Palestine Polytechnic University

College of Engineering & Technology

Electrical & Computer Engineering Department

Graduation Project

Filling and packaging Machine of Solid Materials: Design and Operation.

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كلية الهندسة و التكنولوجيا

دائرة الهندسة الكهربائية و الحاسوب

اسم المشروع

Filling and Packaging Machine of Solid Materials: Design and Operation.

فريق العمل

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ياسر عناد حشيش

بناء على نظام كلية الهندسة و التكنولوجيا و إشراف و متابعة المشرفين القائمين على المشروع و موافقة أعضاء اللجنة الممتحنة تم تقديم هذا المشروع إلى دائرة الهندسة الكهربائية و الحاسوب و ذلك للوفاء بمتطلبات درجة البكالوريوس في الهندسة الكهربائية تخصص هندسة أتمتة صناعية

توقيع المشرف

م. نزار عمرو.....

توقيع اللجنة الممتحنة

....

توقيع رئيس الدائرة

د. رائد عمرو .....

Abstract

After we finished the idea of the machine, we start to buy the metal and all materials that needed for project. The first work is turning the iron places, roll boxes and its columns, after that we start to do the bodywork of the machine, the cone and the screw. Then accumulating all parts on the body. At the finishing of mechanical stage we Calibrate all part of all operations.

Then we drift to electrical stage, at this stage we assembly the electrical board with all components, and programming the PLC controller to control all operations. After that we examine and calibrate steps with final works. All stages of machine work probably; from pulling the roll, filling and ironing stage.

الملخص

تم شراء الحديد و المواد اللازمة للمشروع و من ثم تم توزيع العمل و ذلك لتوفير الوقت.حيث بدأ العمل بخراطة مكاوي اللحام و طارات السحب و أعمدتها و بكسات أعمدة السحب و أعمدة الحركة، و من ثم قمنا بعمل شصي الماكنة و تجميع البلاطة الرئيسية عليها، و تجميع القطع التي تم خراطتها.بعد ذلك قمنا بعمل صندوق التعبئة (المخروط)كما تم عمل حلزون. بعد ذلك تم عمل مجسم الماكنة و معايرة جميع القطع. بعد هذه العمليات تم تجميع اللوحة الكهربائية و برمجة ال PLC و تجربة خطوات العمل و معايرتها بشكل نهائي و تشغيل الماكنة. وقد عملت جميع مراحل الماكنة من سحب الرول والتعبئة وتغليف الكيس.

Dedication

To our dear parents and families ……

To whom who have added anything to the science …….....

To whom who taught us any letter, word or information ……..

To our colleagues and instructors ……..

To whom we love ……..

We dedicate this modest work

Project team

Acknowledgment

Here as we finished our project, we stop for a moment to express our genuine gratitude to every body who has helped us to complete this work.

First, we want to thank our supervisor, Eng. Nezar Amro who gave us a lot of his time and experience in order to complete the project, and gave us the opportunity to start a real scientific life.

Second, to Integration with industry unit leaded by Dr. Maher Al-Ja'bari for the all support covering some financial sides and other activities.

Third, to the educational staff in the university including the head of the electrical and computer engineering department for all the help and facilities they offered to prepare ourselves for such a serious moment.

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1.1 Introduction

In the past when people wanted to do any traditional work, whatever the work is, difficult or easy, time spending or not, whatever its field is; agriculture, industrial ….etc, the work needs many to success; a lot of workers, more effort, and high cost. But the world is changing, so these things are not acceptable at every time; because the work must be done more quickly, in less time, and at low cost.

Human's thinking more and more to overcome the traditional work obstacles and try a lot of time to make and design new technologies to get easiest work, work hard time, and to harness any thing in order to help him in his life and get new technologies, until he reach a speed life.

In the industrial world human get more technologies to effortless the product making, design new machines and get a comfort in the work. One of these machines is filling machine.

Filling machines at past designs were manually controlled but now most of them are automatically controlled.

The manual filling machines are very complicated and having difficulties in dealing with. Any operation of these machines needs many workers to perform this operation, also needs a big effort, high cost and wasting time. Machines need a person to turn on the machine, another one at least to prepare the materials, one to put the roll, and one to stow the final products….

Nowadays, the industrial operations have been changed and became comfortable to owners of factories. The products now are rapidly performing; need fewer workers, less cost, and designs become more accurate. Some of these machines need one person only to control the machine and involve when an error occurred.

Automatic filling machines are very easy to deal with, getting a good product in low cost. So, as any automatic machines, the filling machines are more efficient than manual machines.

1.2 Reasons for the selections of this project

This project is a design requirement for Industrial Automation Engineering bachelor degree.

The industrial automation in world is very forerunner technologies, but in our country, Palestine, the industry is so weak and using a traditional methods for controlling. Most factories' owners facing a lot of problems in their products, some of owners are having problems in dealing with workers, having problems in maintenance of the traditional machines. Mainly, the real problem is located in the machine itself.

So to improve our industrial life and get good products to competitive other products abroad; we must help the factories to develop their products and reduce the problems to reach good level in the world industry.

Automatic machines will help the industry improve the products, because they need a little maintenance, little works, fewer cost, and less position, finally get good products.

1.3 Description of the project

The filling machine is a full automatic machine for filling the solid materials. The controller for controlling all operations of this machine is PLC (Programmable logic control).

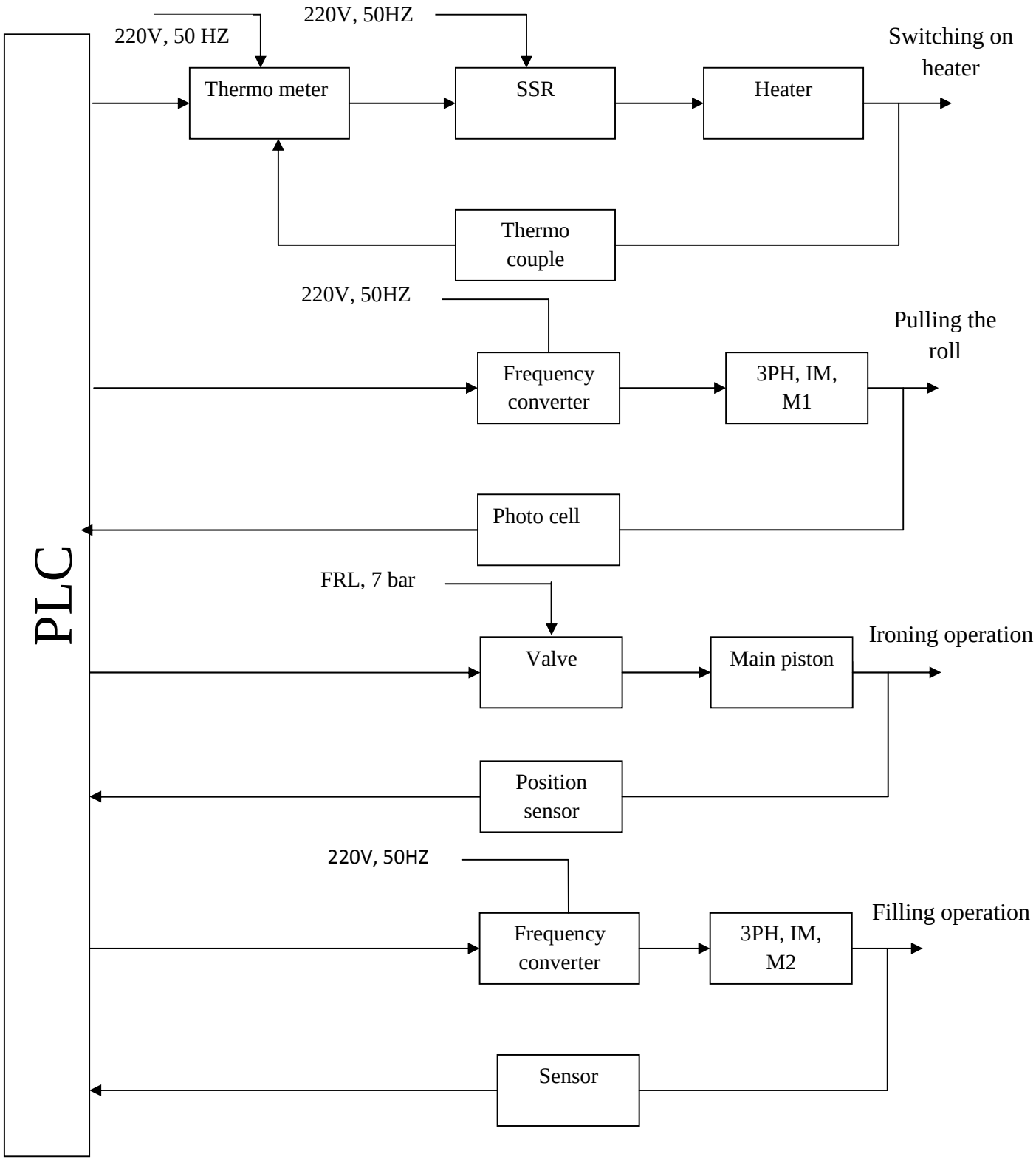
The machine contains a box at the above includes the solid material. A screw in the box moves by motor, the PLC program determines the quantity of material. When the materials are coming to finish from the box sensor will indicate and get a sign to the worker to put the materials.

Another part of the machine is a roller-carrier, carrying a roll of plastic. The roller will move by a motor and pull the plastic roll. To stop the roll under the inlet of the box, a sensor will control this operation and stop the roll at the accurate position.

An ironing process starts from three sides: right, lift, and lower side. Then filling will be started to fill the sack, and after finishing the filling operation, the iron will ironing the upper side, the sacks will be cut from the roll and finally gone down to the conveyer and stow the sacks one by one.

The main focus of this project is to deal with our industrial society, to develop the industry in Hebron city. Also, this prototype may be transferred to any factory in Palestine.

1.4 Block diagrams



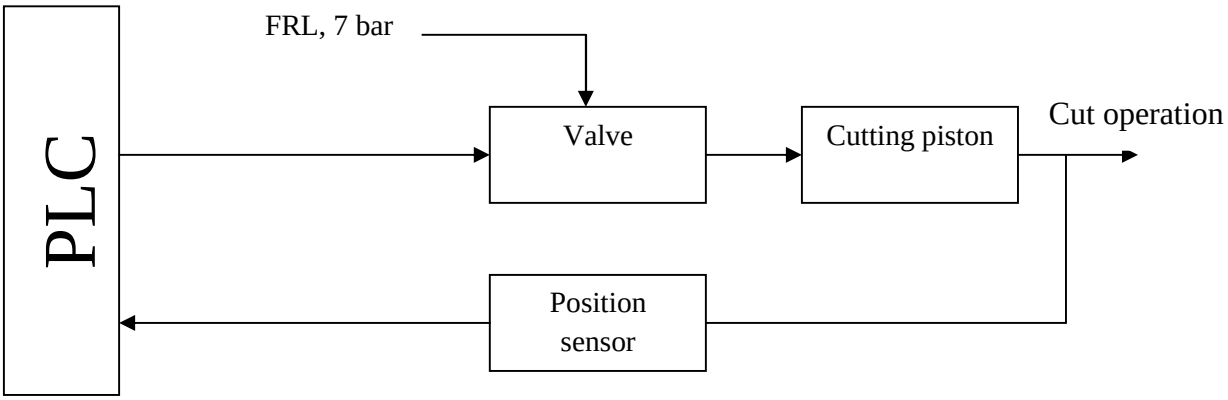


Figure (1.1): Block diagram of all operations

The details of above diagram will described in the following:

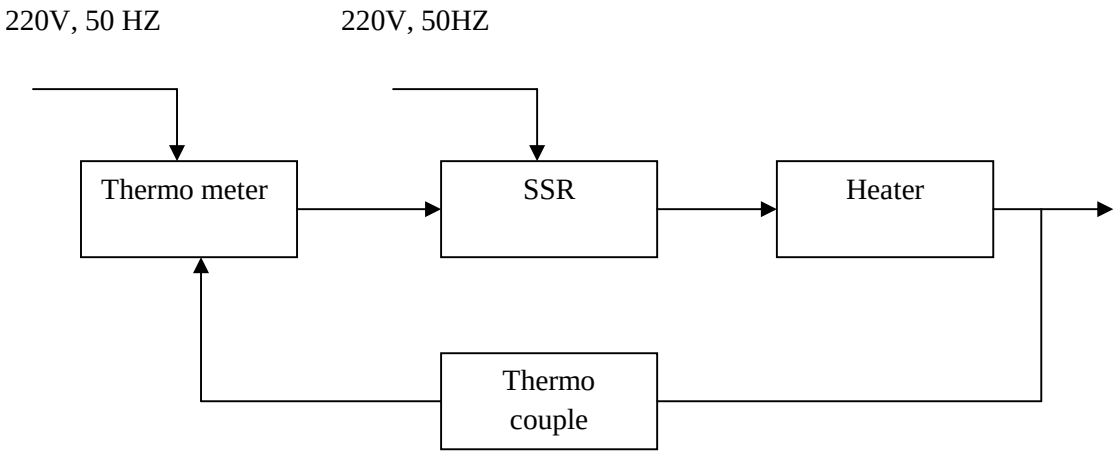


Figure (1.2): Switching on heater

The first operation is switching on heaters, we fixed the set value temperature at appropriate value, when the pre value reach at the set value the solid state relay will switch off, thermo couple sensor is to measure the pre value.

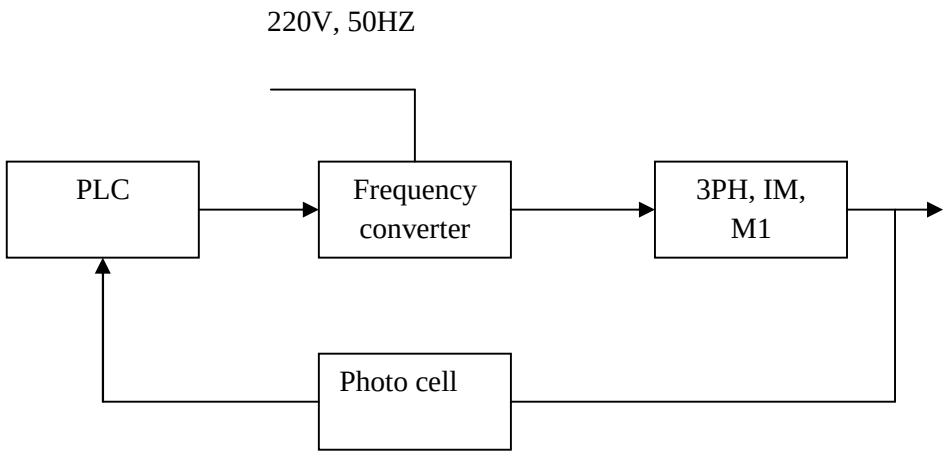


Figure (1.3) Pulling the roll

Second operation is pulling the roll, the AC motor move the roll. To determine the speed of the motor is the frequency convertor that connected to the PLC.

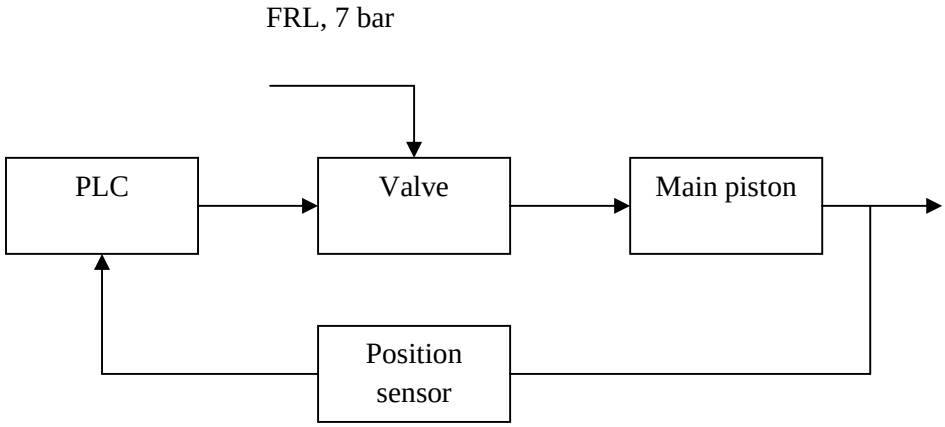


Figure (1.4): Ironing operation

Third operation is ironing operation, the piston move the horizontal and vertical heaters, the valve take the signal from the compressor and give it to the pistons.

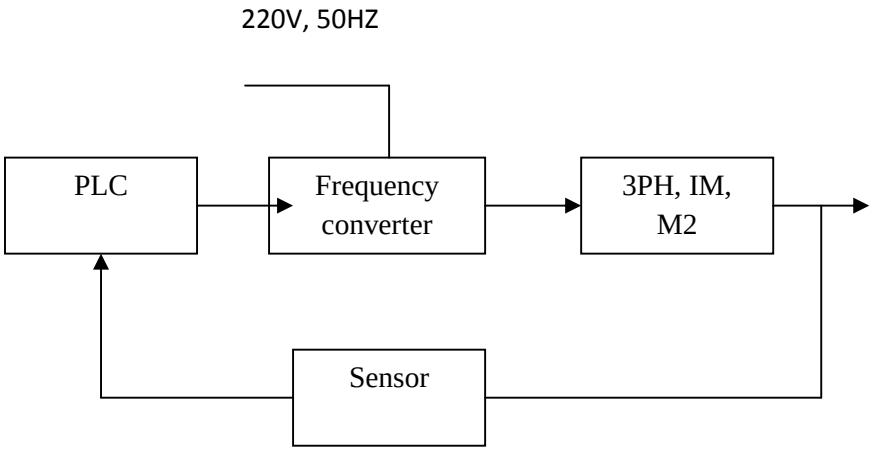


Figure (1.5): Filling operation

Fourth operation is filling operation, the AC motor move the screw. To determine the speed of the motor is the frequency convertor that connected to the PLC.

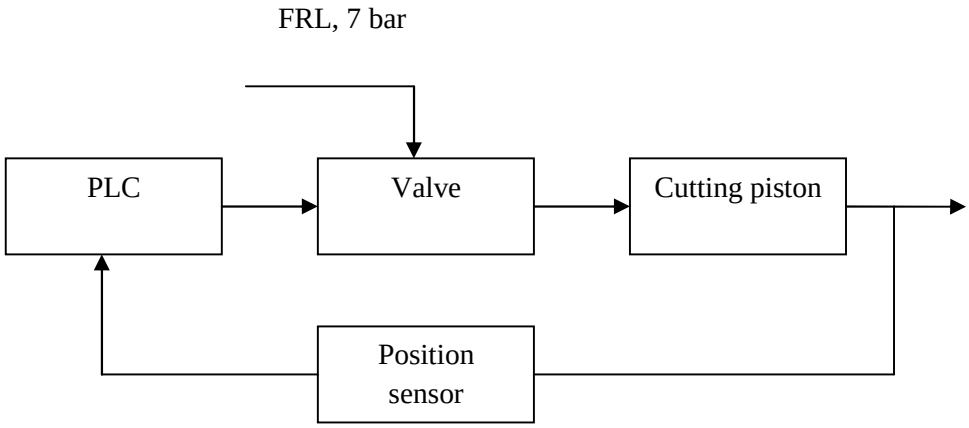


Figure (1.6): Cut operation

Fifth operation is cutting operation, the piston move the cutter, the valve take the signal from the compressor and give it to the pistons.

1.5 Project objectives

- Design an automatic machine instead of manual.
- Get more efficiency than the manual machine.
- Increasing the accuracy of machine.
- Using programmable logic controller (PLC) technology.
- Increasing machine production.
- Using industrial safety.
- Help the society for such developments.
- Creating the chance for further studies and projects connected with electric automation process.

1.6 Literature review

Many studies and projects were done in this field, most of them are in liquid filling machines. Locking for machines concepts from internet and see the designs for them. Other projects that we depend on it in our project are using PLC controller as our project. The projects are:

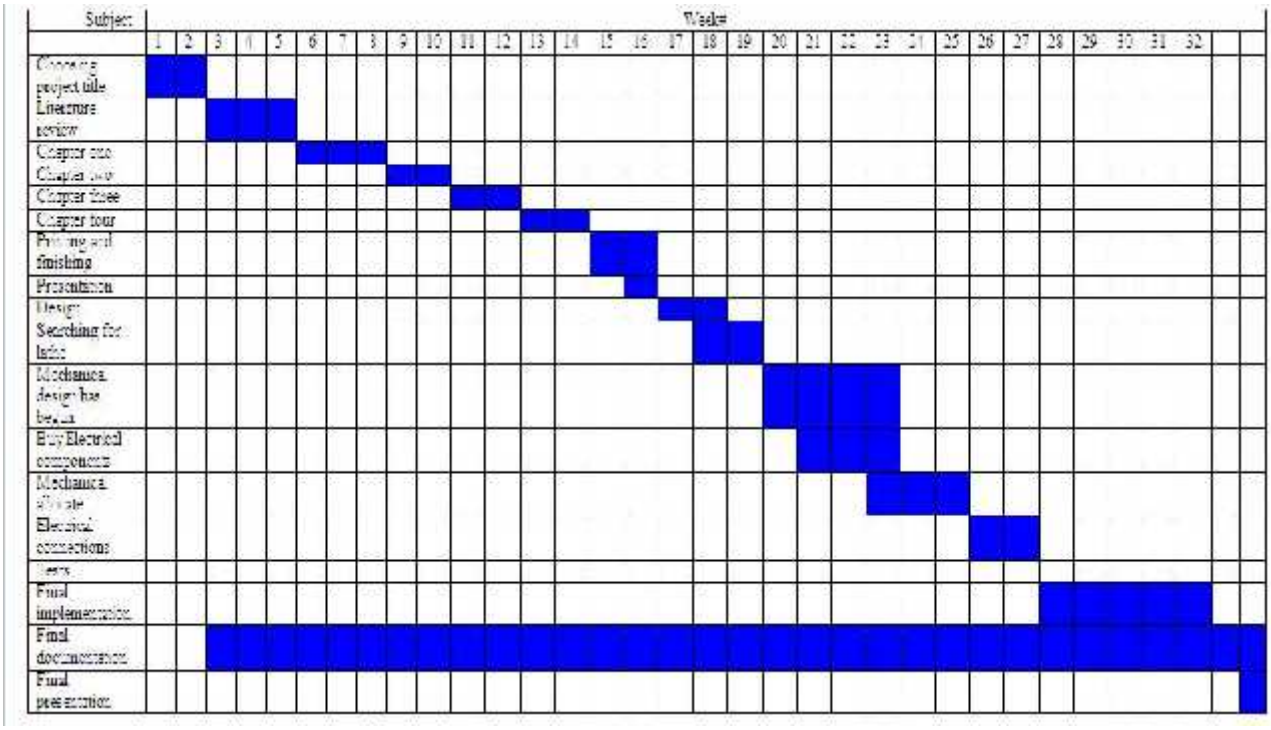
Full Automatic Coffee Powder Filling Machines. In this machine using a PLC controller for all operations, have a pneumatic, electrical and mechanical types. And do calculations for its design.

A second machine is a Filling Machine: this is a liquid filling machine using PLC controller. It is have for stages: placing cans, filling stage, closing stage, and stamping stage. It is contain a hydraulics drive, electrical and mechanical.

Fully Automatic Form Fill and Seal Machinery. This machine is used for solid and liquid materials. Another one is a Fully Automatic Capsule Filling Machine. And there are more and more filling machines like our project.

1.7 Time table

Table (1.1): Time table



1.8 The cost

Table (1.2): Cost table

Type	Price/ Unit NIS	Number of units	Total NIS
Induction motor(0.5HP,220V)	125	2	250
Heater(120mmlength ,12mm diameter)	110	8	880
Magnetic proximity sensor (PNP)	20	2	40
Thermometer +Thermo couple(J)	200	1	200
Photo cell	300	1	300
PLC (Delta ES)	780	1	780
Frequency converter (0.75W)	650	1	650
Push button switch.	20	6	120
Relay (24V DC, 8 pin)	25	5	125
Emergency switch	20	1	20
1/2 automatic single phase (6A,32A)	8	4	32
GV2 overload(1.6A)	40	2	80
Main switch ON/OFF(3ph,25A)	30	1	30
Selector switch(auto/manual)	20	1	20
Selector switch	15	1	15
Timers (24 DC)	40	3	120
Contactor (S.SHD)	25	2	50
Cylinders	90	5	450
Valves (selectors 3/2)	40	1	40
Valves (selectors 5/2)	50	2	100
DC power supply (24 V, 1.5 A)	100	1	100
Solid state relay	40	2	80
Indicator lamps (V)	5	6	30
Trunks, wires, clement and campus air	600	-	1,200
Box (60X80)	680	1	680
Filter, regulator, lubricator	250	1	250
Filling machine body	-	-	800
Nylon polling roller	60	4	240
Box+ bearing	85	10	580
Stainless steel selo	-	-	2000
Roll	-	-	400
Welding iron	-	-	600
Gears + chains			350
Total			11612

1.9 Flow chart

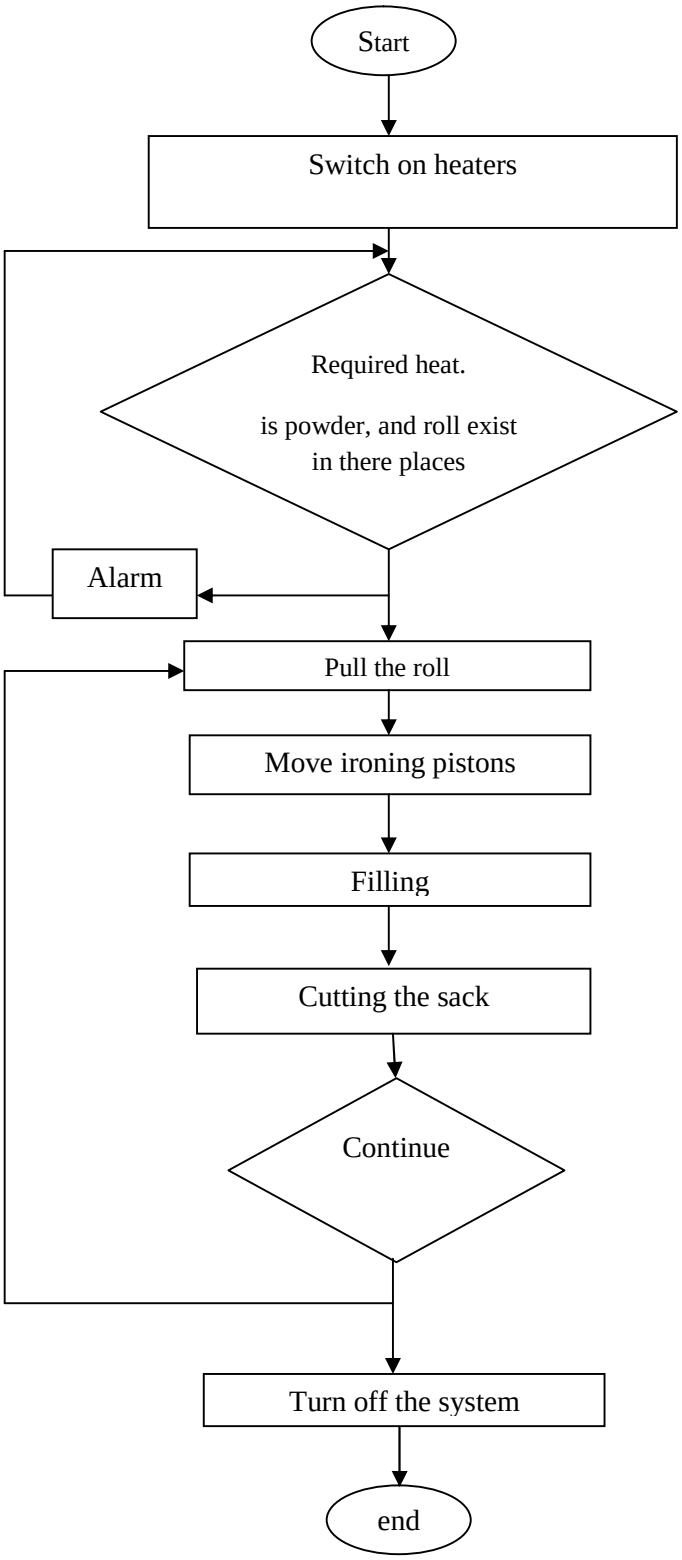


Figure (1.7): Flow chart

All operations in the flow chart was described in the block diagrams.

