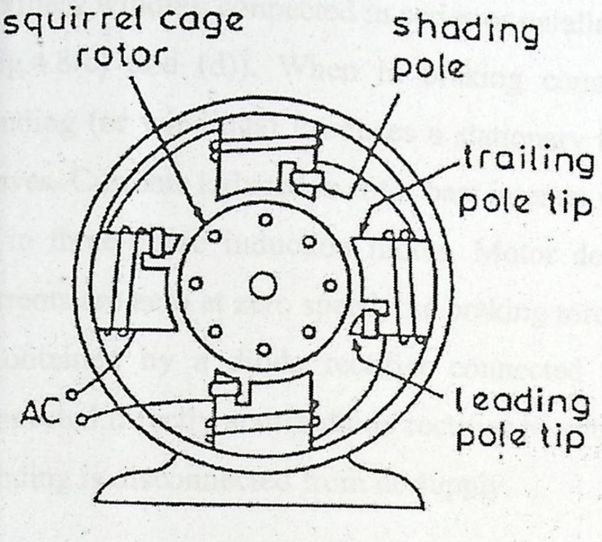
4.3.4 Capacitor-start and Capacitor run motors

When good running performance combined with high starting torque is required ,two capacitor are used (Fiig.4.6(c)) .One is used all the time and its value chosen to obtain good running performance. other capacitor is used only during start and run up. The combined value of the two is chosen to get high starting Torque. Thus, the motor combines the advantages of capacitor-run and capacitor start motors, i.e. good running power factor, efficiency ,quiet and smooth operation ,and high starting torque. Typical applications are refrigerators , compressor, conveyers, air condition , pumps.

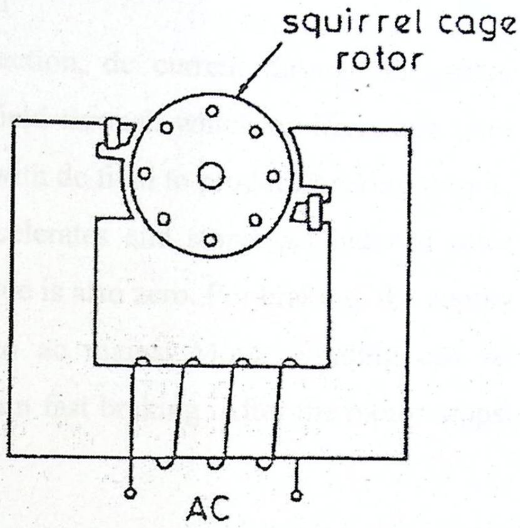
4.3.5 Shaded Pole motor

The construction of stator f a shaded pole motor is different from other single phase induction motor .Typical construction of a four-pole motor is shown in fig. 4.7(a) .A two pole motor may use the construction of Fig. 4.7(b) .The stator has a salient pole, with a single-phase winding .A small portion of each pole is surrounded by a copper ring , called shading coil. The alternating flux created by ac excitation of the main winding induces (cmf) in the shading coil in which current flows .Because of the inductive nature, shading coil current causes flux in the shaded portion to be delayed in time phase with respect to the flux in the unshaded portion of the pole .space and time phase displacements between fluxes of unshaded and shaded portions produce a sort of rotating flux which periodically shift from unshaded to shaded portion. The rotor turns from unshaded to shaded portion .It is direction of rotation cannot be reverses.

Since flux does not rotate through 360° but sweeps over pole faces only and the phase angle displacement between two fluxes is rather small ,the motor has a low staring torque, but good enough to turn small load. Motor is therefore available in small sizes 1/300 to 1/10 KW. Because of simple construction, particularly for two poles (Fig. 4.7(b)), the motor is very rugged and has low coast, efficiency and power factor. Applications include small fans, hair driers, gramophones, tape recorders and slide projects.



(a) Four pole motor



(b) Two pole motor

Figure 4.7: Shaded pole motors

4.4 Braking of single-phase induction motors

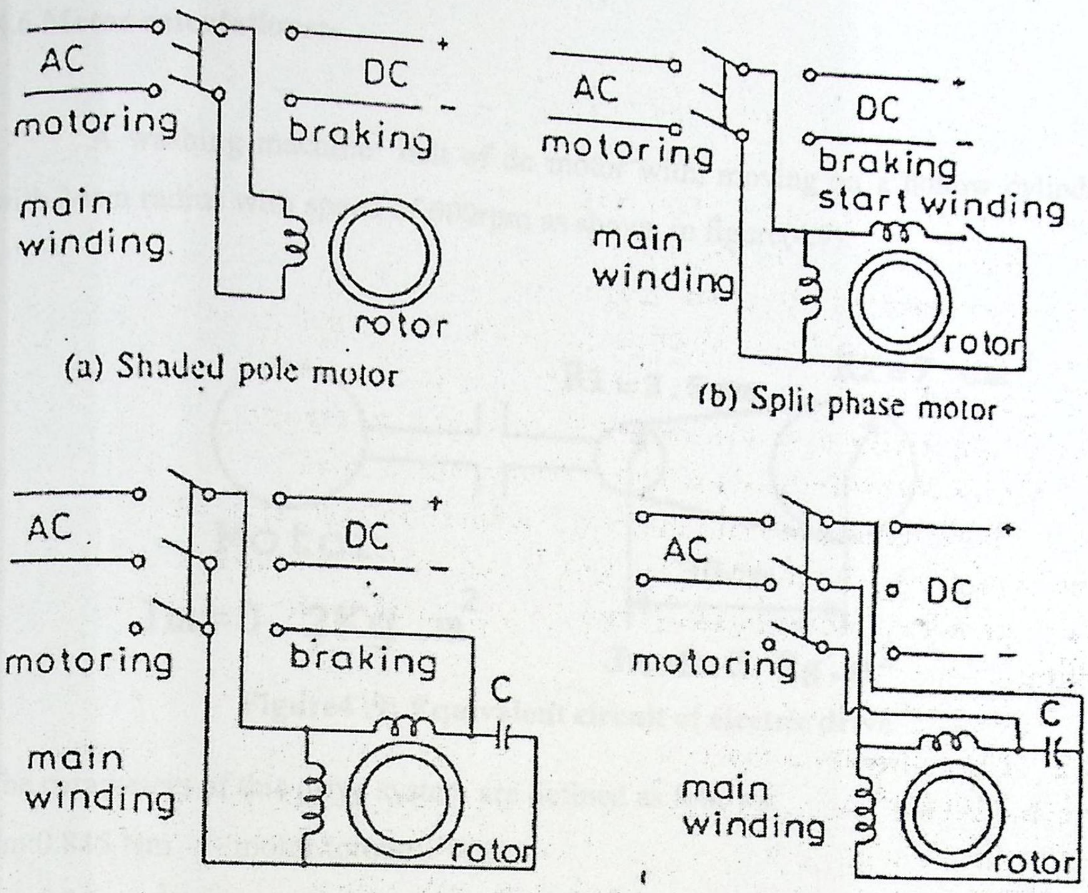
These motors can be braked by dynamic and plugging

4.4.1dc Dynamic Braking

It is commonly used for braking of single phase induction motors. With the help of a double pole double throw (DPDT) switch or triple pole double throw (TPDT), motor connection is shifted from ac (motoring) to dc source for braking.
For various single-phase induction motors these connections are shown in Fig. 4.8 In case of split-phase, capacitor run, and capacitor start and capacitor run motors, either ,main winding alone can be connected across the dc source (Fig. 4.8 (b)) or main and auxiliary winding connected in series or parallel
(Fig.4.8(c) and (d)). When in braking connection, dc current through the stator winding (or windings) Produces a stationary field through which squirrel cage rotor moves. Currents induced in rotor bars interact with dc field to produce braking torque, as in three-phase induction motor. Motor decelerates and stops. As induced rotor currents are zero at zero speed, the braking torque is also zero. For braking, the supply is obtained by a diode rectifier connected to ac mains. Motor winding can be connected directly across diode rectifier to obtain fast braking .After the motor stops, winding is disconnected from dc supply.

4.4.2 Plugging and Reversal

Except n case of shaded pole motor ,plugging and speed reversal is obtained by changing phase sequence by reversing polarity of, one of the windings.



(a) Shaded pole motor

(b) Split phase motor

(c) Capacitor-run motor, parallel winding connection for braking

(d) Capacitor-run motor, series winding connection for braking

Figure 4.8: DC dynamic braking of single phase induction motors

4.5 Speed control of single-phase induction motors

Speed of a single-phase induction motor is generally controlled by controlling its stator voltage which can be controlled by connecting a variable resistance in series with the stator. Because of poor efficiency the resistance control is now rarely used. Stator voltage can also be controlled by the use of ac voltage controllers . The speed of the motor can also be controlled by variable frequency control .However, it is rarely used because for most of the variable speed applications of single-phase motors ,the stator voltage controls good enough.

4.6 Motor calculations:-

A washing machine belt of dc motor with, moving on a hollow cylindrical with 24cm radius with speed of 600rpm as shown in figure(4.9).

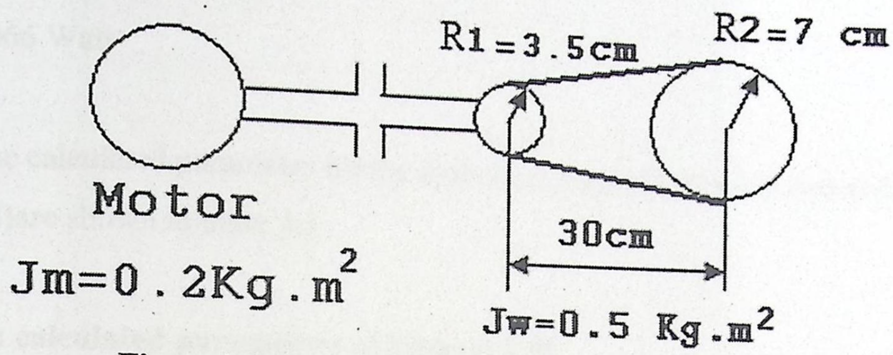


Figure4 .9: Equivalent circuit of electric drive

The parameters of this drive system are defined as follows:

Tm:0.845 Nm motor torque.

Jm: 0.2 $kg.m^2$ motor moment of inertia.

Jw: 0.5 $kg.m^2$ cylindrical moment of inertia.

Tw:5Nm friction torque at cylindrical.

The calculations of the motor are mentioned in the below equations :

= 5Kg **(4.14)** $W = \rho \pi L(R^2_{out} - R^2_{in})$

where:

: material density. ρ

: length L .

W : the weight.

Rout : the outer radius of the cylindrical tube.

Rin : the inner radius of the cylindrical tube.

the total moment of inertia on the shaft is:

Je= Jm + Jw **(4.15)**

=0.2+0.5=0.7 kg.m2

The equivalent motor torque is:

TL = Tm + Tw

= 0.845 + 5=5.845NM **(4.16)**

Tn=TL **(4.17)**

Pn= W * Tn

= (600*2*3.14)/60 * 5.845 **(4.18)**

= 367.066 Watt

The calculated parameter for the system in Figure(4.9) using equations. (4.14-4.18)are shown in table 4.3.

Table4 .1: calculated parameters of Figure(4.9).

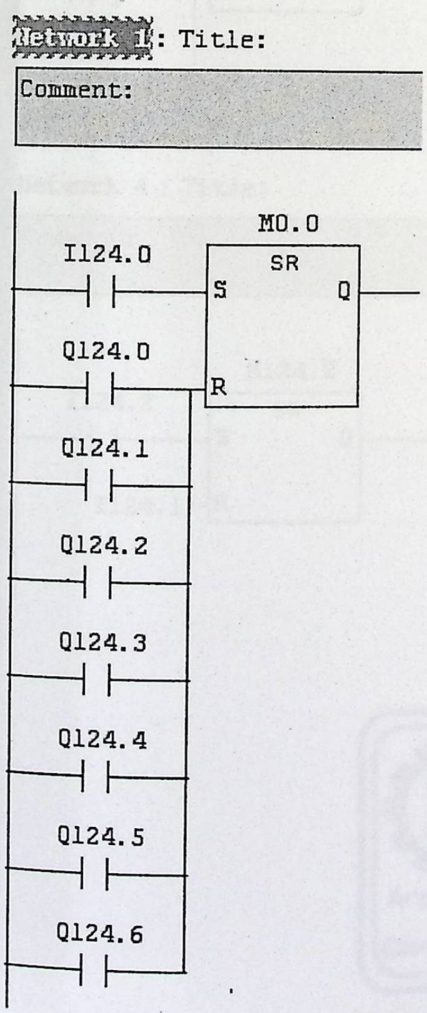
Par.	Wm	Je	Tl	Tn	P
Unit	1/s	$kg.m^2$	Nm	Nm	W
value	600	0.7	5.845	0.845	367.066

Chapter Five

PLC Programs

5.1Washing machine PLC program

We designed and programmed the washing machine to be worked step by step, we divided the washing process into many states or processes , the washing process starts by pressing on the start pushbutton , the valve start filling the tube of washing with water from the tank , after water reached to a limited level the valve must be off , the heating process begin and still for (15s) to heat the water for a suitable temperature , then washing clothes start , the tube of washing turns in CW direction for (5s) , the stop and still stopping for (3s) , then the tube of washing turns in CCW direction for (5s), and this process programmed to be for (3 cycles) ,these cycles can be increases or decreases from the program , the programmer can changed it. After finishing washing process the inflection process start , where the dirty water inflected by using a pump , after that the final process start , the drying clothes still for (15s) and the pump still start with drying process.



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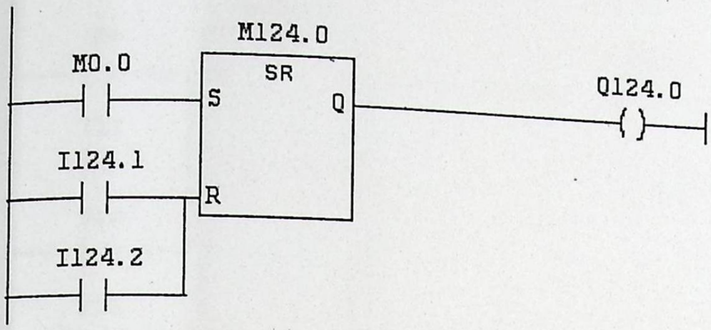

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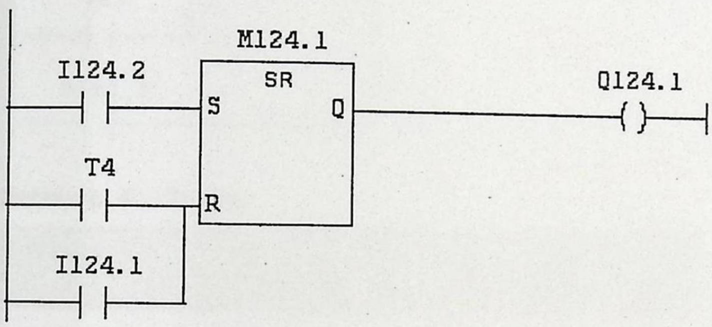

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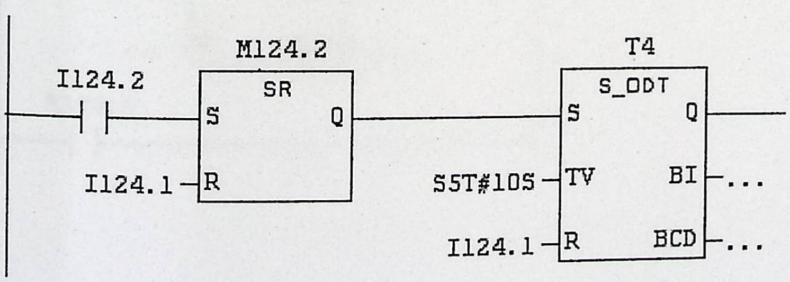

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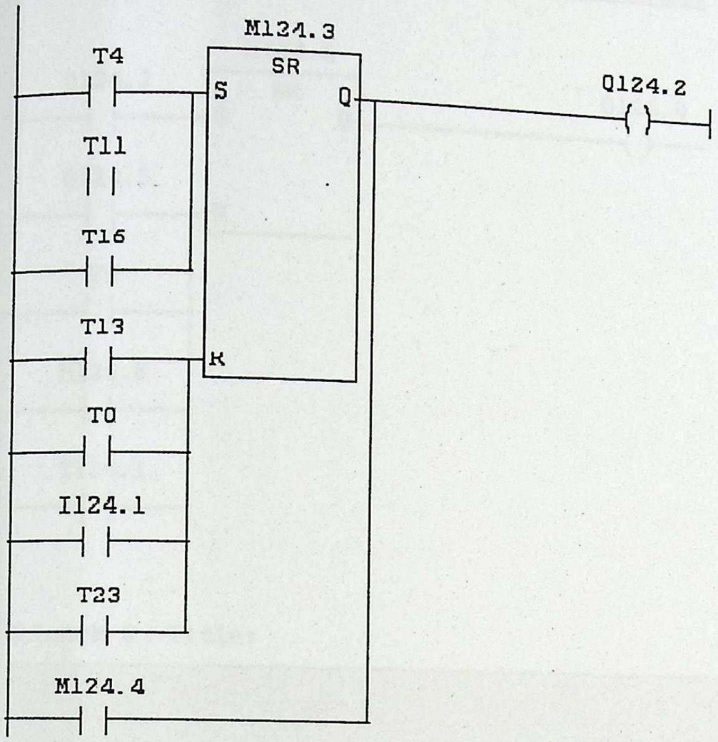

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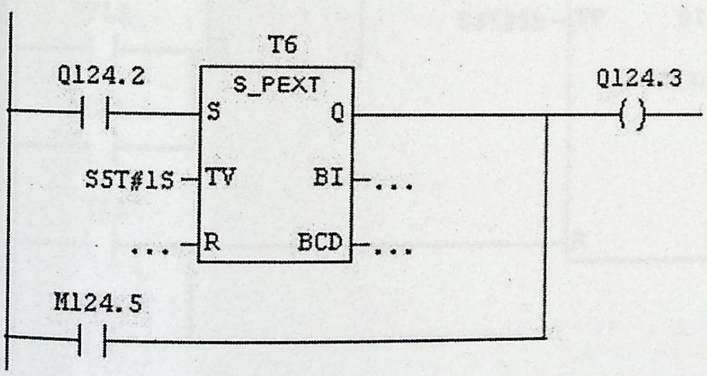

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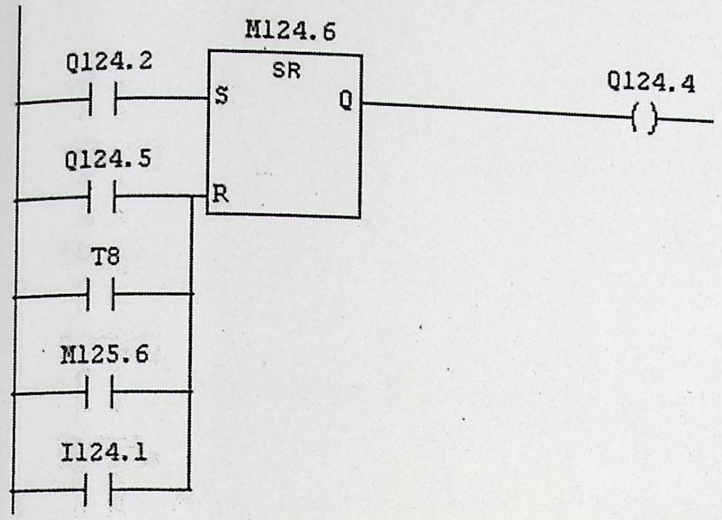

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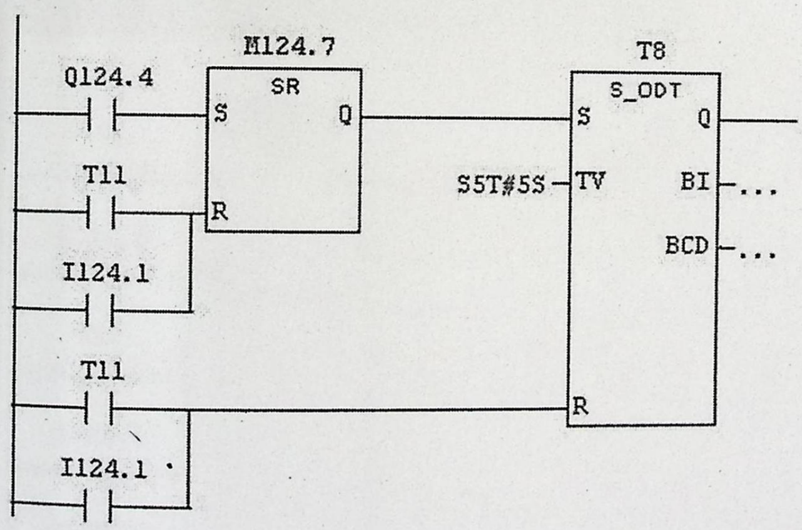

