Palestine Polytechnic University

COLLEGE OF ENGINEERING AND TECHNOLOGY
ELECTRICAL AND COMPUTER ENGINEERING DEPARTMENT

Graduation project

Designing and Building A Stone Forming Machine

BY

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<u>CERTIFICATION</u>

Palestine Polytechnic University (PPU)

Hebron- Palestine

The Senior Project Entitled:

Designing and Building A Stone Forming Machine

Prepeared By:

Alaa Mraish **Shadi Abu Omar**

In accordance with the recommendation of the project supervisors, and the acceptance of all examining committee members , this project has been submitted to the Department of Electrical and Computer Engineering in the College of Engineering and Technology in partial fulfillment of the requirements of Department for the degree of Bachelor of Science in Engineering.

Project Supervisors **Department Chairman**

Dedication

TO our family

TO our parents,

TO our sisters and brothers,

to all whom I love, to all of our loyal teacher, to all who help us to reach this level of education, and to who has made the development of this project, to all of our friends .

ACKNOWLEDGEMENT

We would like to express our thanks and gratitude to Allah, the Most Beneficent, the most Merciful who granted us the ability and willing to start and complete this project. We pray to his greatness to inspire us the right path to his content and enable us to continue the work started in this project to benefits of our country.

We wish to express our deep and sincere thanks and gratitude to Palestine Polytechnic University, the electrical and computer engineering department , College of Engineering and Technology. We wish to express our thanks to Dr. Abdel-Karim Daud , for a valuable help, encouragement, supervision and guidance in solving the problems that we faced from time to time during this project.

We can find no words to express our sincere, appreciation and gratitude to our parents, sisters and brothers, for their endless support and encouragement, we are deeply indebted to you and we hope that we may someday reciprocate it in some way.

Work Team

ABSTRACT

Till now stone forming process is passed on manually – acting task thought using classical instruments and human interference .

Classical methods are characterized with less quality , time consuming and wasting row material. Based on that our project presents design and implementation of store forming machine , where the surface in process according to specific requirements .

PLC control technique in applied in controlling whole production process, The implemented protect model fulfills the predetermined task with acceptable quality . The design can be improved in future work .

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CHAPTER ONE

INTRODUCTION

1.1 General Description of the Project

The stone industry is a pillar of the Palestinian economy in general and income is important for residents of the city of Hebron special, so we pay attention to this industry and its development because of its significant role in the industrial sector, where are the first in the industrial field.

Today, the stone enters the house in various forms, has become of great interest to the formation of stone, but unfortunately with the huge development in the extraction of stone and manufacture, but still a stone depends on the manual method in formation; this method requires time and great effort, leading slow in manufacture of stone.

Hence we hope in this project build a machine for the formation of stone in an automatic .

In Figure 1.1 show the components and design of the machine , where it has four single phase induction motors , three of them responsible to move the head in three direction. and the motors x,y and z connect with lead screw gear to give linear motion .

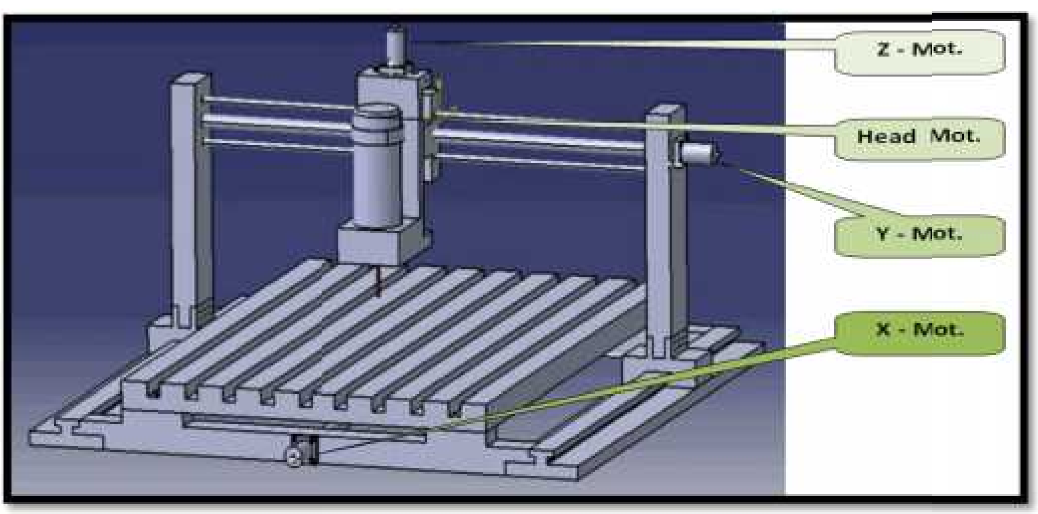


Fig.1.1: Construction of machine

1.2 Project Selection

In this project work to reduce the time and effort in the process of stone formation exerted manual methods. and work to increase the production of this form of stone, commensurate with the demand. and at the same time increase the quality like as manual process in the formation .

1.3 Previous Studies

We did not find a lot of previous studies that talk about the same subject, but there are some machines that are similar to the principle of the work of machine, like washing stone machine and some cutting machine, its similar the machine in this project .[1]

Of course, we will dependent on references and studies on the induction motor, which is part of the machine.[2]

1.4 Time Plan

1st week to 8st week we studied the project and collected data from the internet and books about the machine and its component, from 8st week to 14st week we wrote of the documentation and make calculation. And in 18st collect the component of machine then in 21st build the machine

And the following figure shows the project schedule :

Table 1.1 : Time Line of Project

No.	Activity	Length of time /weeks																															
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
1.	Choose a title																																
2.	Writing the research plan																																
3.	Collection data about the machine and its component																																
4.	Write the documentation and make calculation																																
5.	Seminar Introduction Project																																
6.	Collect the Component of Machine																																
7.	Build the Machine																																
8.	Seminar Project																																

1.5 Finance Study

The following table shows a cost of the project .

Table 1.2 : Cost of Project

Component Name	NO.	Price Per Component (NIS)	Total Price (NIS)
Induction Motors	3	250	750
Inverter	1	500	500
PLC Unit	1	1000	1000
Switches	3	30	90
Relays	5	25	125
Iron	---	800	800
Pneumatics	---	550	550
wires	---	150	150
Total Price			3965

CHAPTER

2 *ELECTROMECHANICALLY CONSTRUCTION*

2.1 Basic Construction AC Induction Motor

2.2 Three_ Phase AC Induction Motor

2.3 Speed Of An Induction Motor

2.4 Torque Equation Governing Motor Operation

2.5 Frequency Converter

CHAPTER TWO

ELECTROMECHANICALLY CONSTRUCTION

In this chapter we will talk about the motors that used in the machine, and the reason for their choice, and we will review their equations , characteristics and control speed of motors .

2.1 Basic Construction AC 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.

Like most motors, an AC induction motor has a fixed outer portion, called the stator and a rotor that spins inside with a carefully engineered air gap between the two.
Virtually all electrical motors use magnetic field rotation to spin their rotors.

A three-phase AC induction motor is the only type where the rotating magnetic field is created naturally in the stator because of the nature of the supply. DC motors depend either on mechanical or electronic commutation to create rotating magnetic fields. A single-phase AC induction motor depends on extra electrical components to produce this rotating magnetic field. Two sets of electromagnets are formed inside any motor.

In an AC induction motor, one set of electromagnets is formed in the stator because of the AC supply connected to the stator windings.

The alternating nature of the supply voltage induces an Electromagnetic Force (EMF) in the rotor (just like the voltage is induced in the transformer secondary) as per Lenz’s law, thus generating another set of electromagnets; hence the name – induction motor. Interaction between the magnetic field of these electromagnets generates twisting force, or torque. As a result, the motor rotates in the direction of the resultant torque.

1) Stator

The stator is made up of several thin laminations of aluminum or cast iron. They are punched and clamped together to form a hollow cylinder (stator core) with Slots as shown in figure 2.1 .

Coils of insulated wires are inserted into these slots. Each grouping of coils, together with the core it surrounds, forms an electromagnet (A pair of poles) on the application of AC supply. The number of poles of an AC induction motor depends on the internal connection of the stator windings.

The stator windings are connected directly to the power source. Internally they are connected in such a way, that on applying AC supply, a rotating magnetic
Field is created .