1.10 Contents and descriptions

The major contributions and studies made in each chapter can be resumed as follows:

Chapter one

It talks about an introduction for the project, and how the automation is developed from past until now. Also this chapter summarize the importance of automatic filling machine in the factories and how to enhancement the product. Then talking the reason for selecting this project, and describe the procedure of the project with its objectives. The Literature review and time table is mention here.

Chapter two

Theoretical information is mentioned in details. Firstly the main thing of the project is the controllers, is talking about the history of controllers, also discuss the difference between many controllers especially the PLC and microcontroller, and decoct the best one. After that is halting to PLC concepts, construction, types, and advantages.

Drivers are important information that this chapter is talking about, at the beginning is talking about for electrical drivers; this section is concentrate for general construction of electrical drivers. After that is mentioned the motors types DC and AC types; and some comparison between them. Then the other section is partake of about three phase induction motors in dilation with its equations and diagrams.

Chapter three

Take in details the designs and calculation of the machine components; as motors, pneumatic cylinders. All calculations are to select an appropriate design and components.

Chapter four:

The protection elements are considered in this chapter, it talks about the contactor principle and operation. Then it talks about the relay definition and operation. Fuses, circuit breakers and overloads concepts and types are mentioned here also.

Chapter five:

Finally, conclusions and the recommendations are mentioned, ended with appendices.

CHAPTER TWO
THEORITICAL BACKGROUND

2.1 Introduction

2.2 Controller

2.3 Frequency converter

2.4 Drivers

2.5 Sensor

2.6 Temperature controller

2.1 Introduction

Before the beginning of any study or design, there should be somehow a comprehensive background of all components and materials used.

Many components are to be discussed, different components but all related and dependent of each other.

2.2 Controllers

Control is a process in a system in which one or more Input- quantities affect other quantities (output quantities) according to specific legality (program).

2.2.1 Control Types

Controllers are of many types, the main types are as follows:

1. **Specification of control processes according to the form of signal representation**

    - Analog Control: Control follows by using continues signals. The most important devices of analog control are Motors, valves, amplifiers… etc.

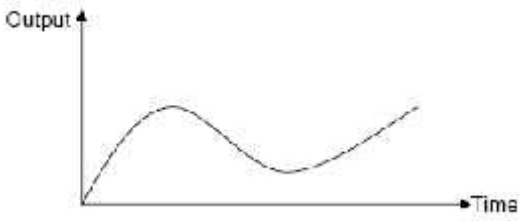


Figure (2.1): Signal representation of analog control

    - Binary Control: Binary controls work with dual-valued signals with only ON or OFF states (1 or 0). If the control signal is generated by

the combination of more than one input-signal, so control process is called logic control.

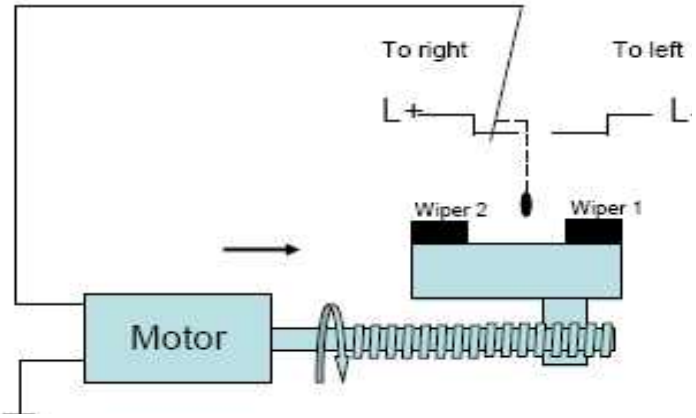


Figure (2.2): Example of binary control.

- Digital Control: the digital control system generates binary coded (BCD codes, Gray codes etc.) signals according to the desired input value. [9]

Most important devices of digital control are coders, micro-processors, digital memories.

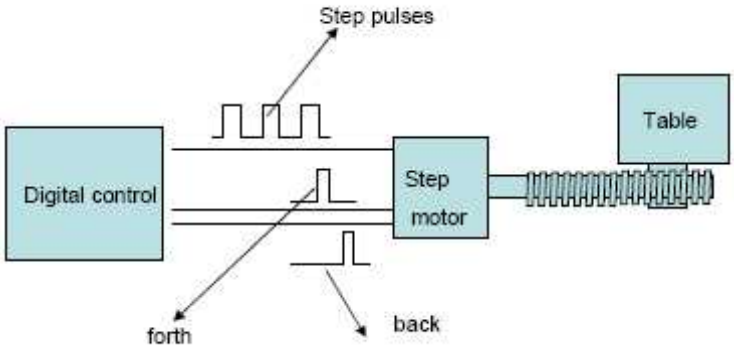


Figure (2.3): Example of digital control.

2. Specification of control processes according to the form of signal processing

- Logic control.

– Is control in which the control signals depend only on a logical combination of the input signals. For the logical combination, the functions AND, OR, NOT can be used. No storage (memory) or - A logic control provides usually time characteristic.

– Control problems that have to deal with protection and security are usually independent on time, thus they can be managed with logic control.

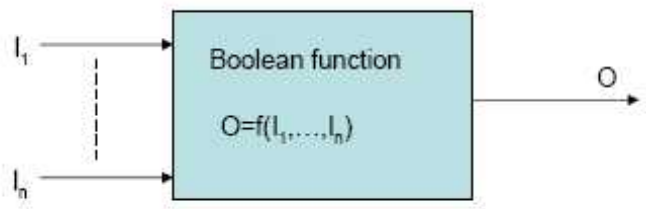


Figure (2.4): Logic control.

- Sequence control.

– Is a control where the control procedure runs step by step? Only One step (order) is active and the transfer from one step to the next one depends on according to in the program specified condition (Transition).

– To realize sequence control, memory elements like Flip Flops are needed.

– For complex control problems, sequence control is more suited than logic control.

– Hence logic control tools exhibit memory devices, the differentiation between logic and sequence control is often difficult. [9]

2.2.2 Comparison between some controllers

To automate a machine (the machine has fairly complicated action) which option is the best. Automation using microprocessor like Pentium and using c/c++ programming or using Programmable logic controller (PLC).

The selection criteria are speed of action and speed of responses to inputs, availability of controlling schemes and accuracy.

Here some comparison between some of controller as seen below in the table(2.1):

Table (2.1): comparison between some controllers.

In Comparison	**Relay systems**	**Computers**	**PLC systems**
Price Per Function	Fairly Low	High	Low
Physical Size	Bulky	Fairly Compact	Very Compact
Operating Speed	Slow	Fairly Fast	Fast
Noise Immunity	Excellent	Fairly Good	Good
installation	Time Consuming in All Phases	Time Consuming in Programming	Easy in All Phases
Complex operation	None	Yes	Yes
Ease of Changes	Very Difficult	Quite Simple	Very Simple
Easy Of maintenance	Poor-large No. Of Contacts	Poor-several Custom Boards	Good-few Standard Cards

2.2.3 PLC Controller

PLC's have coming into wide use, both to replace electromechanical control devices such as relays, timers, and drum switches, and to provide control functions that are beyond the capacity of the control provided by electromechanical means.

PLC is an industrial computer that controls a machine or process. A PLC interfaces with the field input and output devices that are part of a control application. Then, through the control program stored in its memory, the PLC uses the data supplied by the input devices to manipulate or control the output devices. The overall PLC process, which is shown in Figure (2.5), is very simple. A PLC measure or sense signals coming from a machine or process. Then, through its internal program, the PLC provides control back to the machine or process.

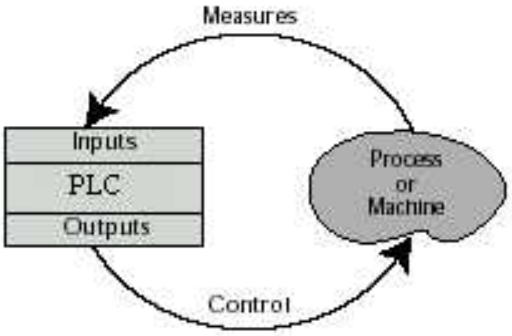


Fig (2.5) PLC Operation

2.2.4 Advantages of PLC

- PLC's are easy to program and install.
- The speed with which internal times operate is much faster than conventional time delay relay systems.
- Access to PLC's could be restricted or protected.

- PLC's have the advantage of problem-solving capabilities, over any other type of control system.

- PLC's are usually designed with communication capabilities that allow interfacing with local or remote computer systems or operator.

- PLC's are extremely reliable.

2.2.5 Components of PLC

Figure (2.6) shows all the component of PLC unit. Those components are as follows:

1. The Power Supply. External or internal (24Vdc, 120Vac, 220Vac).
2. The CPU and MEMORY.
3. Input / output interface.
4. The Program.
5. The Programming Languages.
6. The Programming Device or Programming Terminal.

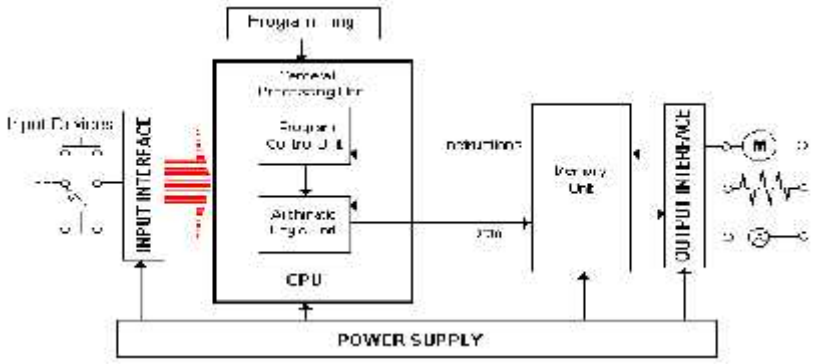


Figure (2.6): PLC components.

2.3 Frequency Converter

A frequency changer or frequency converter is an electronic device that converts alternating current (AC) of one frequency to alternating current of another frequency. The device may also change the voltage, but if it does, that is incidental to its principal purpose.

Traditionally, these devices were built out of electromechanical components such as motor-generator sets or rotary converters. But with the advent of solid state electronics, it has become possible to build completely electronic frequency changers. These devices usually consist of a rectifier stage (producing direct current) which is then inverted to produce ac of the desired frequency.

The inverter may use thyristors or IGBTs. If voltage conversion is desired, a transformer will usually be included in either the ac input or output circuitry and this transformer may also provide galvanic isolation between the input and output ac circuits. A battery may also be added to the dc circuitry to improve the converter's ride-through of brief outages in the input power.

Frequency changers vary in power-handling capability from a few watts to megawatts. Frequency Converter also offers line isolation, harmonic cancellation, power factor correction, phase conversion, voltage conversion with balanced, smooth, controlled power output.

2.3.1 Applications

Frequency changers are used to control the speed and the torque of the AC motors. In this application, the most typical frequency converter topology is the three-phase two-level voltage source inverter.

Another application is in the aerospace and airline industries. Often airplanes use 400 Hz power, so 50 Hz or 60 Hz to 400 Hz frequency convertor is needed for use in the ground power unit used to power the airplane wile its on the ground.

Frequency changers are typically used to control the speed of pumps and fans. In many applications significant energy saving are achieved. The most demanding application areas are found in the industrial processing lines, where the control accuracy requirement can be high.

2.3.2 Three phase frequency converter

The frequency converter for the AC induction motor drives is a device that converts the standard three-phase AC line voltage to a variable-frequency, and variable-voltage three-phase AC waveforms. The AC induction motor drive supplied by the frequency converter becomes a variable speed drive and is used for the control of technologies and machines. The present-day frequency converter is a highly sophisticated device, which allows the manual control of motor rotation speed, automatic control according to the signals of an appropriate sensor [1, 2] or computer-based control. The frequency converters usually utilize a converter-inverter structure as shown in Fig. (2.7).

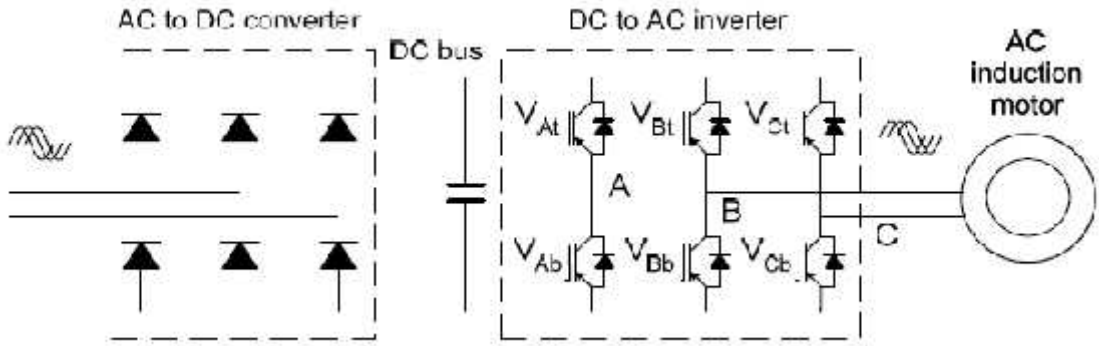


Figure (2.7): Simplified diagram of the frequency converter

The AC to DC converter (Fig.2.7) creates DC from the fixed AC line while the DC to AC inverter develops the variable-frequency, and variable-voltage AC

from DC. The rectifier, which provides rectification of the fixed AC line voltage, is used for converting AC to DC. The primary part of the frequency converter is the DC to AC inverter. It includes the power stage, which contains six power switches.

The IGBT transistors V_{At}-V_{Cb} commonly used as power switches are controlled by an algorithm, and which is executed in the control unit to create the proper AC waveforms.

The fault detection and shutdown circuitry must be incorporated into the inverter to guarantee safe operating of the power stage. Among the problems that are urgent in AC variable speed drives are fault situations when the motor, during the deceleration, starts to operate in a regenerative.

2.4 Drivers

Drivers are divided into electrical and mechanical drivers.

2.4.1 Electrical driver

Electric motors convert electrical energy into mechanical motion and are broadly classified into two different categories: DC (Direct Current) and AC (Alternating Current). Within these categories are numerous types, each offering unique abilities that suit them well for specific applications. In most cases, regardless of type, electric motors consist of a stator (stationary field) and a rotor (the rotating field or armature) and operate through the interaction of magnetic flux and electric current to produce rotational speed and torque.

In this part we will compare between different drives to select the correct one for driving the machine, and we will compare the benefits and advantages of AC vs. DC, and we will compare the disadvantages of those motors.

2.4.1.1 AC Motors

The AC motor is divided into two major categories: asynchronous (induction) and synchronous. When driven by a fixed-frequency AC source with a constant load, the induction motor operates near the frequency of the input source (or multiple thereof), while the synchronous motor will operate at the input source frequency (or multiple thereof). As the frequency of the source is varied, both motor classes will accordingly change rotational speed. However, as the load changes, the difference between the input line frequency and the rotational speed of the rotor for the induction machine will be greater than that of the synchronous machine because of magnetic slip (the difference in rotor speed versus stator speed in a motor) caused by induction.

AC motors rotate by producing a rotating magnetic field pattern in the stator that causes the rotor to follow the rotation of this field pattern. While induction machines produce rotor movement by inducing a magnetic field in the rotor, the rotation tends to lag and be asynchronous to the movement of the stator magnetic field. However, synchronous AC motors produce magnetic fields that cause the rotor to synchronize to the rotation of the stator magnetic field and tend to be more efficient than induction motors in applications requiring more than several hundred horsepower. In addition, synchronous motors are often employed with asynchronous motors in large industrial applications to stabilize voltage and improve overall power factor performance due to the synchronous motor's ability to provide leading power factor.

Single-phase AC motors are extremely low cost and usually operate at a multiple of line speed for single speed operation. Poly-phase AC machines are the choice for higher-performance drives requiring more torque in smaller motor frames.

The most common and simple industrial motor is the three phase AC induction motor, sometimes known as the "squirrel cage" motor. Substantial information can be found about any motor by checking its (nameplate).

2.4.1.2 Three phase Induction motor

AC induction motors are the most common motors used in industrial motion control systems, as well as in main powered home appliances. Simple and rugged design, low-cost, low maintenance and direct connection to an AC power source are the main advantages of AC induction motors.

A poly-phase electrical supply is available, the three-phase (or poly-phase) AC induction motor is commonly used, especially for higher-powered motors. The phase differences between the three phases of the poly-phase electrical supply create a rotating electromagnetic field in the motor.

These motors are self-starting and use no capacitor, start winding, centrifugal switch or other starting device.

Induction motors are the workhorses of industry and motors up to about 500 kW (670 horsepower) in output are produced in highly standardized frame sizes,

Three-phase AC induction motors are widely used in industrial and commercial applications. There are two types of rotors used in induction motors: squirrel cage rotors and wound rotors (slip-ring rotor).

2.4.1.2.1 Squirrel Cage rotors

An electric motor with a squirrel cage rotor is sometimes called a squirrel cage motor. In overall shape it is a cylinder mounted on a shaft. Internally it contains longitudinal conductive bars of Al-minimum or copper set into grooves and connected together at both ends by shorting rings forming a cage-like shape. The name is derived from the similarity between this rings-and-bars winding and a hamster wheel (presumably similar wheels exist for pet squirrels).

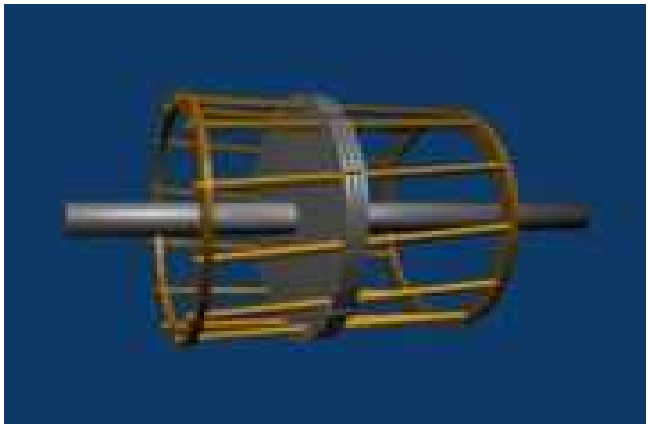


Figure (2.8): Squirrel Cage rotors

The field windings in the stator of an induction motor set up a rotating magnetic field around the rotor. The relative motion between this field and the rotation of the rotor induces electrical current flow in the conductive bars. In turn these currents flowing lengthwise in the conductors react with the magnetic field of the motor to produce force acting at a tangent to the rotor, resulting in torque to turn the shaft. In effect the rotor is carried around with the magnetic field but at a slightly slower rate of rotation. The difference in speed is called “slip” and increases with load.

In figure (2.9) shows atypical poly-phase squirrel-cage induction motor torque-speed curve.

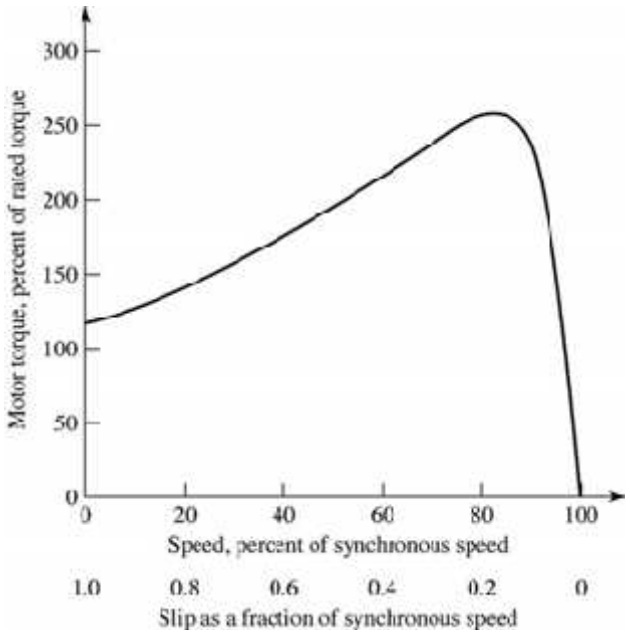


Figure (2.9) typical induction-motor torque-speed
Curve for constant-voltage, constant-frequency operation.

The conductors are often skewed slightly along the length of the rotor to reduce noise and smooth out torque fluctuations that might result at some speeds due to interactions with the pole pieces of the stator. The number of bars on the squirrel cage determines to what extent the induced currents are fed back to the stator coils and hence the current through them. The constructions that offer the least feedback employ prime numbers of bars.

Iron core serves to carry the magnetic field across the motor. In structure and material it is designed to minimize losses. The thin laminations, separated by varnish insulation, reduce stray circulating currents that would result in eddy current loss. The material is a low carbon but high silicon iron with several times the resistance of pure iron, further reducing eddy-current loss. The low carbon content makes it a magnetically soft material with low hysterics loss.

The same basic design is used for both single-phase and three-phase motors over a wide range of sizes. Rotors for three-phase will have variations in the depth and shape of bars to suit the design classification.

2.4.1.2.2 Wound rotor

An alternate design, called the wound rotor, is used when variable speed is required. In this case, the rotor has the same number of poles as the stator and the windings are made of wire, connected to slip rings on the shaft. Carbon brushes connect the slip rings to an external controller such as a variable resistor that allows changing the motor's slip rate. In certain high-power variable speed wound-rotor drives, the slip-frequency energy is captured, rectified and returned to the power supply through an inverter.

Compared to squirrel cage rotors, wound rotor motors are expensive and require maintenance of the slip rings and brushes, but they were the standard form for variable speed control before the advent of compact power electronic devices. Transistorized inverters with variable-frequency drive can now be used for speed control, and wound rotor motors are becoming less common. (Transistorized inverter drives also allow the more-efficient three-phase motors to be used when only single-phase mains current is available, but this is never used in household appliances, because it can cause electrical interference and because of high power requirements).

Several methods of starting a poly-phase motor are used. Where the large inrush current and high starting torque can be permitted, the motor can be started across the line, by applying full line voltage to the terminals (Direct-on-line, DOL). Where it is necessary to limit the starting inrush current (where the motor is large compared with the short-circuit capacity of the supply), reduced voltage starting using series inductors, an autotransformer, a thyristors or other devices are used. A technique sometimes used is (Star-Delta, YΔ) starting, where the motor coils are initially connected in wye for acceleration of the load, then switched to delta when the load is up to speed. This technique is more common in Europe than in North America. Transistorized drives can directly vary the applied voltage as required by the starting characteristics of the motor and load.

This type of motor is becoming more common in traction applications such as locomotives, where it is known as the asynchronous traction motor.

The speed of the AC motor is determined primarily by the frequency of the AC supply and the number of poles in the stator winding, according to the relation:

$$N_S = \frac{120 f}{p} \qquad (2.1)$$

Where:

Ns = Synchronous speed, in revolutions per minute.

f = AC power frequency.

P = Number of poles per phase winding.

The slip of the AC motor is calculated by:

$$S = \frac{N_S - N_r}{N_S} \qquad (2.2)$$

Where:

Nr = Rotational speed, in revolutions per minute.

S = Normalized Slip, 0 to 1.

The speed in this type of motor has traditionally been altered by having additional sets of coils or poles in the motor that can be switched on and off to change the speed of magnetic field rotation. However, developments in power electronics mean that the frequency of the power supply can also now be varied to provide a smoother control of the motor speed.

2.4.2 Mechanical drivers

Mechanical drivers are of many types, but this project concentrates only on one field of mechanical drivers, which is the pneumatic system.

Pneumatic systems use pressurized gases to transmit and control power. As the name implies, pneumatic systems typically use air (rather than some other gas) as the fluid medium, because air is a safe, low-cost, and readily available fluid. It is

particularly safe in environments where an electrical spark could ignite leaks from system components.

There are several reasons for considering the use of pneumatic systems in stead of hydraulic systems. Liquid exhibit greater inertia than do gases. Therefore in hydraulic systems the weight of oil is a potential problem when accelerating and decelerating actuators and when suddenly opening and closing valves.

Due to Newton's low of motion (force equal mass multiplied by acceleration), the force required to accelerate oil is many times greater than that required to accelerate an equal volume of air. Liquids also exhibit greater viscosity than do gases. This results in larger friction pressure and power losses. Also, since hydraulic systems use a fluid foreign to the atmosphere, they require special reservoirs and no-leak system design. Pneumatic systems use air that is exhausted directly back in to the surrounding environment. Generally speaking, pneumatic systems are less expensive than hydraulic systems.

However, because of the compressibility of air, it is impossible to obtain precise, controlled actuator velocities with pneumatic systems. Also, precise positioning control is not obtainable. In applications where actuator travel is to be smooth and steady against the variable loads, the air exhaust from the actuator is normally metered. Whereas pneumatic pressure are quite low due to compressor design limitations (less than 250 psi), hydraulic pressure can be as high as 10,000 psi. thus hydraulic can be high-power systems, whereas pneumatic are confined to low-power applications.

In pneumatic systems, compressors are used to compress and supply the necessary quantities of air. Pneumatic systems normally use a large centralized air compressor, which is considered to be an infinite air source. Free air from the atmosphere contains varying amounts of moisture.

The majority functions of pneumatic systems are:

1- Sensors: to determine the status of processor.
2- Processors: to process information.
3- Control elements: to switching actuators.
4- Actuators: carrying out work.

General applications:

1- Packaging.
2- Filling.
3- Door control.
4- Transfer of materials.

Selection criteria for the working section:

1- Force.
2- Stroke.
3- Type of motion.
4- Speed.
5- Service life.
6- Safety and reliability.
7- Energy costs.
8- Controllability.
9- Storage.

2.4.2.1 Structure and signal flow of pneumatic systems

Pneumatic systems consist of an interconnection of different groups of elements.

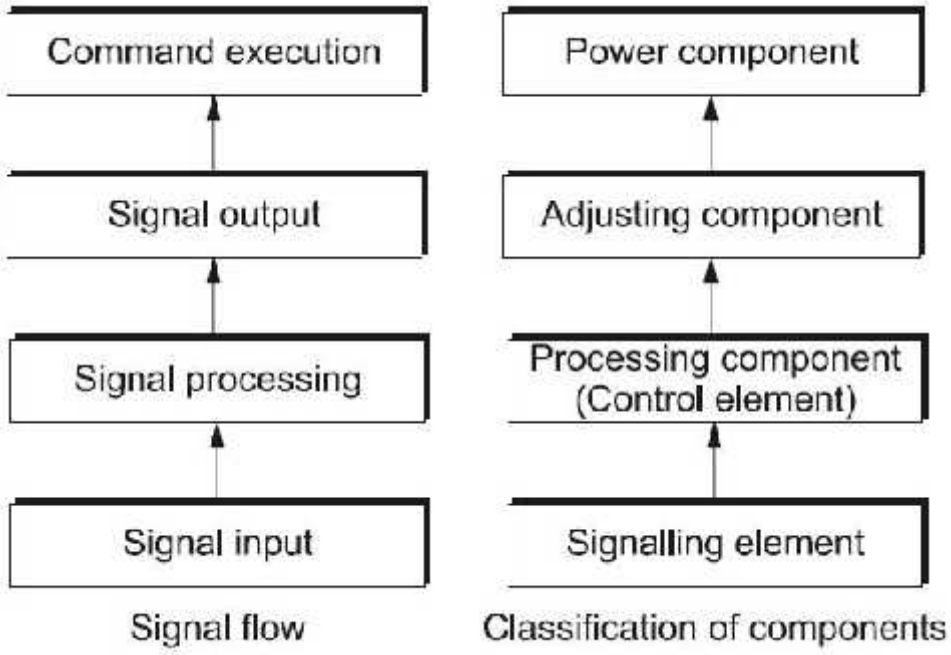


Figure (2.10) signal flow

This group of elements forms a control path for signal flow, starting from the signal section (input) through to the actuating section (output). Control elements control the actuating elements in accordance with the signals received from the processing elements.