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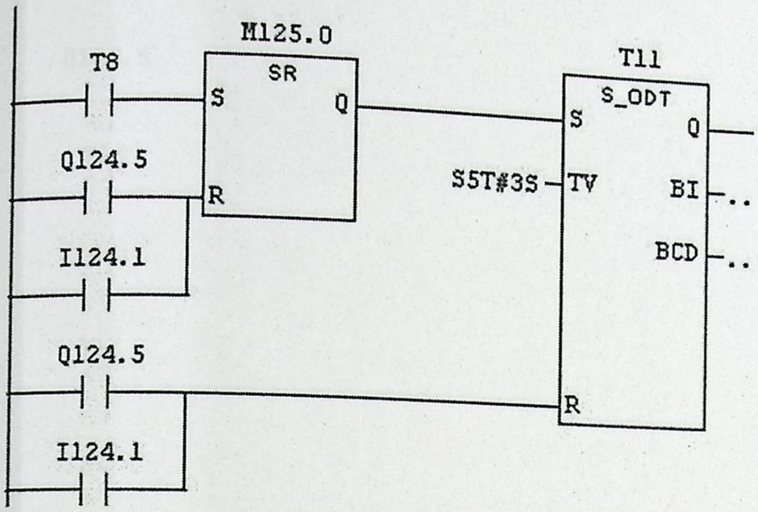

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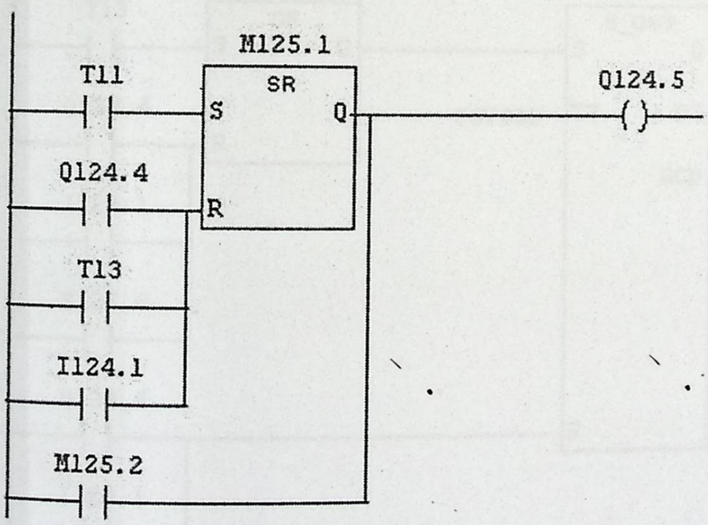

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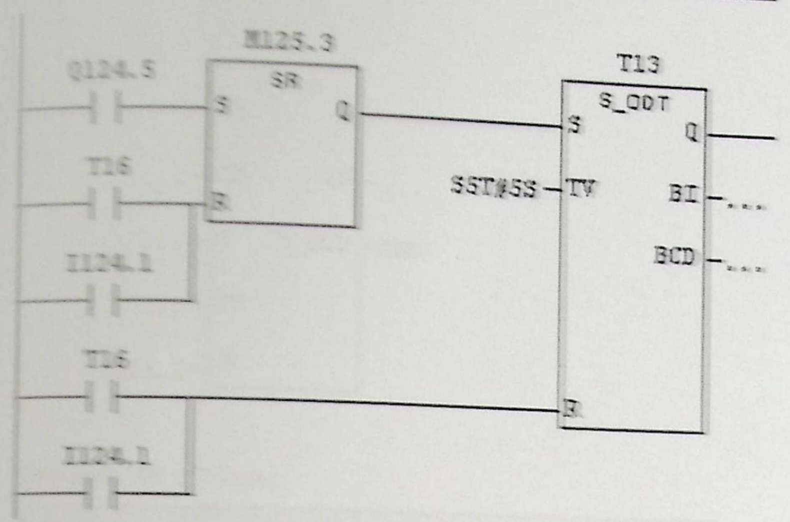

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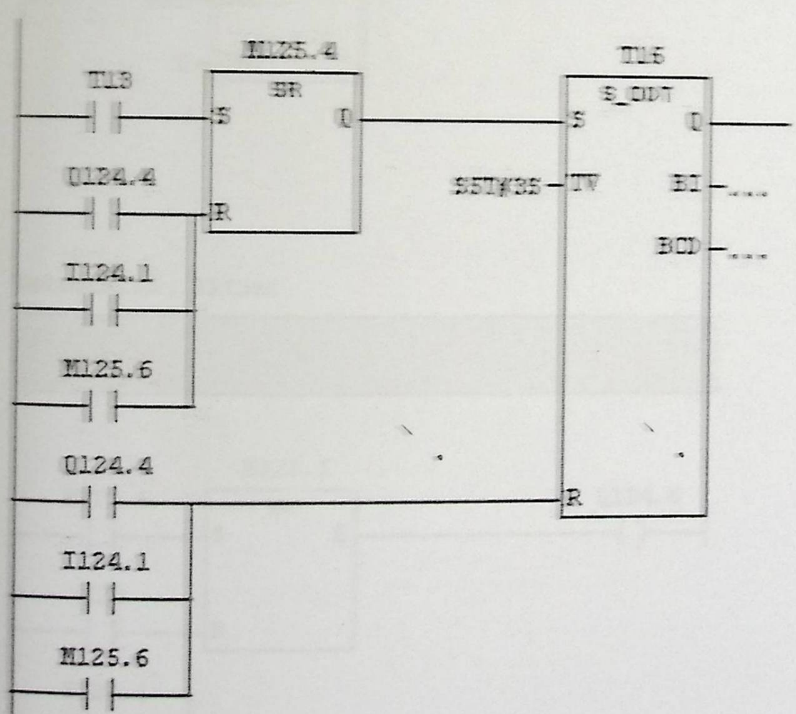

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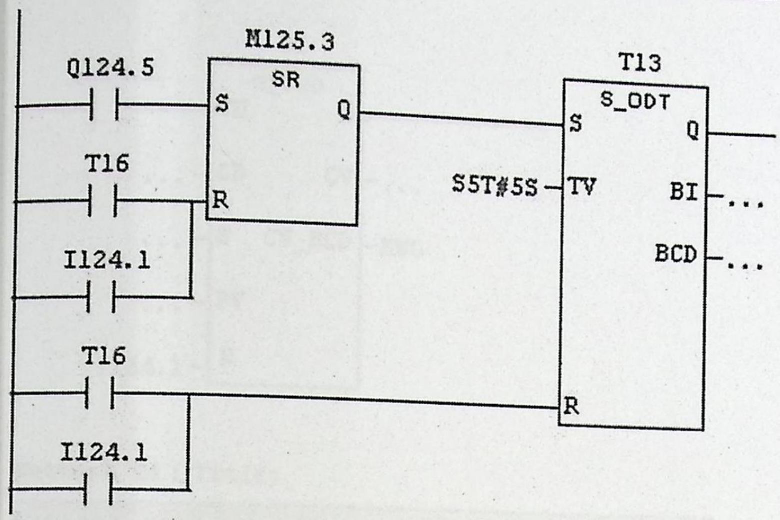

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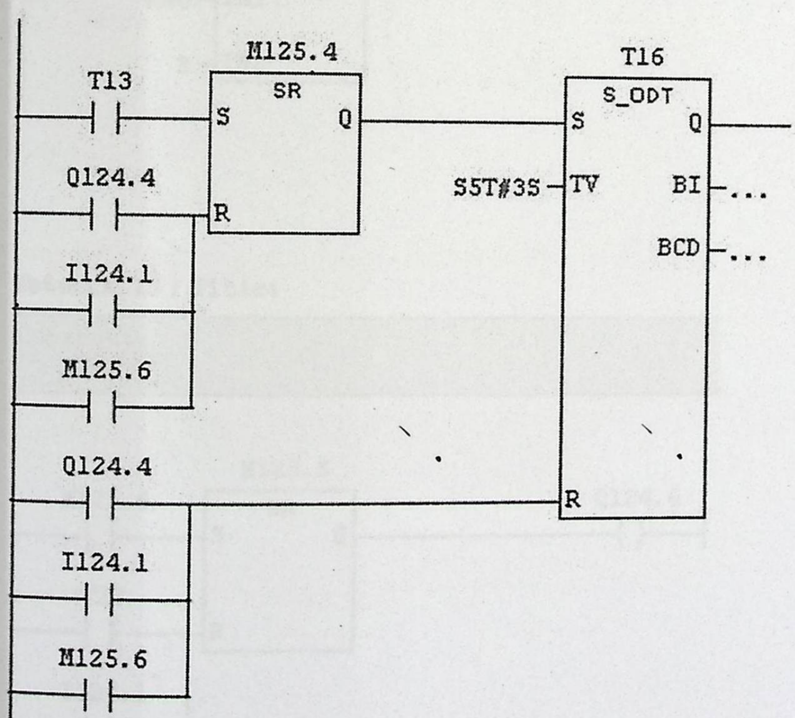

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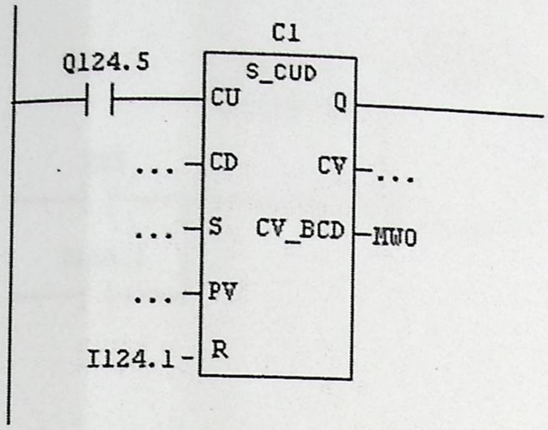

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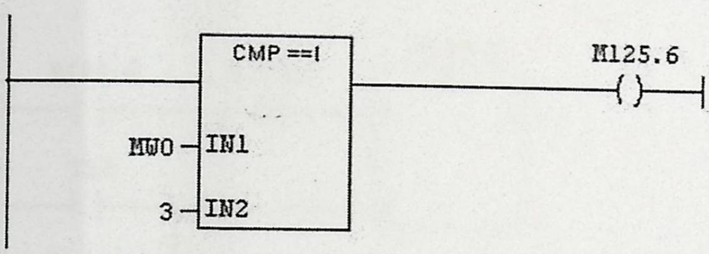

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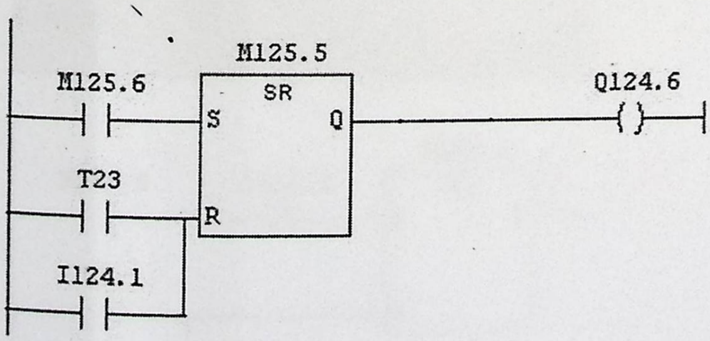

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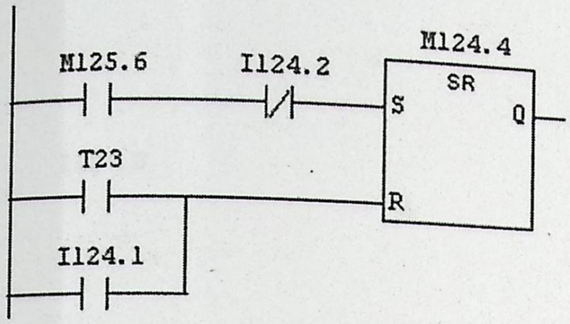

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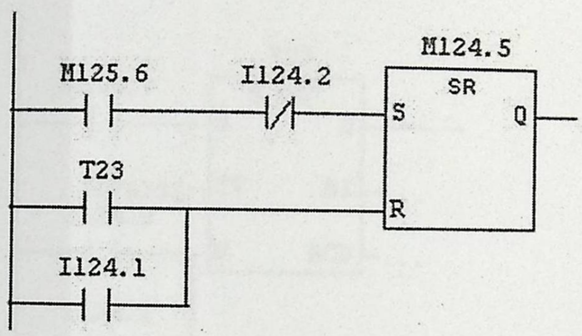

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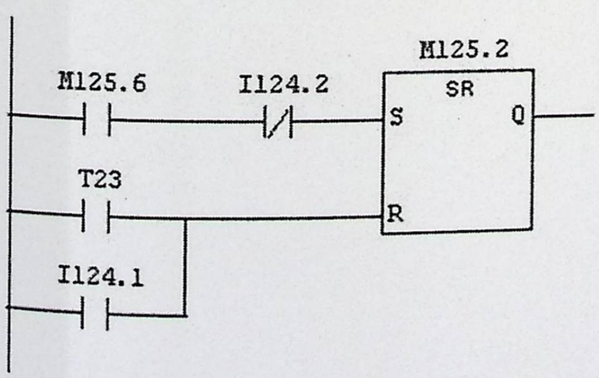

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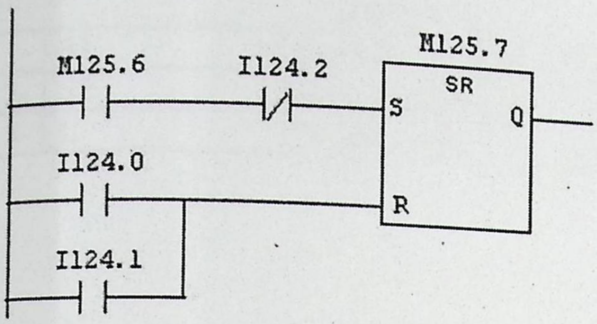

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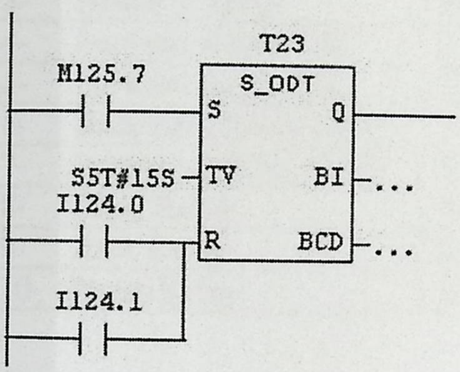


Table 5.1: Washing machine PLC (inputs)

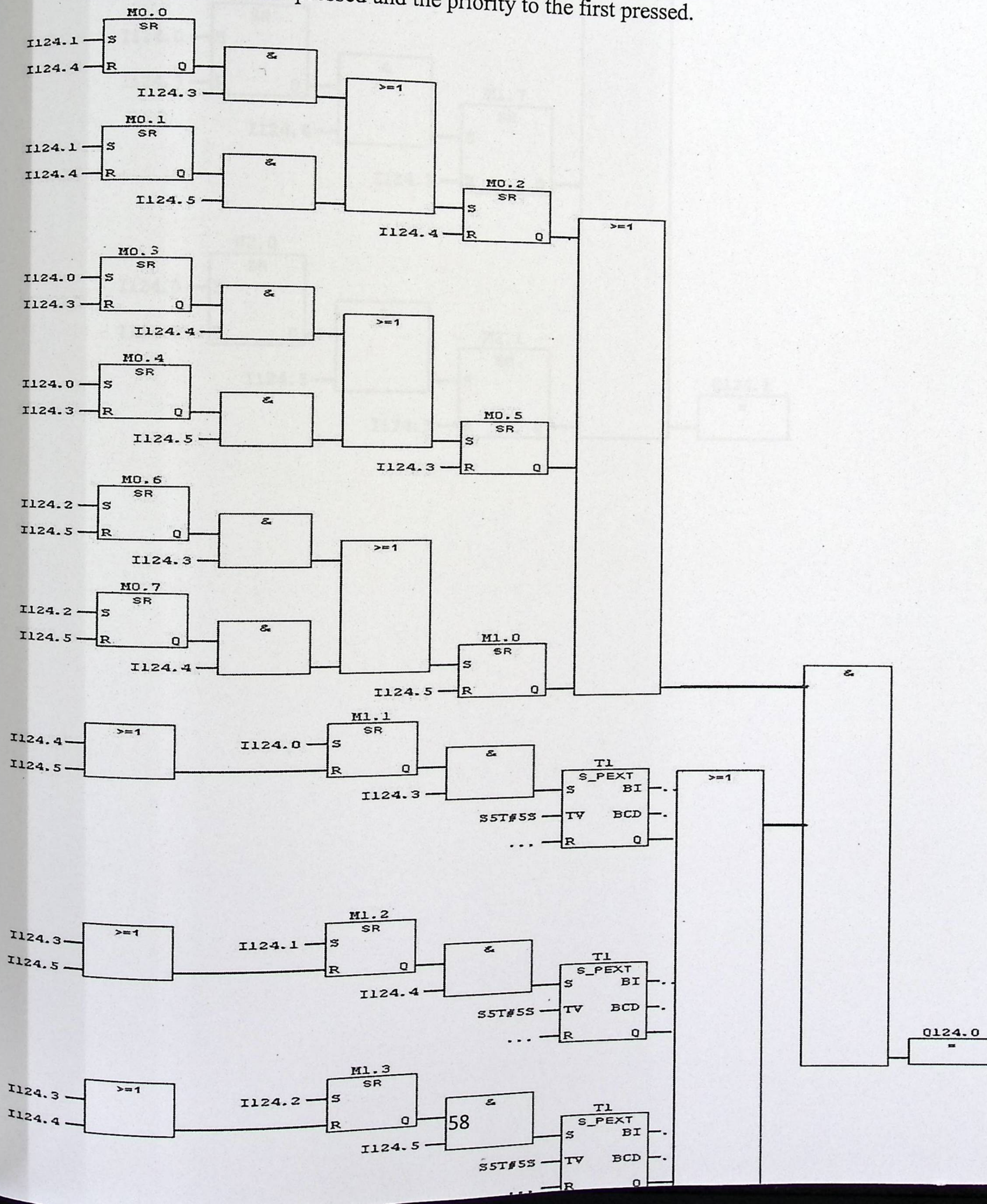
Washing machine PLC (INPUTS)			
1-	S1	Start Pushbutton	I124.0
2-	S2	Stop Pushbutton	I124.1
3-	L	Water Level	I124.3

Table 5.2: Washing machine PLC (outputs)

Washing machine PLC (OUTPUTS)			
1-	Water Valve	Taken water	Q124.0
2-	Heater 1 Relay	Heating Water	Q124.1
3-	Heater 2 Relay	Heating Water	Q124.1
4-	Forward Relay CW	Turning the tube CW	Q124.4
5-	Forward Relay CW	Turning the tube CW	Q124.4
6-	Backward Relay CCW	Turning the tube CCW	Q124.5
7-	Backward Relay CCW	Turning the tube CW	Q124.5
8-	Main Relay	Connect with source	Q124.2
9-	ASR Relay	Drying	Q124.3
10-	Pump Relay	Inflection water	Q124.6

5.2 Elevator PLC program

The elevator is a ready module but our work is programmed it , it compound of three level . If pushbutton of level one pressed the elevator move to the level one and stay for (3s) limited in the program. If pushbutton of level two pressed the elevator move to the level two and stay for (3s) , if pushbutton of level three pressed the elevator move to the level three and stay for (3s) . Or if there are two pressed the elevator execute the fast pressed and the priority to the first pressed.