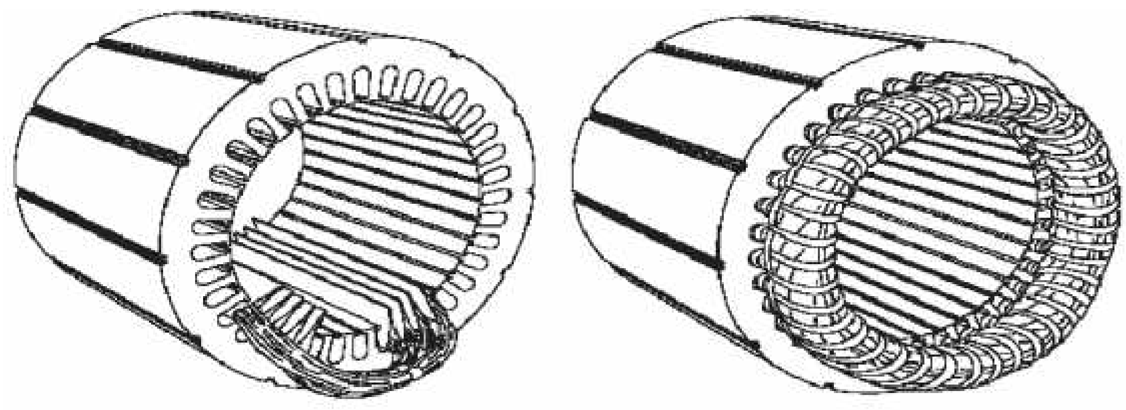


Figure 2.1: A Typical Stator

2) Rotor

The rotor is made up of several thin steel laminations with evenly spaced bars, which are made up of aluminum or copper, along the periphery.

In the most popular type of rotor (squirrel cage rotor), these bars are connected at ends mechanically and electrically by the use of rings. Almost 90% of induction motors have squirrel cage rotors. This is because the squirrel cage rotor has a simple and rugged construction. The rotor consists of a cylindrical laminated core with axially placed parallel slots for carrying the conductors. Each slot carries a copper, aluminum, or alloy bar. These rotor bars are permanently short-circuited at both ends by means of the end rings, as shown in figure 2.2 . This total assembly resembles the look of a squirrel cage, which gives the rotor its name. The rotor slots are not exactly parallel to the shaft. Instead, they are given a skew for two main reasons.

The first reason is to make the motor run quietly by reducing magnetic and to decrease slot harmonics.

The second reason is to help reduce the locking tendency of the rotor. The rotor teeth tend to remain locked under the stator teeth due to direct magnetic attraction
between the two. This happens when the number of stator teeth is equal to the number of rotor teeth.

The rotor is mounted on the shaft using bearings on each end; one end of the shaft is normally kept longer than the other for driving the load. Some motors may have an accessory shaft on the non-driving end for mounting speed or position sensing devices. Between the stator and the rotor, there exists an air gap, through which due to induction, the energy is transferred from the stator to the rotor. The generated torque forces the rotor and then the load to rotate. Regardless of the type of rotor used, the principle employed for rotation remains the same.

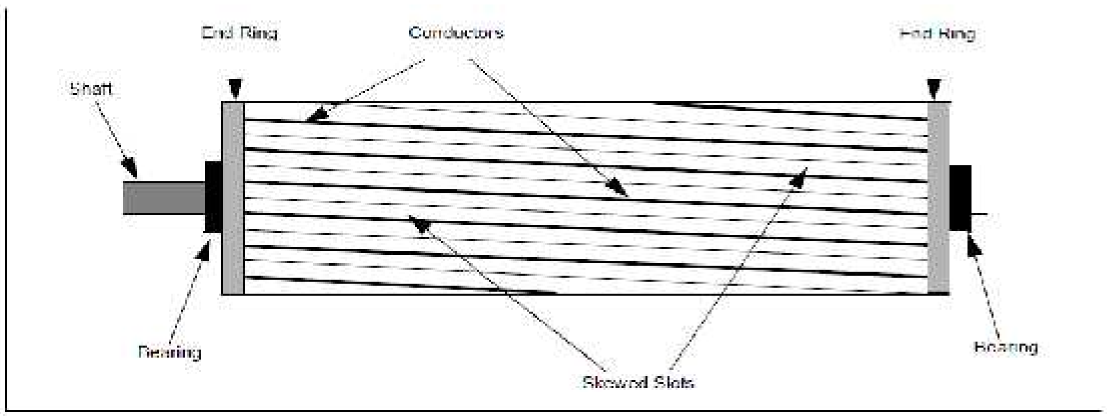


Figure 2.2: A Typical Squirrel Cage Rotor

Generally, induction motors are categorized based on the number of stator windings. They are:
- Single-phase induction motor
- Three-phase induction motor

2.2 Three-Phase Ac Induction Motor

3-phase AC induction motors are widely used in industrial and commercial applications. They are classified either as squirrel cage or wound-rotor motors.

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

They produce medium to high degrees of starting torque. The power capabilities and efficiency in these motors range from medium to high compared to their single-phase counterparts. Popular applications include grinders, lathes, drill presses, pumps, compressors, conveyors, also printing equipment, farm equipment, electronic cooling and other mechanical duty applications.

- Squirrel Cage Motor :

Almost 90% of the three-phase AC Induction motors are of this type. Here, the rotor is of the squirrel cage type and it works as explained earlier. The power ratings range from one-third to several hundred horsepower in the three-phase motors. Motors of this type, rated one horsepower or larger, cost less and can start heavier loads than their single-phase counterparts.

- Slip-Ring Motor :

The motor or wound-rotor motor is a variation of the squirrel cage induction motor. While the stator is the same as that of the squirrel cage motor, it has a set of windings on the rotor which are not short-circuited,
but are terminated to a set of slip rings. These are helpful in adding external resistors and contactors.

The slip necessary to generate the maximum torque (pull-out torque) is directly proportional to the rotor resistance. In the slip-ring motor, the effective rotor resistance is increased by adding external resistance through the slip rings. Thus, it is possible to get higher slip and hence, the pull-out torque at a lower speed.

A particularly high resistance can result in the pull-out torque occurring at almost zero speed, providing a very high pull-out torque at a low starting current. As the motor accelerates, the value of the resistance can be reduced, altering the motor characteristic to suit the load requirement. Once the motor reaches the base speed, external resistors are removed from the rotor.

This means that now the motor is working as the standard induction motor.

This motor type is ideal for very high inertia loads, where it is required to generate the pull-out torque at almost zero speed and accelerate to full speed in the minimum time with minimum current draw.

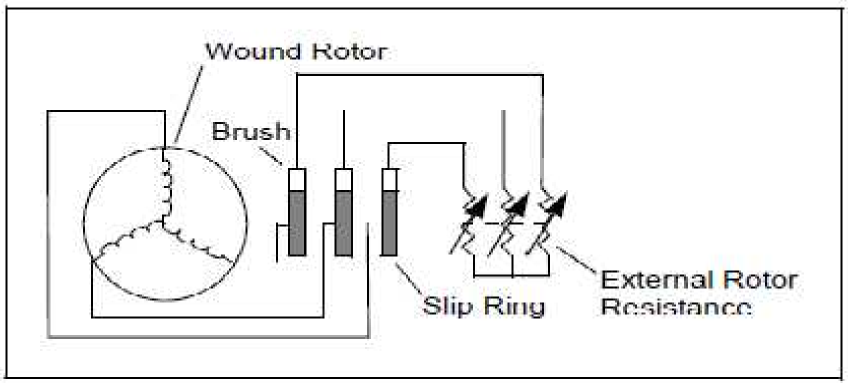


Figure 2.9: Typical Wound-Rotor Induction Motor

The downside of the slip ring motor is that slip rings and brush assemblies need regular maintenance, which is a cost not applicable to the standard cage motor. If the rotor windings are shorted and a start is attempted (i.e., the motor is converted to a standard induction motor), it will exhibit an extremely high locked rotor current typically as high as 1400% and a very low locked rotor torque, perhaps as low as 60%. In most applications, this is not an option.

Modifying the speed torque curve by altering the rotor resistors, the speed at which the motor will drive a particular load can be altered. At full load, you can reduce the speed effectively to about 50% of the motor synchronous speed, particularly when driving variable torque/variable speed loads, such as printing presses or compressors.

Reducing the speed below 50% results in very low efficiency due to higher power dissipation in the rotor resistances. This type of motor is used in applications for driving variable torque/ variable speed loads, such as in printing presses, compressors, conveyer belts, hoists and elevators .

2.3 Speed of an Induction Motor

The magnetic field created in the stator rotates at a synchronous speed (*NS*).