The primary levels in a pneumatic system are:

- Energy supply
- Input elements (sensors)
- Processing elements (processors)
- Control elements
- Power components (actuators)

2.4.2.2 Valves

The function of valves is to control the pressure or flow rate of pressure media. Depending on design, these can be divided into the following categories:

- Directional control valves
    - Input/signaling elements
    - Processing elements
    - Control elements
- Non-return valves
- Flow control valves
- Pressure control valves
- Shut-off valves

The directional control valve controls the passage of air signals by generating, Canceling or redirecting signals.

- Number of ports or openings (ways)
- Number of positions
- Methods of actuation of the valve
- Methods of return actuation

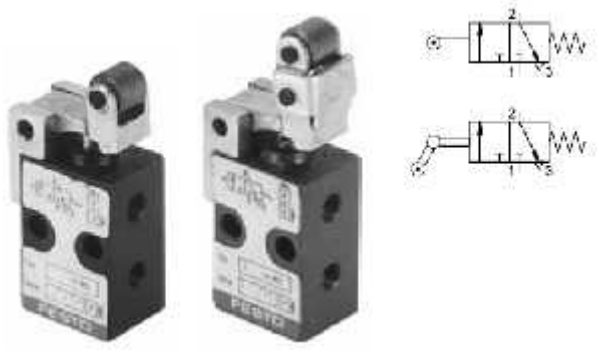


Figure (2.11) 3/2 way roller lever valve

As a processing element the directional control valve redirects or cancels signals depending on the signal inputs received.

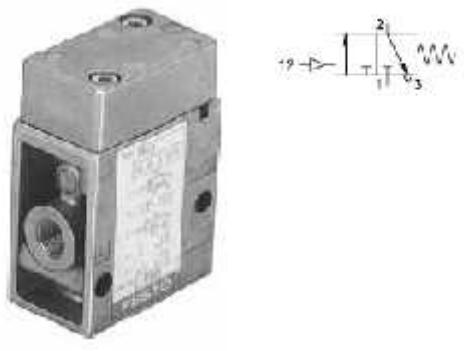


Figure (2.12) 3/2 way air actuated valve,
Single pilot valve, with spring return

As a control element the directional control valve must deliver the required quantity of air to match the power component requirements.

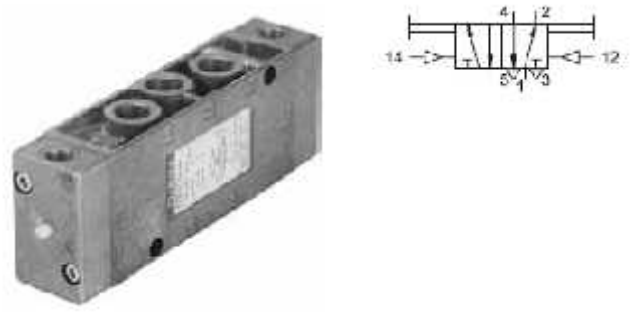


Figure (2.13) 5/2 way valve for cylinder
Control: double pilot valve

The non-return valve allows a signal to flow through the device in one direction and in the other direction blocks the flow. Amongst others, this principle is applied in shuttle valves or quick exhaust valves.

2.5 Sensors

A sensor is a type of transducer (Direct-indicating sensors). A sensor is a device which can respond to some properties of the environment and transform the

response into an electric signal. The general working mechanism of a sensor is illustrated by the following scheme in figure (2.19):

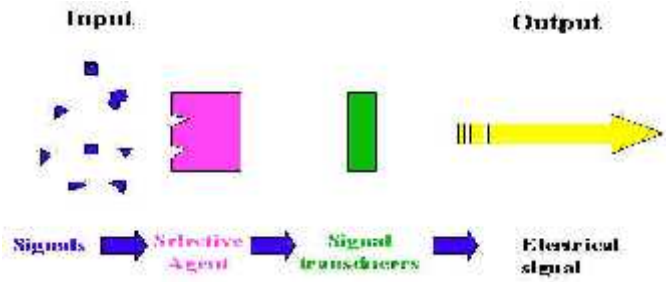


Figure (2.14) Mechanism of a sensor

Sensors are used in everyday objects such as touch-sensitive elevator buttons and lamps which dim or brighten by touching the base. There are also innumerable applications for sensors of which most people are never aware. Applications include automobiles, machines, aerospace, medicine, industry, and robotics.

2.5.1 Proximity Sensor

A Proximity sensor can detect objects without physical contact. A proximity sensor often emits an electromagnetic field or beam and look for changes in the field. The object being sensed is often referred to as the proximity sensor's target. Different proximity sensor targets demand different sensors. For example, a capacitive or photoelectric sensor might be suitable for a plastic target; an inductive proximity sensor requires a metal target.

Proximity sensor selection depends on the material to be sensed. Proximity sensor probes for sensing non-conducting surfaces or insulators vary slightly from those for conducting surfaces. Non-conducting probe signals are also more difficult to be linearized.

2.5.1.1 Capacitive Proximity Sensors

Capacitive sensors detect the change in capacitance caused by the approach of an object.

Capacitive proximity sensors are similar to inductive proximity sensors. The main difference between the two types is that instead of an electromagnetic field. Capacitive proximity switches will sense metal as well as nonmetallic materials such as paper, glass, liquids, and cloth.

Figure (2.15): Capacitive Proximity Sensors.

A typical capacitive proximity sensor has a 10-mm sensing range and is 30 mm in diameter. The proximity sensor incorporates a potentiometer to allow fine tuning of the sensing range and can repetitively detect objects within 0.01 mm of the set point. Switching frequency is 10 Hz, and operating temperature range is -14 to 158°F.

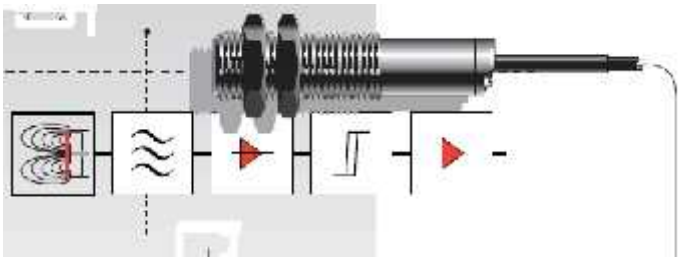


Figure (2.16): Principle operation of proximity sensor

2.5.1.1.1 Advantages of capacitive proximity sensors

1- Detect conductive or non-conductive materials.
2- Target detection is not affected by color.

3- Adjustable sensitivity potentiometer allows differentiation between materials, ability to "tune out" mounting hardware or intermediate barrier materials.
4- Relatively longer range / higher sensitivity for small metal parts and wires.

2.5.1.1.2 Applications of capacitive proximity sensors

The following figures appear the main applications of a capacitive proximity sensor, either for leveling of liquids and inspection of packaging contents.

(a) (b)

Figure (2.17): (a) Level control or monitoring via sight glass.
(b) Inspect for package contents

2.5.1.2 Inductive proximity sensor

Coil inductance is greatly affected by the presence of ferromagnetic materials here the proximity of a ferromagnetic plate is determined by measuring the inductance of a coil.

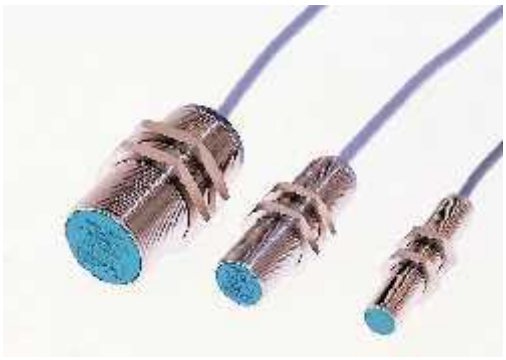


Figure (2.18): Inductive sensor

2.5.2 Photo-electric sensor

Three types of photoelectric sensors are available:

1- Direct Reflection (Diffused): emitter and receiver are housed together and use the light reflected directly off the object for detection.

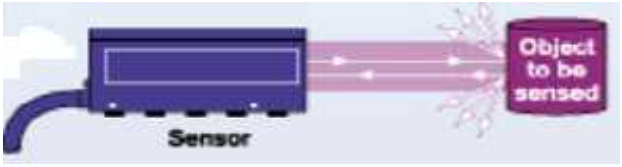


Figure (2.19): Diffused sensor.

2- Reflection with Reflector (Retro reflective): emitter and receiver are housed together and require a reflector. An object is detected when it interrupts the light beam between the sensor and reflector.

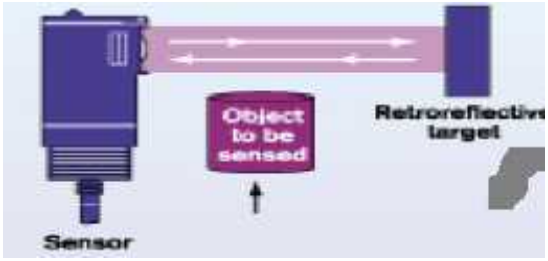


Figure (2.20): Reflector sensor.

3- Thru Beam: emitter and receiver are housed separately and detect an object when it interrupts the light beam between the emitter and receiver.

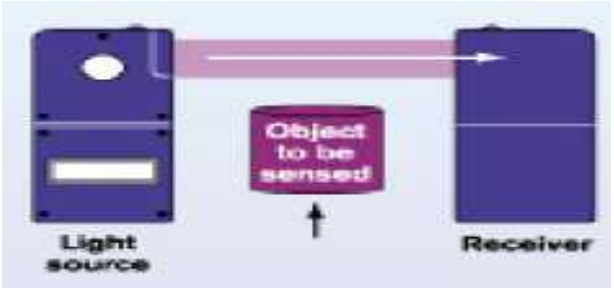


Figure (2.21): Thru beam sensor.

2.5.3 Light sensors

Light sensors often use an infrared LED as a light source. Infrared LED's have a greater intensity than LED's that emit visible light. And when infrared photodiodes are used the sensors are relatively insensitive to ambient light.
Photoelectric light sources are often modulated at a given frequency to prevent interference from ambient light. But flashes or reflections can still fool light-activated sensors. This problem is solved by using a modulated receiver. Here the detector is synchronized to the light source frequency.

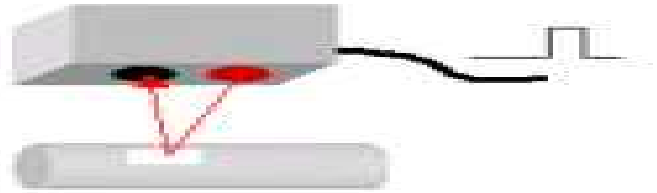


Figure (2.22): Light sensors

2.5.4 Magnetic sensor

Magnetic sensors are actuated by the presence of a permanent magnet. Their operating principle is based on the use of reed contacts, which consist of two low reluctance Ferro-magnetic reeds enclosed in glass bulbs containing inert gas. The reciprocal attraction of both reeds in the presence of a magnetic field, due to magnetic induction, establishes an electrical contact.

2.5.5 Thermocouple sensor

In electronics and in electrical engineering, thermocouples are a widely used type of temperature sensor, and can also be used as a means to convert thermal potential difference into electric potential difference. They are cheap and interchangeable, have standard connectors, and can measure a wide range of temperatures. The main limitation is accuracy; system errors of less than one degree Celsius (°C) can be difficult to achieve.

It is important to note that thermocouples measure the temperature difference between two points, not absolute temperature. In traditional applications, one of the junctions the cold junction was maintained at a known (reference) temperature, while the other end was attached to a probe.

When two wires composed of dissimilar metals are joined at both ends and one of the ends is heated, there is a continuous current which flows in the thermoelectric circuit. Thomas Seebeck made this discovery in 1821.

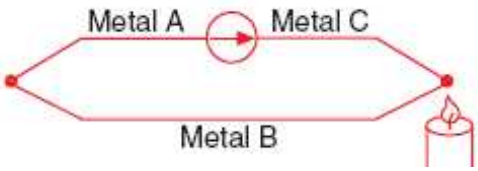


Figure (2.23): The seebeck effect.

If this circuit is broken at the centre, the net open circuit voltage (the See beck voltage) is a function of the junction temperature and the composition of the two metals.

Figure (2.24): See beck voltage.

Thermocouples are most suitable for measuring over a large temperature range, up to 1800 °C. They are less suitable for applications where smaller temperature differences need to be measured with high accuracy, for example the range 0–100 °C with 0.1 °C accuracy. For such applications, thermistors and resistance temperature detectors are more suitable.

2.6 Temperature controller

Temperature control is a process in which the temperature of an object is measured and the passage of heat energy into or out of the object is adjusted to achieve a desired temperature.

2.6.1 Principle of operation

To accurately control process temperature without extensive operator involvement, a temperature control system relies upon a controller, which accepts a temperature sensor such as a thermocouple or RTD as input. It compares the actual temperature to the desired control temperature, or set point, and provides an output to a control element. The controller is one part of the entire control system, and the whole system should be analyzed in selecting the proper controller.

2.6.2 Considerations for selecting temperature controllers

The following items should be considered when selecting a controller:

- Type of input sensor (thermocouple, RTD) and temperature range.
- Type of output required (electromechanical relay, SSR, analog output).
- Control algorithm needed (on/off, proportional, PID).
- Number and type of outputs (heat, cool, alarm, limit).

2.6.3 Temperature controller types

1- On-Off Controllers

On-Off controllers are the simplest type of controllers featuring on-off control action.

Figure (2.25): on-off controller

2- Auto-tune PID Controllers

PID controllers provide very tight control but the PID algorithm requires tuning. Auto-tune controllers provide that function.

Figure (2.26): Auto-tune PID Controllers

3- Multi loop Controllers.

Each control loop normally consists of one input and at least one output.

Figure (2.27): Multi loop Controllers

4- Safety Limit Controllers

A safety limit controller is an off-off controller with a latching output. When

the output changes state it requires a manual reset to change it back. Safety limit controllers are typically used as redundant controllers, to shut down a process when undesirable limits are reached.

Figure (2.28): Safety Limit Controllers

5- Temperature Switches

A safety limit controller is an off-off controller with a latching output. When the output changes state it requires a manual reset to change it back. Safety limit controllers are typically used as redundant controllers, to shut down a process when undesirable limits are reached.

Figure (2.29): Temperature Switches

CHAPTER THREE
DESIGN

3.1 Introduction

3.2 Electrical design

3.3 Power and control circuits for filling and pulling motor

3.4 Pneumatic design

3.5 Mechanical design

3.6 Controller

3.7 Quantity of product

3.1 Introduction

In the designing process, steps were divided into four stages, electrical, mechanical, pneumatic and control. Each stage of the previous points will be discussed in details in the following sections of this chapter.

3.2 Electrical design

In this section, there are two motors used, one for filling operations, and the second is used for rolls pulling. Also there are heaters and temperature controllers.

3.2.1 Filling motor

This motor is used in our machine for driving the auger needed to delimit the quantity of powder.

All calculations of motor power depend on load torque, as shown in the following equations.

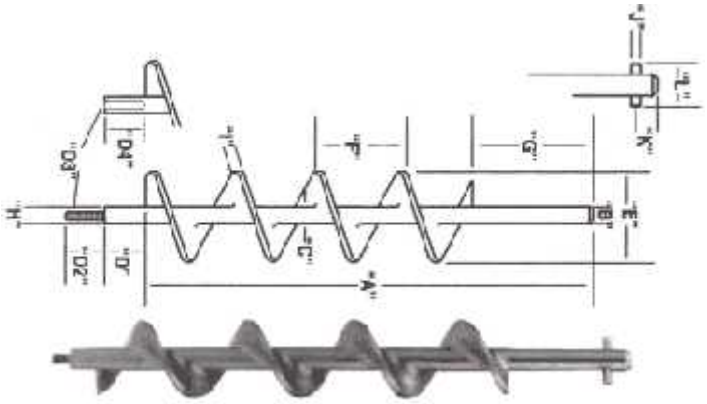


Figure (3.1): Screw dimension

$$F = n_t w \text{«} \qquad (3.1)$$

Where:

F: Force required for rotate the screw. (N)

n_t: Number of screw teeth

W: Wight of powder.(N)

« : Coefficient of friction between powder and screw material.

r = 15mm = 0.015m

n_t = number of teeth

μ = 0.3

λ = 1.5

Where : λ is the safety factor.

n_m = 600 rpm

$$\omega = \frac{2\pi 600}{60} = 26.83\ rad/s$$

$$F = 15 * 39.2 * 0.3$$
$$= 176.4\ \text{N}$$

$$T = F * r \qquad (3.2)$$
$$= 2.646\ \text{Nm}$$

Where:

T: Load torque.(N.M)

r: screw radius.(M)

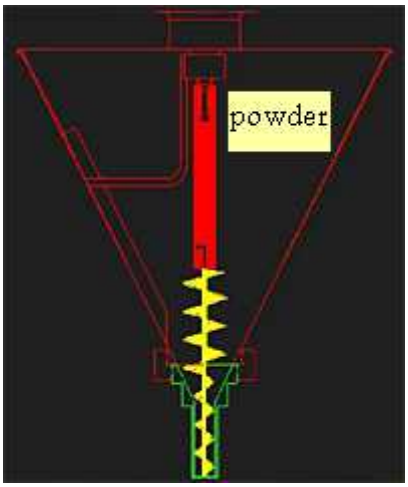


Figure (3.2): Auger construction

$$Tm = T * a \qquad (3.3)$$

$$= 3.97 N.M$$

Where:

Tm: motor torque (N.m).

λ: safety factor.

$$p = Tm * w \qquad (3.4)$$

$$= 3.97 * 62.83$$

$$= 250\ Watt$$

Where:

P: motor power.

w: motor speed (rad/sec)

3.2.2 Roll pulling motor

This motor is used to pull the roll that uses a construct sacks.

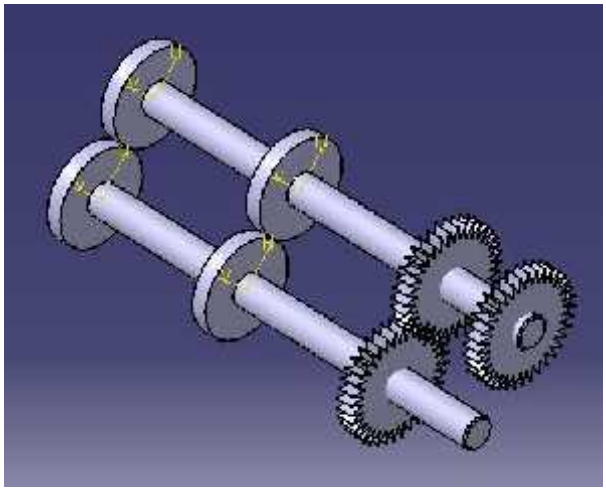


Figure (3.3): Pulling roll construction

$$Tl = T_{L0} + J_1 \sim + \frac{J_2 \sim}{\vdots} + T_{roll} \qquad (3.5)$$

Where:

T_l : Instantaneous value of developed load torque.(N.M).

T_{L0}: Instantaneous value of load (resisting) torque, referred to motor shaft.(N.M).

J_1: Moment of inertia for first cylinder.(Kg-m^2).

J_2: Moment of inertia for second cylinder.(Kg-m^2).

a: Ratio of gear and equal 1.

$\sim = \frac{d\mu}{dt}$: Angular acceleration.

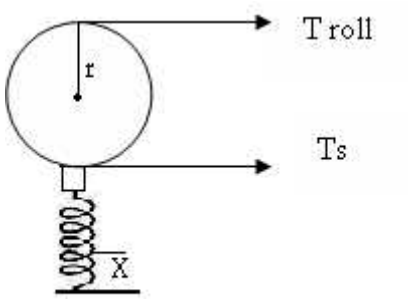


Figure (3.4): Moving the roll

$$T_{roll} = Ts + J\frac{d\mu}{dt} \qquad (3.6)$$
$$= 2KXr + J\sim$$

Where:

$$F_s = KX \qquad (3.7)$$

$$Ts = 2(KX)r \qquad (3.8)$$

$$Tl = T_{L0} + J_1\sim + \frac{J_2\sim}{} + T_{roll} \qquad (3.9)$$

$$Tm = Tl * a \qquad (3.10)$$

$$p = Tm * w \qquad (3.11)$$

Where:

K: stiffness of spring.

X: compression distance of spring.

3.3 Power and control circuits for filling and pulling motor

- **Power circuit**

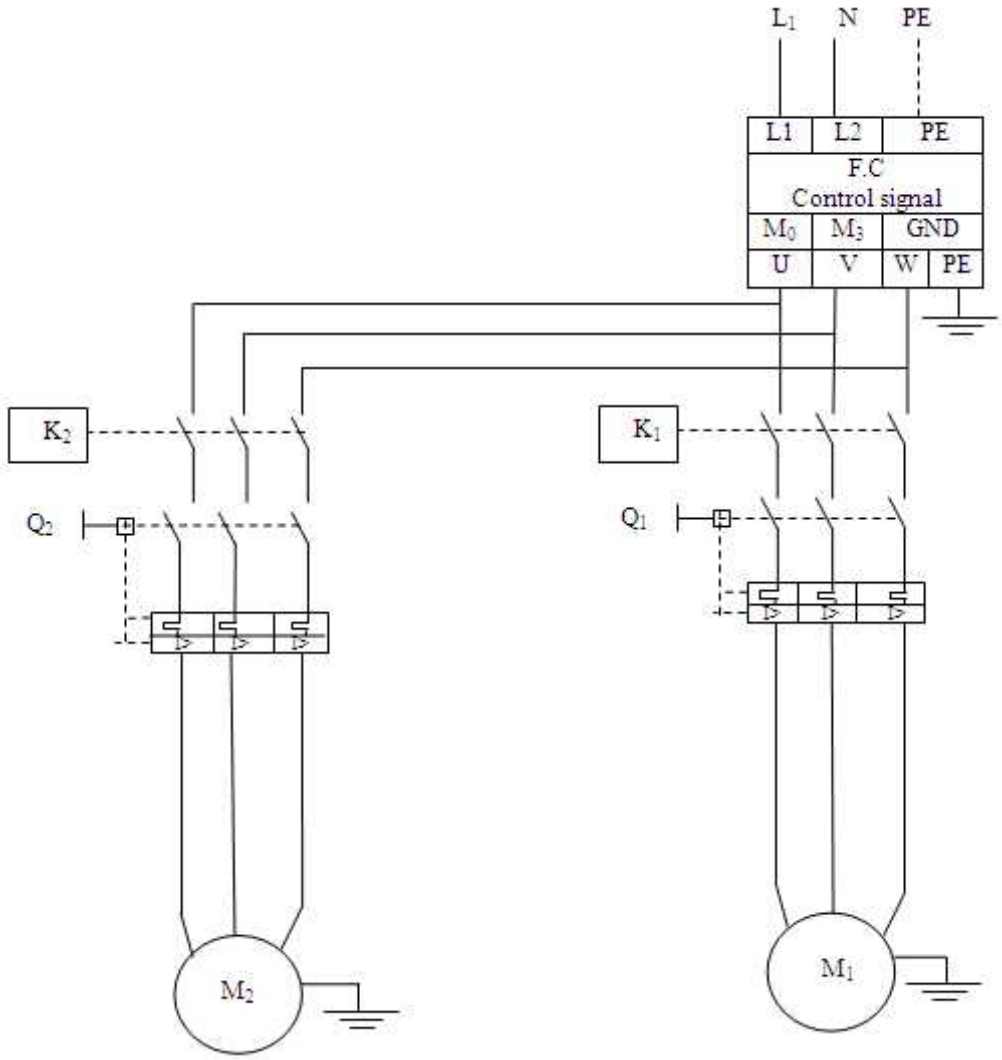
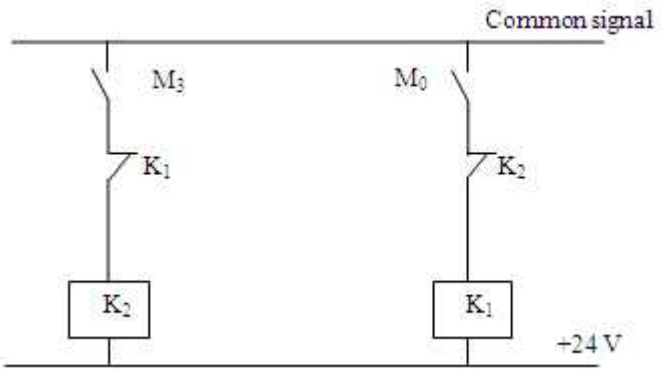


Figure (3.5): Motors power circuit

- **Control circuit**



Figure(3.6): Control circuit

3.4 Pneumatic design

In this part we will calculate the cross section of the pistons.

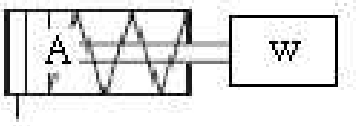


Figure (3.7): Piston load

$$F = w\ll + m * a + Fext \qquad (3.12)$$

$$A = \frac{F}{P} \qquad (3.13)$$

Where:

w: weight (N)

μ: friction factor

m: mass (kg)

a: linear acceleration (m/s^2)

F_{ext}: force needed to ironing the sack (N)

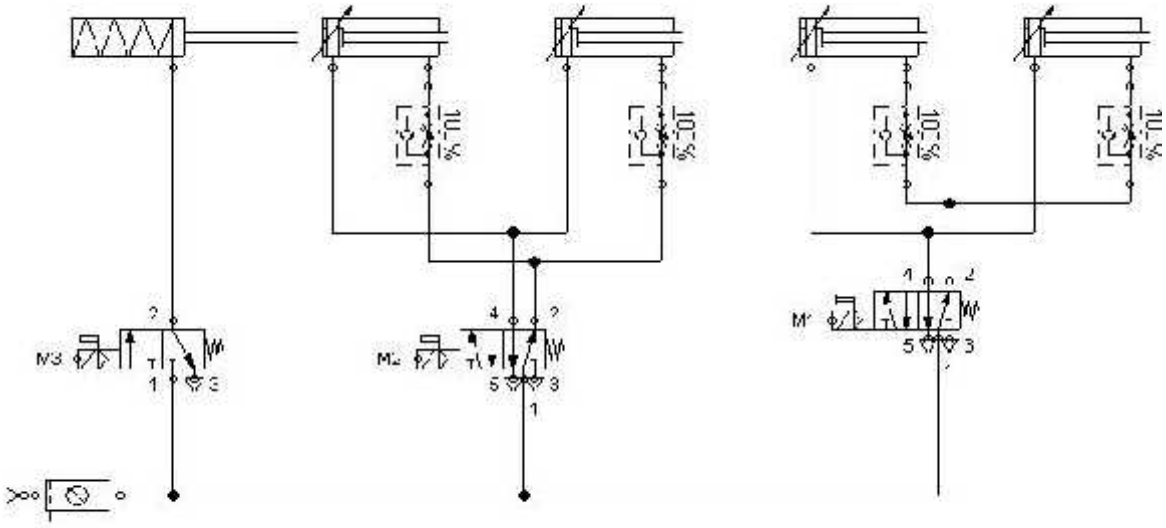
F: force (N)

A: cross section area of piston (m^2)

P: pressure (bar)

3.4.1 Pneumatic circuit power

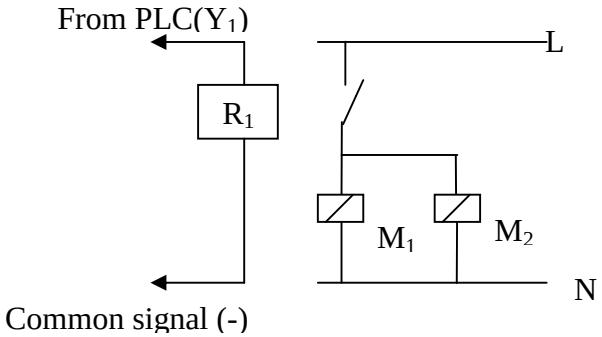
This circuit describe the pistons that move the ironing unit and the cutter.