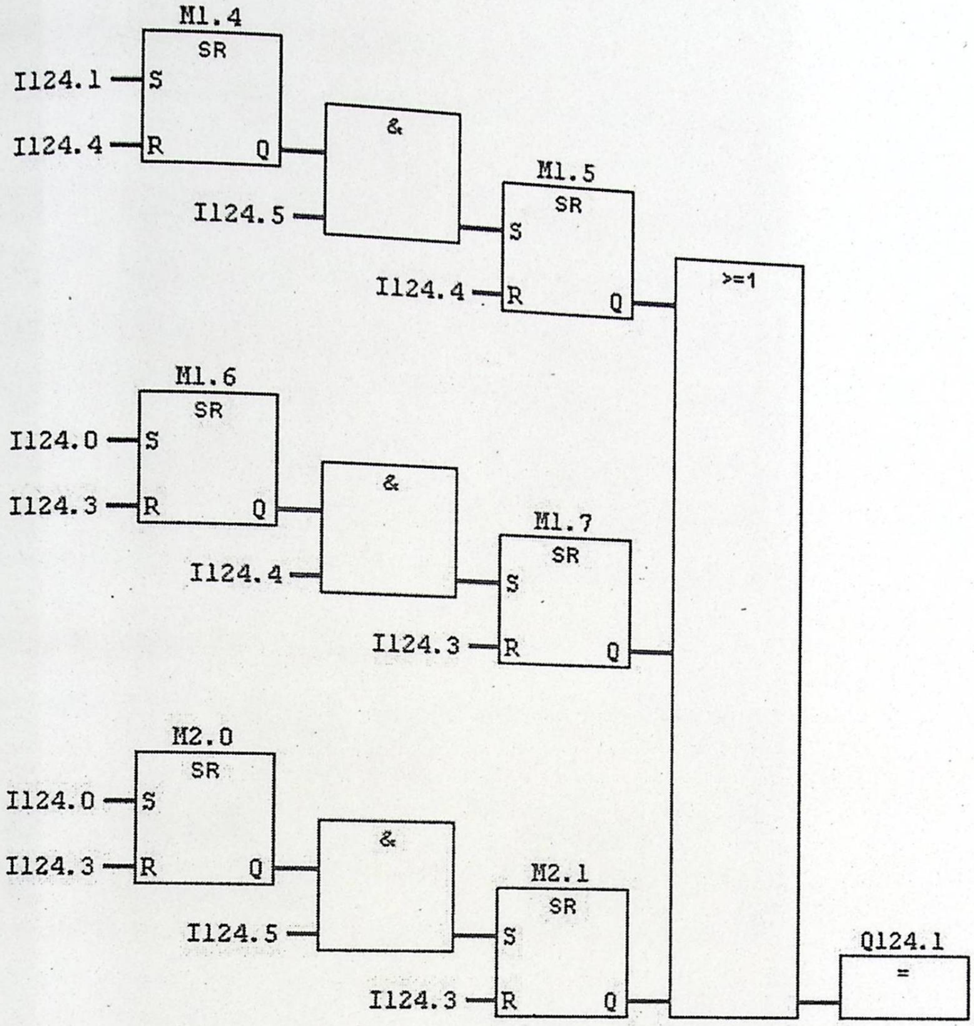

M1.4
SR
I124.1
S
I124.4
R
Q
&
I124.5
M1.5
SR
S
I124.4
R
Q
>=1
M1.6
SR
I124.0
S
I124.3
R
Q
&
I124.4
M1.7
SR
S
I124.3
R
Q
M2.0
SR
I124.0
S
I124.3
R
Q
&
I124.5
M2.1
SR
S
I124.3
R
Q
Q124.1
=

Table 5.3: Elevator PLC (inputs)

Elevator PLC (INPUTS)			
1-	S1	Pushbutton for level 1	I124.0
2-	S2	Pushbutton for level 2	I124.1
3-	S3	Pushbutton for level 3	I124.2
4-	L1	Limit switch for 1	I124.3
5-	L2	Limit switch for 2	I124.4
6-	L2	Limit switch for 3	I124.5

Table 5.4: Elevator PLC (outputs)

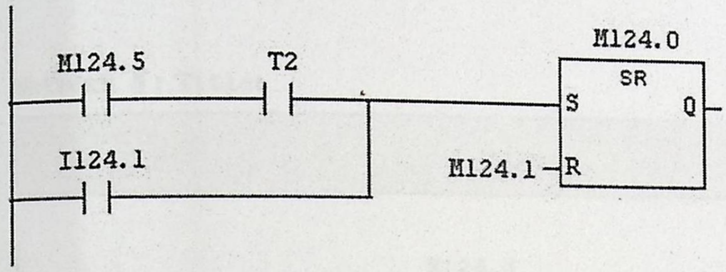
Elevator PLC (OUTPUTS)			
1-	K1	Start Relay	Q124.0
2-	K2	Reverse Relay	Q124.1

5.3 Fan system PLC program

We designed the fan system and programmed it , the fan system compound from one pushbutton and two fans, the work of it if we pressed first pressed on the pushbutton the one of the two fans start , the second pressed turn on the fan number two and the third pressed the two fans stopped after (3S.) by triggering a timer for (3s.)

Network 1 : Title:

Comment:



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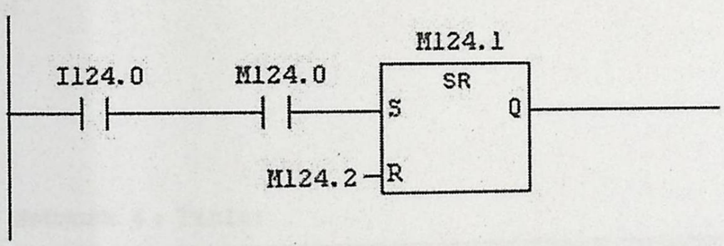

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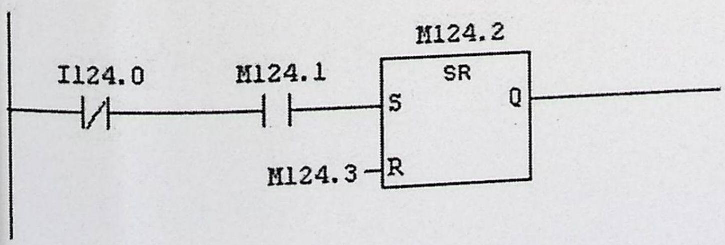

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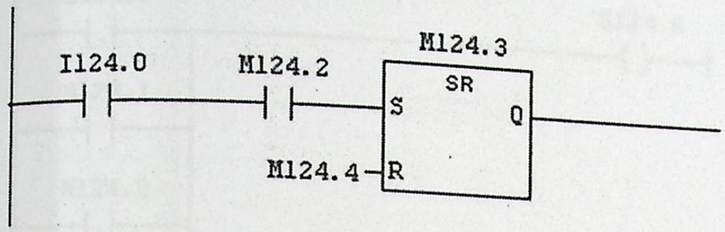

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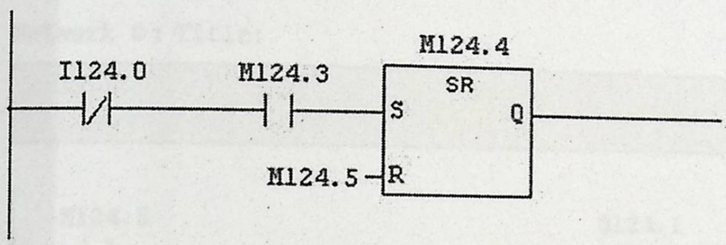

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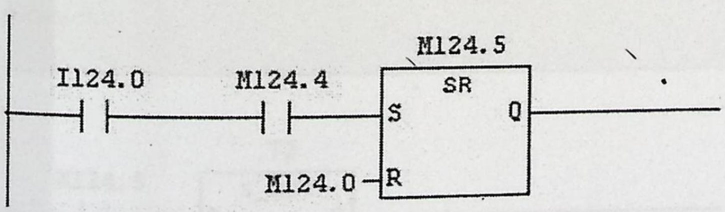

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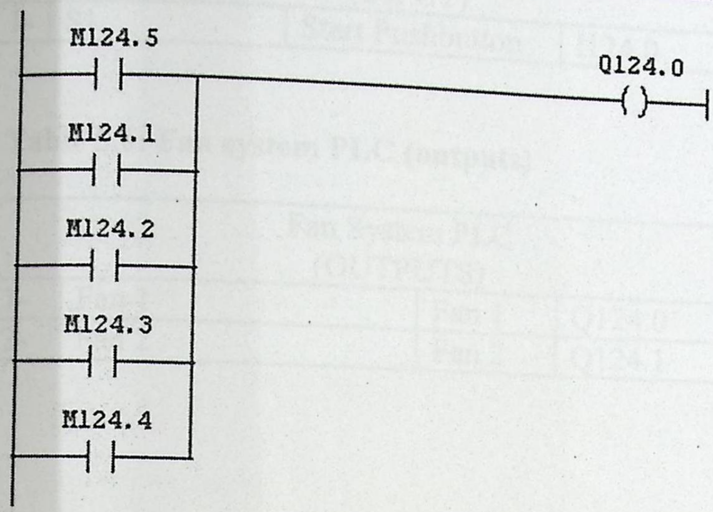

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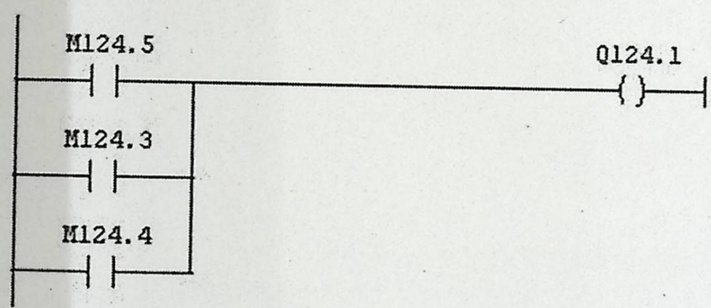

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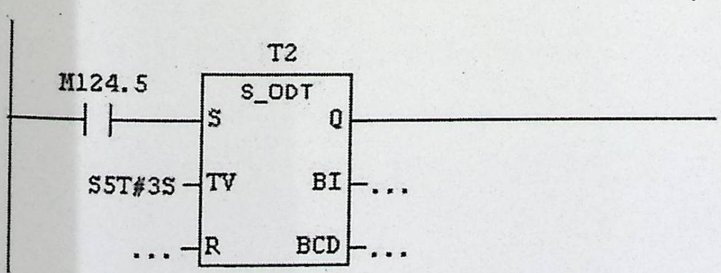


Table 5.5: Fan system PLC (input)

Fan System PLC (INPUT)			
1-	S1	Start Pushbutton	I124.0

Table 5.6: Fan system PLC (outputs)

Fan System PLC (OUTPUTS)			
1-	Fan 1	Fan 1	Q124.0
2-	Fan 2	Fan 2	Q124.1

Chapter six
Machine design

6.1 washing machine design

In washing machine we started from the body or the shape, it's designed from iron as shown in fig. 6.1

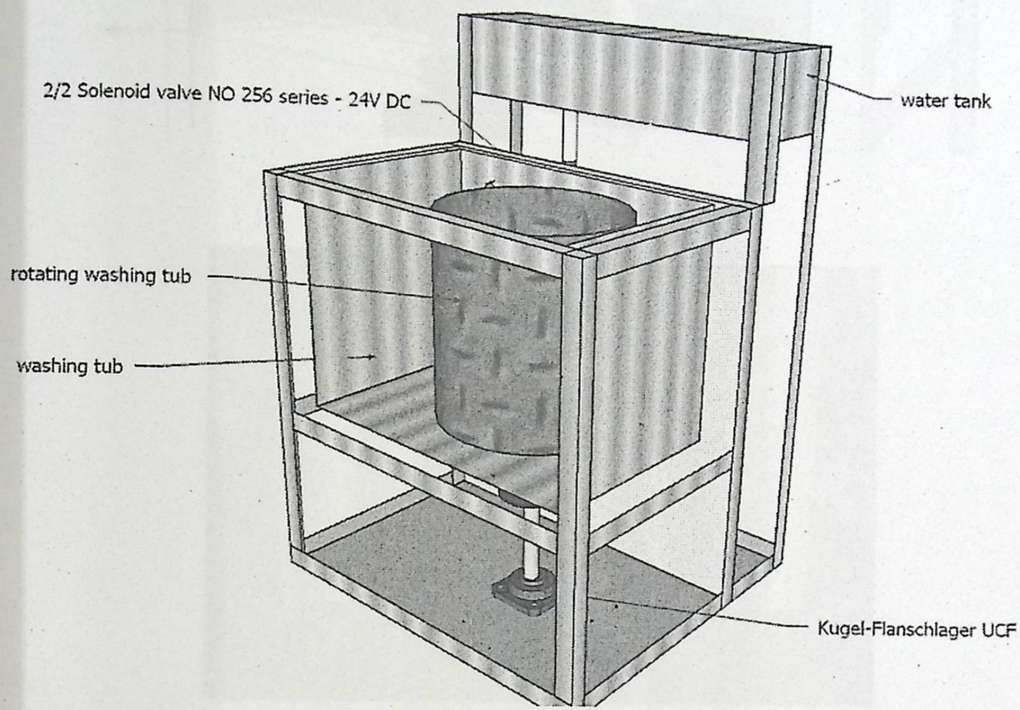


Fig.6.1: Washing machine iron shape

The iron that we used in the body is $90°$ angle and $2.5 * 2.5cm$ we configured it by cutting and welding.

Washing tube constructed from four sides three is from iron with thickness 1.5 mm and the 4^{th} is from glass 4 mm the plate on the bottom is 8 mm thickness to loading and to absorb the vibration and to fixed the other component (lager and rubber belling) as shown in figures (6.2,6.3 and 6.4)

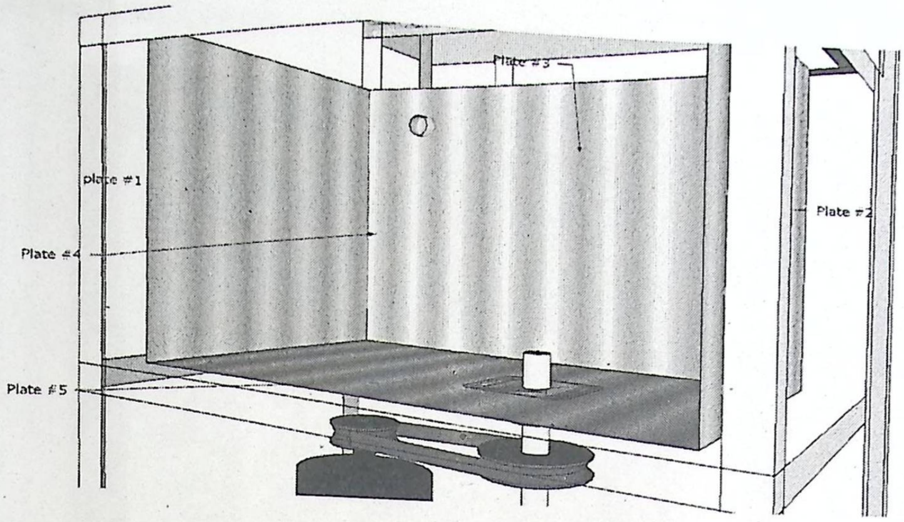


Fig.6.2: Washing machine tub

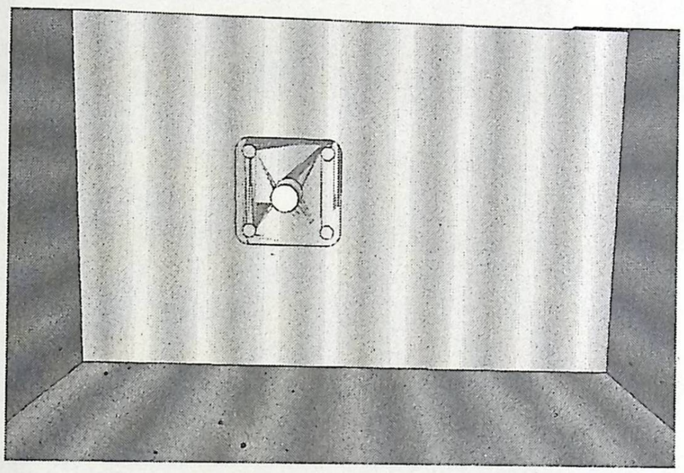


Fig. 6.3:Plate # 5

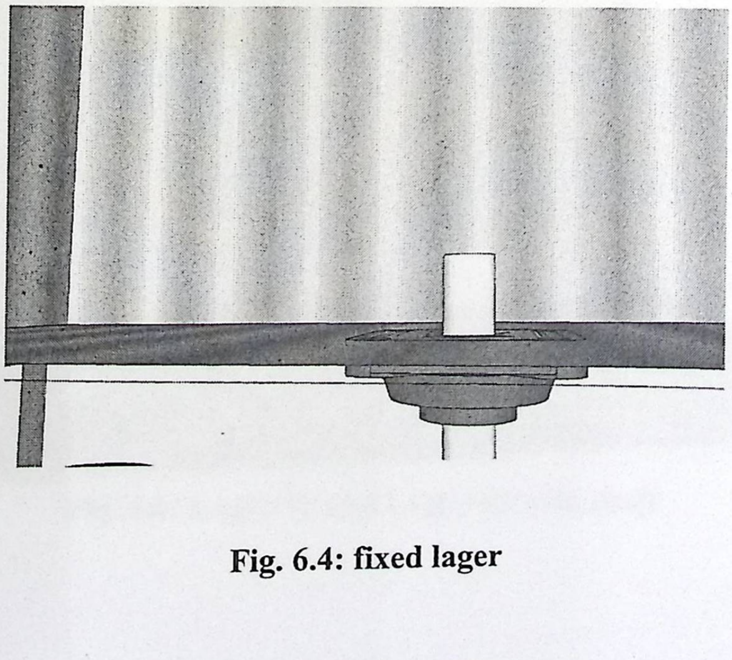


Fig. 6.4: fixed lager

In plate #3 we fixed 2 heaters as shown in fig. 6.5

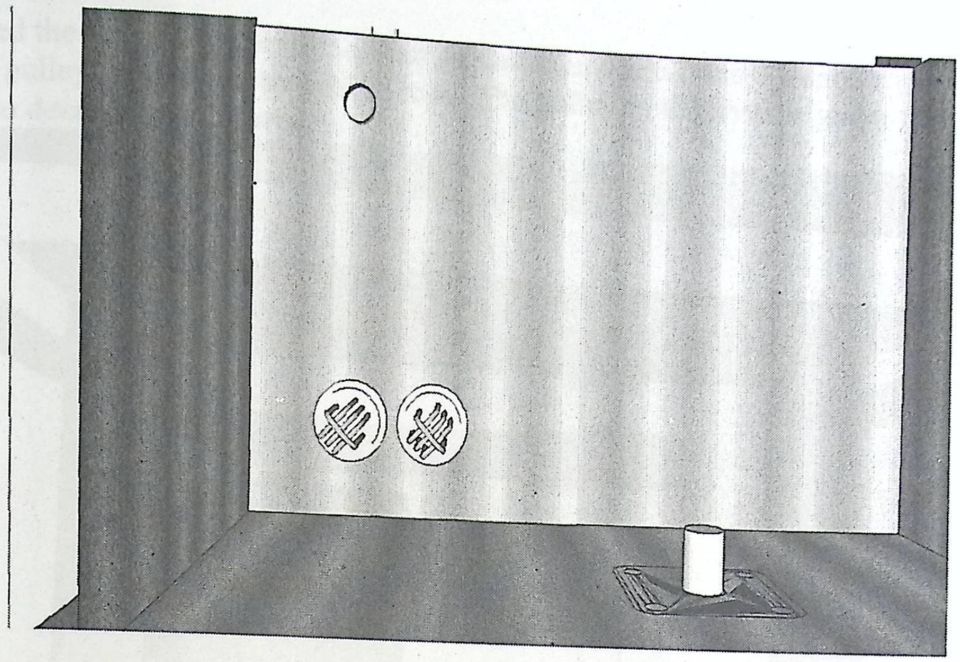


Fig. 6.5: Heaters position

The lager #2 is fixed on the end of the shaft as shown in (fig. 6.6) and centered with lager #1.