- *Equation 1*:

$$N_S = 120 \times \frac{f}{P}$$

where:
N_S = the synchronous speed of the stator magnetic field in RPM
P = the number of poles on the stator
f = the supply frequency in Hertz

The magnetic field produced in the rotor because of the induced voltage is alternating in nature.

To reduce the relative speed, with respect to the stator, the rotor starts running in the same direction as that of the stator flux and tries to catch up with the rotating flux. However, in practice, the rotor never succeeds in "catching up" to the stator field. The rotor runs slower than the speed of the stator field. This speed is called the Base Speed (*Nb*).

The difference between *NS* and *Nb* is called the slip. The slip varies with the load. An increase in load will cause the rotor to slow down or increase slip. A decrease in load will cause the rotor to speed up or decrease slip.

The slip is expressed as a percentage and can be determined with the following formula:

- *Equation 2:*

$$\%\ slip = \frac{N_S - N_b}{N_S} x100$$

where:
N_S = the synchronous speed in RPM
N_b = the base speed in RPM

2.4 Torque Equation Governing Motor Operation

The motor load system can be described by a fundamental torque equation.

- *Equation 3:*

$$T - T_l = J\frac{d\omega_m}{dt} + \omega_m\frac{dJ}{dt}$$

where:

T = the instantaneous value of the developed motor torque (*N-m* or *lb-inch*)

T_l = the instantaneous value of the load torque (*N m* or *lb inch*)

ω_m = the instantaneous angular velocity of the motor shaft (rad/sec)

J = the moment of inertia of the motor – load system (*kg-m*^{2} or *lb-inch*^{2})

For drives with constant inertia, (dJ/dt) = 0. Therefore, the equation would be:

- *Equation 4:*

$$T = T_l + J\frac{d\omega_m}{dt}$$

This shows that the torque developed by the motor is counter balanced by a load torque, *Tl* and a dynamic torque, *J*(*dωm*/*dt*). The torque component, *J*(*dω*/*dt*), is called the dynamic torque because it is present only during the transient operations. The drive accelerates or decelerates depending on whether *T* is greater or less than *Tl*. During acceleration, the motor should supply not only the load torque, but an additional torque component, *J*(*dωm*/*dt*), in order to overcome the drive inertia. In drives with large inertia, such as electric trains, the motor torque must exceed the load torque by a large amount in order to get adequate acceleration.

In drives requiring fast transient response, the motor torque should be maintained at the highest value and the motor load system should be designed with the lowest possible inertia. The energy associated with the dynamic torque, *J*(*dωm*/*dt*), is stored in the form of kinetic energy (KE) given by, *J(*ω2 *m*/*2*). During deceleration, the dynamic torque, *J*(*dωm*/*dt*), has a negative sign. Therefore, it assists the motor developed torque *T* and maintains the drive motion by extracting energy from the stored kinetic energy.

To summarize, in order to get steady state rotation of the motor, the torque developed by the motor (*T*) should always be equal to the torque requirement of the load (*Tl*).

The torque-speed curve of the typical three-phase induction motor is shown in figure 2.10 .

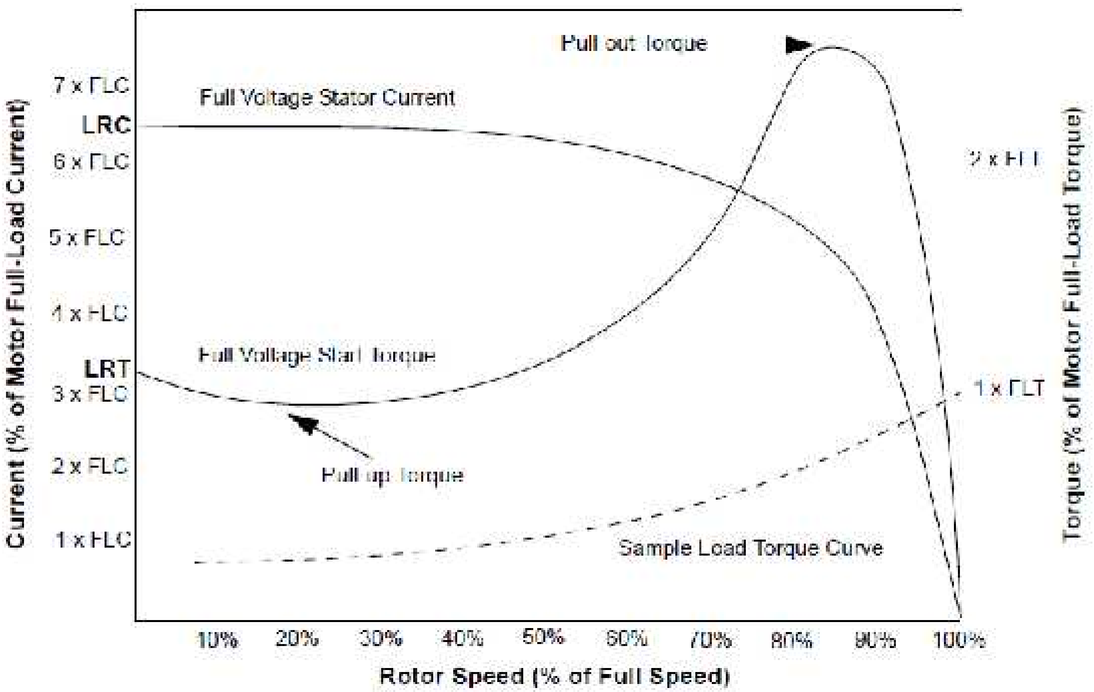


Figure 2.10: Typical Torque-Speed Curve Of 3-Phase Ac Induction Motor

2.5 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 electromechanical machines called a motor-generator set . Also devices with mercury arc rectifiers or vacuum tubes were in use. With the advent of solid state electronics, it has become possible to build completely electronic frequency changers economically. 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, IGCTs 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[3].

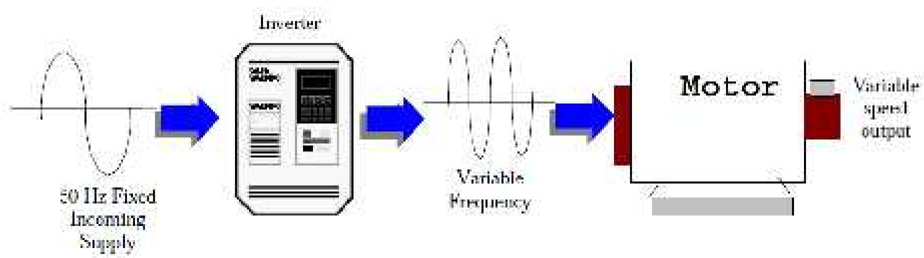


Fig. 2.11 : Principal frequency inverter

- Applications :

Aside from the obvious application of converting bulk amounts of power from one distribution standard to another, frequency changers are also used to control the speed and the torque of AC motors. In this application, the most typical frequency converter topology is the three-phase two-level voltage source inverter. The phase voltages are controlled using the power semiconductor switches and pulse width modulation (PWM). Semiconductor switching devices and anti-parallel connected freewheeling diodes form a bridge, which can connect each motor phase to the positive or negative dc-link potential. The PWM changes the connections of the phases between the positive and the negative dc-link potentials so that the fundamental wave voltage has the desired frequency and amplitude. The motor reacts primarily to the fundamental frequency and filters out the effects of harmonic frequencies.

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 converter is needed for use in the ground power unit used to power the airplane while it is on the ground. Airlines might also utilize the converters to provide in-air wall current to passengers for use with laptops and the like.

In renewable energy systems, frequency converters are an essential component of doubly fed induction generators (DFIGs) as used in modern multi-megawatt class wind turbines.

Frequency changers are typically used to control the speed of motors, primarily pumps and fans. In many applications significant energy savings are achieved. The most demanding application areas are found on the industrial processing lines, where the control accuracy requirements can be very high. This is particularly true in the nuclear power and weapons industry, where these devices regulate the operation of refinement centrifuges.

CHAPTER

3 *MECHANICAL PART*

3.1 Lead Screw

3.1.1 Square Thread

3.1.2 Trapezoidal Thread

3.1.3 Buttress Threads

3.2 Characteristics

3.4 Mechanics

CHAPTER 3

MECHANICAL PART

3.1 Lead Screw

A lead screw (or leadscrew) , also known as a power screw[or translation screw, is a screw designed to translate radial motion into linear motion. common applications are machine slides (such as in machine tools), vises, presses, and jacks.

In figure 3.1 shows , the lead screw connect with motor to translate radial motion into linear motion .

In this chapter we will examine all kinds of lead screw to determine the best possible use for the type of movement, and gives us the required speed .