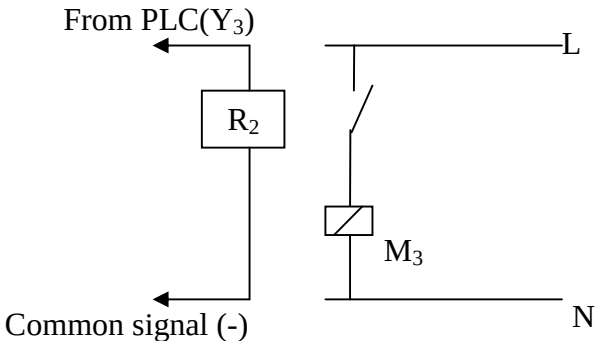
Figure(3.8): Hydraulic power circuit

3.4.2 Control circuit

1- For vertical and horizontal piston



2- For cutting piston



(b)

Figure(3.9): Control circuits, (a): ironing unit, (b) cutting piston

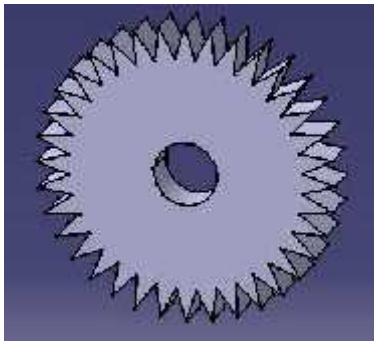
3.5 Mechanical design

This section talks about mechanical machine parts and elements used, then how the implementation method is to be constructed. Also there are detailed dimensions of the whole elements used with directed positions.

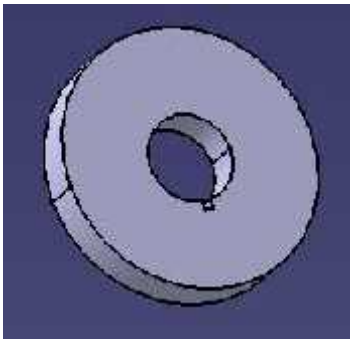
The mechanical system in the project has main parts, those parts are combined together to form mechanical units, and those units are combined also together for forming the machine. Following is a brief discussion about each one of the components.

In the project according to the mechanical side, the machines rigid body (base-table) represents the main supporter of the machine that takes the trouble of handling all other components such as pulling units, movement units, filling unit and ironing unit.

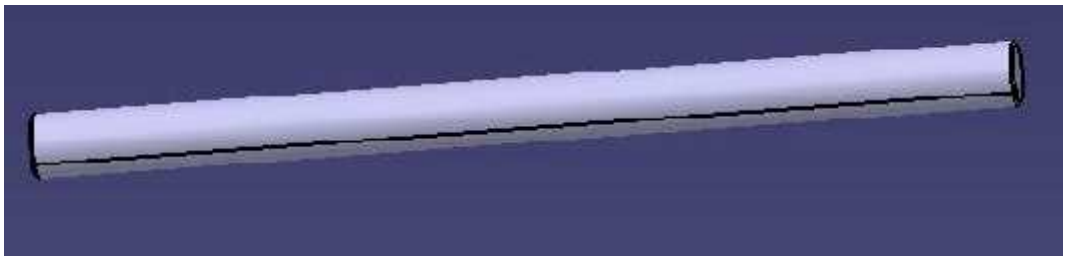
Pulling units represent pulling induction motor, pulling columns and wheels. Following figures appear the previous mentioned parts.



(a)



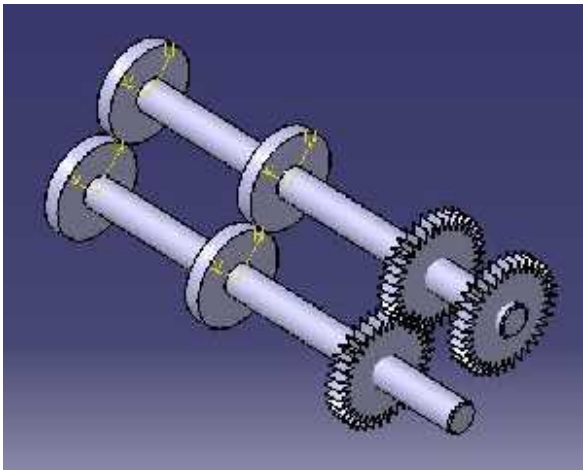
(b)



(c)

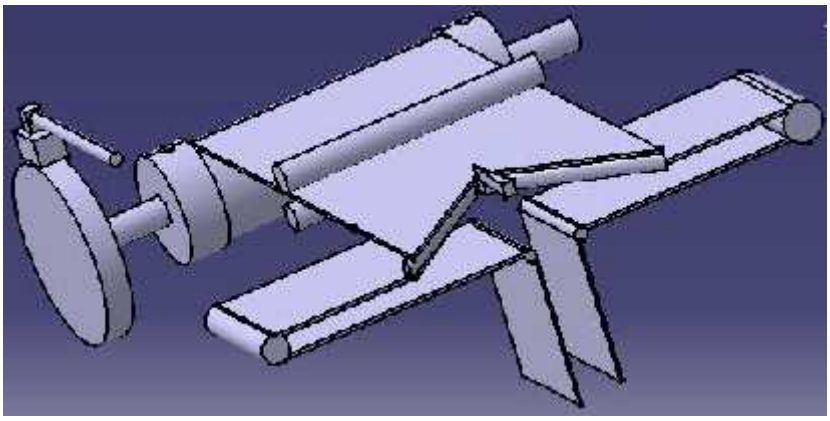
Figure (3.10): Pulling units parts: (a): 1:1 gear, (b): Pulling desk, (c): Pulling rod

Now those parts are to be connected together to form the following figure.



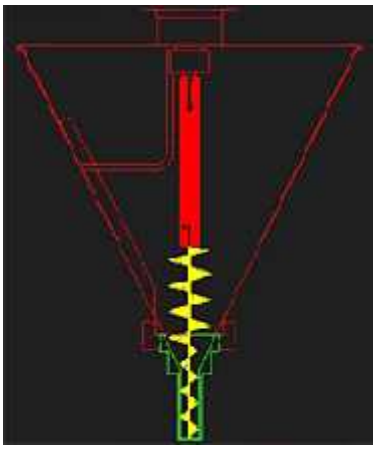
Figure(3.11): Pulling unit

Movement units represent rollers that move the plastic roll. This unit contains rollers. For more details see the figure below.



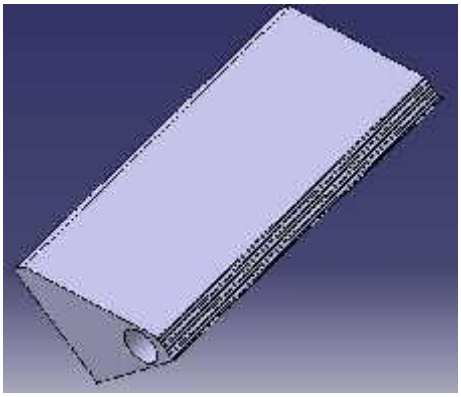
Figure(3.12): Movement units

Filling units represent a cone, auger and the filling motor.

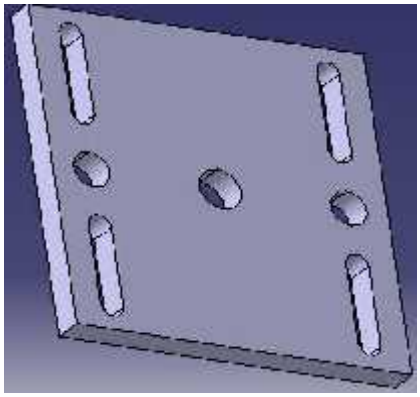


Figure(3.13): Filling unit

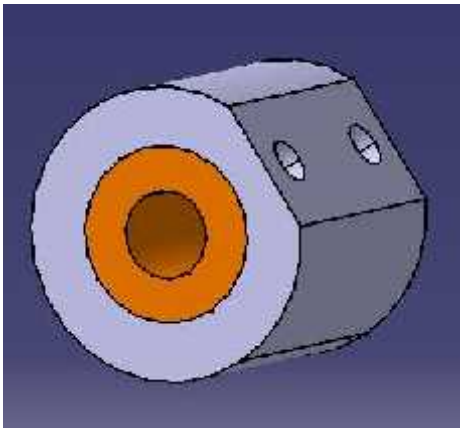
Ironing units contains the heater handler, boxes and pulling pistons. For more details see the figure below.



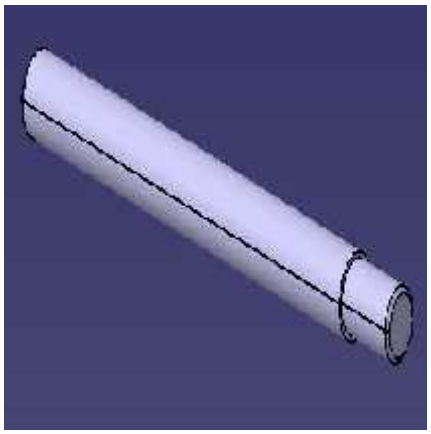
(a)



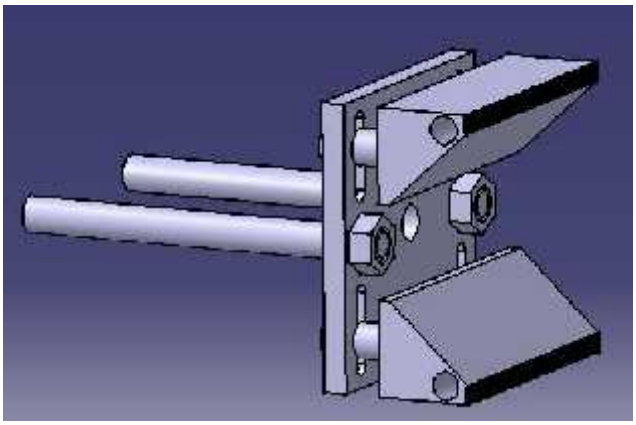
(b)



(c)

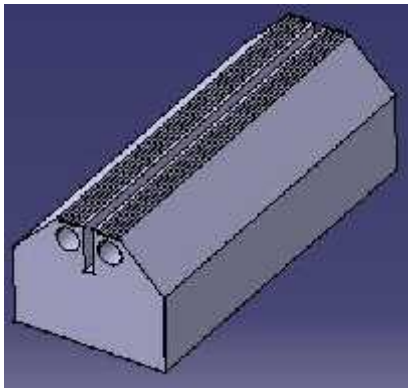


(d)

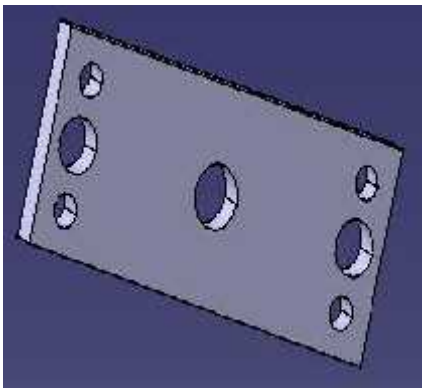


(e)

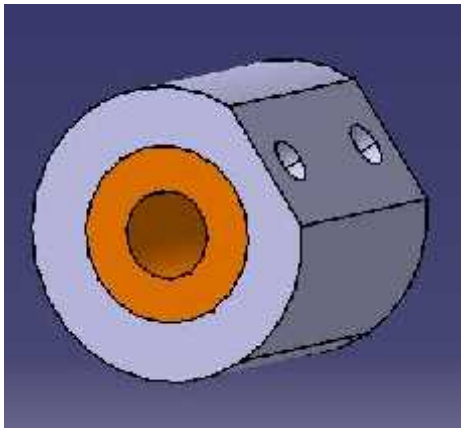
Figure(3.14): Ironing vertical heater: (a): vertical heater, (b): Held plat , (c): Box (d): Rod mover, (e): Vertical heater unit



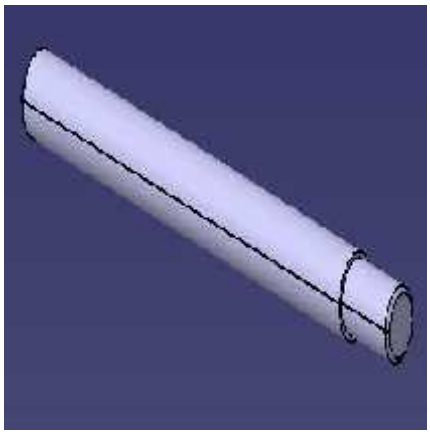
(a)



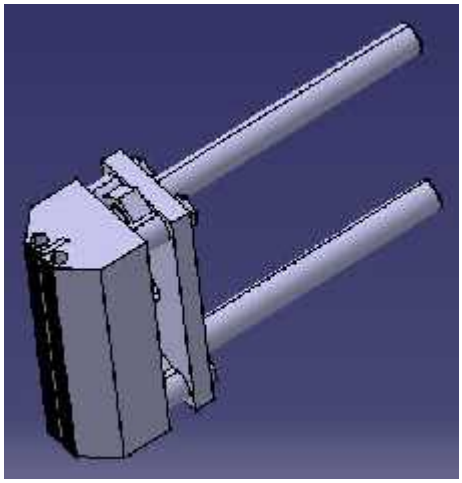
(b)



(c)



(d)



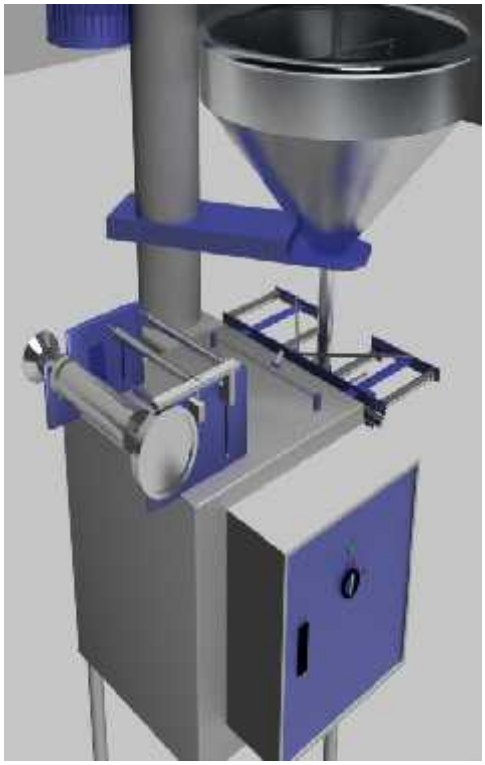
(e)

Figure(3.15):Ironing horizontal heater: (a): horizontal heater, (b): Held plat , (c): Box (d): Rod mover, (e): horizontal heater unit

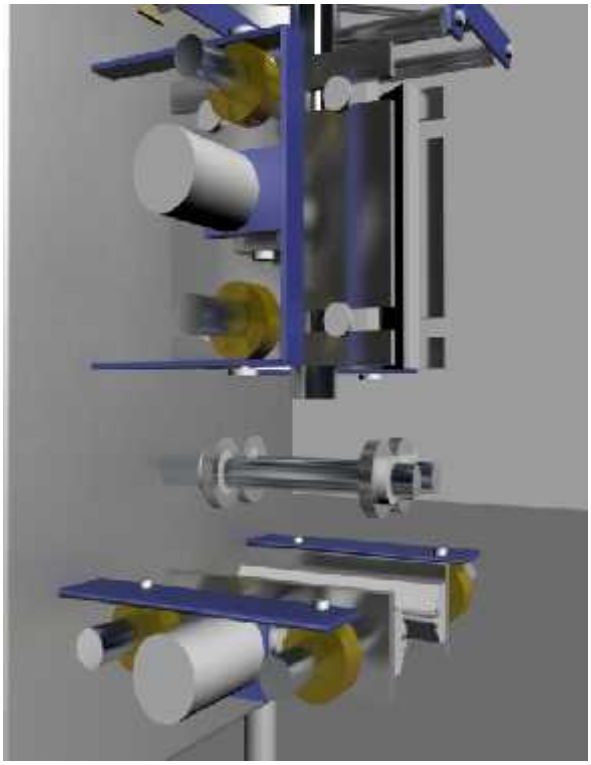
All mechanical components were assembled together to form the final shape of the machine. That configuration is clear enough in the comprehensive figure shown below.

(a)

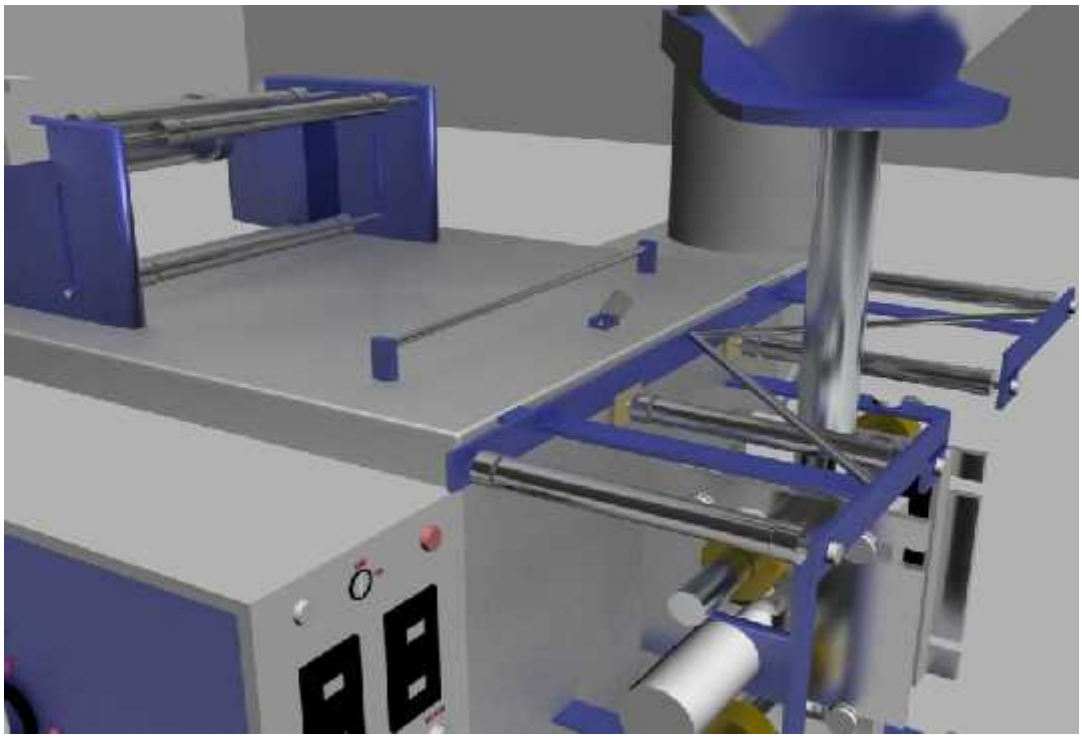
(b)



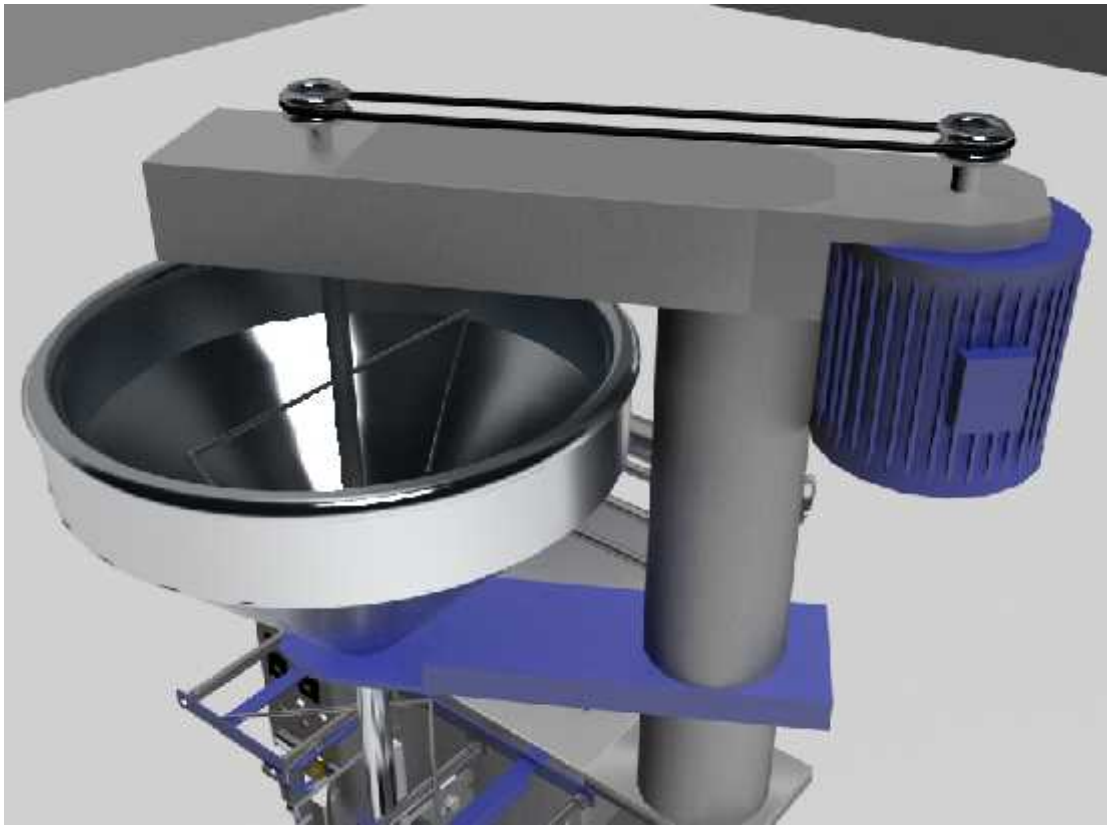
(c)



(d)



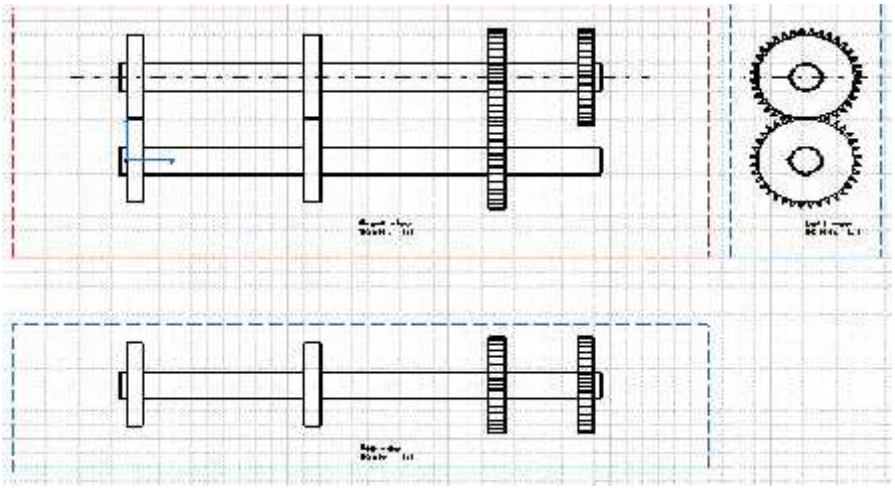
(e)



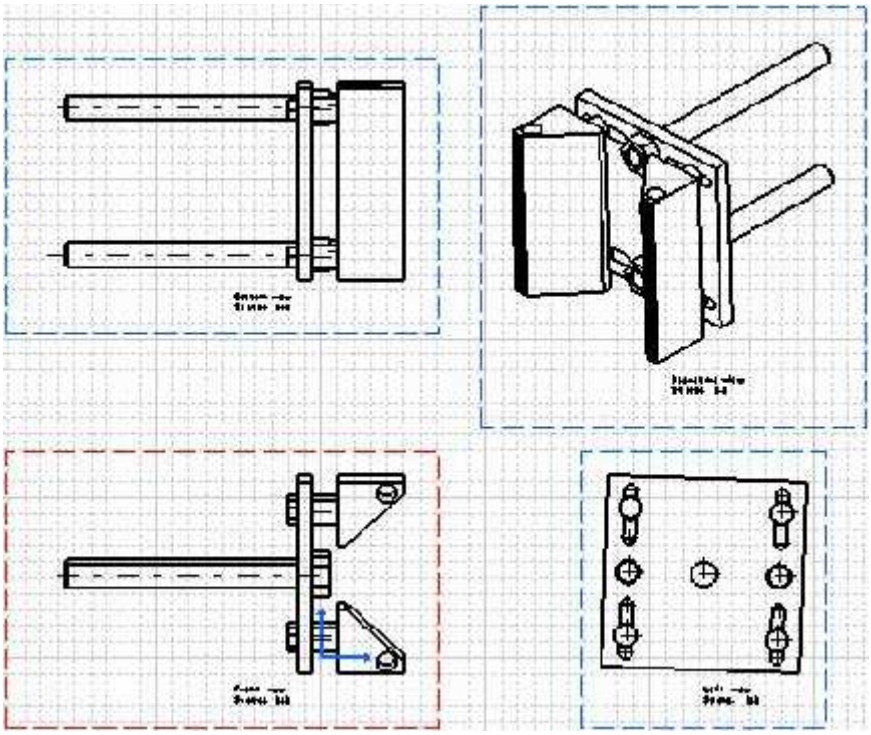
(f)

Figure(3.16): assembly of machine: (a): Front view, (b): Left view, (c):Roll view, (d): Heaters view, (e): roll movement view, (f): cone view

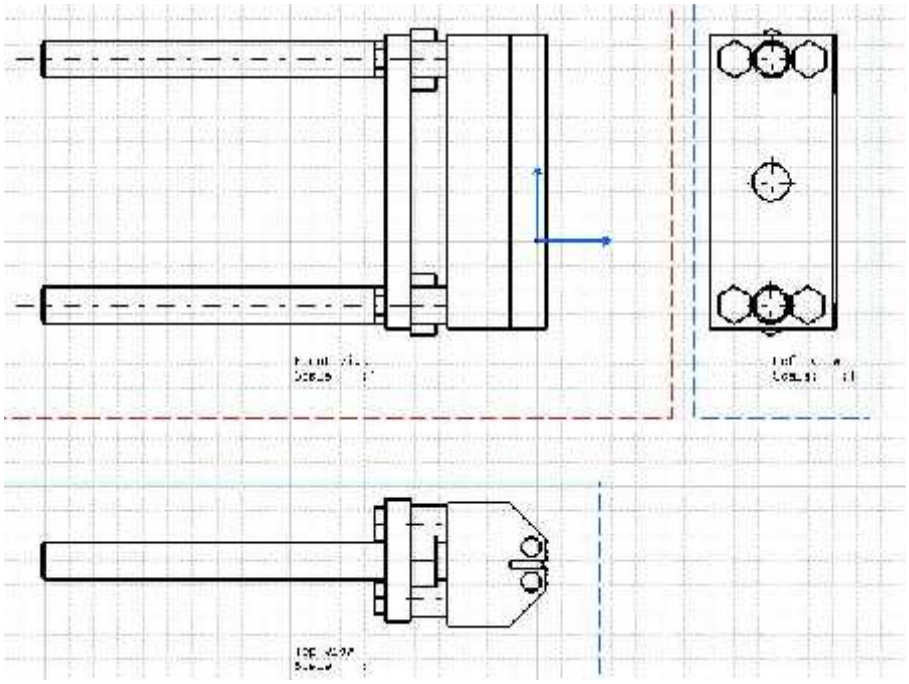
Following figure shows the projections of the main machine platform.