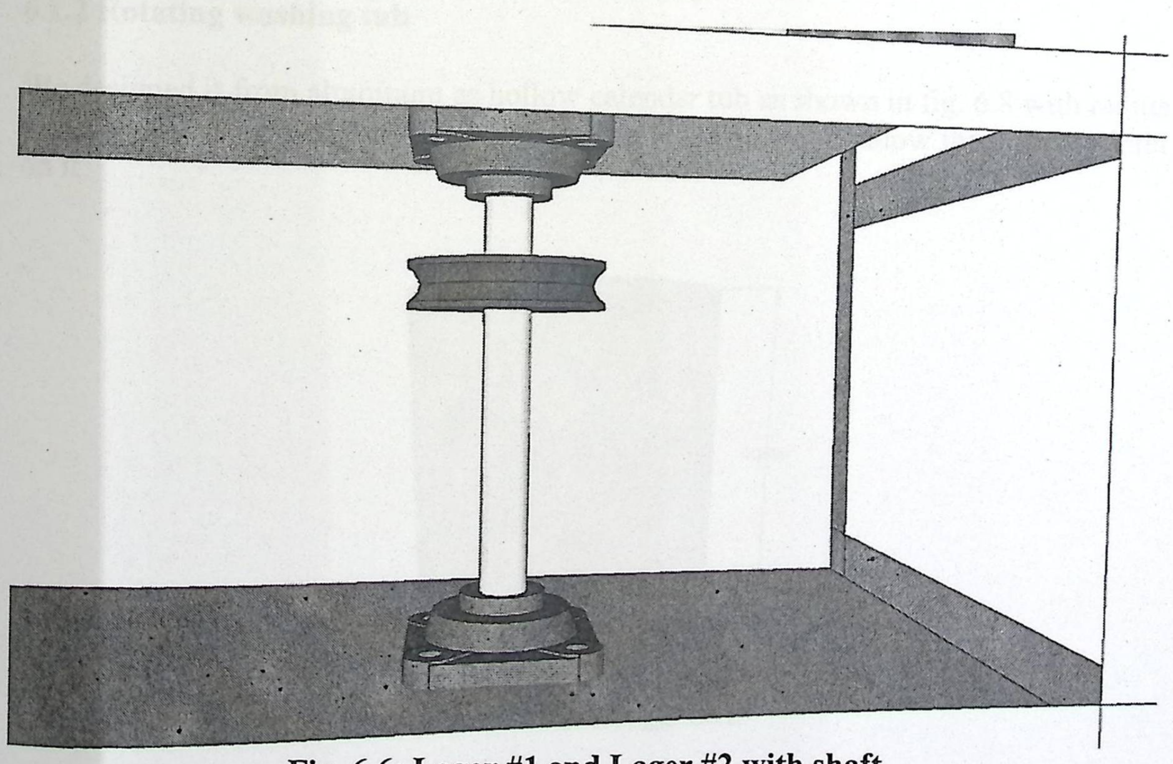


Fig. 6.6: Lager #1 and Lager #2 with shaft

6.1.1 Motor configuration

We fixed the motor on side of the shaft as shown in fig. 6.7 and we connect between it by two pulleys connected by rubber rope. The pulley in the shaft is grater then motor pulley to decreasing the speed.

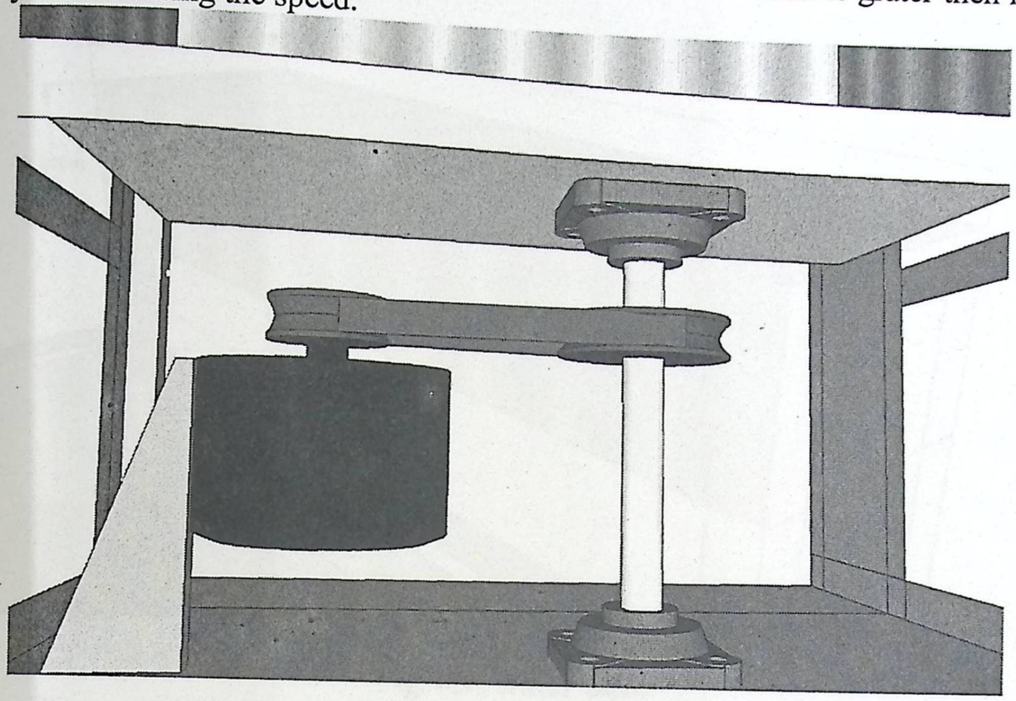


Fig. 6.7: Motor configuration

6.1.2 Rotating washing tub

We designed it from aluminum as hollow calendar tub as shown in fig. 6.8 with radius 12cm and high of 35cm and it have many random hollows to allow the water to inter on it

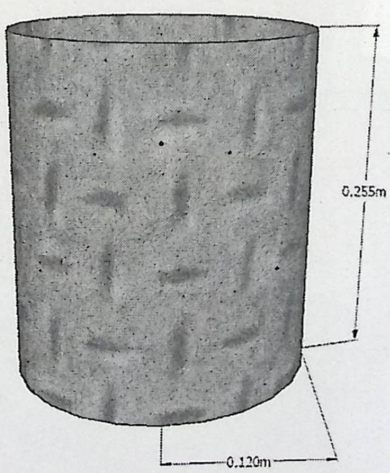


Fig. 6.8: Rotating washing tub

On the top of the model we put a small water tank top complete the process of washing without any need to another source, its from iron 1.5mm as shown in fig. 6.9

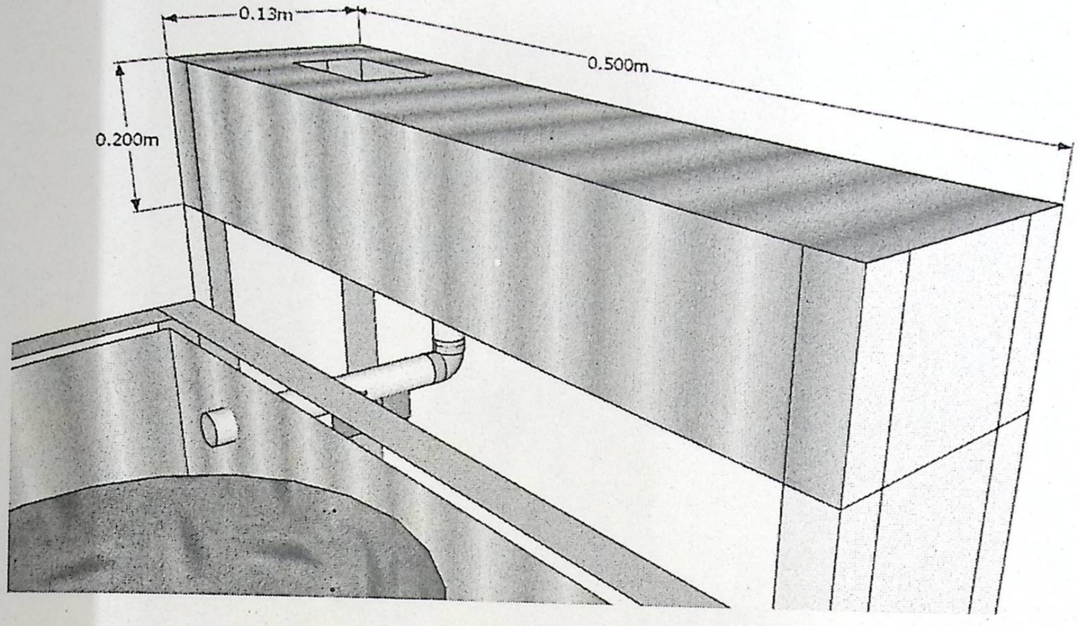


Fig. 6.9: water tank

6.1.3 Final shape

We designed the outer shape by wood as shown in fig. 6.10

Fig. 6.10: Final shape

6.2 Fan system

This model has two fans, the shape made from wood as shown in fig.6.11

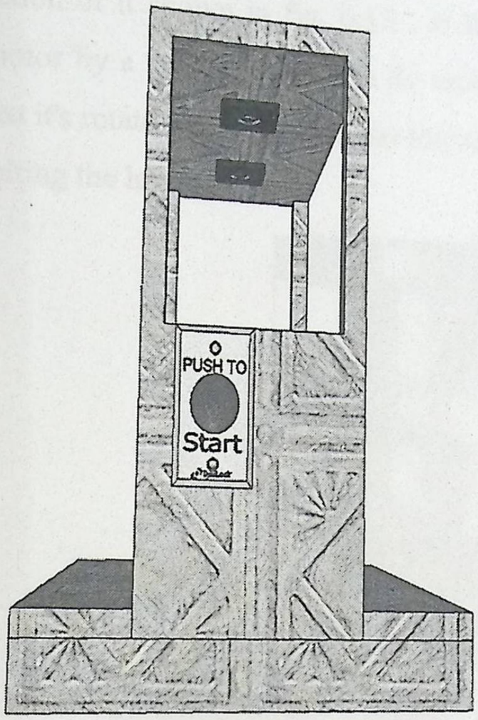


Fig.6.11: Fan system shape wood

6.3 Elevator

This model designed by siemens Co. it's a small model that explain the work of real elevator.

The construction of it shown in fig. 6.12 , it has three level and has a cabin joined with a dc motor by a string , when the dc motor rotate in CW direction the cabin go up and when it's rotate in CCW direction the cabin go under. And it has three limit switches to limiting the levels.

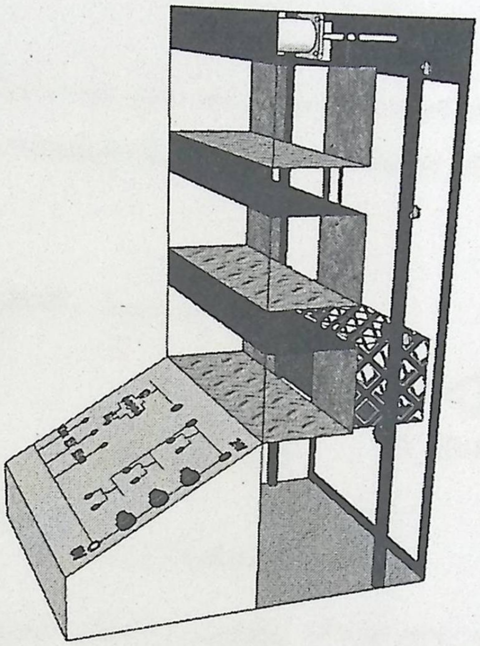


Fig. 6.12: The construction of elevator

6.4 Electrical design

6.4.1 Washing machine

This model constructed from main parts as mention in chapter two:-

- Single phase motor.
- Heaters.
- Water valve.
- Inflection pump.

The equivalent circuit for every part are show in a separated fig. Fig. 6.13 has shown the direct connection between the valve and the output of the PLC, because the coil of the valve is 24Vdc.

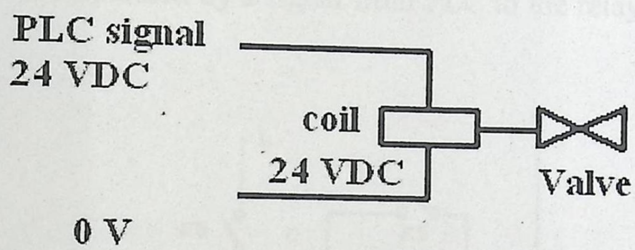


Fig. 6.13: Valve circuit

The 2nd part is the heater which is needed 24Vdc relay to connect it with the output of PLC. The connection shown in fig. 6.14.

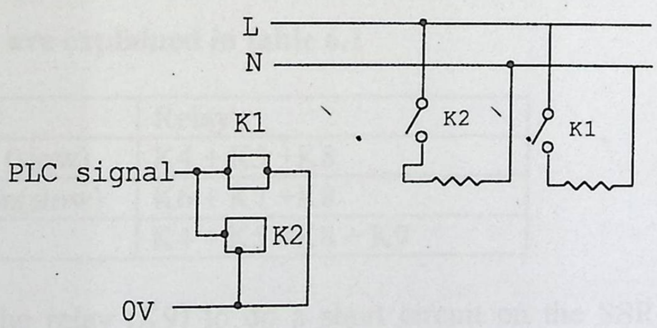


Fig. 6.14: The heater connection

The 3rd main part is the motor, because we need two speed one for washing and the other for drying, and we need to reverse the direction of rotating, we made the circuit as shown in fig. 6.15.

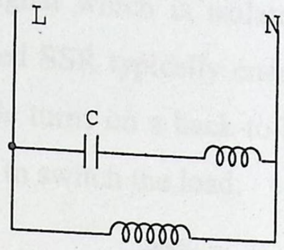


Fig. 6.15:Single-phase induction motor

This circuit needed from us to open the motor and separate end point of starting and running windings. And connect this circuit out of motor. The circuit shown in fig. 6.16 it's operated by a signal from PLC to the relays to rotate the motor in CW or CCW.

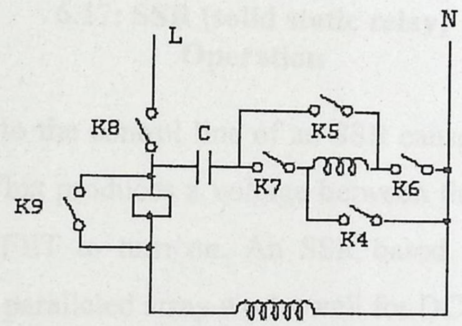


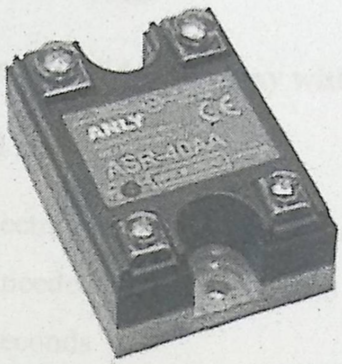
Fig.6.16: Additional connection on the motor

The relay's work are explained in table 6.1

Operation	Relay's
Forward direction (slow)	K4 + K5 +K8
Backward direction(slow)	K6 + K7 +K8
Drying (fast)	K4 + K5 +K8 + K9

We used the relay (K9) to do a short circuit on the SSR for (1s) in every starting operation of motor in two directions and still on in drying operation because we need a high speed.

A solid state relay (SSR) is an electronic switch, which, unlike an electromechanical relay, contains no moving parts. The types of SSR are photo-coupled SSR, transformer-coupled SSR, and hybrid SSR. A photo-coupled SSR is controlled by a low voltage signal which is isolated optically from the load. The control signal in a photo-coupled SSR typically energizes an LED which activates a photo-sensitive diode. The diode turns on a back-to-back thyristor, silicon controlled rectifier, or MOSFET transistor to switch the load.



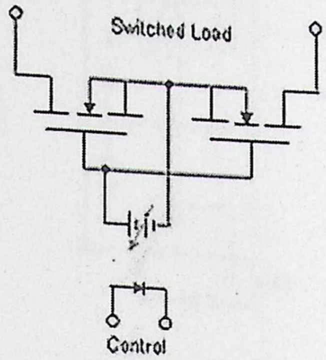
6.17: SSR (solid static relay)

Operation

Voltage applied to the control line of an SSR causes the LED to shine on the photo-sensitive diode. This produces a voltage between the MOSFET source and its gate, causing the MOSFET to turn on. An SSR based on a single MOSFET, or multiple MOSFETs in a paralleled array works well for DC loads.

There is an inherent substrate diode in all MOSFETs that conducts in the reverse direction. This means that a single MOSFET can't block current in both directions. For AC (bi-directional) operation, two MOSFETs are arranged back to back with their source pins tied together. Their drain pins are connected to either side of the output. The substrate diodes then are alternately reverse biased in order to block current when the relay is off. When the relay is on, the common source is always riding on the instantaneous signal level and both gates are biased positive relative to the source by the photo-diode.

It is common to provide access to the common source so that multiple MOSFETs can be wired in parallel if switching a DC load. There is also commonly some circuitry to discharge the gate when the LED is turned off, speeding the relay's turn-off.



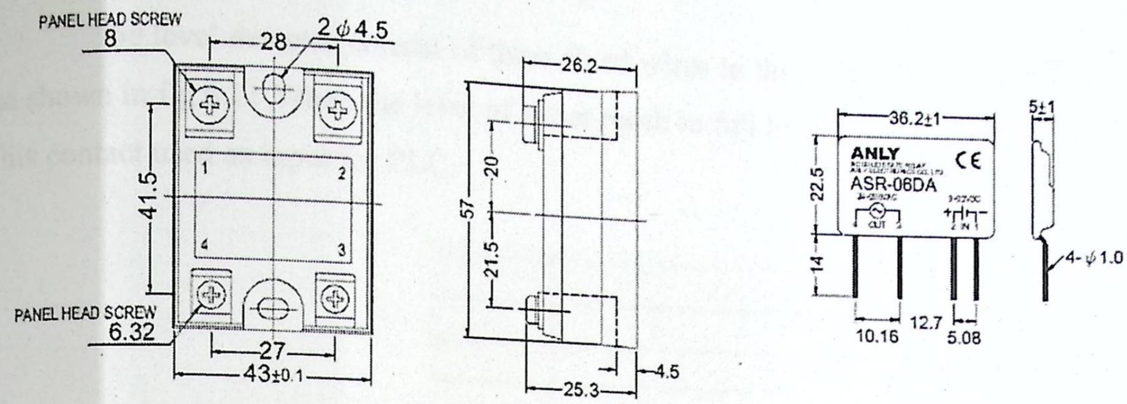
6.18:Bi-directional solid state relay with opto-isolation

Advantages over mechanical relays

- SSRs are faster than electromechanical relays; their switching time is dependent on the time needed to power the LED on and off, on the order of microseconds to milliseconds
- Increased lifetime due to the fact that there are no moving parts, and thus no wear
- Clean, bounceless operation
- Decreased electrical noise when switching
- Can be used in explosive environments where a spark must not be generated during turn-on
- Totally silent operation
- Smaller than a corresponding mechanical relay.

`Disadvantages

- Fail short more easily than electro-mechanical relays
- Increased electrical noise when conducting
- Higher impedance when closed (-> heat production)
- Lower impedance when open
- Reverse leakage current when open (µA range)
- Possibility of false switching due to voltage transients
- Isolated bias supply required for gate charge circuit
- Higher Transient Reverse Recovery time (Trr) due to the presence of Body diode



6.19: Outline dimensions of SSR: mm

The water pump consists of a fan fixed on ac motor the electrical connection with PLC is shown in fig. 6.20.

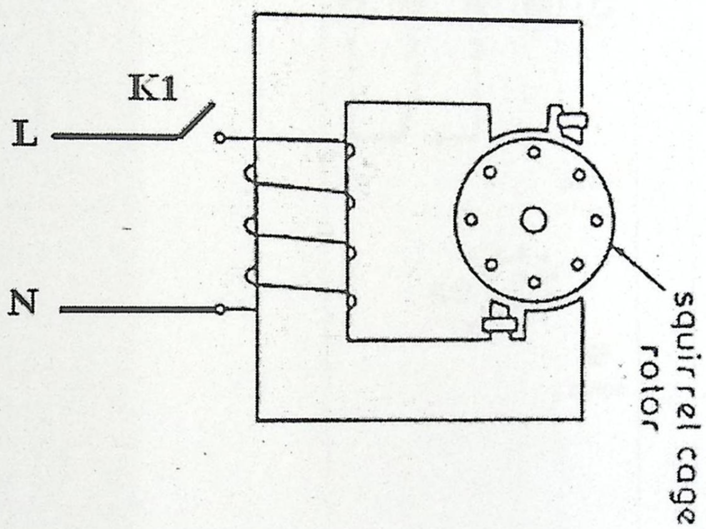


Fig.6.20: Motor of water pump

The level detector consist of three fixed wires in the tube of washing machine as shown in fig.6.21.When the level of water reach to full level the solenoid is closed, this contact used as input for PLC.