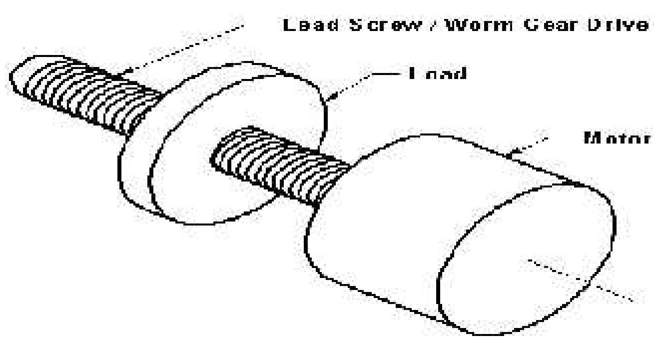


Fig 3.1: Lead Screw Drive System

Power screws are classified by the geometry of their thread. V-threads are less suitable for leadscrews than others such as Acme because they have more friction between the threads. Their threads are designed to induce this friction to keep the fastener from loosening. Leadscrews, on the other hand, are designed to minimize friction. Therefore, in most commercial and industrial use, V-threads are avoided for leadscrew use. Nevertheless, V-threads are sometimes successfully used as leadscrews, for example on micro lathes and micro mills.

3.1.1 Square thread

The square thread form is a common thread form for leadscrews. It gets its name from the square cross-section of the thread.

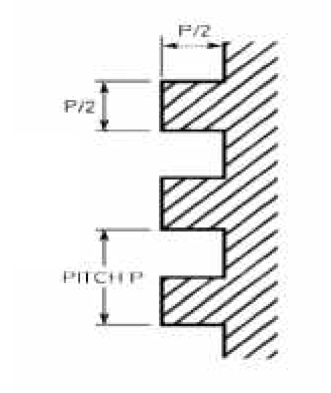


Fig 3.2: Square thread

- *Advantages & disadvantages* :

The greatest advantage of square threads is that they have a much higher intrinsic efficiency than acme threads. Due to the lack of a thread angle there is no radial pressure, or bursting pressure, on the nut. This also increases the nut life.

The greatest disadvantage is the difficulty in machining such a thread. The single- point cutting tools or taps and dies used to cut the thread cannot have efficient rake and relief angles (because of the square form), which makes the cutting slow and difficult. Square threads also cannot carry as much load as a trapezoidal thread, because the root of the square thread is smaller. Also, there is no way to compensate for wear on the nut, so it must be replaced when worn out.

3.1.2 Trapezoidal thread (Acme threads)

Acme threads have a 29° thread angle, which is easier to machine than square threads. They are not as efficient as square threads, due to the increased friction induced by the thread angle.

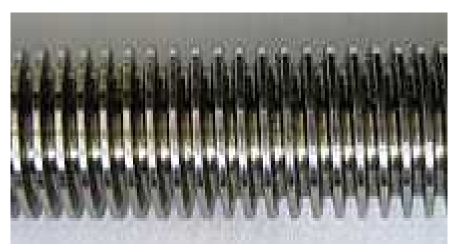


Fig. 3.3 : Acme thread

- Trapezoidal thread characteristics :

He acme thread form has a 29° thread angle with a thread height half of the pitch; the apex and valley are flat. This shape allows the use of a milling machine for manufacture, which is much cheaper than the single point cutter used in machining square threads. The tooth shape also has a wider base which means it is stronger (thus, the screw can carry a greater load) than a similarly sized square thread. This thread form also allows for the use of a split nut, which can compensate for nut wear.

The disadvantages of the Acme thread form are the much lower efficiency and the greater radial load on the nut, due to the thread angle.

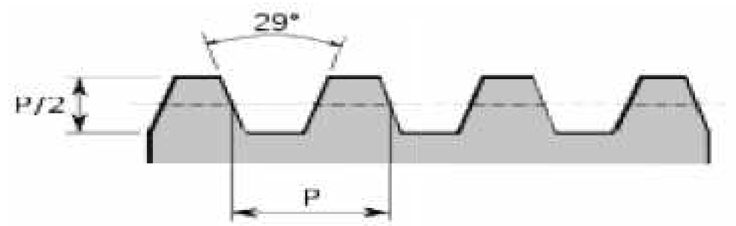


Fig. 3.4 :Dimensions of an Trapezoidal Thread

When created prior to 1895, Acme screw threads were intended to replace square threads and a variety of threads of other forms used chiefly for the purpose of traversing motion on machines, tools, etc. Acme screw threads are now extensively used for a variety of purposes. Long-length Acme threads are used for controlled movements on machine tools, testing machines, jacks, aircraft flaps, and conveyors. Short-length threads are used on valve stems, hose connectors, bonnets on pressure cylinders, steering mechanisms, and camera lens movement.

The following table shows the diameter of lead screw and the pitch .

Table 3.1 : Standard Acme thread pitches for customary diameters.

Nominal diameter [in]	Pitch [in]
1/4	1/16
5/16	1/14
3/8	1/12
1/2	1/10
5/8	1/8
3/4, 7/8	1/6
1, 1 1/4	1/5
1 1/2, 1 3/4, 2	1/4
2 1/2	1/3
3	1/2

3.1.3 Buttress threads

Buttress threads are of a triangular shape. It combines the advantages of the square and acme thread forms with only one difference, it only works in one direction.

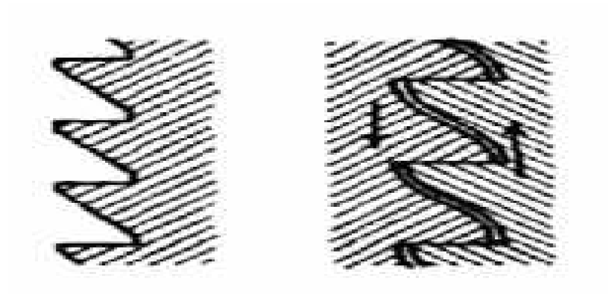


Fig. 3.5 :Buttress thread form

In machinery, the buttress thread form is designed to handle extremely high axial thrust in one direction. The load-bearing thread face is perpendicular to the screw axis. or at a slight slant (usually no greater than 7°) The other face is slanted at 45°. The resulting thread form has the same low friction properties as a square thread form but at about twice the strength due to the long thread base. This thread form also is easy to machine on a thread milling machine, unlike the difficult to machine square thread form. It can also compensate for nut wear using a split nut, much like the Acme thread form.

Buttress threads have often been used in the construction of artillery, particularly with the screw-type breechblock because the thread can withstand the axial load placed on it when the powder charge explodes. They are also often used in vises, because great force is only required in one direction.[6]

3.2 Characteristics

A leadscrew nut and screw mate with rubbing surfaces, and consequently they have a relatively high friction compared to mechanical parts which mate with rolling surfaces and bearings. Leadscrew efficiency is typically between 25 and 70%, with higher pitch screws tending to be more efficient. A higher performing but more expensive alternative is the ball screw.

The high internal friction means that leadscrew systems are not usually capable of continuous operation at high speed, as they will overheat. Due to inherently high static friction, the typical screw is self-locking (i.e. when stopped, a linear force on the nut will not apply a torque to the screw) and are often used in applications where back driving is unacceptable, like holding vertical loads or in hand cranked machine tools.

Leadscrews are typically used well greased, but, with an appropriate nut, they may be run dry with somewhat higher friction. There is often a choice of nuts, and manufacturers will specify screw and nut combination as a set.

The mechanical advantage of a leadscrew is determined by the crew pitch and lead. For multi-start screws the mechanical advantage is lower, but the traveling speed is better.

Backlash can be reduced with the use of a second nut to create a static loading force known as preload; alternately, the nut can be cut along a radius and preloaded by clamping that cut back together.

A lead screw will back drive, whereby forces on the nut applied parallel with the lead screw will cause a free-moving leadscrew to begin to rotate. A lead screw’s tendency to back drive depends on its thread helix angle, coefficient of friction of the interface of the components (screw/nut) and the included angle of the thread form. In general, a steel acme thread and bronze nut will back drive when the helix angle of the thread is greater than 20°.