Figure(3.17): Pulling unit projection

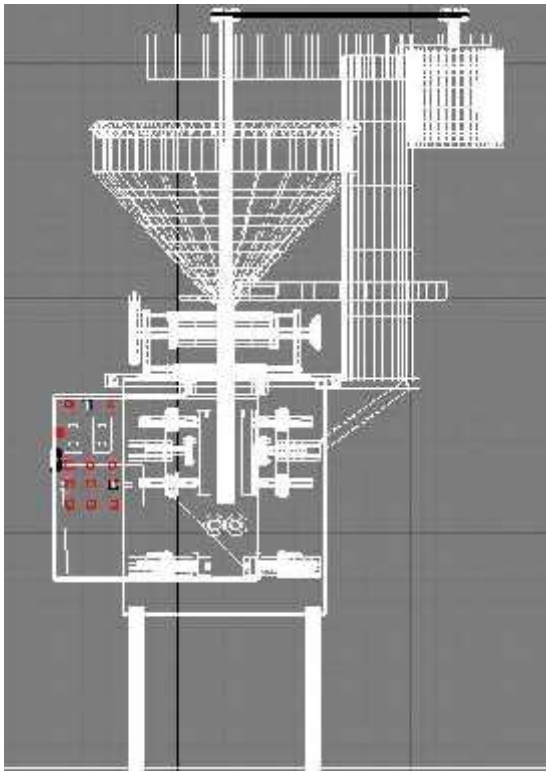


(a)

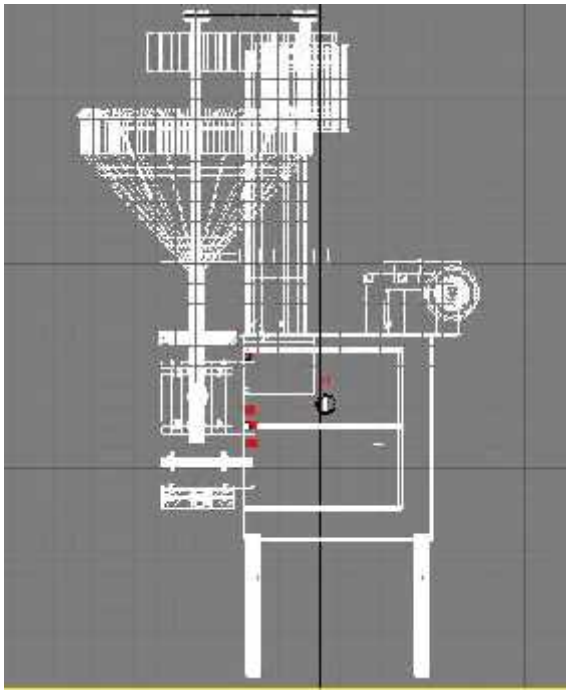


(b)

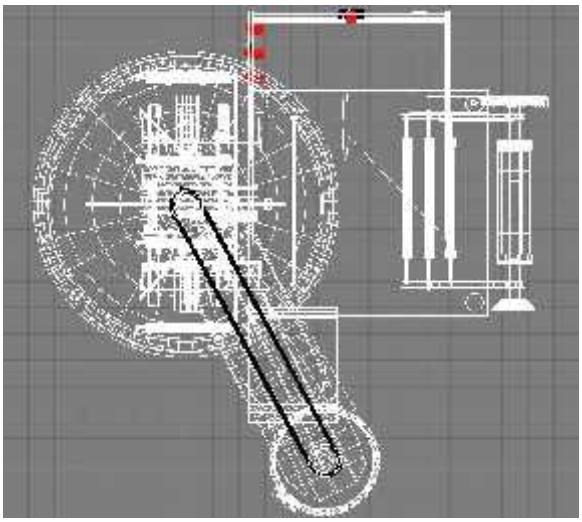
Figure(3.18): Ironing unit (a): Vertical heater, (b): horizontal heater



(a)



(b)



(c)

Figure(3.19): Projection of the machine: (a): front, (b): left, (c): top

3.6 Controllers

In this project it has been used two main controllers which are PLC controllers and temperature controllers.

3.6.1 PLC program

PLC controller takes the trouble of controlling many operations within the machine such as roll pulling, ironing period, filling and cutting.

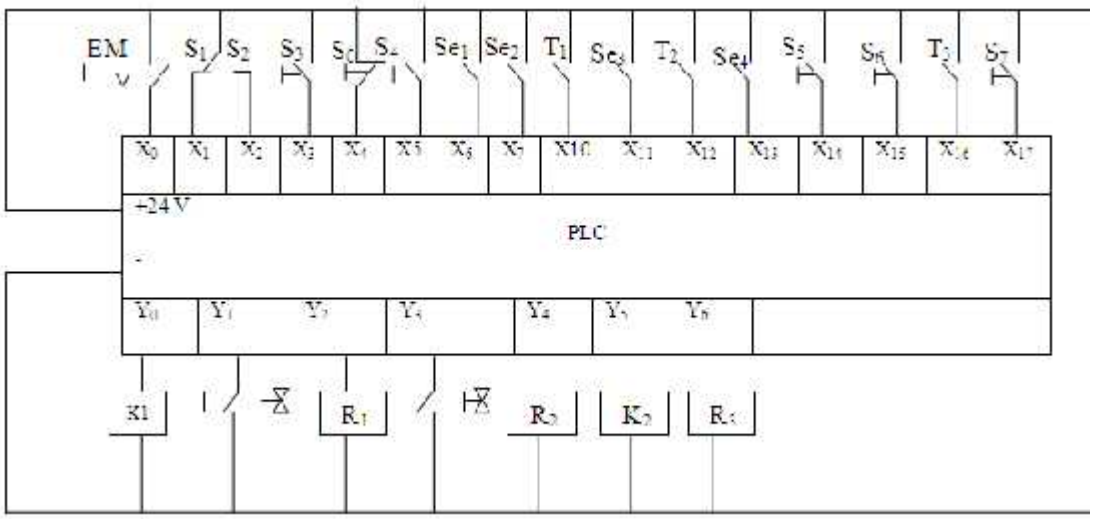
Following is the allocation table of the PLC program that has been used for operations control.

Table (3.1): allocation table

Inputs	**Symbol**	**Logic allocation**
Select auto switch on.	S_1	S_1: Auto operation.
Select manual switch on.	S_2	S_2: Manual operation
Emergency	EM	EM: Is pressed all operation are off.
Start	S_3	S_3: Is pressed, machine on.
Stop	S_0	S_0: Is pressed, machine off
Manual start roll	S_4	S_4:Is pressed, pulling the roll
Temperature control alarm	Se_1	Se_1: Heater alarm, $se_1 = 1$
Photo cell	Se_2	Se_2:Stop roll , $se_2 = 1$.
Pulling roll timer	T_1	T_1: Start pull the roll; T=1.
Piston sensor	Se_3	Se_3: Stop piston; $Se_3 = 1$
Ironing timer	T_2	T_2: Start ironing operation,T_2=1
Cutting piston sensor	Se_4	Se_4:Go back piston; Se_4=1.
Manual start cutting	S_5	S_5: Is pressed, cutting process.
Manual start ironing	S_6	S_6: Is pressed, ironing process.
Filing timer	T_3	T_3: Start filing,T_3=1
Manual filling	S_7	S_7: Is pressed filling start

Output.		
Roll motor	Y_0	Y_0= 1, Start run motor.
Start piston move	Y_1	Y_1 = 1, Piston move
Ironing timer	Y_3	Y_3 = 1, Timer start.
Filling motor	Y_4	Y_4 = 1, Start filling.
Filling timer	Y_5	Y_5 = 1, Start timer.
Pulling roll timer	Y_6	Y_6 = 1: Start timer

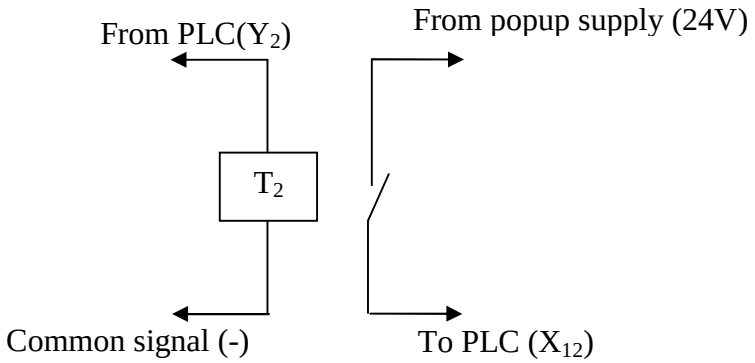
The PLC connection is shown below in figure (3.20).



Figure(3.20): PLC connection

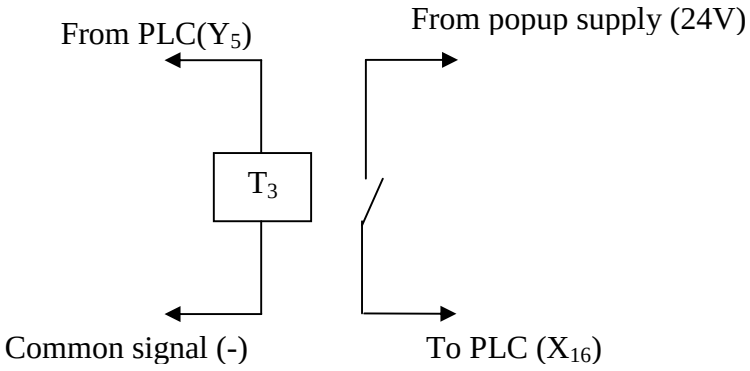
3.6.1.1 Timer circuits

1- Ironing timer



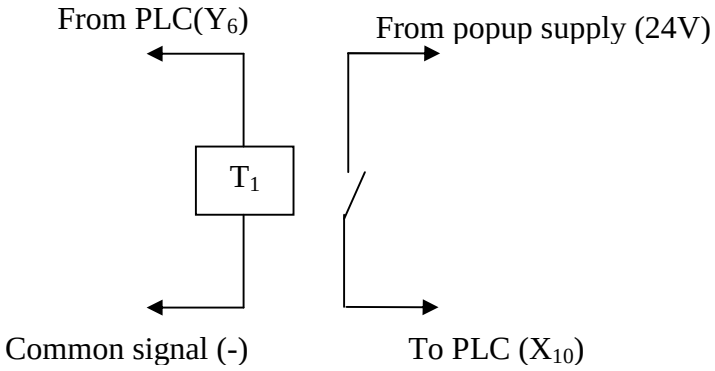
(a)

2- Filing timer



(b)

3- Pulling timer



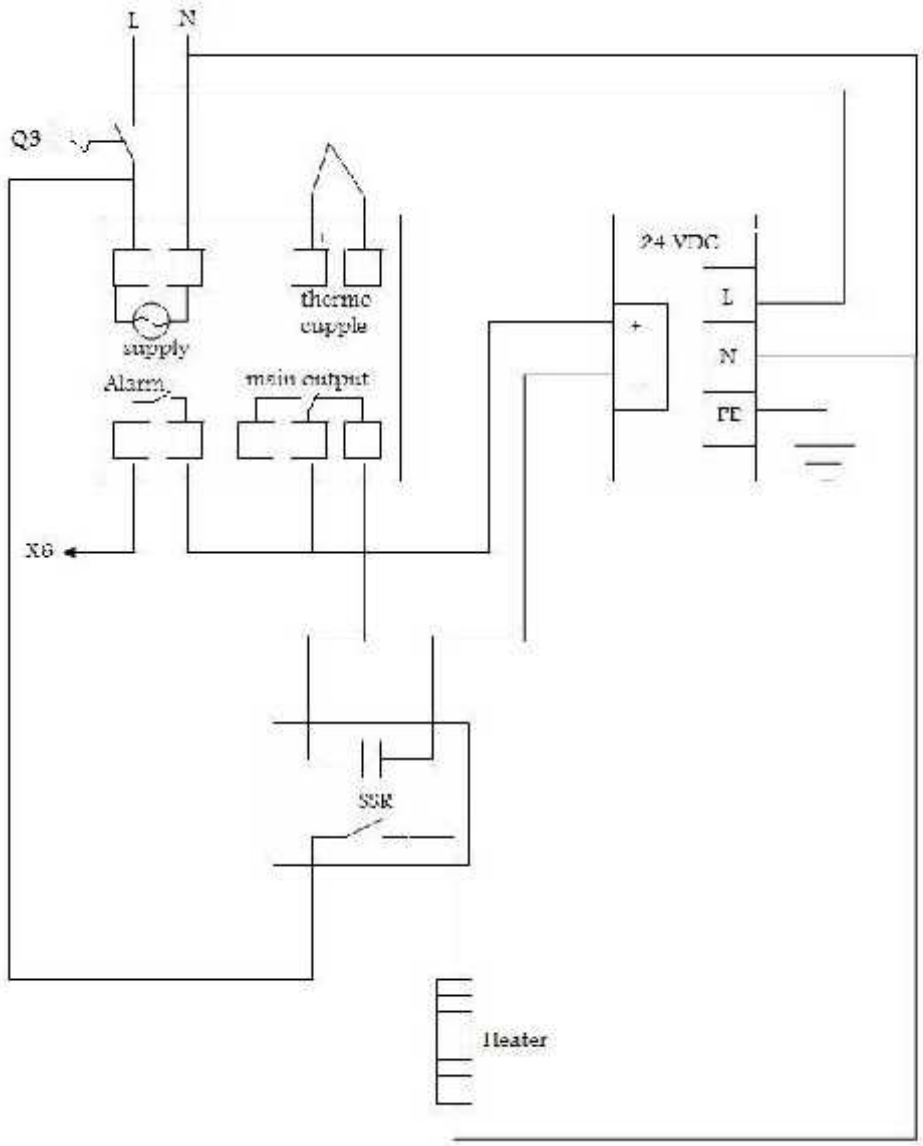
(c)

Figure(3.21): Timer control circuits: (a) Ironing timer, (b) Filling timer, (c) Pulling timer

3.6.2 Temperature controllers

Those controllers take the trouble of controlling directions of both sides of the sack, horizontal and vertical directions.

Following figure shows the connection technique of one of the above temperature controllers, and the second one is to be connected in a similar way.



Figure(3.22): Temperature control circuit

3.7 Quantity of product

After testing the filling motor we find that every one revolution fill 10 gram

1 rev …….. 10g

X = 200 g

$X = \frac{200}{10}$ = 20 rev (3.14)

n= 600 rpm

where

n: motor speed

number of sacks that we fill it in one minute

$$sacks = \frac{600}{20} = 30 \text{ sacks} \qquad (3.15)$$

Time needs for filling one sack= $\frac{60}{30}$ = 2 sec

- **Roll motor time**

The length of sack is constant = 12 cm

We need one sack

$$r = \frac{12}{2\pi} = 2 \qquad (3.16)$$

Where

r: radius of pulling roller

in one revolution we pull one sack

n_{mot} = 600 rpm

To pull one sack we need $\frac{60}{600} = 0.1$ s

<u>ironing piston</u>

the acceleration of push piston is

a = 0.3m/s^2

the distance between heaters = 4 cm

the distance that one heater ……. = 0.2 m

$$t = \sqrt{\frac{0.02}{0.3}} = 0.3 \text{ s}$$

Let the ironing time and cut time = 5 seconds

The time that needed to prepare the sack and fill it = 2 + 0.1 + 0.3 = 2.4 sec

2.4 * 2 = 4.8 sec

$\frac{60}{4.8}$ = 12.5 sack

That mean the machine will produce 13 sacks in one minute.

CHAPTER FOUR

PROTECTION

4.1 Introduction

4.2 Contactor

4.3 Relay

4.4 Fuse

4.5 Circuit breaker

4.6 Over load

4.1 Introduction

The power circuit of an automatic control system must perform the function of isolation, safety control, functional control and electrical protection, which detected overloads and short circuits.

Protection devices must be used in electrical control circuits to detect any electrical and mechanical problems, which can occur in the load.

Any protection devices must allow the motor to start but also protect the motor by preventing its operation when an over current occurs for too long a time period.

4.2 Contactor

A contactor is an electrically controlled switch (relay) used for switching a power circuit. A contactor is activated by a control input which is a lower voltage / current than that which the contactor is switching. Contactors come in many forms with varying capacities and features. Unlike a circuit breaker a contactor is not intended to interrupt a short circuit current

Contactors range from having a breaking current of several amps and 110 volts to thousands of amps and many kilovolts. The physical size of contactors ranges from a few inches to the size of a small car.

Contactors are used to control electric motors, lighting, heating, capacitor banks, and other electrical loads.

Figure (4.1): Contactor

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.

Contactors are designed to be directly connected to high-current load devices, not other control devices, 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 reduct the gap, increasing the inductive impedance of the circuit.

4.3 Relay

A relay is an electrical switch that opens and closes under the control of another electrical circuit. In the original form, the switch is operated by an electromagnet to open or close one or many sets of contacts. Because a relay is able to control an output circuit of higher power than the input circuit, it can be considered to be, in a broad sense, a form of an electrical amplifier.

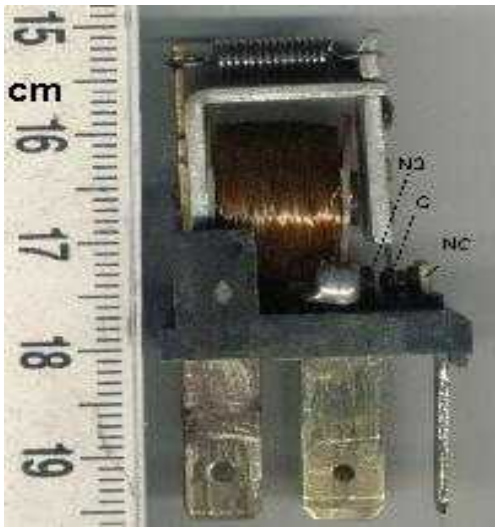


Figure (4.2): relay

When a current flows through the coil, the resulting magnetic field attracts an armature that is mechanically linked to a moving contact. The movement either makes or breaks a connection with a fixed contact. When the current to the coil is switched off, the armature is returned by a force approximately half as strong as the magnetic force to its relaxed position. Usually this is a spring, but gravity is also used commonly in industrial motor starters. Most relays are manufactured to operate quickly. In a low voltage application, this is to reduce noise. In a high voltage or high current application, this is to reduce arcing.

4.3.1 Relays are used to

- Control a high-voltage circuit with a low-voltage signal.
- Control a high-current circuit with a low-current signal..
- Detect and isolate faults on transmission and distribution lines by opening and closing circuit breakers.
- Isolate the controlling circuit from the controlled circuit when the two are at different potentials.
- Perform logic functions.
- Perform time delay functions. Relays can be modified to delay opening or delay closing a set of contacts.

4.4 Fuse

In electronics and electrical engineering a fuse is a type of over current protection device. Its essential component is a metal wire or strip that melts when too much current flows. When the metal strip melts, it opens the circuit of which it's a part, and so protects the circuit from excessive current.

Fuses (and other over current devices) are an essential part of a power distribution system to prevent fire or damage. When too much current flows through a wire, it may overheat and be damaged or even start a fire. Wiring regulations give the maximum rating of a fuse for protection of a particular circuit. Local authorities will incorporate national wiring regulations as part of law. Fuses are selected to

allow passage of normal currents, but to quickly interrupt a short circuit or overload condition.

Figure (4.3): kind of fuse

The fuse is a piece of wire which can carry a stated current. If the current rises above this value it will melt. If the fuse melts (blows) then there is an open circuit and no current can then flow thus protecting the equipment by isolating it from the power supply. The fuse must be able to carry slightly more than the normal operating current of the equipment to allow for tolerances and small current surges. With some equipment there is a very large surge of current for a short time at switch on. If a fuse is fitted to withstand this large current there would be no protection against faults which cause the current to rise slightly above the normal value.

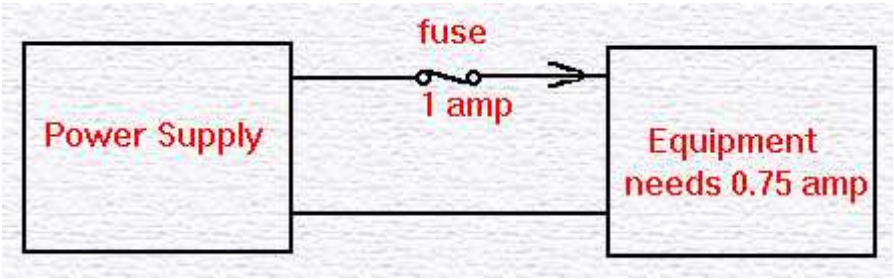


Figure (4.4): Principle operation of fuse

Therefore special antis urge fuses are fitted. These can stand 10 times the rated current for 10 milliseconds. If the surge lasts longer than this the fuse will blow.

Always find out why the fuse blew before replacing it. Occasionally they grow tired and fail. If the fuse is black and silvery then it is likely that there is a dead short (very low resistance) somewhere.

4.4.1 Interrupting rating

A fuse also has a rated interrupting capacity, also called breaking capacity, which is the maximum current the fuse can safely interrupt. Generally this should be higher than the maximum prospective short circuit current. Miniature fuses may have an interrupting rating only 10 times their rated current. Fuses for small low-voltage wiring systems are commonly rated to interrupt 10,000 amperes. Fuses for larger power systems must have higher interrupting ratings, with some low-voltage current-limiting "high rupturing capacity" (HRC) fuses rated for 300,000 amperes. Fuses for high-voltage equipment, up to 115,000 volts, are rated by the total apparent power (megavolt-amperes, MVA) of the fault level on the circuit.

4.4.2 Voltage rating

As well as a current rating, fuses also carry a voltage rating indicating the maximum circuit voltage in which the fuse can be used. For example, glass tube fuses rated 32 volts should never be used in line-operated (mains-operated) equipment even if the fuse physically can fit the fuse holder. Fuses with ceramic cases have higher voltage ratings. Fuses carrying a 250 V rating may be safely used in a 125 V circuit, but the reverse is not true as the fuse may not be capable of safely interrupting the arc in a circuit of a higher voltage. Medium-voltage fuses rated for a few thousand volts are never used on low voltage circuits, due to their expense and because they cannot properly clear the circuit when operating at very low voltages.

4.5 Circuit breaker

A circuit breaker is an automatically-operated electrical switch designed to protect an electrical circuit from damage caused by overload or short circuit. Unlike a fuse, which operates once and then has to be replaced, a circuit breaker can be reset (either manually or automatically) to resume normal operation. Circuit breakers are made in varying sizes, from small devices that protect an individual household appliance up to large switchgear designed to protect high voltage circuits feeding an entire city.

Figure (4.5): kind of circuit breaker

Magnetic circuit breakers are implemented using a solenoid (electromagnet) that's pulling force increases with the current. The circuit breaker's contacts are held closed by a latch and, as the current in the solenoid increases beyond the rating of the circuit breaker, the solenoid's pull releases the latch which then allows the contacts to open by spring action.

The maximum short-circuit current that a breaker can interrupt is determined by testing. Application of a breaker in a circuit with a prospective short-circuit current higher than the breaker's interrupting capacity rating may result in failure of the breaker to safely interrupt a fault.

4.5.1 Types of circuit breakers

There are many different technologies used in circuit breakers and they do not always fall into distinct categories. Types that are common in domestic, commercial and light industrial applications at low voltage (less than 1000 V) include:

- MCB (Miniature Circuit Breaker rated current not more than 100 A. Trip characteristics normally not adjustable, Thermal or thermal-magnetic operation. Breakers illustrated above are in this category.
- MCCB (Moulded Case Circuit Breaker) rated current up to 1000 A. Thermal or thermal-magnetic operation. Trip current may be adjustable.
- Vacuum circuit breaker with rated current up to 3000 A.
- Air circuit breaker with rated current up to 10,000 A

4.6 Overload

To protect the motor and related circuits from accidental overloads, either the starter of the motor should be equipped with automatic devices that will open the circuit should an overload exist; this protection can be provided by fuses, circuit breaker or overload relay.

An "Over current Relay" is a type of protective relay which operates when the load current exceeds a preset value. In a typical application the over current relay is used for over current protection, connected to a current transformer and calibrated to operate at or above a specific current level. When the relay operates, one or more contacts will operate and energize a trip coil in a Circuit Breaker and trip (open) the Circuit Breaker.

4.6.1 Thermal Overload

Overload heaters work on principle that motor load (and therefore motor temperature) is directly related to the current drawn by the motor. Current flowing from the motor contactor to the motor passes through the motor.

Overload heaters (one per phase) which are mounted in the control overload block. If the motor current exceeds the desired value, the heat produced by the motor overload heater will cause a control circuit contact in the overload block to open, drop out the contactor coil, and stop the motor. Manufacturers provide Heater Selection Charts from which the correct heater is chosen based on the motor nameplate Full Load Amps (FLA).

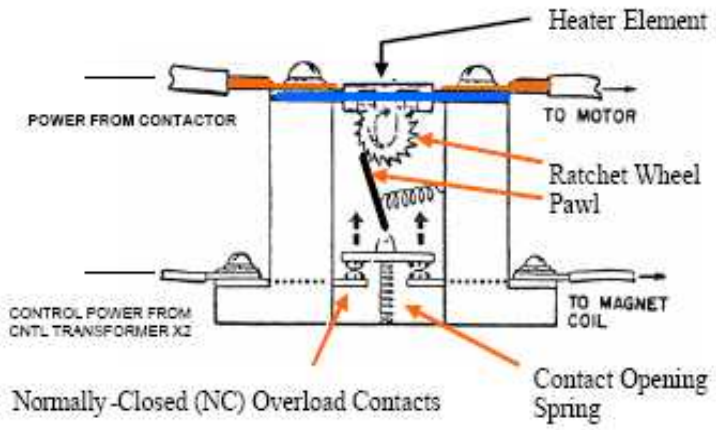


Figure (4.6): Melting Alloy Type Overload

4.6.1.1 Operating Principle

When the motor current exceeds the rated value, the temperature will rise to a point where the alloy melts; the ratchet wheel is then free to rotate, and the contact pawl moves upward under spring pressure allowing the control circuit contacts to open. After the heater element cools, the ratchet wheel will again be held stationary and the overload contacts can be reset. Severe fault currents can damage the heater

element and they should be replaced after such an occurrence. However, normally overloads, usually, will not affect the heater element or alter its accuracy.

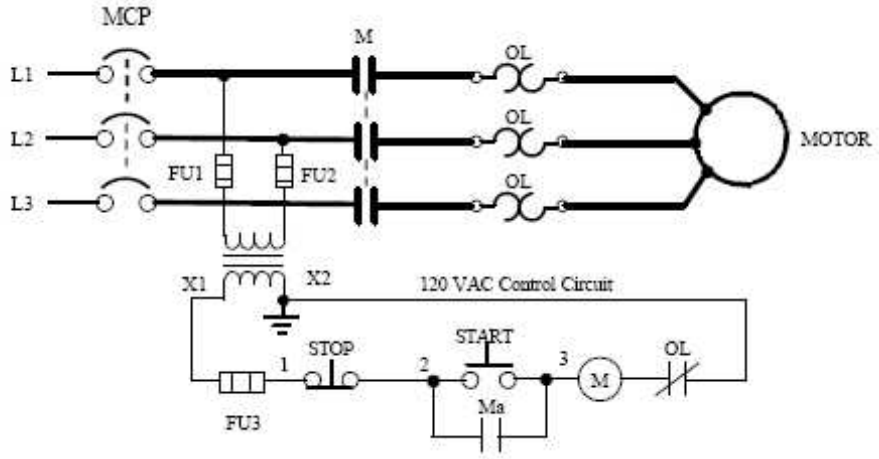


Figure (4.7): Schematic Diagram

Circuit operation is as follows:

- Close MCP to apply power to the circuit.
- Depress momentary START push button. This causes the Main Contactor Coil M to be energized.
- Main Contactor Coil M closes M contacts (3) to start motor and also closes the Ma auxiliary contact.
- Auxiliary Contact Ma seals around the momentary START push button which can now be released.
- The motor continues to run until the normally closed STOP push button is momentarily depressed.
- In the event of an overload, the overload heaters will open the normally closed OL contact and drop-out the Main Contactor M and stop the motor.
- After an overload trip, the overload heaters must cool to permit resetting of the overload contact.

Chapter five

Conclusions and Recommendation

5.1 Conclusion

5.2 Recommendation

5.1 Conclusion

Powder filling machines come in a wide variety of sizes, shapes, filling principles and degrees of technical sophistication in response to the ever-widening diversity of powder filling applications around.

The powder filling machine consist of several stages each of them has its own work (auger), but the most important is the filling one, we can developed this stage by weight sensor to get more accuracy.

The variations of auger filling systems available are almost as many as the diversity of powder filling applications.

In low loads as a powder we can brake the AC motor by deceleration parameter in the frequency convertor, without needed a traditional clutch/brake drive.

In the other machines there are ready sacks, but in our machine we have a roll of plastic and the machine prepare the sack and packaging it.

The productivity for this machine is excellent and it can reduce labor cost, time and increase the overall efficiency.

There are many controllers that used to control machines, such as microprocessor, PC, and PLC. The more suitable one is a PLC, because it is fast, very simple, and easy in all phases in installation.