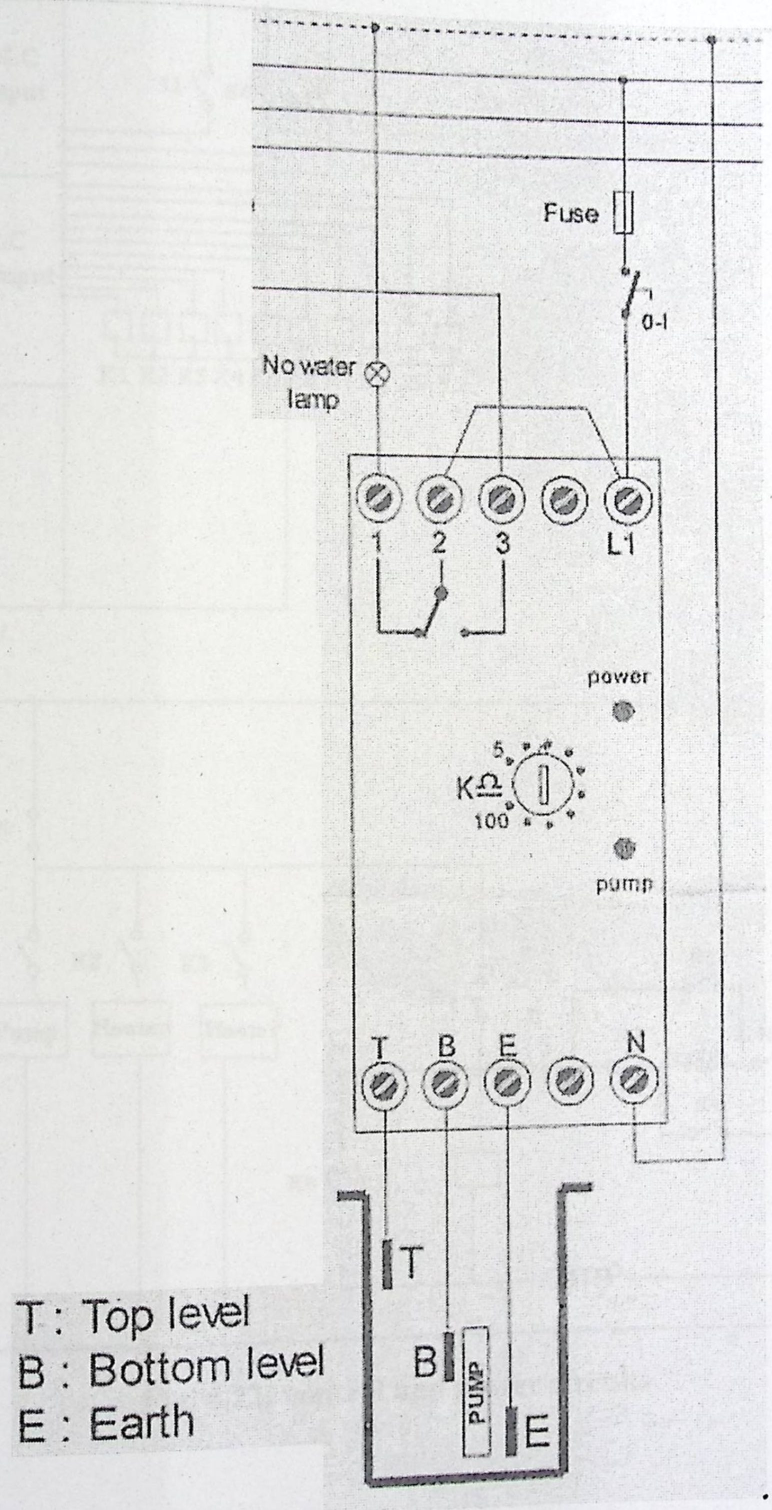


Fig.6.21: Level detector

6.5 The operating circuit of washing machine

The fig. 6.22 shows the all connection of control and power circuits.

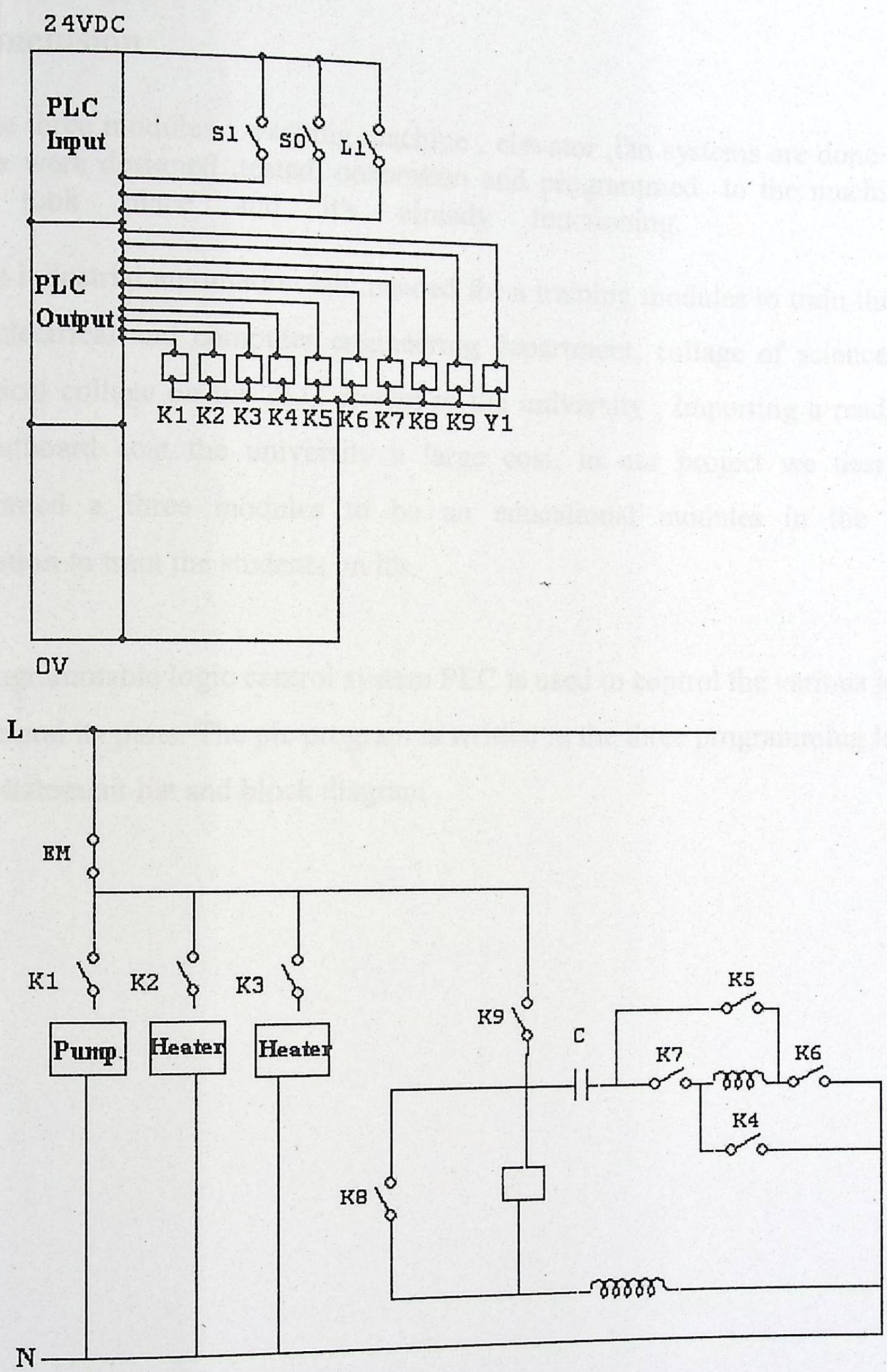


Fig. 6.22: control and power circuits

Chapter Seven

Conclusion and Recommendation

7.1 Conclusion

The three modules : washing machine , elevator ,fan systems are done as planed all parts were designed ,tested, calibration and programmed to the machines as a whole took place and it's already functioning.

The industrial automation lab. needed for a training modules to train the students of the electrical and computer engineering department, collage of science, and the mechanical collage on the PLC system in the university . Importing a ready module from outboard cost the university a large cost. in our project we designed and programmed a three modules to be an educational modules in the industrial automation to train the students on it's.

Programmable logic control system PLC is used to control the various jobs of the machine and its parts. The plc program is written in the three programming languages: ladder, statement list and block diagram

7.2 Recommendation

Additional to the PLC control system we carried out, we recommend other graduation projects to see other control systems such as the personal computer PC, microprocessor, complex programmable logic device CPLD using HDL and the pick microcontroller using one socket connection to the four systems, in order to make comparison between them to find the optimized system.