3.3 Advantages & disadvantages

The advantages of a leadscrew are:

- Large load carrying capability
- Compact
- Simple to design
- Easy to manufacture; no specialized machinery is required
- Large mechanical advantage
- Precise and accurate linear motion
- Smooth, quiet, and low maintenance
- Minimal number of parts
- Most are self-locking

The disadvantages are that most are not very efficient. Due to the low efficiency they cannot be used in continuous power transmission applications. They also have a high degree for friction on the threads, which can wear the threads out quickly. For square threads, the nut must be replaced; for trapezoidal threads, a split nut may be used to compensate for the wear.[7]

3.4 Mechanics

He torque required to lift or lower a load can be calculated by "unwrapping" one revolution of a thread. This is most easily described for a square or buttress thread as the thread angle is 0 and has no bearing on the calculations. The unwrapped thread forms a right angle triangle where the base is πd_m long and the height is the lead (pictured to the right). The force of the load is directed downward, the normal force is perpendicular to the hypotenuse of the triangle, the frictional force is directed in the opposite direction of the direction of motion (perpendicular to the normal force or along the hypotenuse), and an imaginary "effort" force is acting horizontally in the direction opposite the direction of the frictional force. Using this free-body diagram the torque required to lift or lower a load can be calculated:

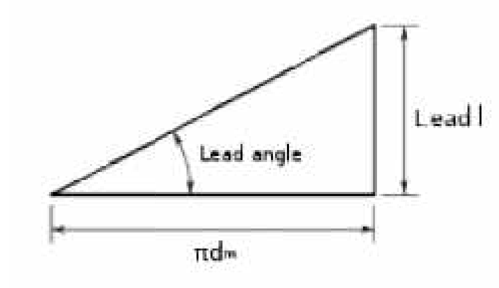


Fig. 3.6: diagram of screw thread

$$T_{raise} = \frac{Fd_m}{2}\left(\frac{l + \pi\mu d_m}{\pi d_m - \mu l}\right) = \frac{Fd_m}{2}\tan(\phi + \lambda) \quad \ldots\ldots\ldots\ldots\ldots (1)$$

where

- T = torque
- F = load on the screw
- d_m = mean diameter
- μ = coefficient of friction (common values are found in the table 3.2)
- l = lead
- ϕ = friction angle
- λ = lead angle

The efficiency, calculated using the torque equations above, is:

$$\text{efficiency} = \frac{T_0}{T_{raise}} = \frac{Fl}{2\pi T_{raise}} = \frac{\tan\lambda}{\tan(\phi + \lambda)} \quad \ldots\ldots\ldots\ldots (2)$$

In table 3.2 shows the Coefficient of friction for different lead screw materials and different nut materials .

Table 3.2 : Coefficient of friction for leadscrew threads :

Screw material	Nut material			
	Steel	Bronze	Brass	Cast iron
Steel, dry	0.15–0.25	0.15–0.23	0.15–0.19	0.15–0.25
Steel, machine oil	0.11–0.17	0.10–0.16	0.10–0.15	0.11–0.17
Bronze	0.08–0.12	0.04–0.06	-	0.06–0.09

In the table 3.4 shows the safe running speeds for various nut materials and loads on a steel screw.

Table 3.3 : Safe running speeds for various nut materials and loads on a steel screw

Nut material	Safe loads [psi]	Speed
Bronze	2500–3500	Low speed
Bronze	1600–2500	10 fpm
Cast iron	1800–2500	8 fpm
Bronze	800–1400	20–40 fpm
Cast iron	600–1000	20–40 fpm
Bronze	150–240	50 fpm

After studying all kinds of lead screws is clear to us that the best kind of screws to use it trapezoidal thread . Where we will adopt this type to work need calculation to know the torque load and speed, and will be relying on the tables attached to choose the appropriate factors.

CHAPTER

4 MACHINE DESIGN

4.1 Block Diagram

4.2 Flow Chart

4.3 Calculation Of Motors

4.3.1 X_ Motor Calculation

4.3.2 Y_ Motor Calculation

4.3.3 Head Motor Calculation

4.4 Simulation System In Matlab

4.5 Layout Of Machine

CHAPTER FOUR

MACHINE DESIGN

In this chapter talk about block diagram and flow chart, and will make calculation to motors, where would we calculate the torque, speed and power of motor. We will also work for the simulation system in matlab.