The mass of the material to be filled depends on the number of turns of auger, and after performing proper calculations which in turn basically depends on auger dimensions and the number of the motor turns the amount of the material to be filled by 200 gm per pocket has been found.

It was depend on the amount of fill and the time of the motor rotation and the time required for the pocket closure to determine production quantity per machine which was equal to 13 pockets per minute.

It is possible to increase the production of the machine by increasing filling speed, polling and ironing but that will affect the accuracy of the required weight so there will be increasing or decreasing in the weight.

At low loads in ac motors the deceleration can be reduced by using frequency converter parameter and by this method we can stop using the classical mechanical methods (clutch/brake drive) because of the stoppage time at the high rotation speeds in the frequency converter is 0.1 second.

5.2 Recommendation

- The metal workshops must have highly trained technician to read the plans and to perform the designs.
- The university should provide the proper toolsets which enable student to assemble his project and to test it the university campus so he could get benefit of experiences in the university.
- Such projects should be handled among different departments according to the project nature (we had lots of mechanical problems that we might solve without having enough previous knowledge.
- Once the university administration financially supported graduation projects this, support must be provided at the beginning of the project work to enable students to do their projects according to the time plan and to test them at the proper time.
- Adding some parts to the machine such as the mass sensor and the touch screen which enable to save some other parts.
- Enhancing the machine to be able to fill more than one material type and different weights and to be able to fill large volumes and weights.
    - Adding transmission built and a unit to sort the filled pockets

NT6-13022

Erwin Sick. 1005824 Registration Scanner

- Scanning range:9mm ± 2mm
- Light source: LED red or green selectable
- Light spot size: green:1.5x5mm; red:1.5 x4mm
- Light spot direction: transverse
- Dimensions(WxHxD)30.4x64x80mm
- Sensitivity: Manual
- Supply voltage: DC 10-30V
- Power consumption: <80 mA
- Switching output: PNP/NPN
- Response time: < 50 µs
- Switching frequency: 10KHz
- Connection type: Cable
- Enclosure rating: IP 67
- Housing material: Die-cast metal
- Ambient operation temperature,0°C - +50°C
- Other models are available - please call

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15- http://www.allfill.co.uk

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Appendix A.

Symbols and standards in pneumatics.

- Symbols used in energy conversion and preparation.

Supply

– Compressor with fixed capacity

– Air reservoir with T junction

– Pressure source

Service equipment

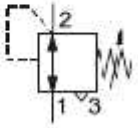
– Filter — Separation and filtration of particles

– Water separator, — Manually operated

– Water separator, automatic

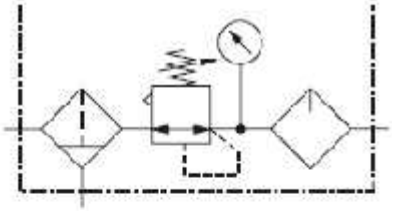
– Lubricator — Metered quantities of oil passed to the air stream

– Pressure regulator — Relieving type - vent hole for excess upstream pressure - adjustable

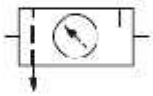


Combined symbols

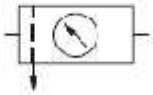
– Air service unit — Filter, Regulator, Gauge, Lubricator



Simplified air service unit



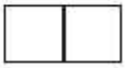
Simplified air service unit without lubricator



- Directional control valves: symbol development.

Valve switching positions
are represented as squares

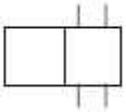
The number of squares shows how many
switching positions the valve has



Lines indicate flow paths,
arrows shows the direction of flow

Shut off positions are identified in the boxes
by lines drawn at right angles

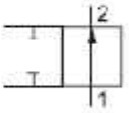
The connections (inlet and outlet ports) are shown
by lines on the outside of the box



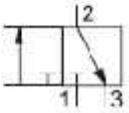
- Directional control valves: ports and positions (ways).

Number of ports
Number of positions

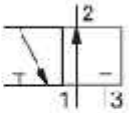
2/2 – Way directional control valve, normally open



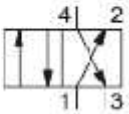
3/2 – Way directional control valve, normally closed



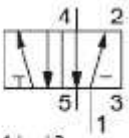
3/2 – Way directional control valve, normally open



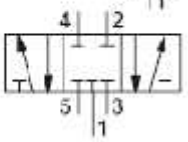
4/2 – Way directional control valve
Flow from 1 → 2 and from 4 → 3



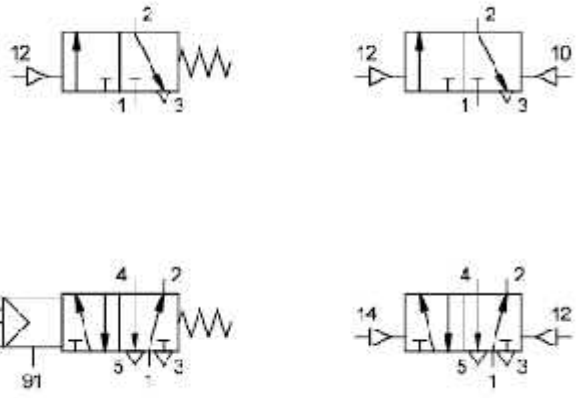
5/2 – Way directional control valve
Flow from 1 → 2 and von 4 → 5



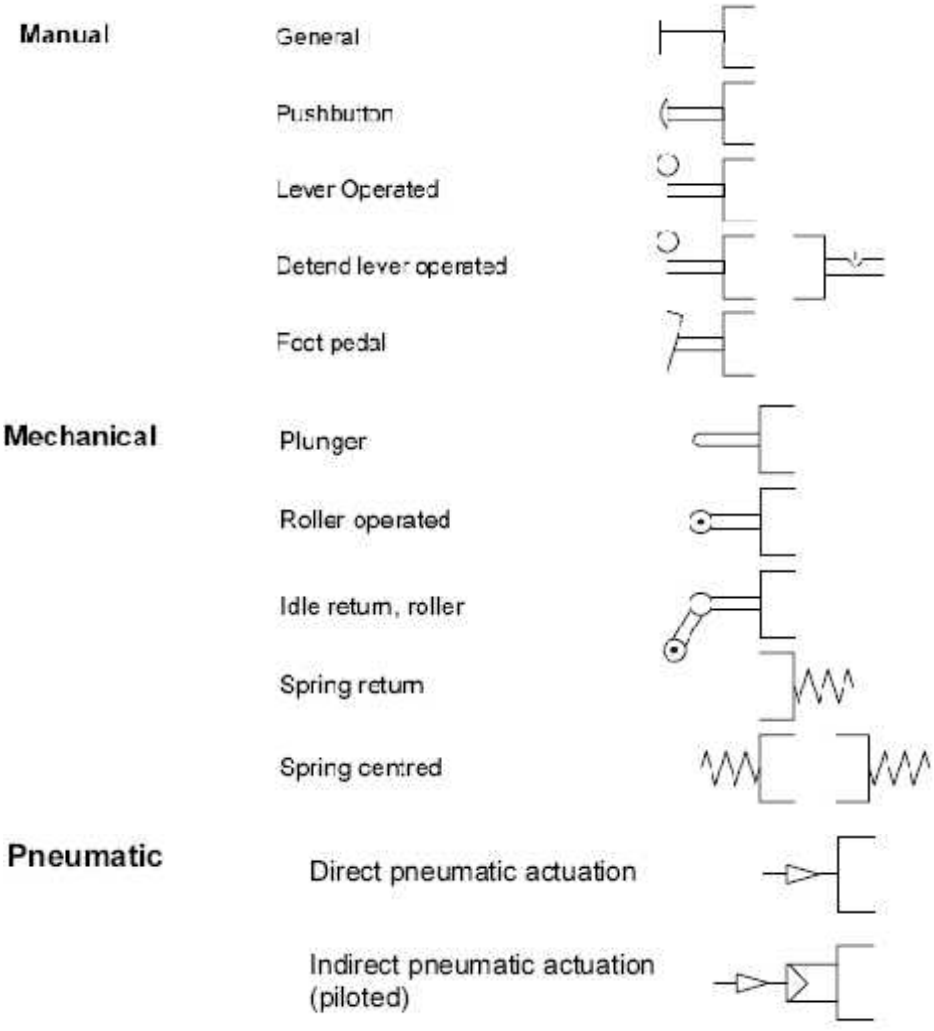
5/3 – Way directional control valve
Mid position closed



- Examples of designations.

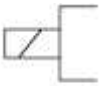


- Methods of actuation.



Electrical

Single solenoid operation



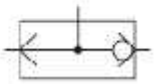
Double solenoid operation

- Non-return valves and derivatives.

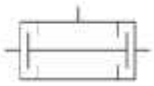
Check valve

Spring-loaded check valve

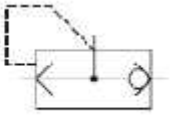
Shuttle valve



Dual-pressure valve



Quick exhaust valve



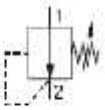
- Flow control valves.

Flow control valve, adjustable

One-way flow control valve

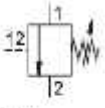
- Pressure valves.

Adjustable pressure regulating valve, non - relieving type

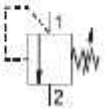


Adjustable pressure regulating valve relieving type

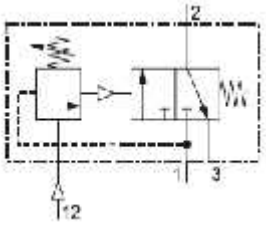
Sequence valve external source



Sequence valve in - line

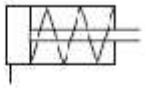


Sequence valve combination

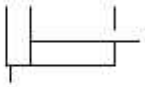


- Linear actuators.

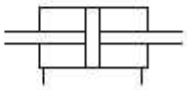
Single-acting cylinder



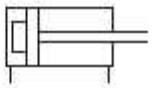
Double-acting cylinder



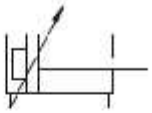
Double-acting cylinder with double ended piston rod



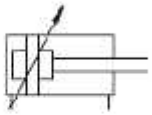
Double-acting cylinder with non-adjustable cushioning in one direction



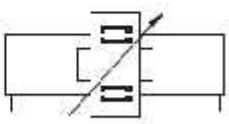
Double-acting cylinder with single adjustable cushioning



Double-acting cylinder with adjustable cushioning at both ends

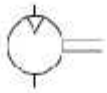


Linear drive with magnetic coupling

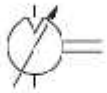


- Rotary motion.

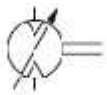
Air motor, rotation in one direction fixed capacity



Air motor, rotation in one direction variable capacity



Air motor, rotation in both directions variable capacity



Rotary actuator

- Auxiliary symbols

Exhaust port without fixture for connection

Exhaust port with threaded connection

Silencer

Line connection

Crossing lines

Pressure gauge

Visual indicator

1- Caopacitive proximity sensor.

CT Series Capacitive Proximity Sensors

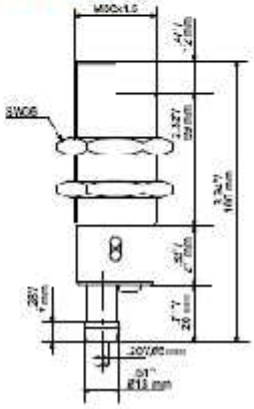
M30 (30 mm) metal – DC

- 6 models available
- Sensitivity adjustment with 20-turns trimmer
- Metal housing with axial cable
- Detects metallic and non-metallic objects
- Complete overload protection
- FCC rated
- Double LED status indicators

CT Series 30DC Capacitive Prox Sensor Selection Chart						
Part Number	Price	Sensing Range	Housing	Output State	Logic	Connection
CT1-AN-1A	<--->	2 to 15mm (0.079-0.59in)	Shielded	N.C.	NPN	2m (6.5') axial cable
CT1-AP-1A	<--->				PNP	2m (6.5') axial cable
CT1-AN-2A	<--->	2 to 20mm (0.079-0.79in)	Unshielded	N.C.	NPN	2m (6.5') axial cable
CT1-AP-2M	<--->				PNP	2m (6.5') axial cable
CT1-CN-2A	<--->	2 to 20mm (0.079-0.79in)	Unshielded	N.C.	NPN	2m (6.5') axial cable
CT1-CP-2M	<--->				PNP	2m (6.5') axial cable

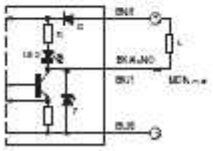
Specifications		
Type	Shielded	Unshielded
Operating Distance	1-15mm (0.039-0.59in)	2-20mm (0.079-0.79in)
Differential Travel	2 to 20%	
Repeat Accuracy	10%	
Operating Voltage	10-30VDC	
Ripple	<10%	
No load Supply Current	8mA	
Load Current	≤200mA	
Leakage Current	≤10μA	
Voltage Drop	1.8 volts maximum	
Output Type	NPN or PNP, N.O. or N.C. (3-wire)	
Switching Frequency	100Hz	
On Time Delay Before Availability	100ms	
Input Voltage Transient Protection	Yes, only if transient peak does not exceed 30VDC	
Input Power Polarity Reversal Protection	Yes	
Output Power Short-Circuit Protection	Yes (device auto resets after overload is removed)	
Temperature Range	-25° to +70° C (-13° to +158° F)	
Temperature Drift	2.5% Nr	
Protection Degree (DIN 40050)	IEC IP65	
LED Indicators	Green: supply Red: N.O. output energized	
Housing Material	Nickel plated brass	
Sensing Face Material	PBT	
Tightening Torque	100Nm (73.7lb.ft.)	
Weight (cable/connector)	200g (19.05oz)	

Dimensions

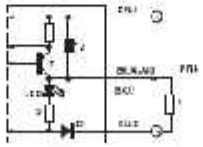


Wiring diagrams

NPN output



PNP output



Cables and Accessories

Cables and accessories can be found starting on page 17-48.

Inductive Proximity Sensor — E2Q2

Limit Switch Style Proximity Sensor with 5-Position Sensing Head

- Sensing face easily adjusts to one of five directions
- Easy to install and same mounting dimensions as a standard limit switch
- Integrated short circuit and reverse polarity protection
- Plastic body with stainless steel screws
- Weld field immune models available
- Conduit openings 1/2" NPT and Brad Harrison MiniChange® connector versions available

Ordering Information

■ DC INPUT TYPE

Type	Sensing distance	Output type	Part number	
			1/2"-NPT conduit opening	4-pin MiniChange connector*
Shielded	20 mm (0.78 in)	NPN (NO+NC)	E2Q2-N20E3-U	E2Q2-N20E3-50
		PNP (NO+NC)	E2Q2-N20F3-U	E2Q2-N20F3-50
Unshielded	30 mm (1.18 in)	NPN (NO+NC)	E2Q2-N30ME3-U	E2Q2-N30ME3-50
		PNP (NO+NC)	E2Q2-N30MF3-U	E2Q2-N30MF3-50

Note: *Use Brad Harrison connector #10400A01F120 (12 foot) or equivalent.

■ AC INPUT TYPE

Type	Sensing distance	Output type	Part number	
			1/2"-NPT conduit opening	4-pin MiniChange connector*
Shielded	15 mm (0.59 in)	SCR (NO or NC)	E2Q2-N15Y4-U	E2Q2-N15Y4-50
Unshielded	30 mm (1.18 in)	SCR (NO or NC)	E2Q2-N30MY1-U	E2Q2-N30MY1-50

Note: *Use Brad Harrison connector #10400A01F120 (12 foot) or equivalent.

■ WELD FIELD IMMUNE TYPES

These sensors withstand 23,400 amps at 1 inch (100 mT)

Type	Sensing distance	Input type	Output type	Part number	
				1/2" NPT conduit opening	MiniChange connector
Shielded	15 mm (0.59 in)	DC	PNP (NO)	E2Q2-N15F1-51	E2Q2-N15F1-52**
		AC	SCR (NO or NC)	E2Q2-N15Y1-51	E2Q2-N15Y1-52**

Note: *Use 4-pin Brad Harrison connector #10400A01F120 (12 foot) or equivalent.
**Use 3-pin Brad Harrison connector #10300A01F120 (12 foot) or equivalent.

Photoelectric proximity sensor.

COMPACT DC POWERED PHOTO-ELECTRIC SENSORS

- RETROREFLECTIVE PROXIMITY (DIFFUSE) & OPPOSED BEAM PAIRS
- MODULATED LED LIGHT BEAMS FOR IMMUNITY TO AMBIENT LIGHT
- +10 to +30 VDC OPERATION WITH REVERSE POLARITY PROTECTION
- NPN & PNP (CURRENT SINKING AND SOURCING) OUTPUTS
- RUGGED VALOX HOUSING MEETS NEMA 1, 2, 3, 3S, 4, 4X, 12, & 13 STANDARDS
- LED SIGNAL STRENGTH INDICATOR MAKES ALIGNMENT EASY & PROVIDES INDICATION OF LIGHT SIGNAL DETERIORATION

CE

DESCRIPTION

These compact self-contained and powerful Retroreflective, Proximity (Diffuse) and Opposed Beam Pair Photo-electric Sensors provide application flexibility in counting, positioning and object detection. All units are interchangeable with conventional 18 mm threaded barrel-type photo-electric and inductive proximity sensors. Their small 3-1/8" x 1-1/4" x 1/2" size, in addition to various mounting options, greatly increases alignment ease and application possibilities.

All units can be powered from −10 to +30 VDC and are reverse polarity protected. Current sinking NPN and current sourcing PNP Open Collector Transistors are protected from continuous overload and inductive load transients and are rated to 150 mA, with low saturation voltage and less than 1 µA of State leakage current. In addition, no false outputs are generated at power-up. A 6 foot long 4 conductor PVC jacketed cable with strain relief provides supply input and transistor outputs.

A *protective* removable back cover provides access to the LIGHT/DARK Operate Mode Selector. When in the "Light Operate" (LO) position, outputs turn on when light is received by the detector. When in the "Dark Operate" (DO) position, the outputs are turned on when sensor light is **not** detected. Also accessible is a 15-turn screwdriver-adjustable GAIN potentiometer that enables precise adjustment of system sensitivity. A rear mounted LED Signal Strength Indicator "lights" whenever the sensor sees a light condition and "blinks" at a rate proportional to the received signal strength (the stronger the signal, the faster the rate). This LED is basic for easy alignment and monitoring of signal strength deterioration due to dirty optics or changes in alignment.

SPECIFICATIONS

1. **POWER REQUIREMENTS:** −10 to +30 VDC, 10% Ripple Max., Reverse Polarity Protected, 25 mA max. (Model EMDC = 20 mA max.)
2. **OUTPUTS:** Current Sinking NPN and Current Sourcing PNP Open Collector Transistors; Short Circuit Protected to +30 VDC, Internal Zener Diode Protected.
   I_{SNK} = 150 mA each; V_{OH} = 30 VDC max.
   NPN V_{SAT} = 0.2 V @ 10 mA load; 1 V max. @ 150 mA max. load.
   PNP V_{SAT} = Less than 1 V @ 10 mA load; less than 2 V @ 150 mA max. load.
   Offstate Leakage Current = Less than 1 µA.
3. **RESPONSE TIME:** Responds to a "light" or "dark" signal duration of 1 msec. or greater.
4. **OPERATING TEMPERATURE:** -4° to +158°F (-20° to +70°C)
5. **WEIGHT:** 3.5 oz (99.2 g)

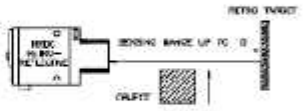
MOUNTING

Various mounting methods have been designed to simplify alignment and provide versatility in any industrial environment. The integral 18 mm threaded lense can be interchanged with existing threaded entries common to 18 mm barrel sensors and inductive proximity switches. The threaded lense can also be installed into panel thicknesses of 5/16" through a 0.71" diameter hole and tightened into place with the supplied mounting nut. Two #4 screw clearance through-holes on 0.95" centers are available for side mounting or side nesting of multiple units on 1/2" centers for scanning large areas or for color reading applications. Units may also be mounted using the stainless steel Bottom-Mount or Side-Mount Bracket Kits (Models MB2 or MB3). These brackets allow 2 axes of movement & greatly simplify alignment.

MODEL RRDC - RETROREFLECTIVE SENSOR

The Model RRDC is a compact, DC powered, retroreflective photo-electric sensor with maximum detection range of 15 feet (with 3" dia. reflector Model RT2). The "visible" LED light beam allows for easy alignment and is modulated, providing immunity to ambient light. The small beam size of 1/2" at 1 foot from the lense, makes it a good choice for detecting relatively small objects.

In operation, the visible LED light beam is directed at a prismatic photo transistor, amplified and demodulated. An object which then breaks this beam will trigger the outputs.



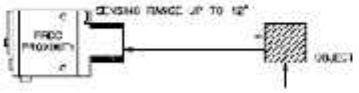
ALIGNMENT

Apply DC power to the RRDC and direct its visible light beam at a reflective target (Models RT1 or RT2) while observing the Signal Strength LED on the back of the unit. Optimum alignment occurs when the sensor is receiving the maximum amount of reflected light and the GAIN (sensitivity) potentiometer is adjusted for the highest pulse rate on the Signal Strength LED. Note that glass, metallic objects, and other highly reflective surfaces may not be detected. In these applications, mount the sensor and reflector at any angle to the object to minimize direct reflections.

MODEL PRDC - PROXIMITY SENSOR

The Model PRDC is a compact, DC powered, Proximity (Diffuse) photoelectric sensor with a 12" maximum detecting distance (as measured with a 90% reflective white test card). This sensor requires no special reflectors or reflective tapes and the limited 12" sensing range reduces detection of background reflections. It is ideally suited for detection of transparent or translucent objects, parts ejected from presses, and rotating targets such as pulley spokes. A modulated "infrared" LED light beam provides immunity to ambient light.

In operation, the modulated light beam is reflected by the object to be detected. Actual sensing range is determined by the surface area and the amount of reflectivity of the object. The reflected light is sensed by a photo-transistor, amplified, demodulated and then energizes the output.

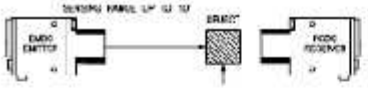


ALIGNMENT

With the PRDC in its sensing position, apply DC Power and direct the infrared light beam at the object to be detected. While observing the Sigma Strength LED, adjust the GAIN (sensitivity) potentiometer for the highest LED pulse rate. Now remove the sensed object. If the LED goes out, no further adjustment is necessary. If the LED remains lit, the sensor is "seeing" reflected light from the background. Reduce the GAIN by steps until the sensor "sees" the object but not the background. Then turn the pot counter clockwise 2 more full turns. If the background is still being sensed, it will be necessary to reduce its reflectivity by either moving it back or painting it flat black.

MODELS EMDC & RCDC - OPPOSED BEAM EMITTER/ RECEIVER SENSOR PAIR

The Models EMDC (Emitter) and the RCDC (Receiver) are compact, DC powered, Opposed Beam photo-electric sensor pairs with a 10 foot sensing range. The emitter contains a high power modulated "infrared" LED. The Receiver contains a sensitive photo-transistor, amplifier-demodulator and output transistors. In operation, these outputs will be triggered when the Receiver detects that an object begins to break the Emitter beam. Due to their high gain, they are ideally suited for detecting opaque objects in dirty and dusty areas or when condensation or oil film environments are present. The small 1/8" well defined beam size allows for sensing small parts accurately and provides repeatable edge sensing of opaque objects to better than 0.01" for accurate positioning applications. Greater accuracies can be achieved by aperturing the Emitter, Receiver or both. However, aperturing will result in reduced sensing distances. While the beam size is small, the Receiver has a wide field of view which allows easy "line-of-sight" alignment.

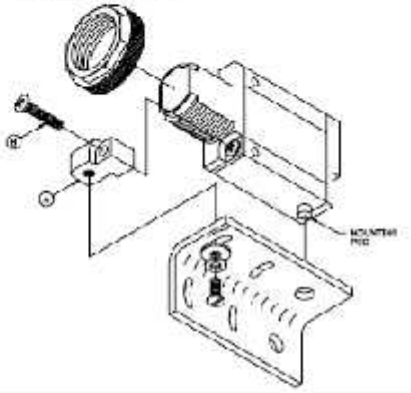


ALIGNMENT

Temporarily mount the Emitter-Receiver Pair opposite, and in line-of-sight to each other. Apply DC power to both and aim the Emitter at the Receiver. Move the Receiver up-down-left-right until the Signal Strength LED lights. Optimum alignment occurs when the Signal Strength LED flashes at the highest rate obtainable with the GAIN (Sensitivity) potentiometer adjusted to the lowest setting needed to light the LED. Mount the units in place. Opposed Beam Pairs should be used at their highest possible gain. There fore, have the object to be detected in "sensing position" and adjust the GAIN potentiometer fully counter-clockwise (maximum gain). If the Signal Strength LED remains on, "burn through" is occurring, and will require that the GAIN pot be backed off (counter clockwise) until the LED goes out and then backed off 2 more full turns. Note that Opposed Beam Pairs must be aligned properly and mounted securely. Excessive movement or vibration can cause loss of alignment and intermittent or false operation.

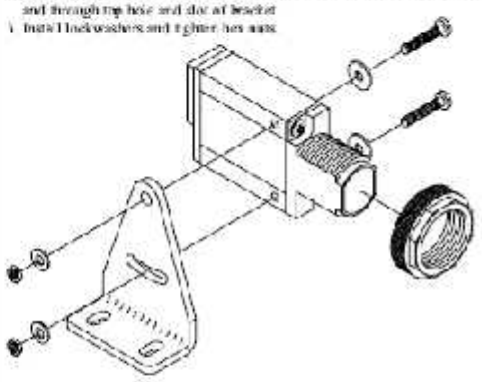
MB2 BOTTOM MOUNT BRACKET KIT INSTALLATION

1. Remove lense mounting nut on sensor and bottom lense screw.
2. Align mounting foot (A) under lense as shown with threaded insert facing down and attach to lense with long 4# supplied screw (B).
3. Place sensor mounting peg into bracket hole.
4. Install screw, with washers, into long slotted bracket hole and into mounting foot threaded insert.



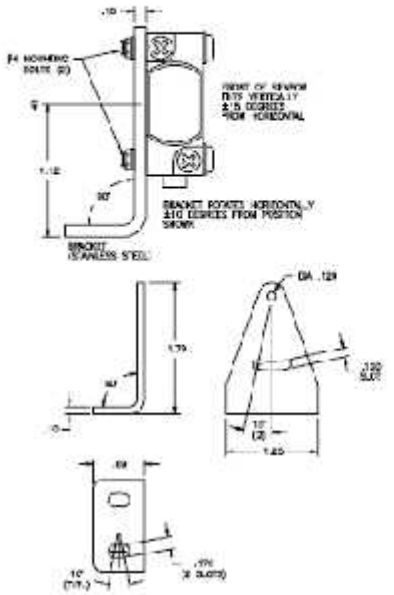
MB3 SIDE MOUNT BRACKET KIT INSTALLATION

1. Remove lense mounting nut from sensor.
2. Install screws with flat washers, through side clearance holes in sensor and through top hole and slot of bracket.
3. Install lockwashers and tighten hex nuts.