Appendices

Appendix A

Project Graph

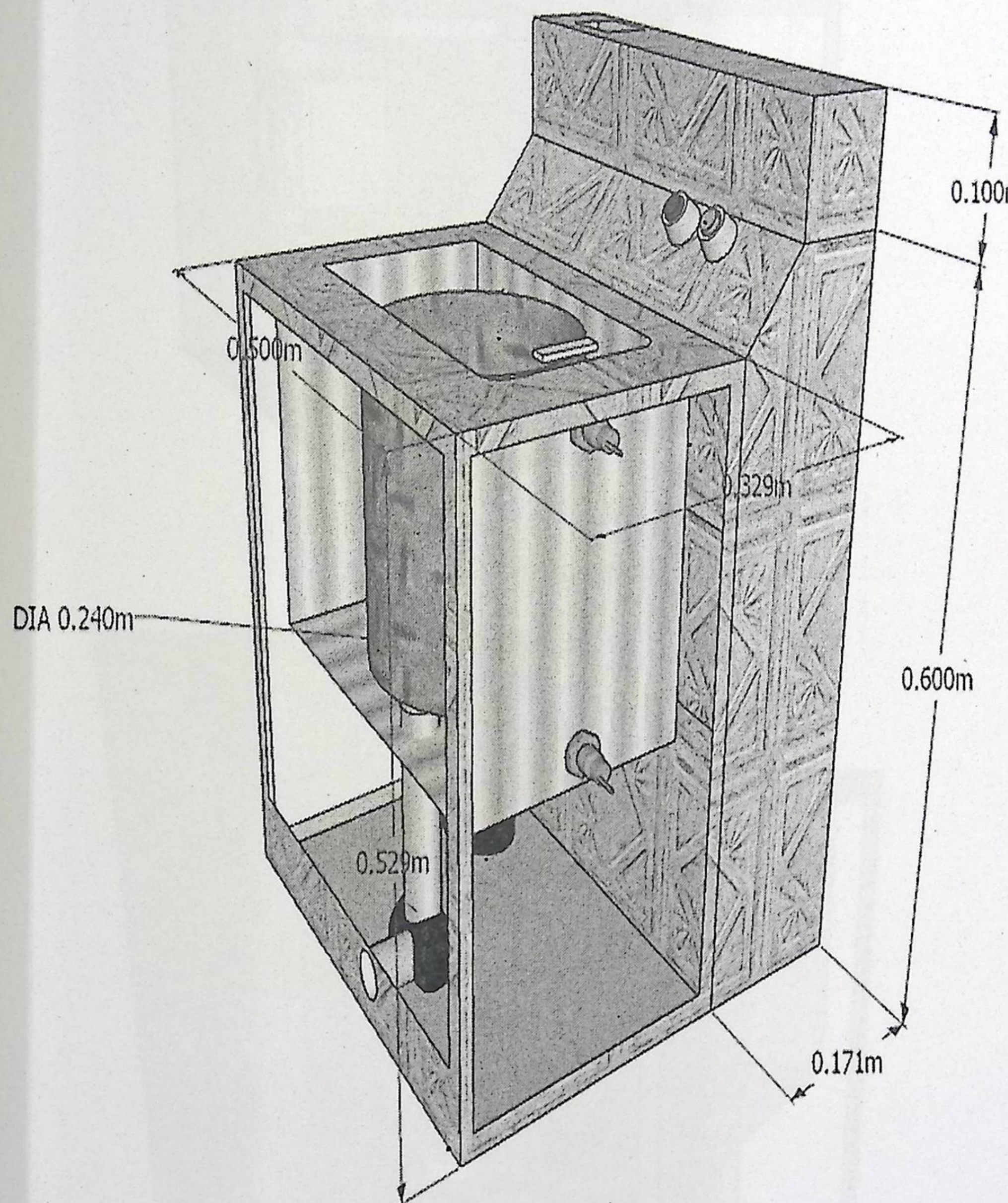


fig.1: Washing machine

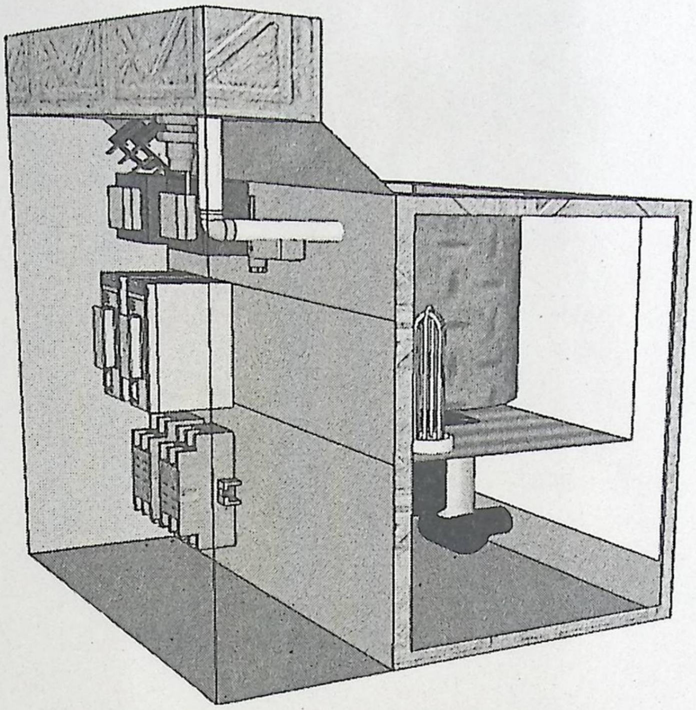


fig.2: Washing machine

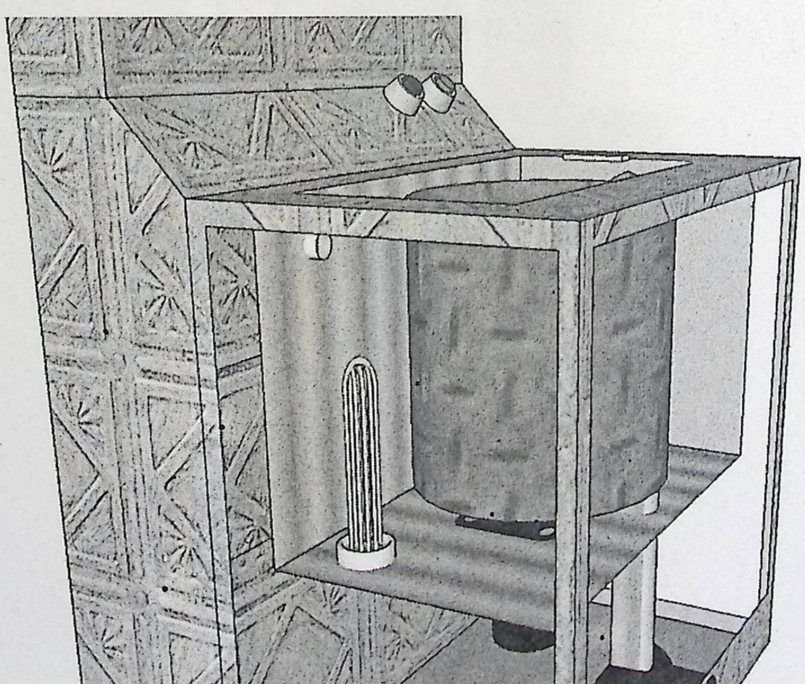


fig.3: Washing machine

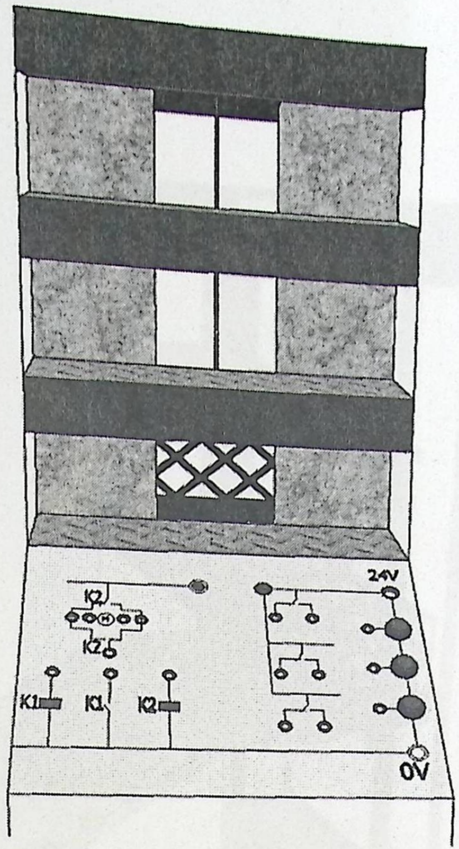


Fig.4: Elevator

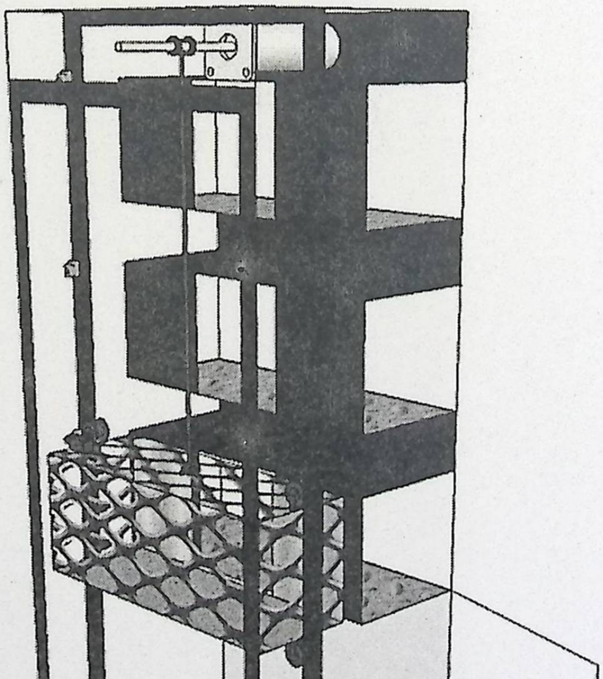


Fig.5: Elevator

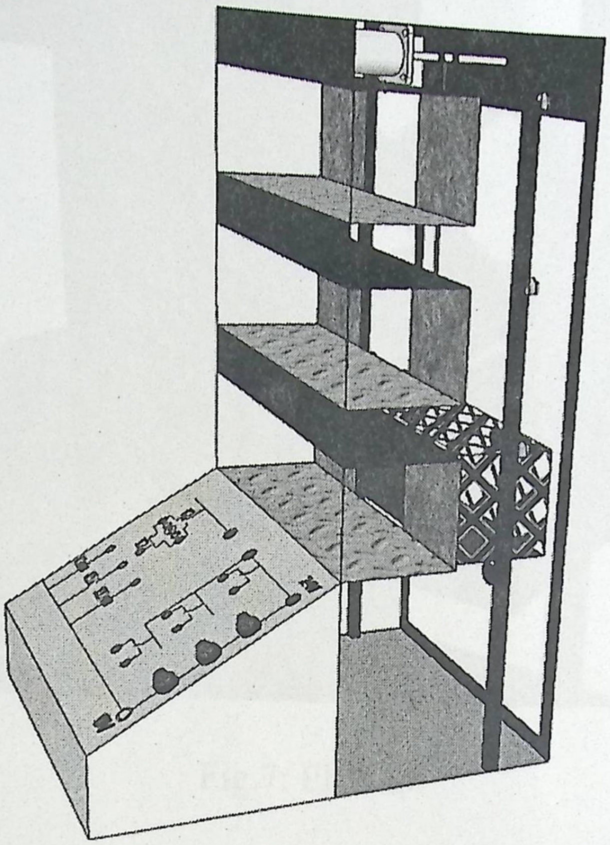


Fig.6: Elevator

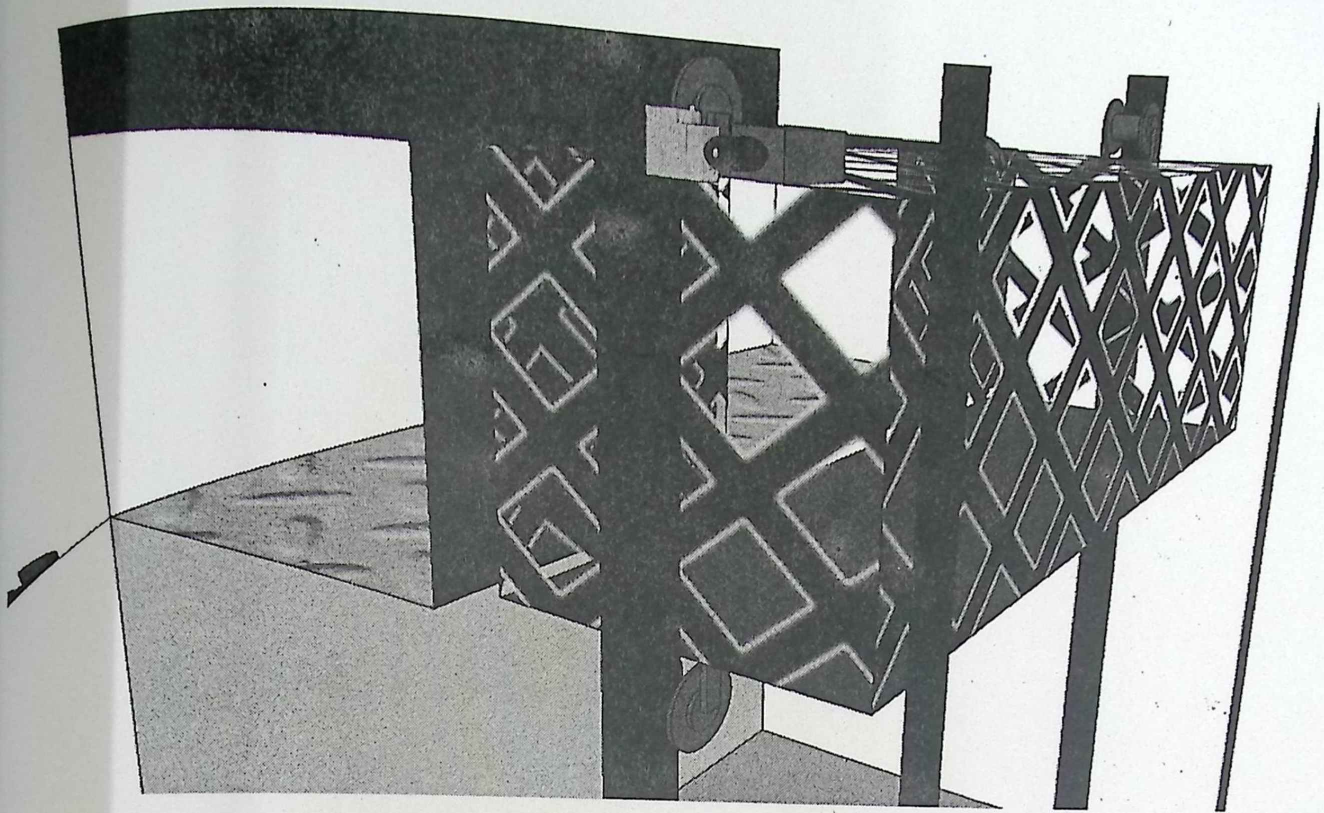


Fig.7: Elevator

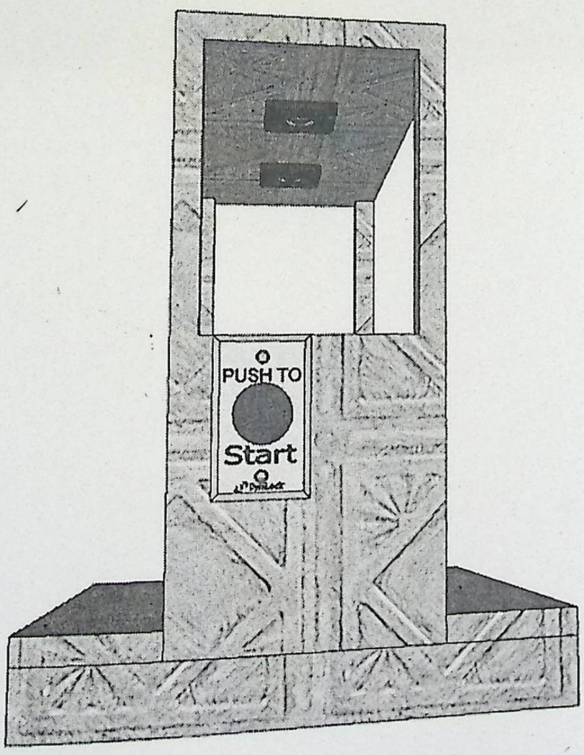


Fig.8: Fan system

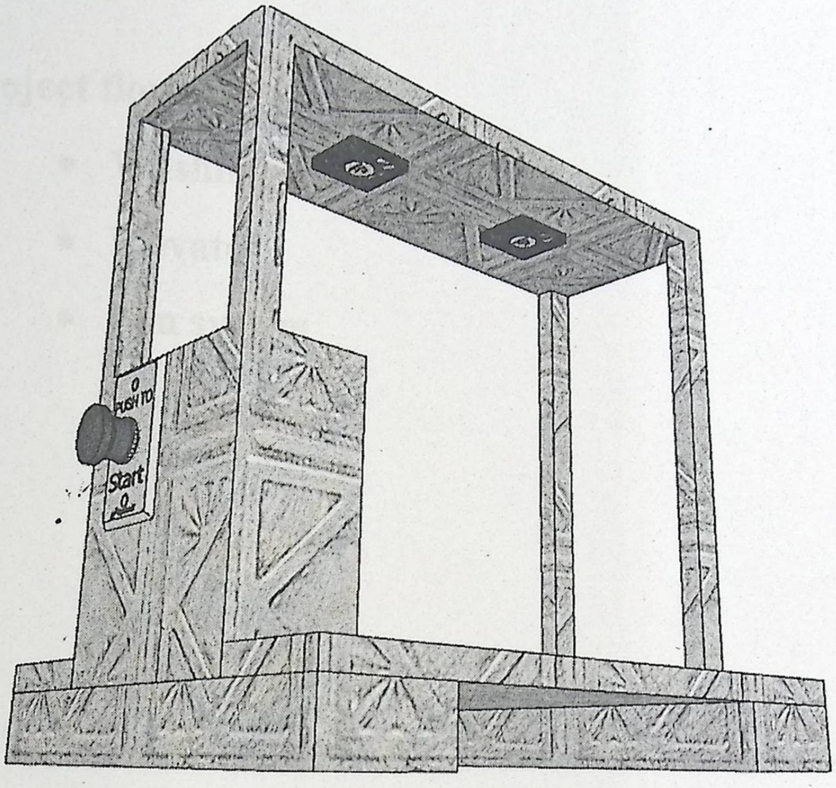


Fig.9: Fan system

Appendix B

Project flowchart

- **Washing machine**
- **Elevator**
- **Fan system**

Appendix B

Project flowchart

- **Washing machine**

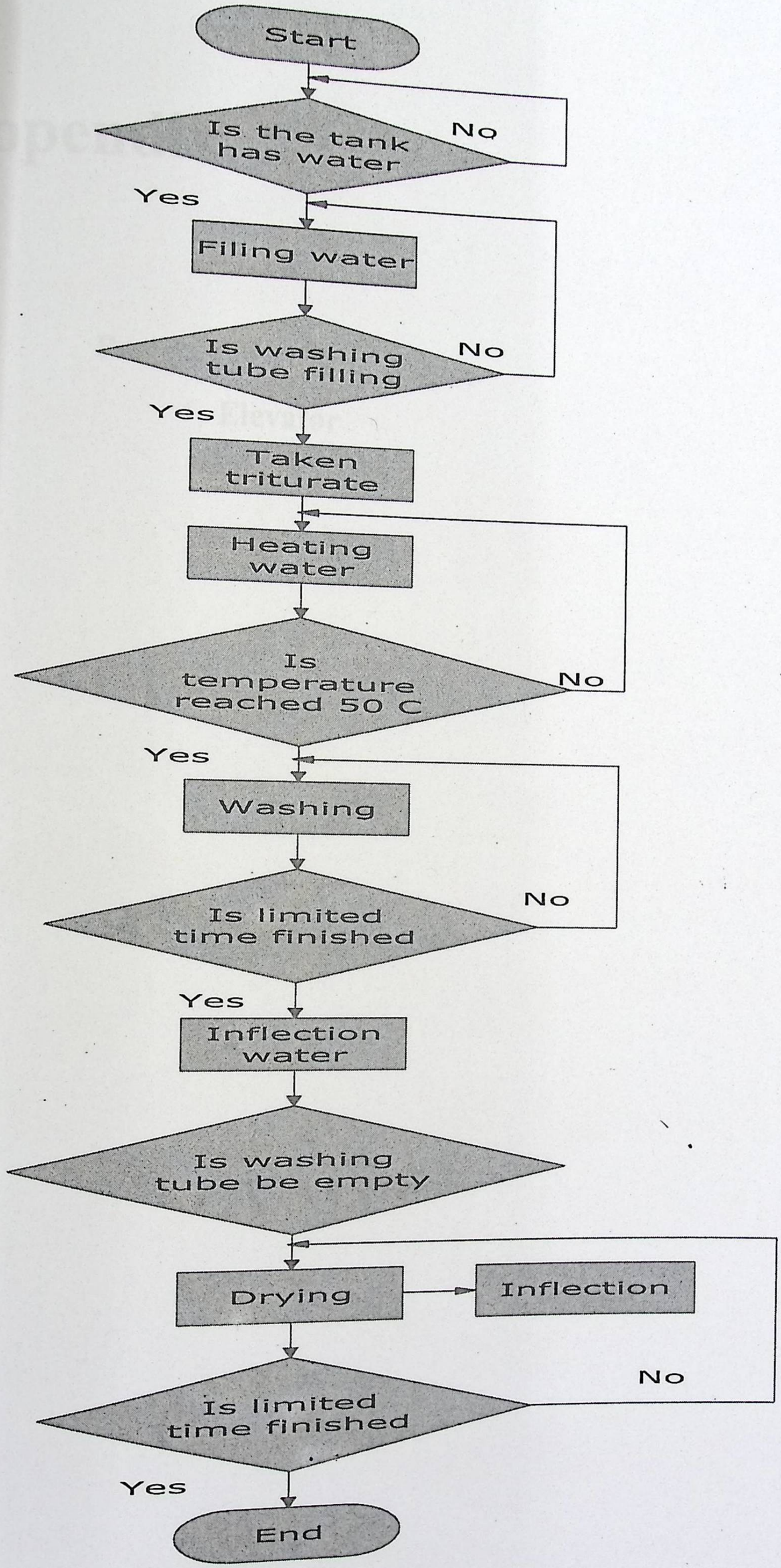


Fig.10: Washing machine flow chart

Appendix B

Project flowchart

- Elevator

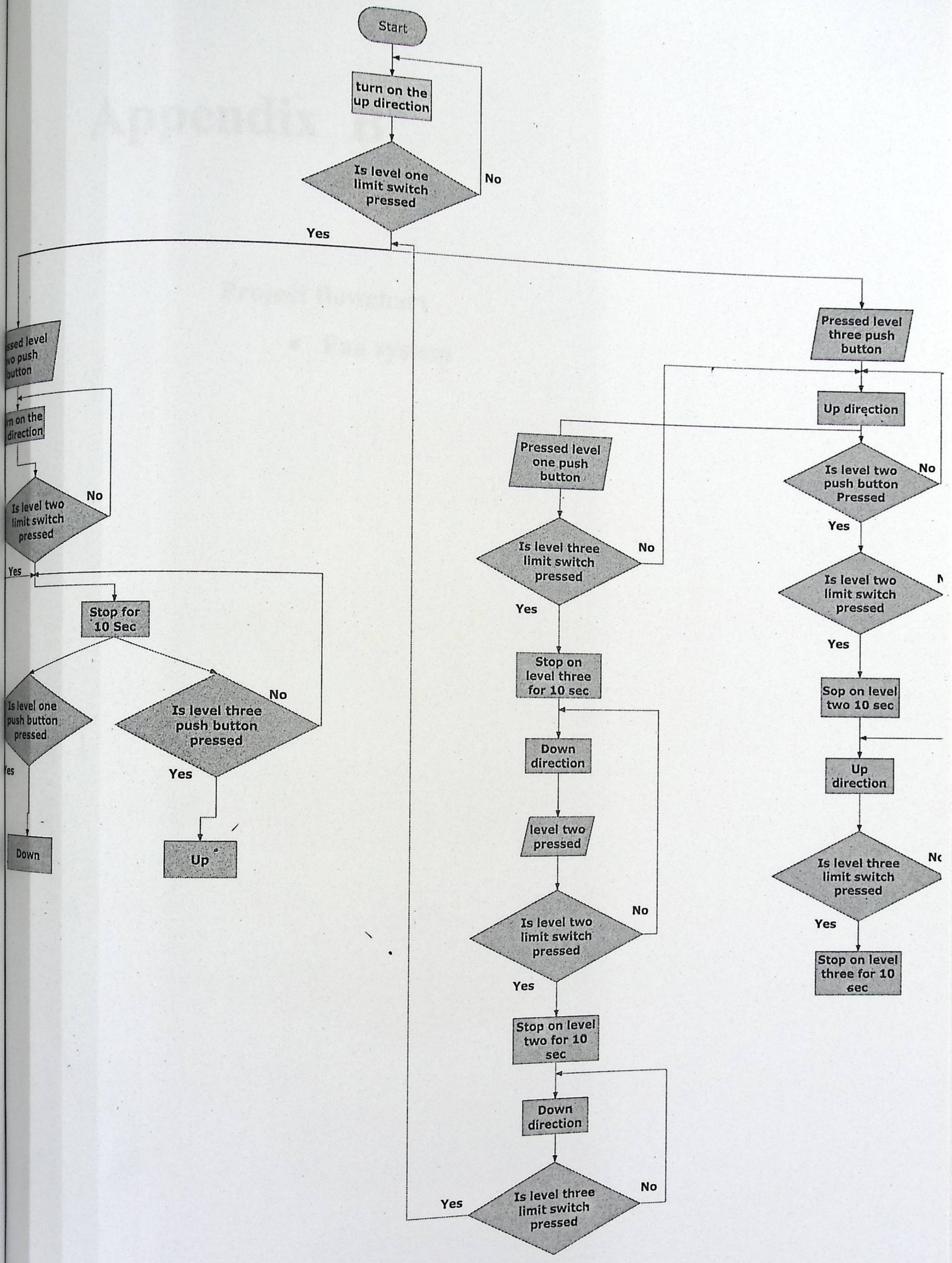


Fig.11: Elevator flow chart

Appendix B

Project flowchart

- **Fan system**

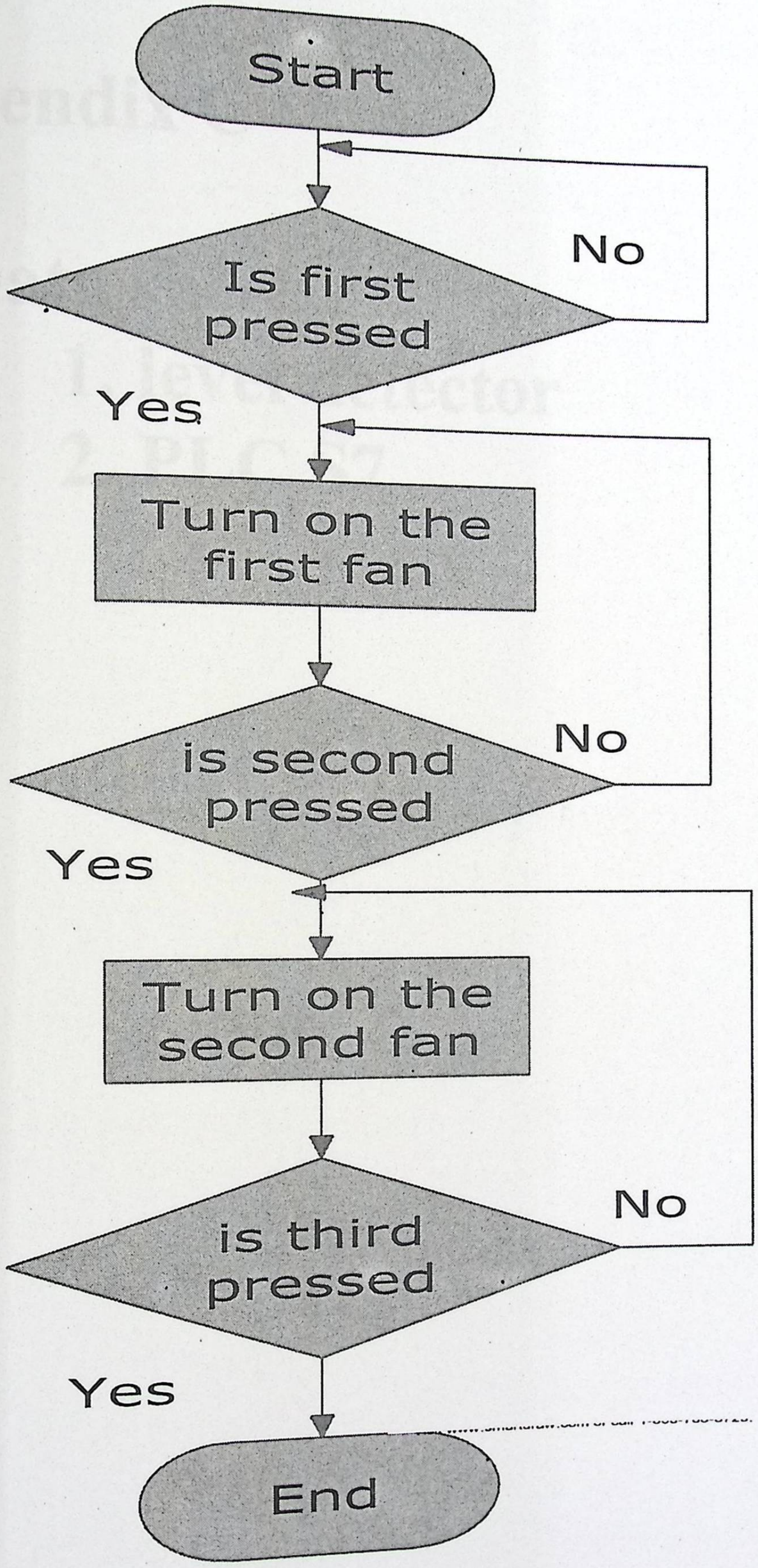


Fig.12: Fan system flow chart

Appendix C

Data sheet

1. level detector
2. PLC S7

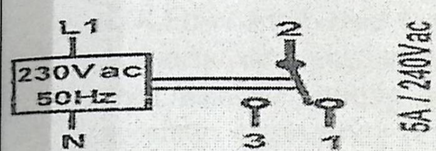
ke-SKR
LEVEL CONTROL DEVICE

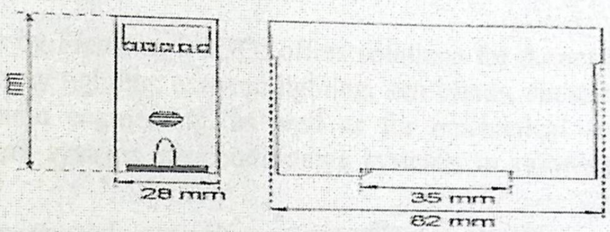
KAEL

Three electrodes are connected to "T","B","E" terminals of device. When conductive liquid rises up to top level electrode (T), relay closes its contacts and energizes the pump output (starts pump).
When the amount of liquid decreases and the level goes below the bottom level electrode (B), relay releases its contacts and cuts off the energy of pump output (pump stops).
Sensitivity adjustment (the impedance between electrodes) can be adjusted between 5-100KΩ using the adjustment knob at front panel.