4.1 Block Diagram

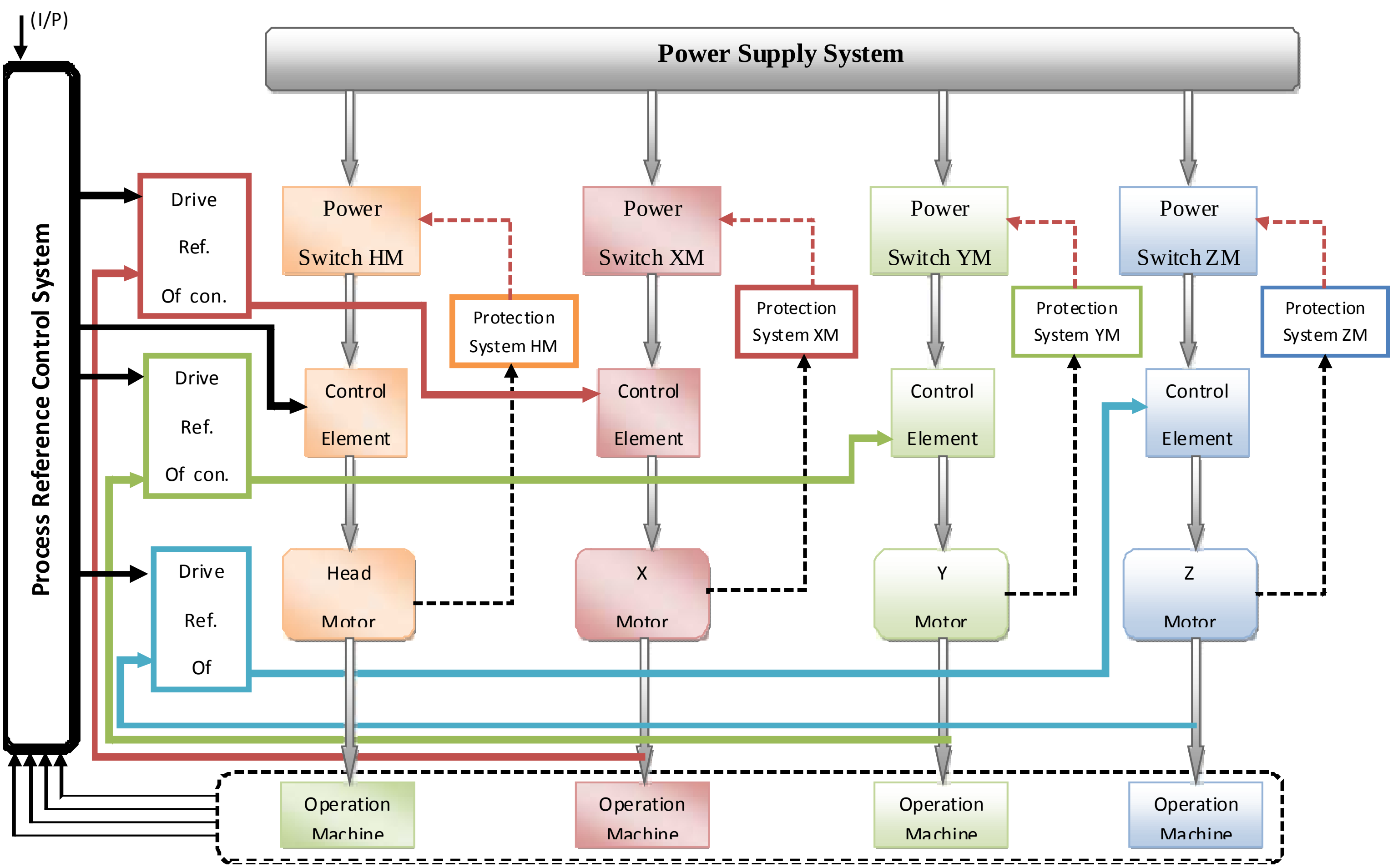


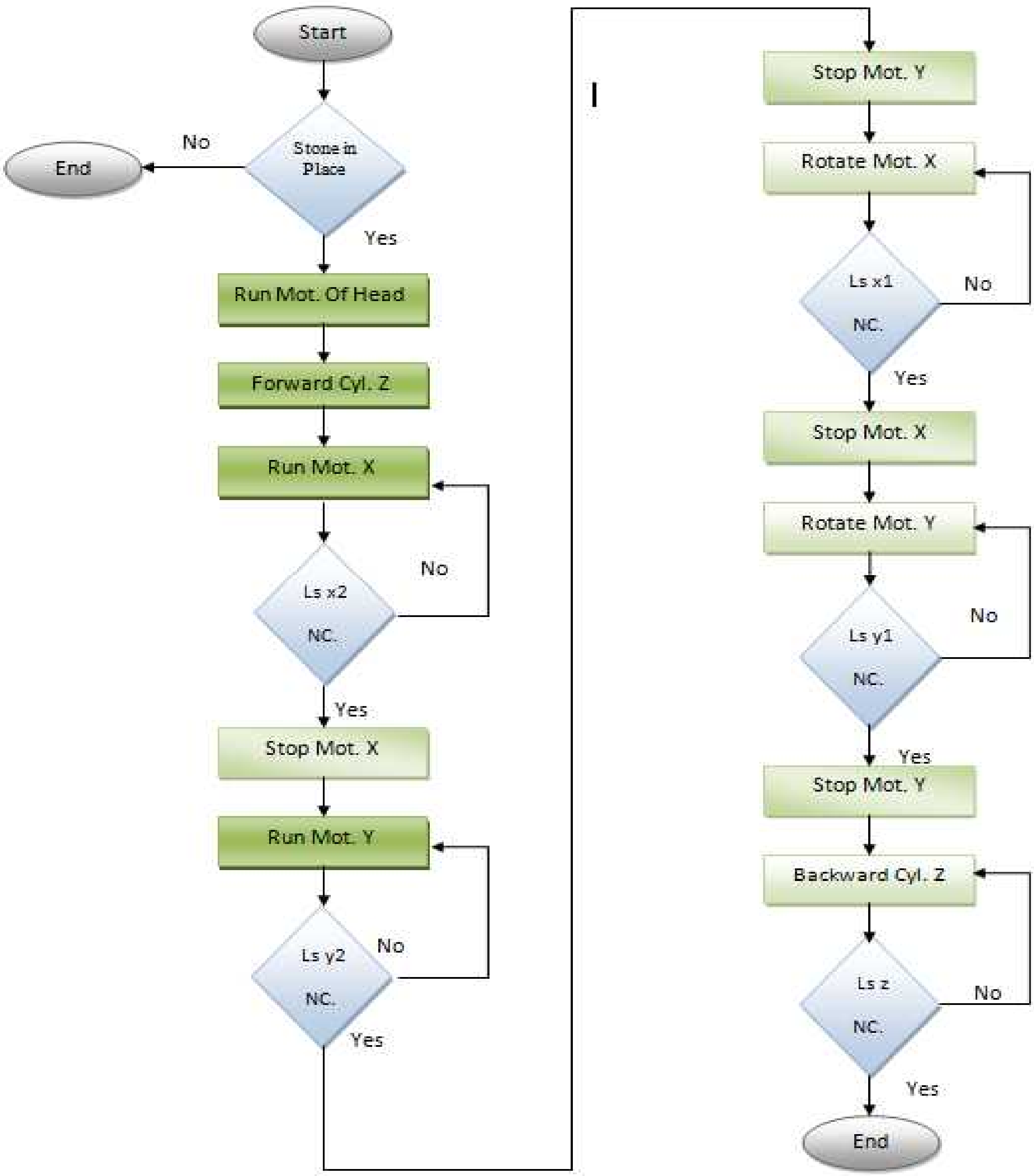
Fig. 4.1: Block diagram

The previous figure 4.1 shows the block diagram of machine . The PLC is the process reference control system , and the all protection system is overload.

The power switch is circuit breaker will connect after the power supply , the power supply used is ac single phase .

And will control speed in X-motor and Y-motor with the frequency converter , and will used one frequency to two motor , there is connect motors in parallel with frequency converter .

4.2 Flow Chart



Note the (LS) means limit switch and (NC) means normally closed .

4.3 Calculation of Motors

There are three motors will be used, two of them to move the load in two direction linear motion, and the other responsible to move the head.

All type motors is an induction motors but different torque and speed , the two motors (X andY) will connect lead screw to make linear velocity , and the diameter of lead screw is (d= 2 cm) .

In two motors (X, and Y) will calculate the torque and speed depended on this equation:

$$T_{raise} = \frac{Fd_m}{2}\left(\frac{l + \pi\mu d_m}{\pi d_m - \mu l}\right) = \frac{Fd_m}{2}\tan(\phi + \lambda) \quad \text{.........} (3)$$

Where

- T = torque
- F = load on the screw
- d_m : mean diameter =1.5 cm
- μ : coefficient of friction = 0.15 (common values are found in the table 3.2)
- l : lead = tan 29 * π * d_m = *3.5 cm*
- ϕ = friction angle
- λ = lead angle

$$n_{\text{screw}} = Vl \times \left(\frac{1\,[rev]}{p\,[m]}\right) \quad \text{.........} (4)$$

Where

- n_{screw} *: screw speed = motor speed*
- *p : pitch = 0.41cm*
- V_l *: linear velocity*

4.2.1 X – Motor Calculation

This motor move the machine in X direction, and the max distance will move is 70 cm, this distance will be crossed in 5 second. And the components weigh is 300 N.

The torque needed to move the load in X direction is:

$$T = \frac{300 * 0.02}{2} \ \frac{0.035 + \pi \times 0.15 \times 0.02}{\pi \times 0.02 - 0.15 * 0.035} = 2.3\ N.m$$

After we calculated the torque needed to move direction X, we will find motor speed to cross 70 cm in 5 sec.

$$Vl = \frac{D}{t}$$

$$Vl = \frac{0.6}{6} = 0.1\, m/s$$

Now the screw speed given by:

$$n_{screw} = 0.1 \ \times \ \frac{1\ [rev]}{0.0041\ [m]} = 24.4\, rps$$

$$= 24.4 \times \ \frac{rev}{sec} \ \times \ \frac{60\ sec}{1\ min} = 1463 rpm$$

Now, the power required to drive the screw could be calculated by:

$$power = T \ \frac{2 \times \pi \times n}{60}$$

$$power = 2.3 \times \ \frac{2 \times \pi \times 1400}{60} = 337 watt = 0.45\ HP$$

4.2.2 Y – Motor Calculation

This motor move the machine in Y direction, and the max distance will move is 20 cm, this distance will be crossed in 2.5 second. And the components weigh is 200 N.

The torque needed to move the load in Y direction is:

$$T = T = \frac{200 * 0.02}{2} \; \frac{0.035 + \pi \times 0.15 \times 0.02}{\pi \times 0.02 - 0.15 * 0.035} = 1.54 \, N.m$$

After we calculated the torque needed to move direction X, we will find motor speed to cross 70 cm in 5 sec.

$$Vl = \frac{D}{t}$$

$$Vl = \frac{0.2}{2} = 0.1 \, m/s$$

Now the screw speed given by:

$$n_{\text{screw}} = 0.14 \, [{}^{m}/_{s}] \times \frac{1 \; rev}{0.0031 \; m} = 24.4 rps$$

$$= 44.8 \times \frac{rev}{sec} \times \frac{60 \, sec}{1 \, min} = 1463 \, rpm$$

Now, the power required to drive the screw could be calculated by:

$$power = T \; \frac{2 \times \pi \times n}{60}$$

$$power = 1.54 \times \frac{2 \times \pi \times 1400}{60} = 225 watt = 0.30 \, HP$$

4.2.3 Head Motor Calculation

This motor is responsible to rotate the head so we will need high speed motor , speed in this motor between 800 rpm to 1400 rpm , and the power of this motor is 2000 watt .

From this information we can calculate the torque of this motor

$$T = \frac{power}{\frac{2 \times \pi \times n}{60}}$$

$$T = \frac{2000}{\frac{2 \times \pi \times 900}{60}} = 21.2\ N.m$$

4.3 Simulation System in Matlab

We use the matlab to make simulation to motors , and depending on this equation :

- This equation used to make simulation to motor speed .

$$n_{screw} = Vl \times \frac{1\,[rev]}{p\,[m]} \qquad (1)$$

- This equation used to make simulation to load torque in screw :

$$T = \frac{F * dm}{2} \; \frac{l + \pi\,\mu\,dm}{\pi\,dm - \mu\,l} \qquad (2)$$

- This equation used to make simulation to total inertia :

$$J_t = \frac{W}{g} \; \frac{1}{2\pi P}^{\;2} + J_{ls} + J_M \qquad (3)$$

W = Weight .
J_l = Load inertia .
g = Gravitational constant .
J_{ls} = Worm gear / lead screw inertia .
J_m = Motor inertia .

This figure 4.3, is block diagram of x – motor in machine and we will make a simulation of it depended on previous equation.

The change in any parameter of speed or load torque can see in display in matlab.