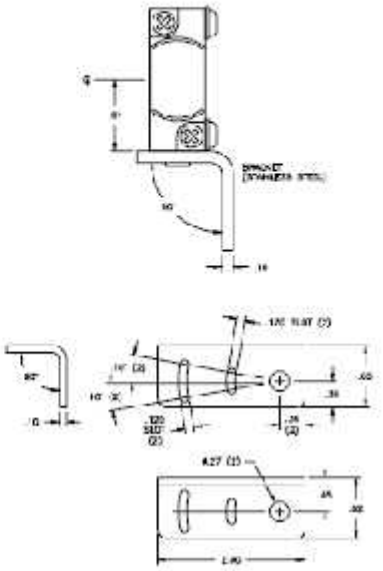


MOUNTING OPTIONS

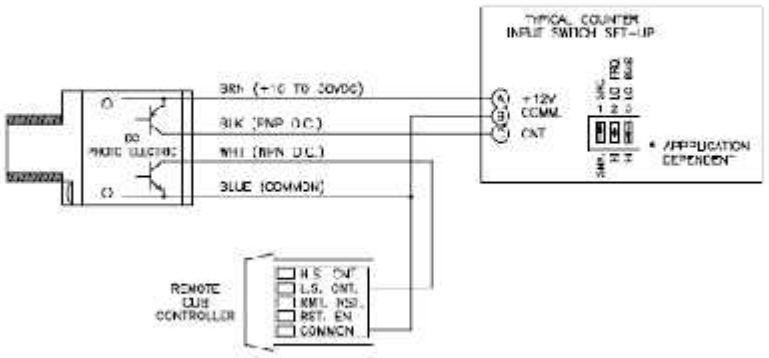
VB3 SIDE MOUNTING BRACKET



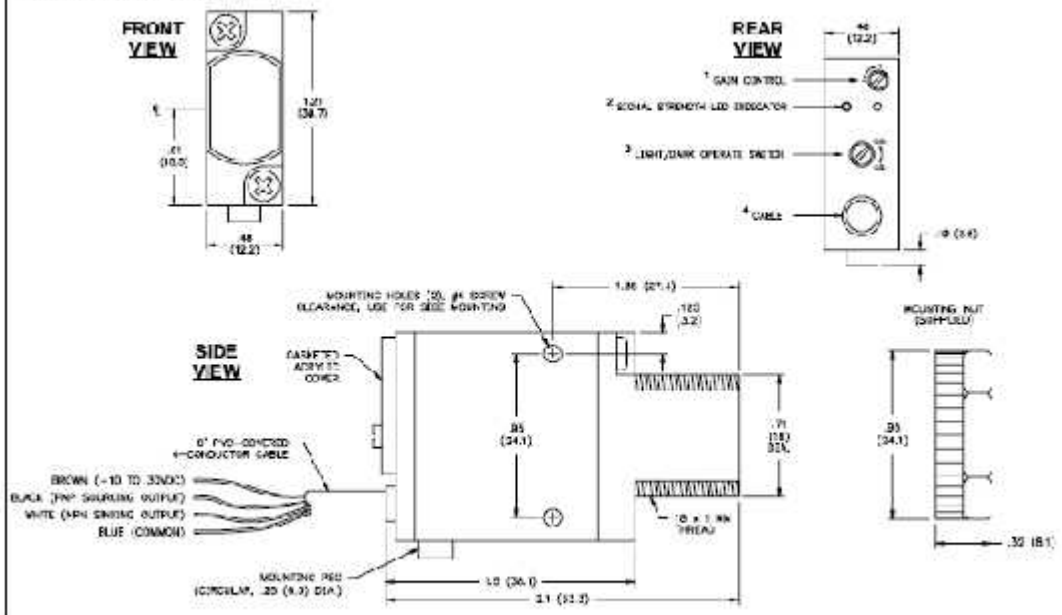
VB2 BOTTOM MOUNTING BRACKET



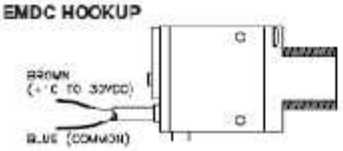
TYPICAL HOOKUP



DIMENSION DRAWINGS



EMDC HOOKUP



1. GAIN (sensitivity) control: rotate clockwise to increase gain.
2. "SIGNAL STRENGTH" LED indicator pulses at rate proportional to received light signal strength.
3. LIGHT/DARK OPERATE SELECT control: DARK OPERATE = fully counterclockwise; LIGHT OPERATE = fully clockwise.
4. 6' PVC jacketed 4-wire cable supplied (2-wire, EMDC).

ORDERING INFORMATION

MODEL NO.	DESCRIPTION	PART NUMBER/S
RRDC	Retroreflective DC Photo-Electric Sensor	RRDC0000
PRDC	Proximity (Diffuse) DC Photo-Electric Sensor	PRDC0000
EMDC	DC Emitter (Opposed Beam Pair)	EMDC0000
RCDC	DC Receiver (Opposed Beam Pair)	RCDC0000
ME2	Bottom Mount Bracket Kit	MB200000
MF3	Side Mount Bracket Kit	MB300000
K1T	1-1/2" Dia. Prismatic Reflector (Model RRDC)	K1T00U0
RT2	3" Dia. Prismatic Reflector (Model RRDC)	RT200000

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Delta Electronics (Jiang Su) Ltd.
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Wujiang City, Jiang Su Province,
People's Republic of China (Post code: 215200)
TEL: 86-512-6340-3008 / FAX: 86-769-6340-7290

Delta Electronics (Japan), Inc.
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Delta Shibadaimon Building, 2-1-14 Shibadaimon,
Minato-Ku, Tokyo, 105-0012, Japan
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Delta Electronics (Korea), Inc.
Donghwa B/D 3F, 235-6, Nonhyun-dong,
Kangnam-gu, Seoul 135-010, Korea
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Delta Electronics (Singapore) Pte. Ltd.
8 Kaki Bukit Road 2, #04-18 Ruby Warehouse Complex,
Singapore 417841
TEL: 65-6747-5155 / FAX: 65-6744-9228

Delta Energy Systems (India) Pvt. Ltd.
Plot No. 27 & 31, Sector-34, EHTP,
Gurgaon-122001 Haryana, India
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AMERICA

Delta Products Corporation (USA)
Raleigh Office
P.O. Box 12173,5101 Davis Drive,
Research Triangle Park, NC 27709, U.S.A.
TEL: 1-919-767-3813 / FAX: 1-919-767-3969

EUROPE

Deltronics (The Netherlands) B.V.
Eindhoven Office
De Witbogt 15, 5652 AG Eindhoven, The Netherlands
TEL: 31-40-2592850 / FAX: 31-40-2592851

20070817VFD-E-E

DELTA ELECTRONICS, INC.

VFD-E

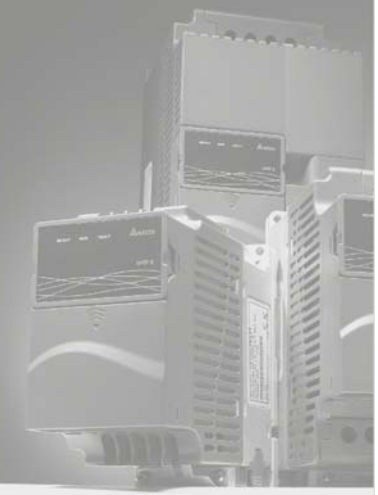
High Performance / Flexible Extension /
Micro Type AC Motor Drives

Variable Speed AC Motor Drive

VFD-E Series

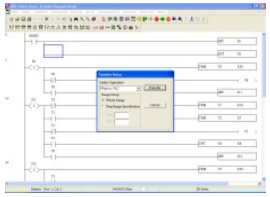
Features

High Performance
Flexible Extension
Micro Type AC Motor Drives



- **Power Range**
  1 phase 115V series:0.2~0.75kW (0.25 ~1hp)
  1 phase 230V series:0.2~2.2kW (0.25 ~ 3hp)
  3 phase 230V series:0.2~7.5kW (0.25~10hp)
  3 phase 460V series:0.4~11kW (0.50~15hp)

- **Built-in PLC Function**
  Easy to write PLC program without additional PLC



- **Side-by-side Installation(40°C)**
  High-efficiency cooling and flexible space

- **Easy Maintenance**
  Removable cooling fan for easy maintenance

Features

- **Modular Design**
  Modular structure and extension with optional cards

- **Standard MODBUS Protocol**
  Standard MODBUS Protocol via RS-485

- **Built-in EMI Filter**
  (230V 1 phase and 460V 3 phase)
  To reduce electromagnetic interference efficiently

- **Compact Design**
  Space saving and easy DIN rail mounting with optional DIN rail adapter

- **Optional Fieldbus Modules**
  Provide connection to a variety of networks, including Profibus, DeviceNet, LonWorks and CANopen

- **Flexible Extension**
  Via optional cards, such as I/O card, Relay card, PG (Encoder) card and USB card, to meet your application requirements

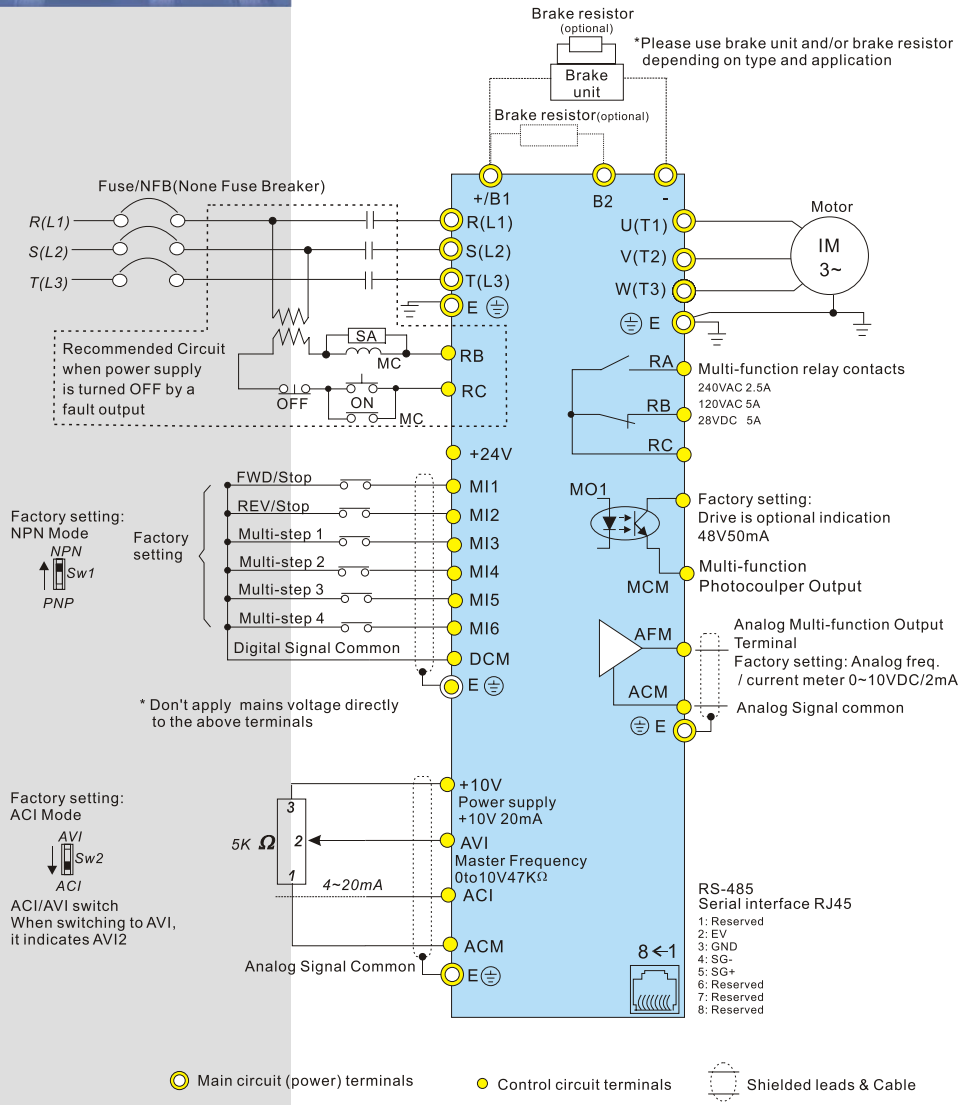
- **RFI-Switch for IT Mains**
  Removable "Y" capacitor for use on IT mains supplies

- **Easy DC BUS Sharing**
  Multiple VFD-E can be connected in parallel to share the regenerative braking energy. In this way, over-voltage is prevented and the DC-bus voltage stabilized.

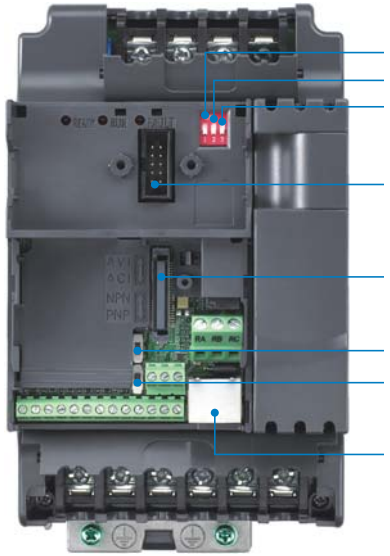
- **Complete Protection Function**
  High precision current detection, full overload protection (oL, oL1 and oL2), over-voltage/over-current stall prevention, short-circuit protection, reset after fault, speed search function and motor overheat protection by PTC.

- **Removable Keypad**
  The standard keypad acts as status monitor. More functions, including parameter modification, RUN/STOP, speed change, and status display, via optional keypad

Basic Wiring Diagram

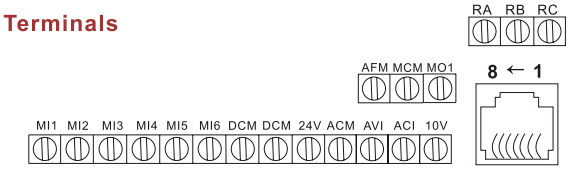


External Parts



- Switch to ON for 50Hz
- Switch to ON for free run to stop
- Switch to ON for setting frequency source to ACI(P 02.00=2)
- Keypad mounting port
- Mounting port for extension card
- ACI terminal ACI/AVI2 switch
- NPN/PNP
- RS-485 port(RJ-45)

Control Terminals



Model Explanation

VFD 007 E 23 A

Series Name
(Variable Frequency Drive)

Applicable Motor Capacity

002:0.25hp(0.2kW)
004:0.5hp(0.4kW)
007:1hp(0.75kW)
015:2hp(1.5kW)
022:3hp(2.2kW)
037:5hp(3.7kW)
055:7.5hp(5.5kW)
075:10hp(7.5kW)
110:15hp(11kW)

Version Type

Mains Input Voltage

11:115V 1-Phase
21:230V 1-Phase
23:230V 3-Phase
43:460V 3-Phase

VFD-E Series

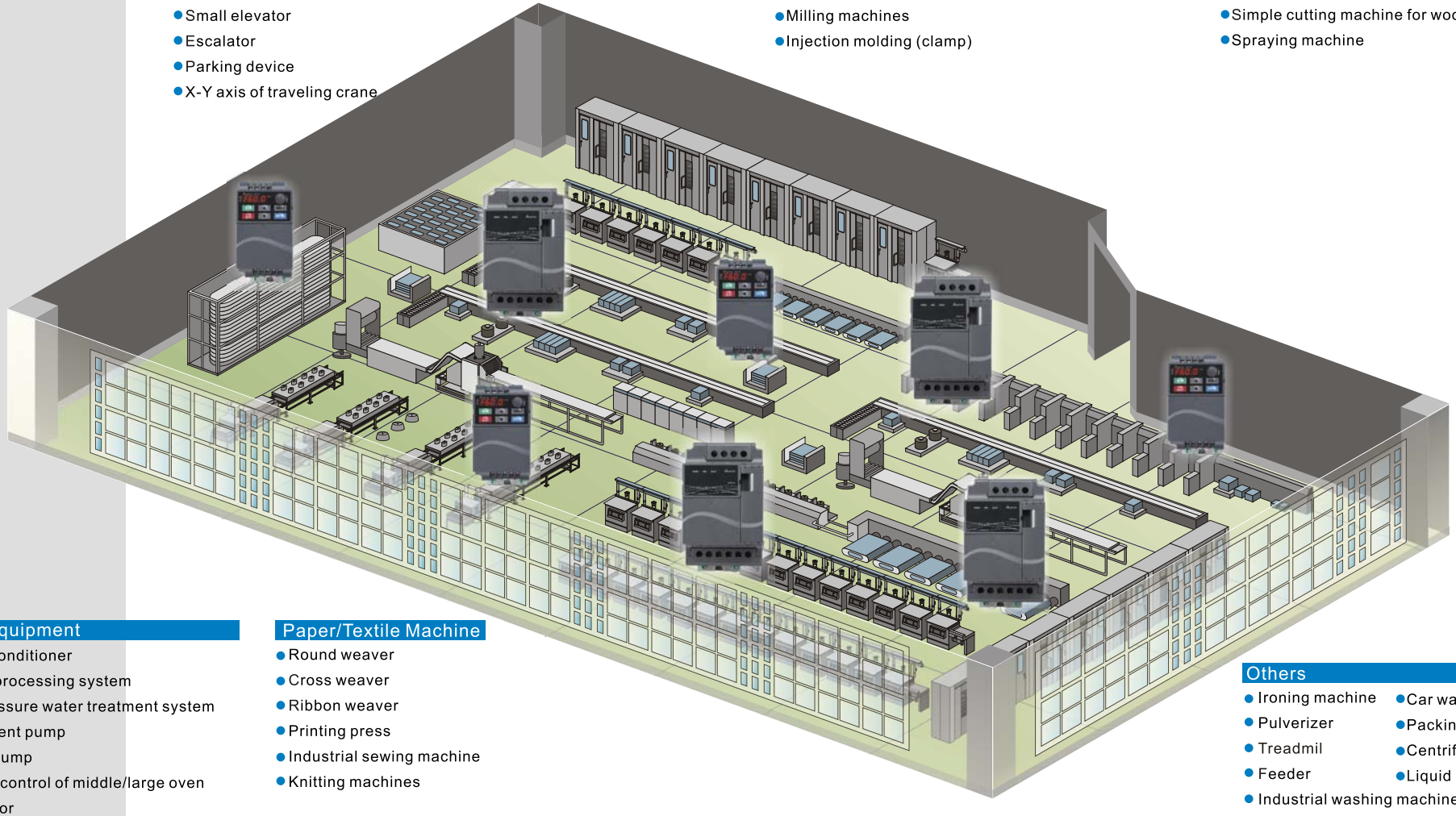
VFD-E Applications

Conveyor and Transportation Machinery
- Conveyor belt
- Automatic doors
- Roller door
- Small elevator
- Escalator
- Parking device
- X-Y axis of traveling crane

Food Processing
- Dumpling maker
- Food stirrer
- Noodle maker

Machine Tool/Metal Processing Machinery
- Grinder
- Drill
- Small lathe
- Milling machines
- Injection molding (clamp)

Wood Working Machinery
- 4 side planer
- Woodcarver
- Wood working machine
- Simple cutting machine for wood working
- Spraying machine



Fan/Pump Equipment
- Building air conditioner
- Wastewater processing system
- Constant pressure water treatment system
- Water treatment pump
- Agricultural pump
- Temperature control of middle/large oven
- Air compressor
- Heat exchange fans
- Building water dispenser system
- Dryer's windmill

Paper/Textile Machine
- Round weaver
- Cross weaver
- Ribbon weaver
- Printing press
- Industrial sewing machine
- Knitting machines

Others
- Ironing machine
- Pulverizer
- Treadmil
- Feeder
- Industrial washing machine
- Car washing machine
- Packing machine
- Centrifuge
- Liquid mixer

Specifications

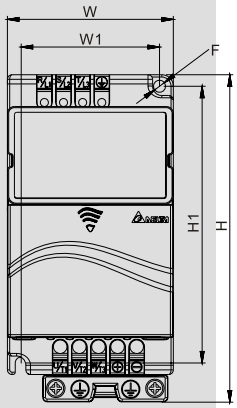
Voltage Class		115V Class		
Model Number VFD-___ E		002	004	007
Max. Applicable Motor Output (kW)		0.2	0.4	0.75
Max. Applicable Motor Output (hp)		0.25	0.5	1.0
Output Rating	Rated Output Capacity (kVA)	0.6	1.0	1.6
	Rated Output Current (A)	1.6	2.5	4.2
	Maximum Output Voltage (V)	3-phase proportional to twice the input voltage		
	Output Frequency (Hz)	0.1~600Hz		
	Carrier Frequency (kHz)	1-15		
Input Rating	Rated Input Current (A)	Single-phase		
		6	9	18
	Rated Voltage/Frequency	Single phase 100-120V • 50/60Hz		
	Voltage Tolerance	±10%(90-132V)		
	Frequency Tolerance	±5%(47-63Hz)		
Cooling Method		Natural Cooling		Fan Cooling
Weight (kg)		1.2	1.2	1.2

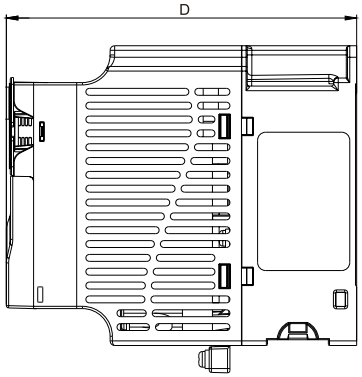
Voltage Class		230V							
Model Number VFD-___ E		002	004	007	015	022	037	055	075
Max. Applicable Motor Output (kW)		0.2	0.4	0.75	1.5	2.2	3.7	5.5	7.5
Max. Applicable Motor Output (hp)		0.25	0.5	1.0	2.0	3.0	5.0	7.5	10.0
Output Rating	Rated Output Capacity (kVA)	0.6	1.0	1.6	2.9	4.2	6.5	9.5	12.5
	Rated Output Current (A)	1.6	2.5	4.2	7.5	11.0	17.0	25.0	33.0
	Maximum Output Voltage (V)	3-phase proportional to input voltage							
	Output Frequency (Hz)	0.1~600Hz							
	Carrier Frequency (kHz)	1-15							
Input Rating	Rated Input Current (A)	Single/3-phase					3-phase		
		4.9/1.9	6.5/2.7	9.7/5.1	15.7/9	24/15	20.6	26	34
	Rated Voltage/Frequency	Single/3-phase 200-240V • 50/60Hz					3-phase 200-240V • 50/60Hz		
	Voltage Tolerance	±10%(180-264V)							
	Frequency Tolerance	±5%(47-63Hz)							
Cooling Method		Natural Cooling			Fan Cooling				
Weight (kg)		1.1	1.1	1.1	1.9	1.9	1.9	3.5	3.5

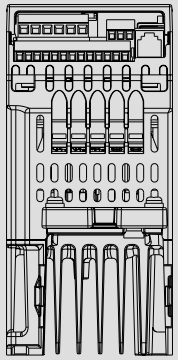
Voltage Class		460V							
Model Number VFD-___ E		004	007	015	022	037	055	075	110
Max. Applicable Motor Output (kW)		0.4	0.75	1.5	2.2	3.7	5.5	7.5	11.0
Max. Applicable Motor Output (hp)		0.5	1.0	2.0	3.0	5.0	7.5	10.0	15.0
Output Rating	Rated Output Capacity (kVA)	1.2	2.0	3.3	4.4	6.8	9.9	13.7	18.3
	Rated Output Current (A)	1.5	2.5	4.2	5.5	8.5	13.0	18.0	24.0
	Maximum Output Voltage (V)	3-phase proportional to input voltage							
	Output Frequency (Hz)	0.1~600Hz							
	Carrier Frequency (kHz)	1-15							
Input Rating	Rated Input Current (A)	3-phase							
		1.9	3.2	4.31	7.1	11.2	14	19	26
	Rated Voltage/Frequency	3-phase 380-480V • 50/60Hz							
	Voltage Tolerance	±10%(342-528V)							
	Frequency Tolerance	±5%(47-63Hz)							
Cooling Method		Natural Cooling		Fan Cooling					
Weight (kg)		1.2	1.2	1.2	1.9	1.9	4.2	4.2	4.2

Control Characteristics	Control System		SPWM (Sinusoidal Pulse Width Modulation) Control (V/f or sensorless vector control)
	Frequency Setting Resolution		0.01Hz
	Output Frequency Resolution		0.01Hz
	Torque Characteristics		Including the auto-torque/auto-slip compensation; starting torque can be 150% at 3.0Hz
	Overload Endurance		150% of rated current for 1 minute
	Skip Frequency		Three zones, setting range 0.1~600Hz
	Accel/Decel Time		0.1to 600 seconds (2 Independent setting of Accel/Decel time)
	Stall Prevention Level		Setting 20to 250% of rated current
	DC Braking		Operation frequency 0.1~600.0Hz, output 0~100% rated current Start time 0~60 seconds, stop time 0~60 seconds
	Regenerated Braking Torque		Approx. 20% (up to 125% possible with optional brake resistor or externally mounted brake unit . 1-15hp models have brake chopper built-in)
	V/f Pattem		Adjustable V/f pattern
Operating Characteristics	Frequency Setting	Keypad	Setting by ▲▼
		External Signal	Potentiometer-5kΩ/0.5W, 0 to +10VDC, 4 to 20mA,RS-485 interface; Multi-function Inputs 3 to 9 (15 steps, Jog, up/down)
	Operation Setting Signal	Keypad	Set by RUN and STOP
		External Signal	2 wires/3 wires (FWD, REV, EF), JOG operation, RS-485 serial interface (MODBUS), programmable logic controller
	Multi-Function Input Signal		Multi-step selection 0 to 15, Jog, accel/decel inhibit, 2 accel/decel switches, counter, external Base Block (NC, NO), auxiliary motor control is invalid, ACI/AVI/AUI selections, driver reset, UP/DOWN key settings, sink/source (=NPN/PNP) selection
	Multi-Function Output Indication		AC drive operating, frequency attained, non-zero frequency, Base Block, fault indication, local/remote indication, auxiliary motor output, drive is ready, overheat alarm, emergency stop and status selections of input terminals (NC/NO)
	Analog Output Signal		Output frequency/current
	Alarm Output Contact		Contact will be On when drive malfunctions (1 Form C/change-over contact or 1 open collector output)
	Operation Functions		Built-in PLC, AVR, accel/decel S-Curve, over-voltage/over-current stall prevention, 5 fault records, reverse inhibition, momentary power loss restart, DC braking, auto torque/slip compensation, auto tuning, adjustable carrier frequency, output frequency limits, parameter lock/reset, vector control, PID control, external counter, MODBUS communication, abnormal reset, abnormal re-start, power-saving, sleep/wake function, fan control, 1st/2nd frequency source selections, 1st/2nd frequency source combination, NPN/PNP selection
	Protection Functions		Over voltage, over current, under voltage, under current, external fault, overload, ground fault, overheating, electronic thermal, IGBT short circuit, PTC
	Display Keypad		6-key, 7-segment LED with 4-digit, 5 status LED, master frequency, output frequency, output current, custom units, parameter values for setup and lock, faults, RUN, STOP, RESET, FWD/REV
	Built-in EMI Filter		For 230V 1-phase and 460V 3-phase models
Environmental Conditions	Enclosure Rating		IP20
	Pollution Degree		2
	Installation Location		Altitude 1,000 m or lower, keep from corrosive gasses, liquid and dust
	Ambient Temperature		-10°C to + 50°C (40°C for side-by-side mounting) Non-Condensing and not frozen
	Storage/Transportation Temperature		-20°C to 60°C
	Ambient Humidity		Below 90% RH (non-condensing)
	Vibration		9.80665m/s^2 (1G) less than 20Hz, 5.88m/s^2 (0.6G) at 20 to 50Hz
Approvals			CE cULus

Dimensions&Options







Unit: mm(inch)

Model	W	W1	H	H1	D	F
VFD002E11A/11T VFD002E21A/21T VFD002E23A/23T VFD004E11A/11T VFD004E21A/21T VFD004E23A/23T VFD004E43A/43T VFD007E21A/21T VFD007E23A/23T VFD007E43A/43T VFD015E23A/23T VFD015E43A/43T	72.0 (2.83)	60.0 (2.36)	142.0 (5.59)	120.0 (4.72)	152.0 (5.98)	5.2 (0.20)
VFD007E11A VFD015E21A VFD022E21A VFD022E23A VFD022E43A VFD037E23A VFD037E43A	100.0 (3.94)	89.0 (3.51)	174.0 (6.86)	162.0 (6.38)	152.0 (5.98)	5.5 (0.22)
VFD055E23A VFD055E43A VFD075E23A VFD075E43A VFD110E43A	130.0 (5.12)	116.0 (4.57)	260.0 (10.24)	246.5 (9.71)	169.2 (6.67)	5.5 (0.22)
VFD002E11P VFD002E21P VFD002E23P VFD004E11P VFD004E21P VFD004E23P VFD004E43P VFD007E21P VFD007E23P VFD007E43P VFD015E23P	72.0 (2.83)	56.0 (2.20)	155.0 (6.10)	143.0 (5.63)	111.5 (4.39)	5.3 (0.21)

New Models

VFD-E-T:Built-in brake chopper for frame A
VFD-E-P:Plate drive

Accessories

Optional Cards

- **EME-R3AA**
  Relay card (3 form A/ NO contacts)

- **EME-R2CA**
  Relay card (2 form C/ Change-over contacts)

- **EME-33A**
  I/O card (photocoupler 3in+3out)

- **EME-A22A**
  Anglog I/O Card(12 bits)

- **EME-PG01**
  PG card

- **CME-USB01**
  Second communication card (USB1.1)

Fieldbus Modules

- DeviceNet

- Profibus

- LonWorks

- CANopen

Others

- Digital keypad

- Brake resistor

- Keypad for communication(PU-06)
- Zero phase reactor
- Keypad cable
- DIN rail(Width35mm)
- EMI Input Filter
- Grounding plate
- Brake unit
- DC Fan
- AC reactor

2006-07-04

5011634301-YIE1

http://www.delta.com.tw/industrialautomation/

DVP-ES/EX

Programmable Logic Controller Instruction Sheet

1 WARNING

This Installation Sheet only provides descriptions for electrical specifications, function specifications, installation & wiring, troubleshooting and peripherals. Other detail infromation about programming and instructions, please see PLC Application Manual. For more information about the optional peripherals, please refer to their individual instruction sheet or user manuals.