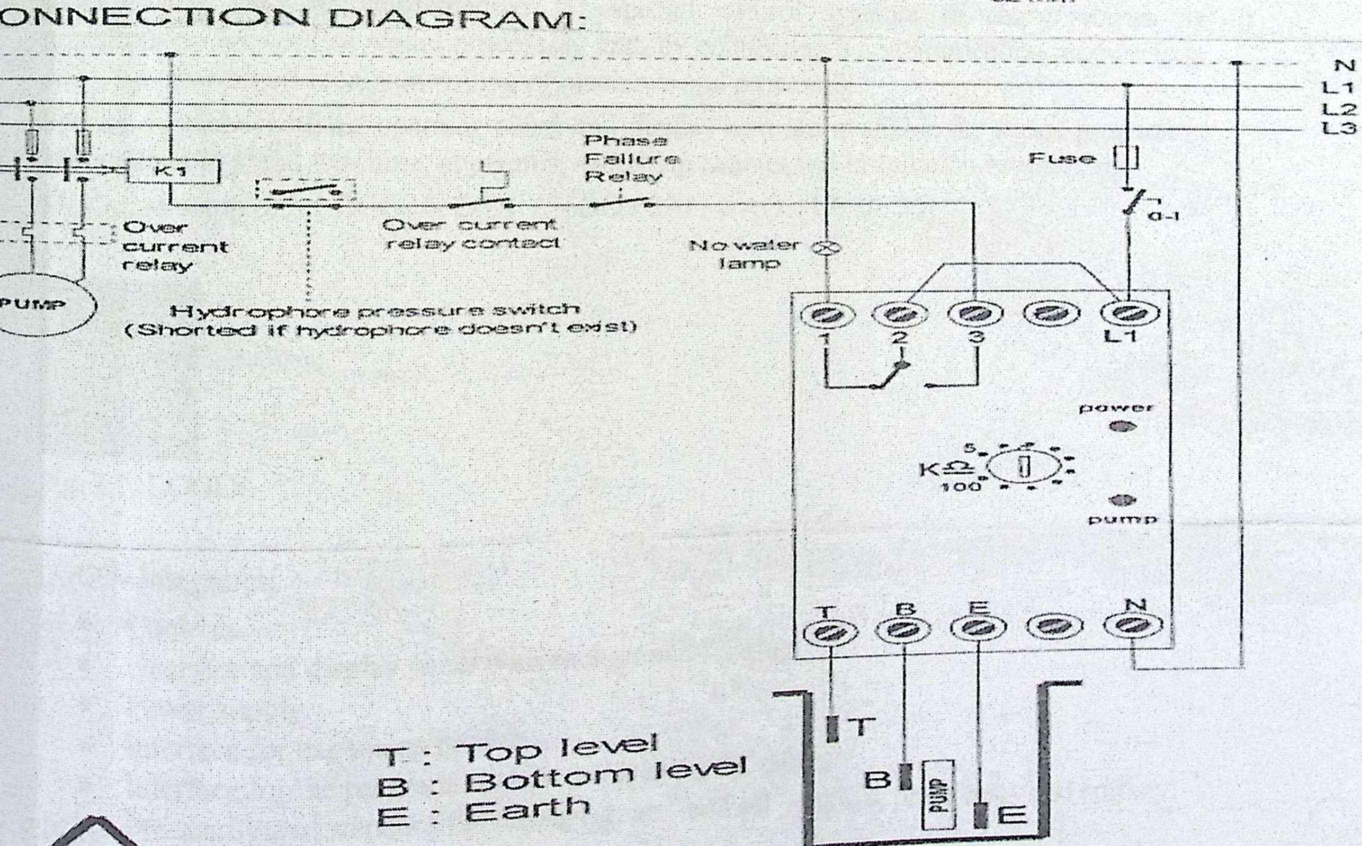
TECHNICAL DATA:

Rated Voltage	: 220/230 Vac
Operating Range	: (0.8 — 1.1)x Un (Un nominal voliage)
Frequency	: 50 Hz.
Sensitivity	: 5-100KΩ adjustable.
Contact Current	: Max.5 Amp/240Vac
Power Consumption	: < 4VA
Device Protection Class	: IP20
Terminal Protection Class	: IP00
Ambient Temperature	: -5 °C....+50 °C
Humidity	: %15....%95 (without condensation)
Connection Type	: on rail
Dimensions	: 28x82x80 mm





CONNECTION DIAGRAM:



Made in TURKEY

Do not use for explosive or flameable liquids. It's strictly advised to well examine technical data of device and fully match connection diagram. Otherwise the device or system may be harmed.

2 PROGRAMMABLE LOGIC CONTROLLERS SIEMENS SIMATIC S7 – HARDWARE AND BASIC PRINCIPLES

Study duration: 90 min.

2.1 Overview of programmable logic controllers SIMATIC S7

Control system SIMATIC are known above all our reliability. Series SIMATIC S5 is older series of SIMATIC. SIMATIC S5 was popular series when the programmable logic controller SIMATIC started . Now is availability series of SIMATIC S7. SIMATIC S7 offers the most modern solution for all types technological aplication.

2.1.1 LOGO!

LOGO! is a universal logic module made by Siemens. LOGO! offers solutions for domestic and installation engineering (e.g. for stairway lighting, external lighting, sun blinds, shutters, shop window lighting etc.), switch cabinet engineering, as well as for mechanical and apparatus engineering (e.g. for gate control systems, air-conditioning systems, or rainwater pumps etc.).

LOGO! can also be implemented for special control systeme in conservatories or greenhouses, for control signal processing and, by connecting a communication module (e.g. ASi), for distributed local controlling of machines and processes.

Special versions without operator panel and display unit are available for series production applications in small machine, apparatus, switching cabinet and installation engineering.

Maximum setup of a LOGO! is 24DI / 16DO / 8AI / 2 AO. [17, 30, 35]

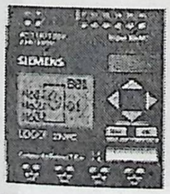


Fig. 2.1: LOGO!.

LOGO! Integrates:

- Controls.
- Operator and display panel with background lighting.
- Power supply.
- Interface for expansion modules.
- Interface for the program module (card) and a PC cable.
- Pre-configured standard functions, e.g. on -and off – delays, pulse relay and softkey.
- Timer.
- PI controller.
- Digital and analog flags.
- Inputs and outputs, according to the device type.

- Digital inputs I5,I6 can be used for high-speed counting max. 2kHz (for LOGO! 12/24 RC/RCo OBA5 a LOGO! 24/24o OBA5).
- Inputs I7 and I8 are analog inputs (voltage 0-10V).

2.1.2 S7-200

The S7-200 series of micro-programmable logic controllers (Micro PLCs) can control a wide variety of devices to support your automation needs.
The S7-200 monitors inputs and changes outputs as controlled by the user program, which can include Boolean logic, counting, timing, complex math operations, and communications with other intelligent devices. The compact design, flexible configuration, and powerful instruction set

combine to make the S7-200 a perfect solution for controlling a wide variety of applications.
Maximum I/O address area is 128DI/120DO / 28AI/14AO. [31, 35]

Properties micro PLCs:

- Execution time for bit operation, min. 0,22μs.
- High-speed counters (typically 30kHz).
- Two digital inputs might be configured as interrupted.
- Can be controlled 8 closed-loop control with PID controller.
- PID controller with autotunning.
- Can be connected expansions modules (position control modul for step motors, measure temperature (TC, RTD), compact weighing electronics systems SIWAREX MS, modul AS – interface, modem modul, PROFIBUS-DP modul, Ethernet modul.

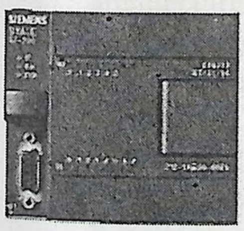


Fig.2.2: Micro PLC - S7-200.

2.1.3 S7-300

Modular Controller - SIMATIC S7-300 is optimized for high performance machina and faktory automation. [17, 32, 35]

- Built-in functions (e.g., high-speed counting, closed-loop control, motion control, etc.).
- Extensive selection of CPUs and modules for almost every application.
- Compact design reduces kontrol cabinet size.
- Integrated system diagnostics assure a high degrese of controller availability.

- Innovative Micro Memory Card provides maintenance- freee (no battery reguired) program backup plus the ability to store production and project information.
- Engineering using a project approach to assist in implementing a tightly integrated system.
- Fail-safe version provides machina safety and standard automation in a single controller.

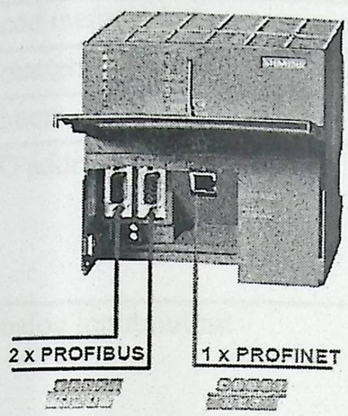


Fig..2.3: Modular Controller S7-300 (with CPU 319 – 3 PN/DP).

2.1.4 S7-400

System Optimized Controller – SIMATIC S7-400 is power controller for system solutions in production and process applications: [17, 33, 35]

- Implement high-speed and complex applicatins using extremely high processing and communication capabilities.
- Perform central coordination of distributed slave controllers in plant-wide architectures
- Virtually no limits on I/O capacities.
- System expansions possible dutiny operation and without interrupting processes thanks to „Configuration in RUN“ and hot-swapping of moduls.
- One controller fits all: integrate machina and process safety with standard automation in a single controller using fail-safe option.
- Keep high-availability processes running wth redundant option.
- Engineered using a project approach to aid in implementing a tightly integrated system.

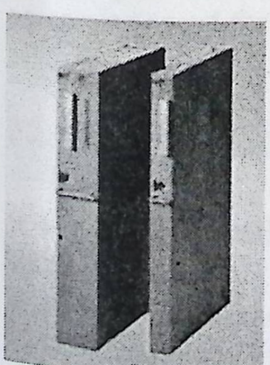


Fig.2.4: Controller SIMATIC S7-400 – CPUs.

Tab. 2.1: Compared basic parameters controllers.

	CPU 224 XP	CPU 314C-2DP	CPU 416-3 DP
Main memory, max.	12kB – program, (10kB data)	64kB 64kB až 8MB	2,8MB, (2,8MB program)
Execution time for bit operation, min.	0,22μs	0,1 μs	0,04 μs
Load memory/mass storage max.	256kB	8MB	64MB
Counters	256	256	2048
Timers	256	256	2048
I/O address area, max.	Max. 168I/O (14 DI /10 DO integrated in CPU)	Max. 1016I/O (24 DI /16 DO integrated in CPU)	131072DI / 121072DO
Analog input/output	30/15 (2AI / 2AO integrated in CPU)	253 (4AI / 2AO integrated in CPU)	8192AI / 8192AO
Networking	PPI,MPI, Freeport, AS-Interface, PROFIBUS, Ind.Ethernet	PPI,MPI, AS-Interface, PROFIBUS/ PROFINET Ind. Ethernet,	PPI,MPI, PROFIBUS / PROFINET Ind.Ethernet
Real time clock	Integrated	Integrated	Integrated

2.2 *PLC S7-300 and its basic characteristics*

The SIMATIC S7-300 saves space, and it is compact and modular. It is a stranger to slot rules, and it has no need for fans. The modules are simply hung on a DIN rail and screwed on to form a rugged, electromagnetically compatible configuration. The backplane bus is already integrated into the modules: just plug in the bus connectors and you're ready to go. With the varied range of modules for the SIMATIC S7-300, centralized expansions and simple distributed structures can be configured - for low-cost spare parts management

There's everything from the entry-level CPU right up to the high-performance unit. Depending on the task, there are CPUs with integral I/O, integrated technological functions, and integrated communications interfaces. They all have one thing in common: efficient processing speed for short machine cycle times.

2.2.1 Standard CPUs

It is used in installations which have distributed automation structures in addition to a centralized I/O.

It is often used as the standard PROFIBUS DP master in SIMATIC S7-300. The CPU is also used as distributed intelligence (DP slave).

It has been optimized in terms of its quantitative framework for using SIMATIC Engineering Tools, e.g.: [17, 32]

- Programming with SCL.
- Sequence control programming with S7-GRAPH.
- In addition, the CPU offers an ideal platform for simple technology tasks implemented in software, e.g.
- Easy Motion Control.
- The solution of closed-loop control tasks with STEP 7 blocks or the runtime software Standard/Modular PID Control.
- Extended process diagnostics can be achieved by using SIMATIC S7-PDIAG.
- CPUs: CPU 312, CPU 314, CPU 315-2DP, CPU 315 – 2 PN/DP, CPU 317-2DP, CPU 317-2PN/DP, CPU 319 – 3 PN/DP.

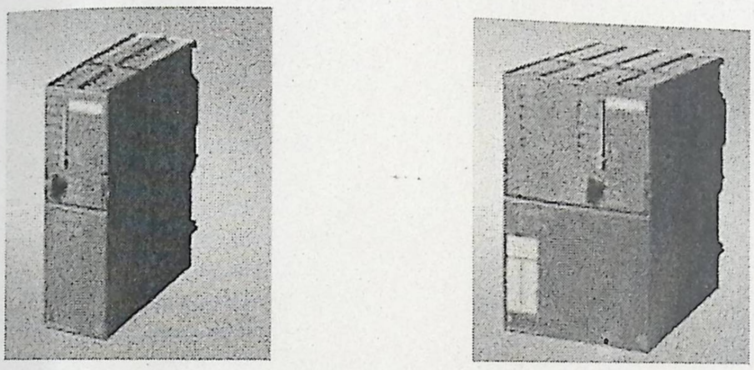


Fig. 2.5: Example of standard CPU and CPU with interface for PROFINET.

Tab. 2.2: Description standard CPU.

CPU				
SIMATIC S7-300	**CPU 312**	**CPU 314**	**CPU 315-2DP**	**CPU 317-2DP**
Work memory	32kB	96kB	128kB	512kB
		Execution time		
Bit operation	0,2 µs	0,1 µs	0,1 µs	0,05 µs
Word operation	0,4 µs	0,2 µs	0,2 µs	0,2 µs
Fixed-point operation	5 µs	2 µs	2 µs	0,2 µs
Floating-point operation	6 µs	3 µs	3 µs	1 µs
S7 timers/counters	128/128	256/256	256/256	512/512
Address areas				
Digital channels (central)	256	1024	1024	1024
Analog channels (central)	64	256	256	256
Networking MPI PROFIBUS DP PROFINET	■	■	■ ■	■ ■

CPU				
SIMATIC S7-300	**CPU 312**	**CPU 314**	**CPU 315-2DP**	**CPU 317-2DP**
PtP - komunikace				

Tab. 2.3: Description standard CPU with integrated interface for PROFINET.

CPU			
SIMATIC S7-300	CPU 315-2 PN/DP	CPU 317-2 PN/DP	CPU 319-3 PN/DP
Work memory	128kB 64kB až 8MB	512kB 64kB až 8MB	1,4MB 64kB až 8MB
	Execution time		
Bit operation	0,1 µs	0,05 µs	0,01 µs
Word operation	0,2 µs	0,2 µs	0,02 µs
Fixed-point operation	2 µs	0,2 µs	0,02 µs
Floating-point operation	3 µs	1 µs	0,04 µs
S7 timers/counters	256/256	512/512	2048/2048
Digital channels (central)		1024	
Analog channels (central)		256	
Networking			
MPI	■	■	■
PROFIBUS DP	■	■	■
PROFINET CBA, Io	■	■	■

2.2.2 Compact Controllers

The CPU 3xxC-2 DP is the compact CPU for installations with a decentralized structure. With its extended working memory the compact CPU is also suitable for medium-sized applications. Integrated digital and analog I/Os enable a direction connection to the process, the PROFIBUS DP master/slave interface allows the connection of standalone I/O units. The CPU 3xxC-2 DP can thus be used both as a local unit for quick pre-processing as a higher-level control with a subordinate fieldbus system. [1, 17, 32]

Additional possibilities of use are provided with the integrated process-related functions:

- Count.
- Frequency measurement.
- PID control.
- CPUs: CPU 312C, CPU 313C, CPU 313 C – 2DP, CPU 313 C – 2PtP, CPU 314 C – 2DP, CPU 314 C – 2PtP.

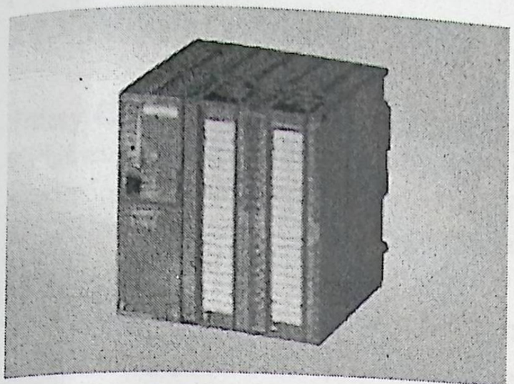


Fig. 2.6: Example of compact controller.

Tab. 2.4: Description of compact PLCs.

	Compact PLCs			
SIMATIC S7-300	CPU 312C	CPU 313C	CPU 313C-2DP CPU 313C-2PtP	CPU 314C-2DP CPU 314C-2PtP
Work memory	32 kB	64 kB	96 kB	96 kB
Execution time				
Bit operation	0,2 µs	0,1 µs	0,1 µs	0,1 µs
Word operation	0,4 µs	0,2 µs	0,2 µs	0,2 µs
Fixed-point operation	5 µs	2 µs	2 µs	2 µs
Floating-point operation	6 µs	3 µs	3 µs	3 µs
S7 timers/counters	128/128	256/256	256/256	256/256
Address areas				
Digital channels (central)	266	1016	1008	1016
Analog channels (central)	64	253	248	253
Networking				
MPI	■	■	■	■
PROFIBUS DP			■	■
PROFINET				
PtP - communication				ASCII, 3964 R only by PtP
Integrated I/O DI/DO AI/AO	10/6	24/16 4/2	16/16	24/16 4/2
Integrated functions				
Counter	2(10 kHz)	3(30 kHz)	3(30 kHz)	4(60 kHz)
Pulse outputs	2(10 kHz)	3(2,5 kHz)	3(2,5 kHz)	4(2,5 kHz)
Open-loop positioning	---	---	---	■
Integrated „Controlling“ FB	PID Controller	PID Controller	PID Controller	PID Controller

2.2.3 Fail-safe Controllers

Safety CPUs integrated automation and machine safety in a single controller. The S7-300F CPUs can be expanded centrally with the safety modules for the ET 200M I/O. Distributed expansion is possible using the safety ET 200S I/O modules, the ET 200M I/O modules, the ET 200pro (IP67) I/O modules or the safety digital block peripheral device ET 200eco (IP67). [17, 32, 35]

- Eliminate the need for separate hardwired electromechanical safety systems.
- Simply wire safety-related sensors directly into the controller.
- Program with the same software tool, use the same spare parts, and share common networks with all the standard controllers in the SIMATIC family.
- Available as a fail-safe controller for both simple and complex safety applications.
- CPUs: CPU 315F-2DP, CPU 315F-2PN/DP, CPU 317F-2DP, CPU 317F-2PN/DP.

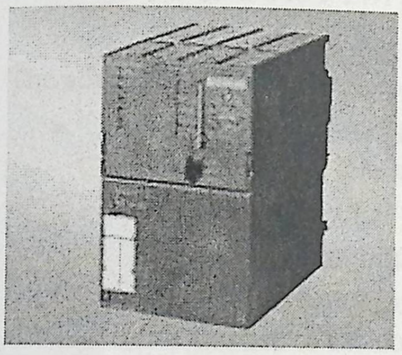


Fig. 2.7: Example of fail-safe controller.

Tab. 2.5: Description fail-safe CPU

Fail-safe CPU				
SIMATIC S7-300	**CPU 315-F 2 DP**	**CPU 315-F 2 PN/DP**	**CPU 317-F 2 DP**	**CPU 317-F 2 PN/DP**
Work memory	192kB	256kB	1MB	
Execution time				
Bit operation	0,1 µs		0,05 µs	
Word operation	0,2 µs		0,2 µs	
Fixed-point operation	2 µs		0,2 µs	
Floating-point operation	3 µs		1 µs	
S7 timers/counters	256/256		512/512	
Networking MPI PROFIBUS DP PROFINET CBA,IO	■ ■	■ ■ ■	■ ■	■ ■ ■

2.2.4 Technology CPUs

Technology SIMATIC CPU contains integrated technology/motion control function with full functionality of the standard e.g. CPU 315-2DP and CPU 317-2DP.

The S7-300 technology CPUs 315T-2 DP and 317T-2 DP provide the full functionality of the powerful standard CPUs with integrated technology functions e.g. PLCopen-compatible motion control functions.

The technology CPUs are compactly built with high-speed distributed I/Os (4 digital inputs, 8 digital outputs) and two PROFIBUS DP interfaces: [15, 32]

- Isochronous PROFIBUS interface DP(DRIVE) for the dynamic motion control of several coupled or single axes.
- MPI/DP interface for connecting other SIMATIC components, for example PG, OP, S7 controllers and distributed I/O. For operation as a DP interface, extended networks can be set up.
- CPUs: CPU 315T-2DP, CPU 317T-2DP.

The advantages at a glance:

- **High economic efficiency and flexibility** by implementing your PLC, motion control and technological demands:
  - **Scaleable PLC performance** (CPU 315T/CPU 317T).
  - **Integration of technology/motion control** in a SIMATIC CPU.
  - Centralised/decentralised expandability for a wide variety of tasks provided by the use of the comprehensive SIMATIC product line.
- **Cost savings** by means of the absolute simple and fast engineering:
  - From drives to motion control to PLC – all with STEP 7.
  - Reduced programming costs/optimised time-to-market by the reuse of existing S7 programs.
  - PLCopen-certified motion control functions facilitate engineering and service
  - Reduced training effort for commissioning and service people thanks to full programming in all SIMATIC languages.

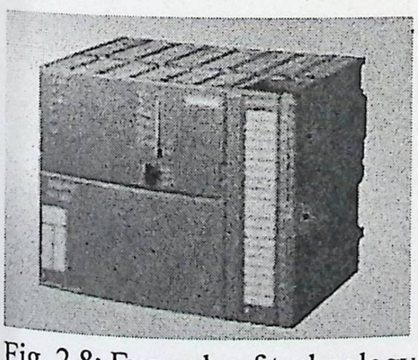


Fig. 2.8: Example of technology controller.