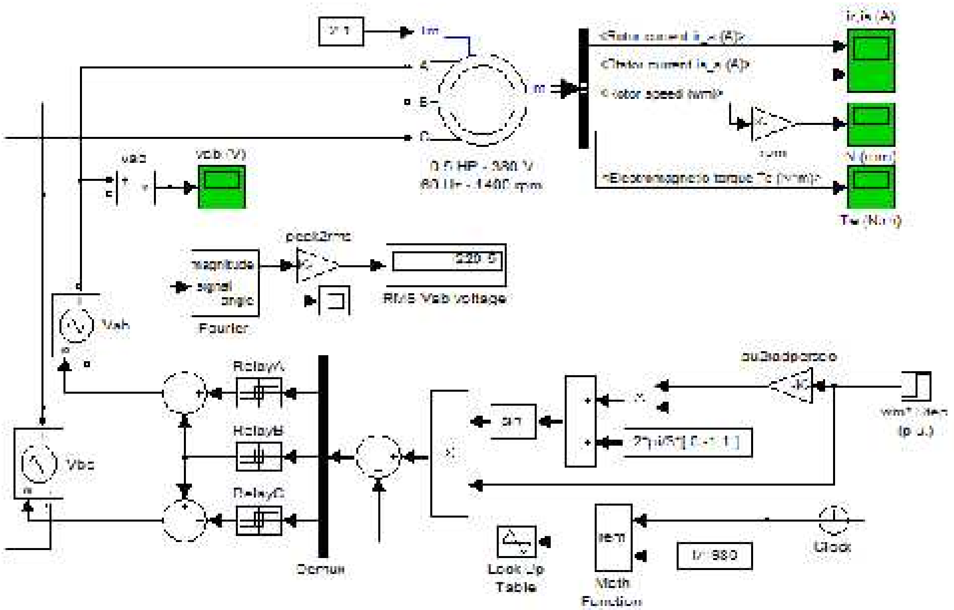


Fig. 4.3: Block diagram of IM matlab

The figure 4.4 shows the motor torque :

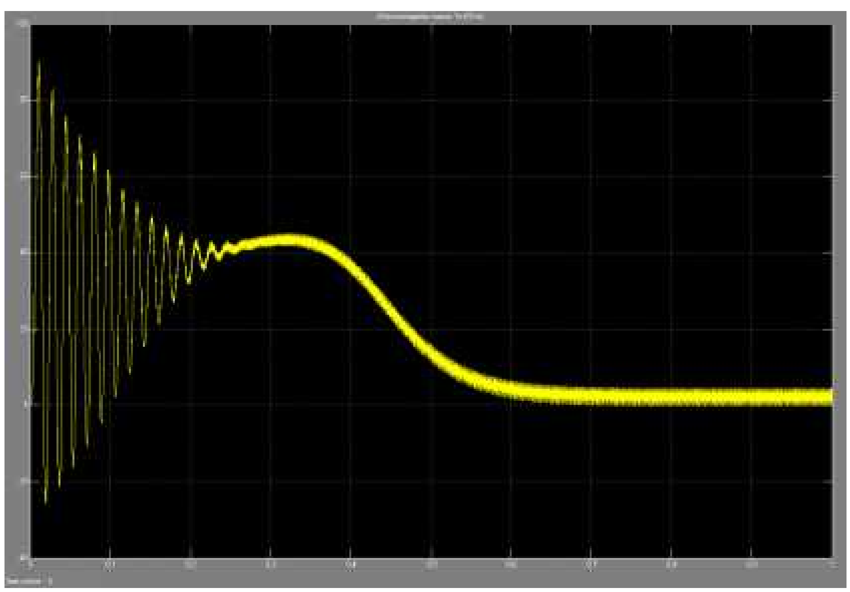


Fig. 4.4: Torque Of The Motor

Figure 4.5 (a) shows the block built refer to equation 2 , and if change the parameter will be change the linear motion and change motor speed. figure 4.6 (b) shows the affect change the time in motor speed .

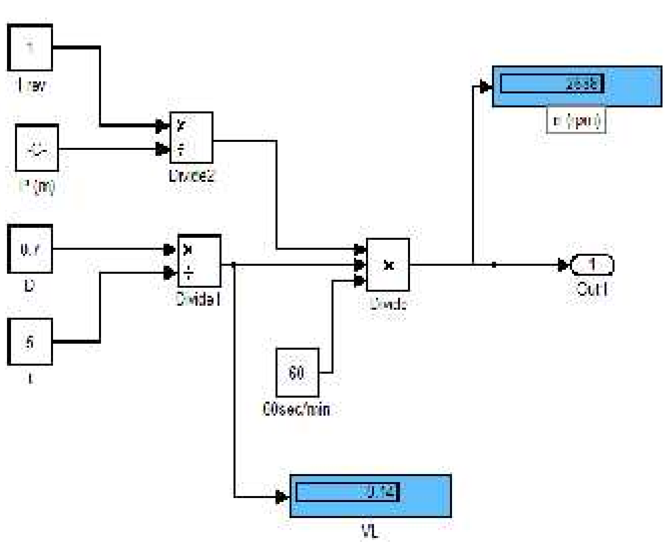


Fig. 4.5 (a): subsystem of speed (n)[t=5 s]

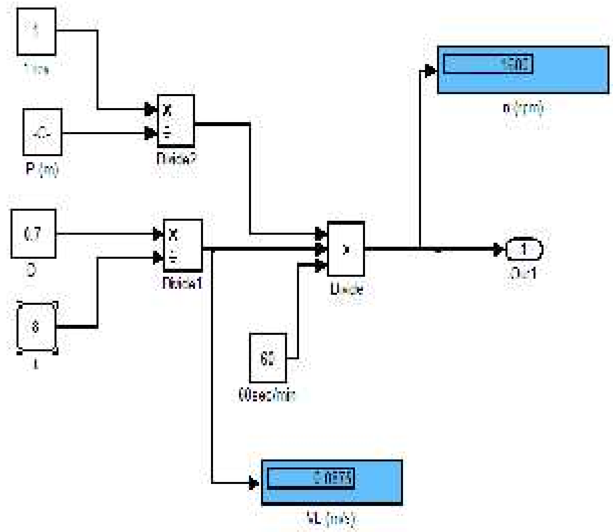


Fig. 4.5(b): subsystem of speed (n)[t=8 s]

The figure 4.6 shows the actual speed curve of the motor :

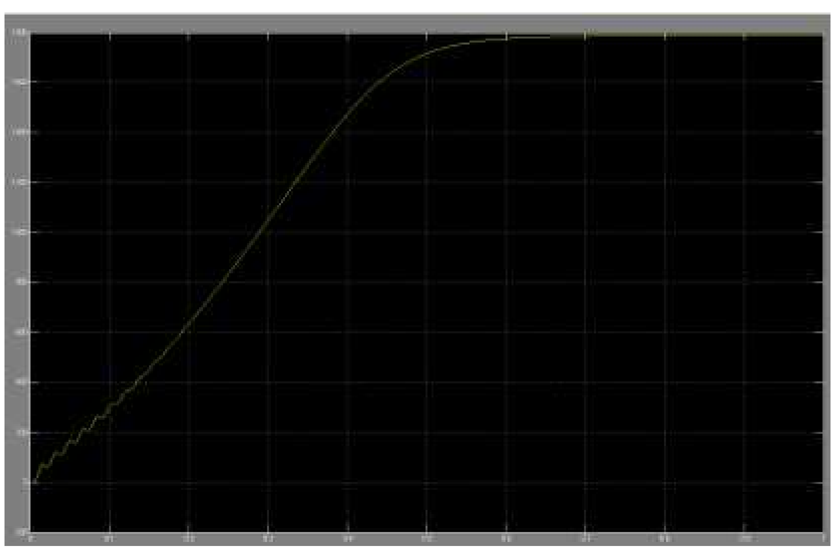


Fig. 4.6 : Actual Speed Of The Motor

From figure 4.6 show the change in motor speed and linear motion when increase the need time to across X-direction the speed will be decreased.