This is an OPEN TYPE PLC. The PLC should be kept in an enclosure away from airborne dust, high humidity, electric shock risk and vibration. Also, it should be equipped with protective methods such as some special tools or keys to open the enclosure, so as to avoid the hazard to users and the damage to the PLC. The power must be OFF before any maintenance.

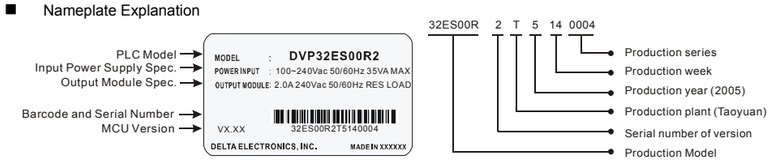
Never connect the AC main circuit power supply to any of the input/output terminals, as it will damage the PLC. Check all the wiring prior to power up. To avoid any electromagnetic noise, make sure the PLC is properly grounded ⏚. Do NOT touch terminals when power on.

2 INTRODUCTION

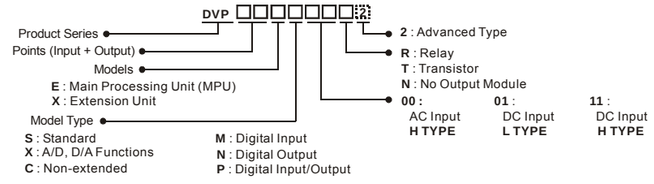
2.1. Model Name Explanation and Peripherals

Thank you very much for purchasing Delta's DVP-ES/EX Series PLC. DVP-ES/EX Series provide the main processing units and extension units. The processing units offer 14~60 points and the extension units offer 8~32 points. The maximum input and output can be extended up to 128 points respectively. Also, it can be used on various applications according to input and output points, power supply, digital input and output modules.

■ Nameplate Explanation



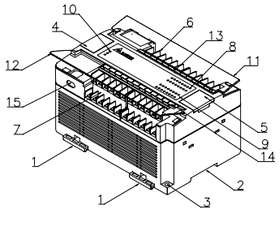
■ Model/Serial Number Explanation



■ Peripherals

◎ DVP-HPP Series: Handheld Programmable Panel
◎ WPLSoft: DVP-PLC Programming Software Tool (Windows based software)
◎ DVPACAB115: 1.5M Cable (HPP ⇔ PLC, provided in DVP-HPP Series)
◎ DVPACAB215: 1.5M Cable (PC ⇔ PLC)
◎ DVPACAB230: 3.0M Cable (PC ⇔ PLC)
◎ DVPACAB315: 1.5M Cable (HPP ⇔ PC)
◎ DVPACAB403: 30cm Cable (Main processing unit ⇔ Extension unit, or Extension unit ⇔ Extension I/O signal extension cable)

2.2. Product Profile and Outline



1. DIN rail clip	9. Input / Output
2. DIN rail (35mm)	10. Status indicators: POWER, RUN, and ERROR
3. Direct mounting holes	11. Input / Output terminal cover
4. Communication Ports Cover (RS-232C)	12. Input / Output terminal cover
5. Extension Port indicators	13. Input / Output terminal nameplate panel
6. Input / Output terminals	14. Input / Output terminal nameplate panel
7. Input / Output terminals	15. RS-485 communication port
8. Input / Output indicators	

2.3. DVP-ES/EX Series Models

◎ ES Standard Main Processing Units (MPU-00)

Model Name	Power	Input Unit Point	Input Unit Type	Output Unit Point	Output Unit Type	Profile
DVP14ES00R2	100~240 VAC	8	DC Sink or Source	6	Relay	❶
DVP24ES00R2		16		8		❷
DVP32ES00R2		16		16		
DVP40ES00R2		24		16		
DVP60ES00R2		36		24		❸
DVP14ES00T2		8		6	Transistor	❶
DVP24ES00T2		16		8		❷
DVP32ES00T2		16		16		
DVP40ES00T2		24		16		
DVP60ES00T2		36		24		❸

◎ ES Standard Main Processing Units (MPU-01,11)

Model Name	Power	Input Unit Point	Input Unit Type	Output Unit Point	Output Unit Type	Profile
DVP14ES01R2	24 VDC	8	DC Sink or Source	6	Relay	❸
DVP24ES01R2		16		8		❹
DVP24ES11R2		16		8		❷
DVP32ES01R2		16		16		❹
DVP14ES01T2		8		6	Transistor	❸
DVP24ES01T2		16		8		❹
DVP32ES01T2		16		16		

◎ EX Special Function Main Processing Units (MPU-00, MPU-11)

Model Name	Power	Input Unit Point DI	Input Unit Point AI	Input Unit Type DI	Input Unit Type AI	Output Unit Point DO	Output Unit Point AO	Output Unit Type DO	Output Unit Type AO	Profile Reference
DVP20EX00R2	100~240 VAC	8	4	DC Sink or Source	-20mA~20 mA or -10V ~ +10 V	6	2	Relay	0~20mA or 0~10V	
DVP20EX00T2		8	4			6	2	Transistor		
DVP20EX11R2	24 VDC	8	4			6	2	Relay		

◎ Digital I/O Extension Unit for DVP-ES/EX Series- 00

Model Name	Power	Input Unit Point	Input Unit Type	Output Unit Point	Output Unit Type	Profile Reference
DVP24XN00R	100~240 VAC	0	DC Sink or Source	24	Relay	
DVP24XP00R		16		8		
DVP32XP00R		16		16		
DVP24XN00T		0		24	Transistor	
DVP24XP00T		16		8		
DVP32XP00T		16		16		

◎ Digital I/O Extension Unit for DVP-ES/EX Series- 01 (L TYPE)

Model Name	Power	Input Unit Point	Input Unit Type	Output Unit Point	Output Unit Type	Profile	Profile Reference
DVP16XM01N	24 VDC	16	DC Sink or Source	0	None	❶	
DVP16XN01R		0		16	Relay	❷	
DVP24XN01R		0		24			
DVP24XP01R		16		8			
DVP32XP01R		16		16			
DVP16XN01T		0		16	Transistor		
DVP24XN01T		0		24			
DVP24XP01T		16		8			
DVP32XP01T		16		16			

◎ Digital I/O Extension Unit for DVP-ES/EX Series-11 (H TYPE)

Model Name	Power	Input Unit Point	Input Unit Type	Output Unit Point	Output Unit Type	Profile	Profile Reference
DVP08XM11N	24 VDC	8	DC Sink or Source	0	None	❶	
DVP16XM11N		16		0		❷	
DVP08XN11R		0		8	Relay	❶	
DVP16XN11R		0		16		❸	
DVP24XN11R		0		24			
DVP08XP11R		4		4		❶	
DVP24XP11R		16		8		❸	
DVP32XP11R		16		16			
DVP08XN11T		0		8	Transistor	❶	
DVP16XN11T		0		16		❸	
DVP24XN11T		0		24			
DVP08XP11T		4		4		❶	
DVP24XP11T		16		8		❸	
DVP32XP11T		16		16			

3 SPECIFICATIONS

3.1. Function Specifications

Items	Specifications	Remarks
Control Method	Stored program, cyclic scan system	
I/O Processing Method	Batch processing (when END instruction is executed)	I/O refresh instruction is available
Execution Speed	Basic commands (several us)	Application instructions (10 ~ hundreds us)
Program Language	Instruction, Ladder Logic, SFC	Including Step instructions

Items		Specifications	Remarks
Program Capacity		3792 Steps	Built-in EEPROM
Instructions		32 basic sequential instructions (including STL / RET)	107 application instructions
Step Relays (Latched)	Initial Step Point	10 points	S0~S9
	Zero Return Point	10 points	S10~S19
	General Step Point	108 points	S20~S127
Auxiliary Relays	General	512+232 points	M0~M511+M768~M999
	Latched	256 points	M512~M767
	Special	280 points	M1000~M1279
Timers	Digital	64 points	T0~T63 (100 ms time base)
		63 points	T64~T126 (10 ms time base, when M1028 is ON)
		1 points	T127 (1 ms time base)
Counters	General	112 points	C0~C111
	Latched	16 points	C112~C127
	High Speed	13 points 1 phase 20KHz, 2 phase 5KHz	C235~C254 (all latched type)
Data Registers	General	408 points	D0 ~ D407
	Latched	192 points	D408~D599
	Special	200 points	D1000~D1143、D1256~D1311
Pointers	P	64 points	P0~P63
Index Registers	E / F	2 points	E(=D1028)、F(=D1029)
Constants	Decimal K	16 bit: -32768~+32767	32 bit: -2147483648~+2147483647
	Hexadecimal H	16 bit: 0000~FFFF	32 bit: 00000000~FFFFFFFF
Serial Communication		2 Ports is provided. RS-232C: Program read/write communication port, RS-485: General function communication port (controlled by RS instruction); Special drive instructions for Delta AC drive are also supported.	
Protection Features		Password, I/O examination, Execution time, Illegitimate instruction or operand	
Monitor / Debug		Program execution time display, Bit/Word, Device setting	

＊ Note: For more information about special relays and data registers, please refer to the Delta PLC Application Manual.

3.2. Electrical Specifications

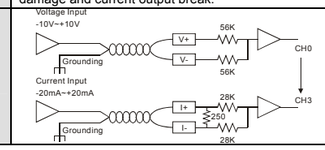
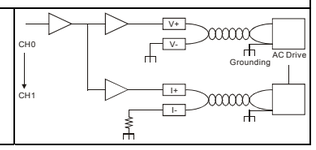
Item \ Model	DVP-14ES00 □	DVP-24ES00 □	DVP-32ES00 □	DVP-40ES00 □	DVP-60ES00 □	DVP-20EX00 □	DVP-14ES01 □	DVP-24ES□□ □	DVP-32ES01 □	DVP-20EX11□
Power Supply Voltage	100~240VAC (-15%~10%), 50/60Hz ± 5%						24VDC (-15%~10%)			
Operation Specification	The PLC start to operate at power supply of 95~100VAC. If the voltage of power supply drops to 70VAC, the PLC will stop. Maximum power loss time is 10ms or less.						Maximum power loss time is 5ms or less.			
Fuse	2 A / 250VAC						2 A / 250VAC			
Power Consumption	20 VA	25VA	30VA	30VA	35VA	30 VA	5.5 W	6.5 W	8 W	8 W
DC24V Supply Current	400mA	400mA	400mA	400mA	400mA	400mA	—	—	—	—
Power Protection	DC24V output short circuit						DC24V input polarity			
Voltage Withstand	1500VAC(Primary-secondary), 1500VAC(Primary-PE), 500VAC(Secondary-PE)									
Insulation Resistance	> 5 MΩ at 500VDC (Between all inputs / outputs and earth)									
Noise Immunity	ESD: 8KV Air Discharge EFT: Power Line: 2KV, Digital I/O: 1KV, Analog & Communication I/O: 250V RS: 26MHz~1GHz, 10V/m									
Grounding	The diameter of grounding wire cannot be smaller than the wire diameter of terminals L and N (All DVP units should be grounded directly to the ground pole).									
Environment	Operation: 0°C ~55°C (Temperature), 50~95% (Humidity), Pollution degree2; Storage: -25°C ~70°C (Temperature), 5~95% (Humidity)									
Vibration / Shock Resistance	Standard: IEC1131-2, IEC 68-2-6（TEST Fc）/ IEC1131-2 & IEC 68-2-27 (TEST Ea)									
Weight (g)	400	552	580	596	750	536	260	414	430	386

Input Point Electrical Specifications		
Input Point Type	Digital Input	Analog Input (EX)
Input Type	DC (SINK or SOURCE)	Voltage input: -10V~+10V, Input Resistance: 112KΩ Current input: -20mA~+20mA, Input Resistance: 250Ω
Input Current	24VDC 5mA	
Active Level (Analog input resolution)	Off→On above 16VDC	Voltage input: 10bit Current input: 10 bit
	On→Off below 14.4VDC	
Reaction Time (Conversion Sampling Time)	About 10ms (An adjustment range of 0~15ms could be selected through D1020 and D1021)	5ms (Time could be adjusted through D1118)

Output Point Electrical Specifications		
Output Point Type	Relay-R	Transistor-T
Current Specification	2A/1 point (5A/COM)	55°C 0.1A/1point, 50°C 0.15A/1 point 45°C 0.2A/1 point, 40°C 0.3A/1 point (2A/COM)
Voltage Specification	Below 250VAC, 30VDC	30VDC
Maximum Load	75VA (Inductive)	9W/1 point
	90 W (Resistive)	
Reaction Time	About 10 ms	Off→On 20us On→Off 30us

3.3. AD/DA Specifications

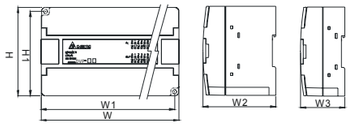
Items	Analog Input (A/D)		Analog Output (D/A)	
	Voltage Input	Current Input	Voltage Output	Current Output
Analog I/O Range	±10V	±20 mA	0 ~ 10V	0 ~ 20 mA
Digital Conversion Range	-512~+511	-512~+511	0 ~ 255	0 ~ 255
Resolution	10 bits(1_{LSB}=19.53125 mV)	10 bits (1_{LSB}=39.0625 μA)	8 bits(1_{LSB}=39.0625 mV)	8 bits (1_{LSB}=78.125 μA)
Input Impedance	> 112 KΩ	250Ω	—	

Items	Analog Input (A/D)		Analog Output (D/A)	
	Voltage Input	Current Input	Voltage Output	Current Output
Output Impedance	–		0.5Ω or lower	
Tolerance Carried Impedance	–		1KΩ~2MΩ	0～500Ω
Overall Accuracy	Non-linear accuracy: ±0.5% of full scale within the range of PLC operation temperature Maximum deviation: ±1% of full scale at 20mA and +10V			
Reaction Time	2ms × channels			
Absolute Input Range	±15 V	±32 mA	–	
Digital Data Format	2's complementary of 16-bit, 10 Significant Bits		2's complementary of 16-bit, 8 Significant Bits	
Average Function	Provided		–	
Isolation Method	Isolation between digital area and analog area. But no isolation among channels.			
Protection	Voltage output has short circuit protection but a long period of short circuit may cause internal wire damage and current output break.			
External Wiring Diagram				

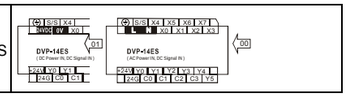
4 INSTALLATION & WIRING

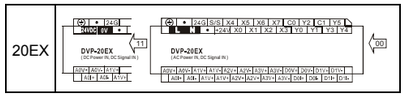
■ Dimensions

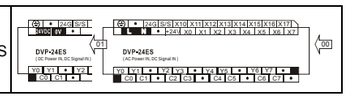
Model Name (mm)	H	H1	W	W1	W2 (H Type)	W3 (L Type)
DVP14ES00(01)[11]R2/T2	100	95	99	104	82	50
DVP24ES00(01)[11]R2/T2	100	95	150	155	82	50
DVP32ES00(01)[11]R2/T2	100	95	150	155	82	50
DVP40ES00R2/T2	100	95	150	155	82	-
DVP60ES00[11]R2/T2	90	85.5	180.5	185	89.6	-
DVP20EX00[11]R2/T2	100	95	150	155	82	-

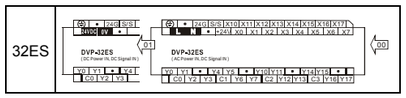


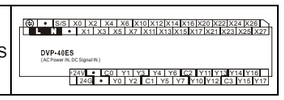
■ Terminal Wiring

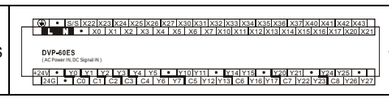
14ES


20EX


24ES


32ES


40ES


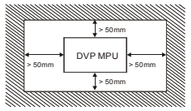
60ES


■ PLC Mounting Arrangements and Installation Notes

■ DIN Rail Installation

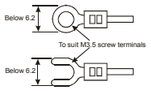
The DVP-PLC can be secured to a cabinet by using the DIN rail that is 35mm high with a depth of 7.5mm. When mounting the PLC on the DIN rail, ensure to use the end bracket to stop any side-to-side motion of the PLC, thus to reduce the chance of the wires being pulled loose. On the bottom of the PLC is a small retaining clip. To secure the PLC to the DIN rail, place it onto the rail and gently push up on the clip. To remove it, use a slotted screwdriver, place it on the groove of the retaining clip and press gently, then pull down on the retaining clip and gently pull the PLC away from the DIN rail.

For heat dissipation,ensure to provide a minimum clearance of 50mm between the unit and all sides of the cabinet. (as the figure shown below)



■ Direct mounting : Use the specified dimensions and install with M4 screws.

● Wiring



1. Please use O-type or Y-type terminals for I/O wiring terminals. The specification for the terminals is shown as the figure on the left. PLC terminal screws should be tightened to between 5~8 kg-cm (4.3~6.9 in-lbs). Only can use 60/75°C copper conducting wire.
2. DO NOT wire to the No Function terminals [•]. I/O signal wires or power supply should not run through the same multi-wire cable or conduit.
3. When tightening the screws and performing the wiring, please avoid that metallic particles fell into PLC. After completing wiring, please remove the label which is used to obstruct the metallic particles on the ventilation hole for well heat dissipation.

● Installation Notes

Incorrect installation may result in a PLC malfunction or premature failure of the PLC. Ensure to observe the following items when selecting a mounting location.

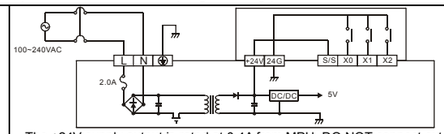
1. Do not mount the PLC in a location subjected to corrosive or flammable gases, liquids, or airborne dust or metallic particles.
2. Do not mount the PLC in a location where temperatures and humidity will exceed specification.
3. Do not mount the PLC in a location where vibration and shock will exceed specification.

■ Power Input Wiring

There are two power inputs provided in DVP series PLC, AC input and DC input. Please pay particular attention to the following notes:

1. Connect the AC input (100VAC~240VAC) to terminals L and N. Any AC110V or AC220V connected to the +24V terminal or input points will permanently damage the PLC.
2. The AC power inputs for the MPU and the I/O Expansion Unit should be ON or OFF at the same time.
3. Please use wires of 1.6mm or above for the grounding of the MPU.
4. If the power-cut time is less than 10ms, the PLC still operates unaffectedly. If the power-cut time is too long or the power voltage drops, the PLC will stop operating and all the outputs will be OFF. Once the power is restored, the PLC will return to operate automatically. (There are latched auxiliary relays and registers inside of the PLC, please be aware when programming.)

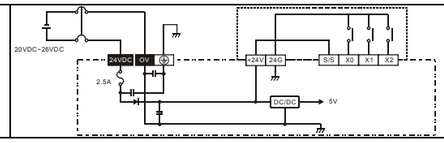
AC Input Type



The +24V supply output is rated at 0.4A from MPU. DO NOT connect external power supply to this terminal. Moreover, it takes 5~7mA to drive each input point, so total of 100mA is needed for 16 input points. As a result, the output loads of +24V should not exceeds 300mA.

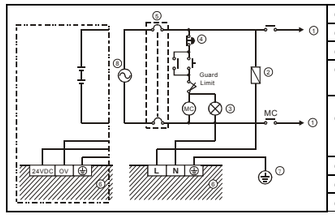
5. When DC voltage is supplied to the PLC, ensure the power is at terminals 24VDC and 0V (power range is 20.4VDC~26.4VDC). When the voltage is lower than 17.5VDC, PLC will stop operating, all outputs will turn OFF and the ERROR LED will flash continuously.

DC Input Type



■ Safety Wiring

Since the PLC is in control of numerous devices, operation of either one device could affect the operation of other devices, therefore the breakdown of either one device would consequently be detrimental to the whole auto control system, and danger will thus be resulted. Please use the recommended wiring below for the power input:

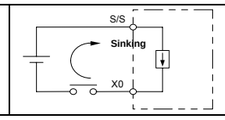
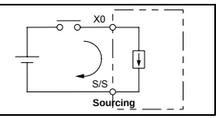


①	Power supply for AC loads
②	Fuse for circuit protection (3A Limit)
③	Power On pilot indicator
④	Emergency stop: PLC must provide a quick manual method to disconnect all system power.
⑤	Circuit isolation device (System Power Disconnect): Utilize the electromagnetic contactor and the relay to be the isolation unit of the power circuit to prevent the possible instability of the system when the power is supplied on and off.
⑥	DVP PLC MPU (main processing unit)
⑦	Grounding resistance: 100Ω or less
⑧	Power supply: AC: 100~240VAC, 50/60Hz, DC: 24VDC

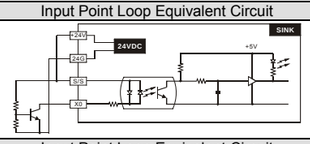
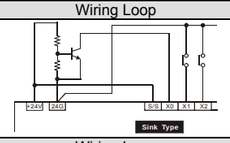
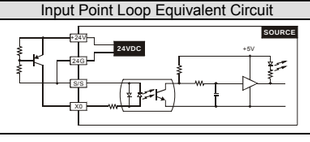
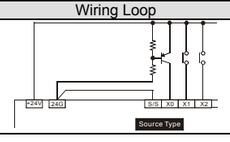
■ Input Point Wiring

The input signal of the input point is the DC power DC input. There are two types of DC type wiring: SINK and SOURCE, defined as follows:

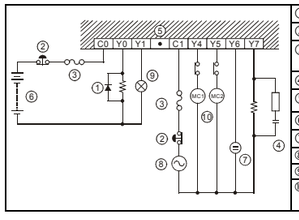
◎ Definition

Sink = Current flows into the common terminal S/S		Source = Current flows out of the common terminal S/S	

◎ Wiring

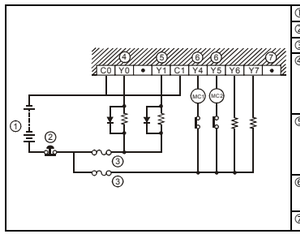
	Input Point Loop Equivalent Circuit	Wiring Loop
DC Type (DC Signal IN) SINK Mode		
DC Type (DC Signal IN) SOURCE Mode		

◎ Practical Relay Output Wiring



①	Surge absorbing diode: increases relay contact life
②	Emergency stop: use an external switch
③	Fuse: use the fuse with a 5~10A capacity at the common end of the output contact to protect the output circuit.
④	Surge absorber: reduces noise on AC inductive loads
⑤	Unused terminal: do not connect
⑥	DC supply
⑦	Indicator: neon indicator
⑧	AC supply
⑨	Incandescent lamp (resistive loading)
⑩	Mutually exclusive outputs: use external hardware interlocks, as well as those in the PLC program, for maximum safety.

◎ Practical Transistor Output Wiring



①	DC supply
②	Emergency stop
③	Fuse for circuit protection
④	As all outputs of the transistor modules are Open Collectors, if the setting of Y0 is pulse train output (using PLSY command), its pull-up resistor must remain an output current of greater than 0.1A for normal operation of the transistor modules.
⑤	As all outputs of the transistor modules are Open Collectors, if the setting of Y1 is pulse train output (using PWM command), its pull-up resistor must remain an output current of greater than 0.1A for normal operation of the transistor modules.
⑥	Mutually exclusive outputs: use external hardware interlocks, as well as those in the PLC program, for maximum safety.
⑦	Unused terminal: do not connect

5 TRIAL RUN

■ Power Indication

1. The "POWER" LED at the front of the MPU or the Extension Units will be lit (in green) if the power is on. If the indicator is not on when the MPU is powered up, it means that there is abnormal condition on the DC power supply of the PLC. It is thus necessary to check the wiring on terminals +24V and 0V. If the ERROR LED is blinking swiftly, it indicates that the +24V power supply of the PLC is insufficient.
2. The "LOW V." LED on the Expansion Unit is an indication that the input power voltage is insufficient, thus all outputs of the expansion unit should be turned off.

■ Operation and Test

1. If the ERROR LED of the MPU is not blinking, use the peripheral device to give the RUN command, and the RUN indicator will then be on.
2. HPP could be utilized to monitor the timer (T), the counter (C) and the data register (D) during operation, and moreover, to force the output contacts to conduct the On/Off action. If the ERROR LED is on (but not blinking), it indicates that the setting of the user's program has exceeded the preset overtime limit, thus users have to double check the program and perform the On/Off function again. (The PLC is at this moment back to STOP status automatically).

■ PLC Input/Output Reaction Time:

The total reaction time from the input signal to the output operation is calculated as follows:
Reaction Time = input delay time + program scan time + output delay time

Input delay time	Default 10ms. Please refer to the usage of special registers D1020~D1021.
Program scan time	Please refer to the usage of special register D1010.
Output delay time	Relay module: 10ms. Transistor module: 20~30us.

6 TROUBLESHOOTING

udge the errors by the indicators on the front panel. When errors occurred on DVP series PLC, please check:

☼ "POWER" LED

There is a "POWER" LED at the front of the MPU. The "POWER" LED will be lit (in green) when the power in connected to MPU. If the indicator is not on when the MPU is powered up and with the input power being normal, it indicates that the PLC is out of order. Please have this machine replaced or repaired at a distributor near you.

☼ PLC "RUN" LED

Identify the status of the PLC. When the PLC is in operation, this light will be on, and the user could thus use HPP or the editing program of the ladder diagram to give commands to make the PLC "RUN" or "STOP".

☼ "ERROR" LED

If an incorrect program is input to the MPU, or the instruction and the device exceed the allowable range, the indicator will blink. At this moment, the user should check the error code saved in the MPU data register D1004 to correct the program. Find out the cause of the error and modify the programs. Then, re-send the correct program to the MPU.

If the ERROR LED is blinking swiftly, it suggests that the +24VDC power supply of the PLC is insufficient. Please check whether the power supply of 24VDC is normal or not.

When the ERROR LED is on (not blinking), it indicates that the execution time of the program loop has exceeded the time-out setting (set by D1000). Please check the program loop or use "WDT" instruction to solve the problem. When the ERROR LED is on, please power down the MPU and start up it one time, and then check if the RUN LED is off. If the RUN LED is not off, please check if there is any noise and interference and check if any conductive material falling into the PLC.

☼ "Input" LED

The On/Off signals of the input point could be displayed through the "Input" LED. Also, the status signal of the input point could be monitored through the device monitoring function of HPP. As long as the input point is activated, the LED is on. Therefore, if an error is detected, please check HPP, the LED indicator and the input signal circuits. Please pay particular attention to check if an electrical switch with significant leakage current is used as it often results in the unexpected operation of input point.

☼ "Output" LED

Output LED indicates if the output signals are on or off. Please check the following items when the LED On/Off indication does not correspond to the commands:

1. Output contacts may be melted and stuck together due to a short circuit or current overload.
2. Check wiring and verify that the screws are tight and secure.