Tab. 2.6: Description technology CPU .

	Technology CPU	
SIMATIC S7-300	CPU 315T-2DP	CPU 317T-2DP
Work memory	128kB	512kB
Execution time		
Bit operation	0,1 µs	0,05 µs
Word operation	0,2 µs	0,2 µs
Fixed-point operation	2 µs	0,2 µs
Floating-point operation	3 µs	1 µs
S7 timers/counters	256/256	512/512
Digital channels (central)	1024	1024
Analog channels (central)	256	256
Networking		
MPI	■	■
PROFIBUS DP	■	■
PROFINET		
PtP - komunikace		
Integrated functions	Gearbox synchronism and curve synchronism, Travel to fixed stop, Print mark correction via probe, Path-or-time dependent cam switching, Positron-controlled positioning.	

Addressing

Slot-based addressing is the default setting, that is, *STEP 7*assigns each slot number a defined module start address.

In slot-based addressing (default addressing), a module start address is allocated to each slot number This is a digital or analog address, depending on the type of module.

User-specific addressing of modules is always requirement when using PROFIBUS-DP or PROFINET IO field device. There is no fixed slot addressing for such a configuration.

User-defined addressing means that you can assign an address of your choice to any module (SM/FM/CP). The addresses are assigned in *STEP7*. Here, you specify the module start address that forms the basis for all other addresses of the module.

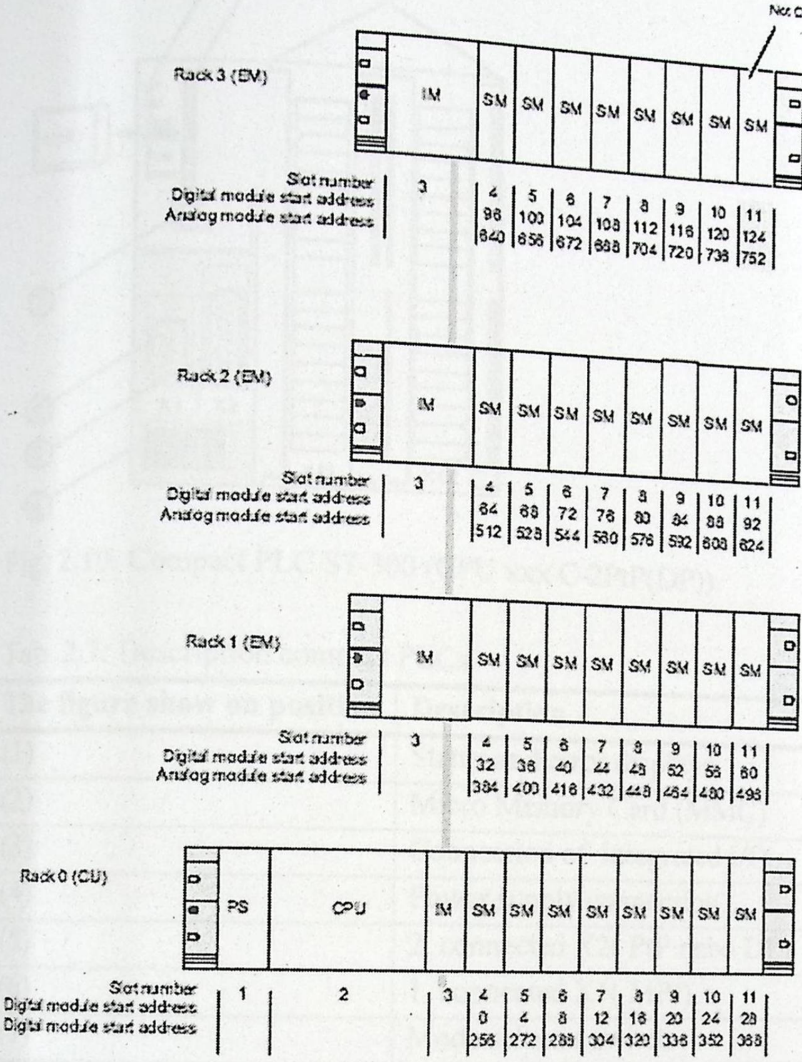


Fig. 2.9: S7-300 slots and the associated module start addresses.

2.3 *Technical specifications S7-300*

User defined addressing is supported by PLC S7-315-2DP. That means, the user can select the addresses for the separate modules. The advantage is the improvement of the address area. [1, 3]

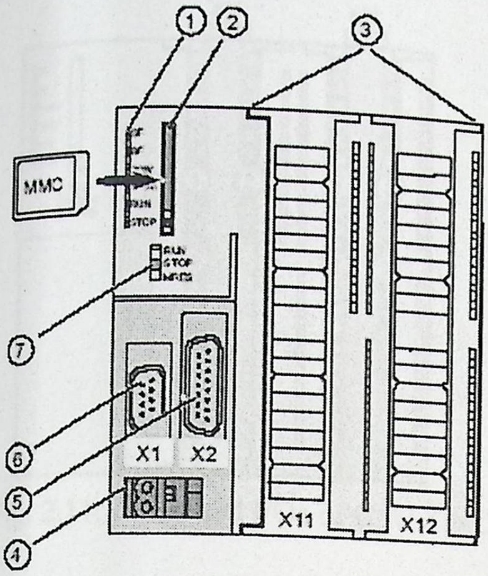


Fig. 2.10: Compact PLC S7-300 (CPU xxx C-2PtP(DP)).

Tab. 2.7: Description compact PLCs.

The figure show on position	Description
(1)	Status and error displays
(2)	Micro Memory Card (MMC)
(3)	Connection of integrated I/O
(4)	Power supply connection
(5)	2. connected X2(PtP nebo DP)
(6)	1. connected X1(MPI)
(7)	Mode selector switch

Tab. 2.8: Status and Error Indicators: CPU 31xC.

LED designation	Color	Meaning
SF	red	Hardware or software error
BF (for CPUs with interface only s DP)	red	Bus error
DC5V	green	5-V power for CPU and S7-300 bus is OK
FRCE	yellow	Force jo bis active
RUN	green	CPU in RUN
STOP	yellow	CPU in STOP and HOLD or STARTUP

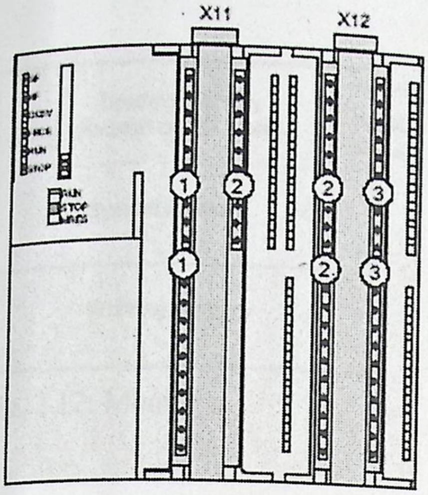


Fig. 2.11: Integrated I/Os of CPU 31xC (CPU 314C-2PtP, for example).

Tab. 2.9.: Description integrated inputs/outputs.

The figures show	The following integrated I/Os
(1)	Analog I/Os
(2)	Each with 8 digital inputs
(3)	Each with 8 digital outputs

Addressing digital inputs

The address of input or output consists of byte and bit part.

For example I 124.2 – input (I – input), byte 124, bit 2

Addressing analog inputs

The address is always for the input or output analog channel word it is 16bit. The addresses are increased after two (bytes).

2.4 *Memory concept*

The memory of CPU has three memory areas.

- The **load memory** is located on the SIMATIC Micro Memory Card (MMC). The size of the load memory corresponds exactly to the size of the SIMATIC Micro Memory Card. It is used to store code blocks, data blocks and system data (configuration, connections, module parameters, etc.). Blocks that are identified as non runtime-related are stored exclusively in load memory. You can also store all the configuration data for your project on the SIMATIC Micro Memory Card.
- **System memory:** The RAM system memory is integrated in the CPU and cannot be expanded. It contains the address areas for address area memory bits, timers and counters, the process image of the I/Os, local data.
- **RAM:** The RAM is integrated in the CPU and cannot be extended. It is used to run the code and process user program data. Programs only run in RAM and system memory.

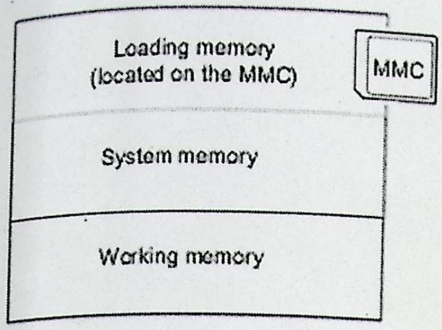


Fig. 2.12: Memory.

2.4.1 Retentivity of load memory, system memory and RAM

Your CPU is equipped with a service-free retentive memory, i.e. its operation does not require a buffer battery. Data is kept in retentive memory across POWER OFF and restart (warm start).

- Retentive data in load memory : Your program in load memory is always retentive: It is stored on the SIMATIC Micro Memory Card, where i tis protecte against power failure or CPU memory restart.
- Retentive data in system memory: The diagnostic buffer, MPI address (and transmission rate) and operating hour counter data and generálky written to retentive memory area on the CPU. Retentivity of the MPI address and baud rate ensures that your CPU can continue to communicate, even after a power loss, memory reset or los sof communication parameters (e.g. due to removal of the SIMATIC Micro Memory Card or deletion of communication parameters.
- Retentive data in RAM: Therefore, the contents of retentive DBs are always retentive at restart and POWER ON/OFF. CPUs V2.1.0 or higher also support volatile DBs (the volatile DBs are initialized at restart of POWER OFF-ON with thein initial values from load memory).

2.5 *Process Images*

The process images are special part of memory whose are stored a status inputs or outputs. The operating system updates the process image periodically.
Process image access, compared to direct I/O access, offers the advantage that a consistent image of process signals is made available to the CPU during cyclic program execution. When the signal status at an input module changes during program execution, the signal status in the process image is maintained until the image is updated in the next cycle. Moreover, since the process image is stored in CPU system memory, access is significantly faster than direct access to the signal modules.

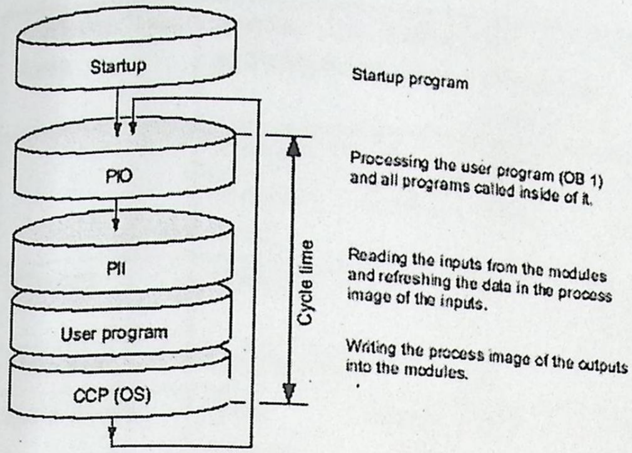


Fig. 2.13: Process images.

2.6 *Logical division of the memory –address areas*

The system memory of the S7 CPUs is divided into address areas (see table below). Using instructions in your program, you address the data directly in the corresponding address area. [18]

Tab. 2.10: Address areas.

Address Area	Access via Units of Following Size	S7 Notation (IEC)	Description
Process image input table	Input (bit)	**I**	At the beginning of the scan cycle, the CPU reads the inputs from the input modules and records the values in this area. (e.g. I 124.0)
	Input byte	**IB**	e.g. IB 124
	Input word	**IW**	e.g. IW 126
	Input double word	**ID**	e.g. ID 128
Process image output table	Output (bit)	**Q**	Dutiny · the scan cycle, the program calculates output values and places them in this area. At the end of the scan cycle, the CPU sends the calculated output values to the output modules. (e.g. Q 124.0)
	Output byte	**QB**	e.g. QB 0
	Output word	**QB**	e.g. QW 2
	Output double word	**QB**	e.g. QD 4
Bit memory	Memory (bit)	**M**	This area provides storage for interim results calculated in the program (e.g. M10.0)
	Memory byte	**MB**	e.g.MB 20

Address Area	Access via Units of Following Size	S7 Notation (IEC)	Description
	Memory word	MW	e.g.MW 200
	Memory double word	MD	e.g. MD 220
Timers	Timer (T)	T	This area provides storage for timers. (e.g. T32)
Counters	Counter (C)	C	This area provides storage for counters.
Data block	Data block, opened with „OPN DB":	DB	Data blocks contain information for the program. They can be defined for general use by all logic blocks (shared DBs) or they are assigned to a specific FB or SFB (instance DB).
	Data bit	DBX	e.g. DBX 0.0
	Data byte	DBB	e.g. DBB 2
	Data word	DBW	e.g. DBW 4
	Data double word	DBD	e.g. DBD 6
	Data block, opened with „OPN DI"	DI	
	Data bit	DIX	
	Data byte	DIB	
	Data word	DIW	
	Data double word	DID	
Local data	Local data bit	L	This area contains the temporary data of a block while the block is being executed. The L stack also provides memory for transferring block parameteres and for recording interim results from Ladder Logic networks.
	Local data byte	LB	
	Local data word	LW	
	Local data double word	LD	
Peripheral (I/O) area: inputs	Peripheral input byte	PIB	The peripheral input and output areas allow direct access to central and distributed input and output modules (DP).
	Peripheral input word	PIW	e.g. PIW272
	Peripheral input double word	PID	e.g. PID274
Peripheral (I/O) area:	Peripheral output byte	PQB	

2.8 *Data types*

2.8.1 User-Defined Data Types (UDT)

User-defined data types are special data structures you create yourself that you can use in the whole S7 program once they have been defined. [18]

- User-defined data types can be used like elementary data types or complex data types in the variable declaration of logic blocks (FC, FB, OB) or as a data type for variables in a data block (DB). You then have the advantage that you only need to define a special data structure once to be able to use it as many times as you wish and assign it any number of variables.
- User-defined data types can be used as a template for creating data blocks with the same data structure, meaning you create the structure once and then create the required data blocks by simply assigning the user-defined data type (Example: Recipes: The structure of the data block is always the same, only the amounts used are different).
- User-defined data types are created in the SIMATIC Manager or the incremental editor just like other blocks.

Structure of a User-Defined Data Type

When you open a user-defined data type, a new working window is displayed showing the declaration view of this user-defined data type in table form.

- The first and the last row already contain the declarations STRUCT and END_STRUCT for the start and the end of the user-defined data type. You cannot edit these rows.
- You edit the user-defined data type by typing your entries in from the second row of the declaration table in the respective columns.
- You can structure user-defined data types from:
  - Elementary data types.
  - Complex data types.
  - Existing user-defined data types.

The user-defined data types in the S7 user program are not downloaded to the S7 CPU. They are either created directly using an incremental input editor and edited, or they are created when source files are compiled.

2.8.2 Elementary Data Types

Each elementary data type has a defined length. The following table lists the elementary data types. [18]

Tab. 2.13: Elementary Data Types.

Type and Description	**Size in Bits**	**Format Options**	**Range and Number Notation (lowest to highest value)**	**Example**

Type and Description	Size in Bits	Format Options	Range and Number Notation (lowest to highest value)	Example
BOOL(Bit)	1	Boolean text	TRUE/FALSE	TRUE
BYTE (Byte)	8	Hexadecimal number	B#16#0 to B#16#FF	L B#16#10 L byte#16#10
WORD (Word)	16	Binary number	2.0 to 2#1111_1111_1111_1111	L 2#0001_0000_0000_0000
		Hexadecimal number	W#16#0 to W#16#FFFF	L W#16#1000
		BCD Decimal	C#0 to C#999	L C#998
		Decimal number unsigned	B#(0.0) to B#(255.255)	L B#(10,20)
DWORD (Double word)	32	Binary number	2#0 to 2#1111_1111_1111_1111 1111_1111_1111_1111	2#1000_0001_0001_1000_1011_1011_0111_1111
		Hexadecimal number	DW#16#0000_0000 to DW#16#FFFF_FFFF	L DW#16#00A2_1234 L dword#16#00A2_1234
		Decimal number unsigned	B#(0,0,0,0) to B#(255,255,255,255)	L B#(1, 14, 100, 120) L byte#(1,14,100,120)
INT (Integer)	16	Decimal number signed	-32768 to 32767	L 1
DINT (Integer, 32 bits)	32	Decimal number signed	L#-2147483648 to L#2147483647	L L#1
REAL (Floating-point number)	32	IEEE Floating-point number	Upper limit: 3.402823e+38 Lower limit: 1.175 495e-38	L 1.234567e+13
S5TIME (SIMATIC time)	16	S7 time in steps of 10 ms (default)	S5T#0H_0M_0S_10MS to S5T#2H_46M_30S_0MS and S5T#0H_0M_0S_0MS	L S5T#0H_1M_0S_0MS L S5TIME#0H_1H_1M_0S_0MS
TIME (IEC time)	32	IEC time in steps of 1 ms, integer signed	-T#24D_20H_31M_23S_648MS to T#24D_20H_31M_23S_647MS	L T#0D_1H_1M_0S_0MS L TIME#0D_1H_1M_0S_0MS
DATE	16	IEC date in	D#1990-1-1 to	L D#1996-3-15

Type and Description	Size in Bits	Format Options	Range and Number Notation (lowest to highest value)	Example
(IEC date)		steps of 1 day	D#2168-12-31	L DATE#1996-3-15
TIME OF DAY (Time)	32	Time in steps of 1 ms	TOD#0:0:0.0 to TOD#23:59:59.999	L TOD#1:10:3.3 L TIME_OF_DAY#1:10:3.3
CHAR (Character)	8	ASCII characters	'A','B' etc.	L 'E'

2.8.3 Complex Data Types

Complex data types define data groups that are larger than 32 bits or data groups consisting of other data types. STEP 7 permits the following complex data types: [18]

- DATE_AND_TIME.
- STRING.
- ARRAY.
- STRUCT.
- UDT (user-defined data types).
- FBs and SFBs.

The following table describes the complex data types. You define structures and arrays either in the variable declaration of the logic block or in a data block.

Table. 2.14: Complex Data Types.

Data Type	Description
DATE AND TIME	Defines an area with 64 bits (8 bytes). This data type saves in binary coded decimal format:
STRING	Defines a group with a maximum of 254 characters (data type CHAR). The standard area reserved for a character string is 256 bytes long. This is the space required to save 254 characters and a header of 2 bytes. You can reduce the memory required for a string by defining the number of characters that will be stored in the character string (for example: string[9] 'Siemens').
ARRAY	Defines a multidimensional grouping of one data type (either elementary or complex). For example: "ARRAY [1..2,1..3] OF INT" defines an array in the format 2 x 3 consisting of integers. You access the data stored in an array using the Index ("[2,2]"). You can define up to a maximum of 6 dimensions in one array. The index can be any integer (-32768 to 32767).

Data Type	Description
STRUCT	Defines a grouping of any combination of data types. You can, for example, define an array of structures or a structure of structures and arrays.
UDT	Simplifies the structuring of large quantities of data and entering data types when creating data blocks or declaring variables in the variable declaration. In STEP 7, you can combine complex and elementary data types to create your own "userdefined" data type. UDTs have their own name and can therefore be used more than once.
UDT	Simplifies the structuring of large quantities of data and entering data types when creating data blocks or declaring variables in the variable declaration. In STEP 7, you can combine complex and elementary data types to create your own "userdefined" data type. UDTs have their own name and can therefore be used more than once.
FB, SFB	You determine the structure of the assigned instance data block and allow the transfer of instance data for several FB calls in one instance DB.

2.8.4 Structure of a UserDefined Data Type

Userdefined data types (UDTs) are special data structures that you create yourself. Since user-defined data types are assigned names they can be used many times over. Once they have been defined, they can be used at any point in the CPU program; in other words, they are shared data types. They can therefore be used:

- In blocks in the same way as elementary or complex data types.
- As templates for creating data blocks with the same data structure.

Questions:

1. *Do you specify groups of programmable logic controllers?*
2. *Do compact programmable logic controllers have integrated technological functions? Do they have integrated function for close loop control?*
3. *What is the difference between compact PLCs and standard PLCs?*
4. *What is the difference between compact PLCs and technology PLCs?*
5. *Can a PLC S7-200 be used for close-loop control?*
6. *Can I use the microsystem LOGO! to communicate through ASi as a slave?*
7. *How is the memory divided?*
8. *Where is the user's program divided?*
9. *Do you specify data types?*
10. *Which types of addressing do you know?*