When change the diameter of lead screw that is will be affected to load torque , and the figure 4.7 (b) shows the change in load torque when change the dm =

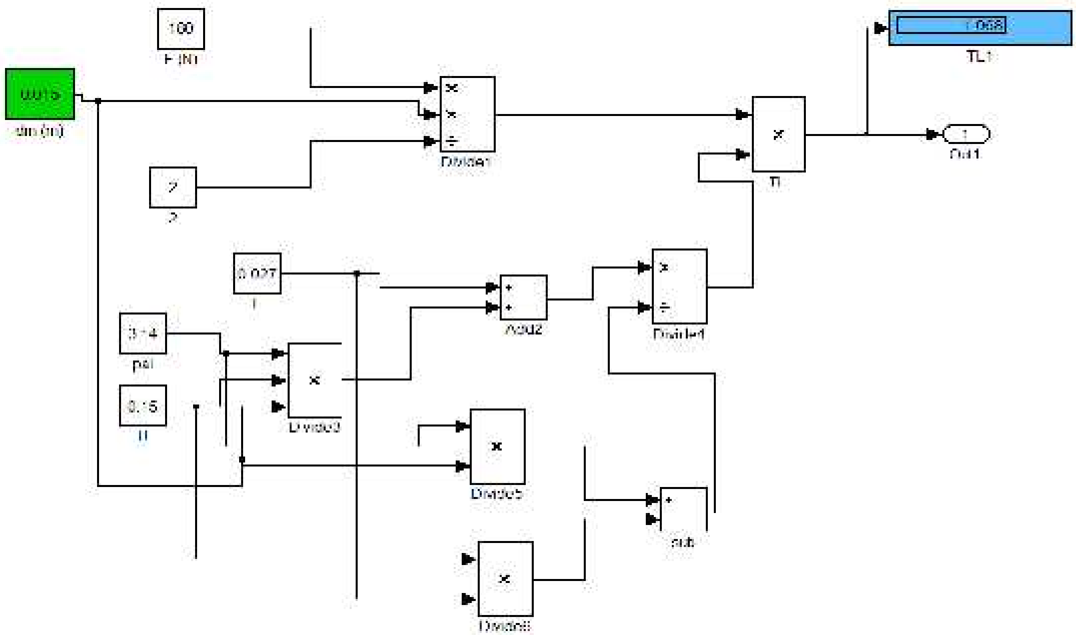


Fig. 4.7 (a) :subsystem of load torque (Tl) [when dm = 1.5 cm].

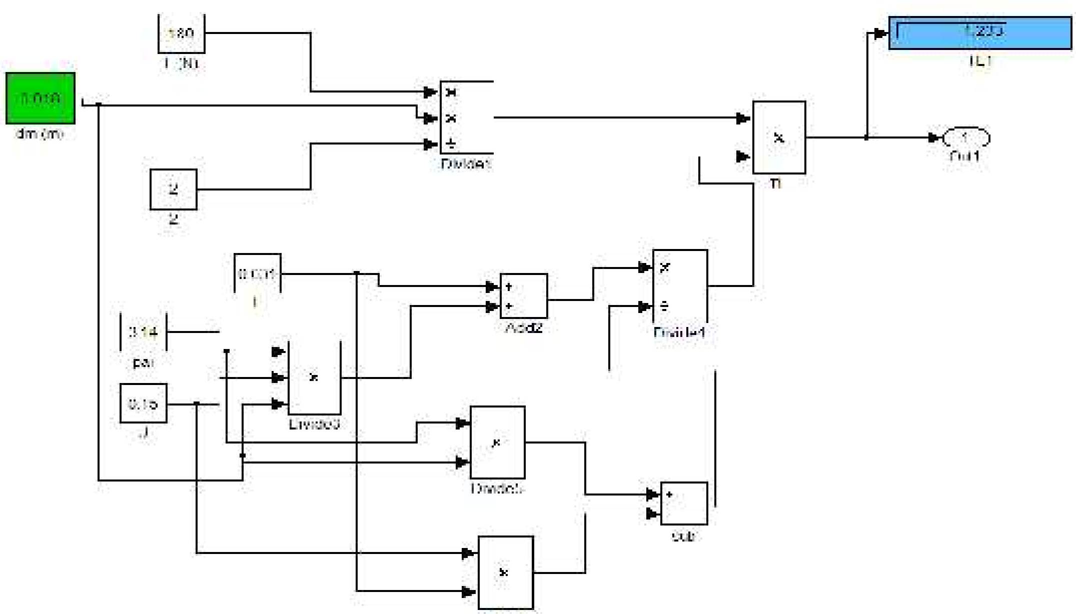


Fig. 4.7 (b) :subsystem of load torque (Tl) [when dm = 1.5 cm].

4.4 Layout Of Machine

figure 4.8 : layout of machine

figure 4.9 : layout of control panel of machine

In this figure show how connection plc with input and output , and the input list is

X0 : emergency , X2 : start switch , X3 : stop switch , X4 : limit switch actuate when up head motor , X6 & X7 : limit switch determine length the stone , X10 & X11 : limit switch determine width the stone , X12 &X13 : determine the forward and backward the cylinder is responsible for push the stone .

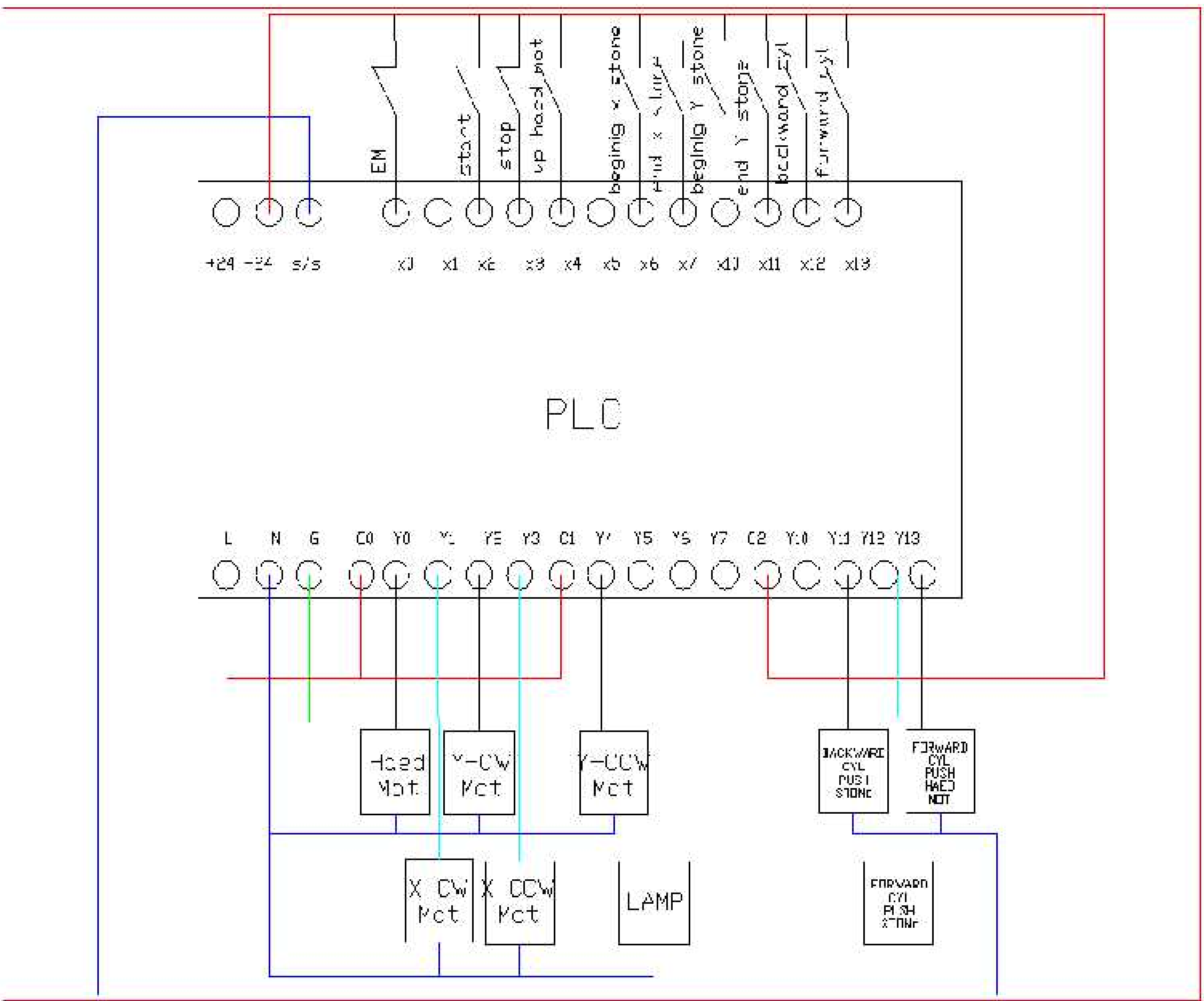


Fig 4.10 : The PLC connection

The output of the plc connect with coils of relays , and in this figure display how connect relays with motors and frequency converter. and in figure show how connect two motors in the same frequency converter and how change the direction of motors

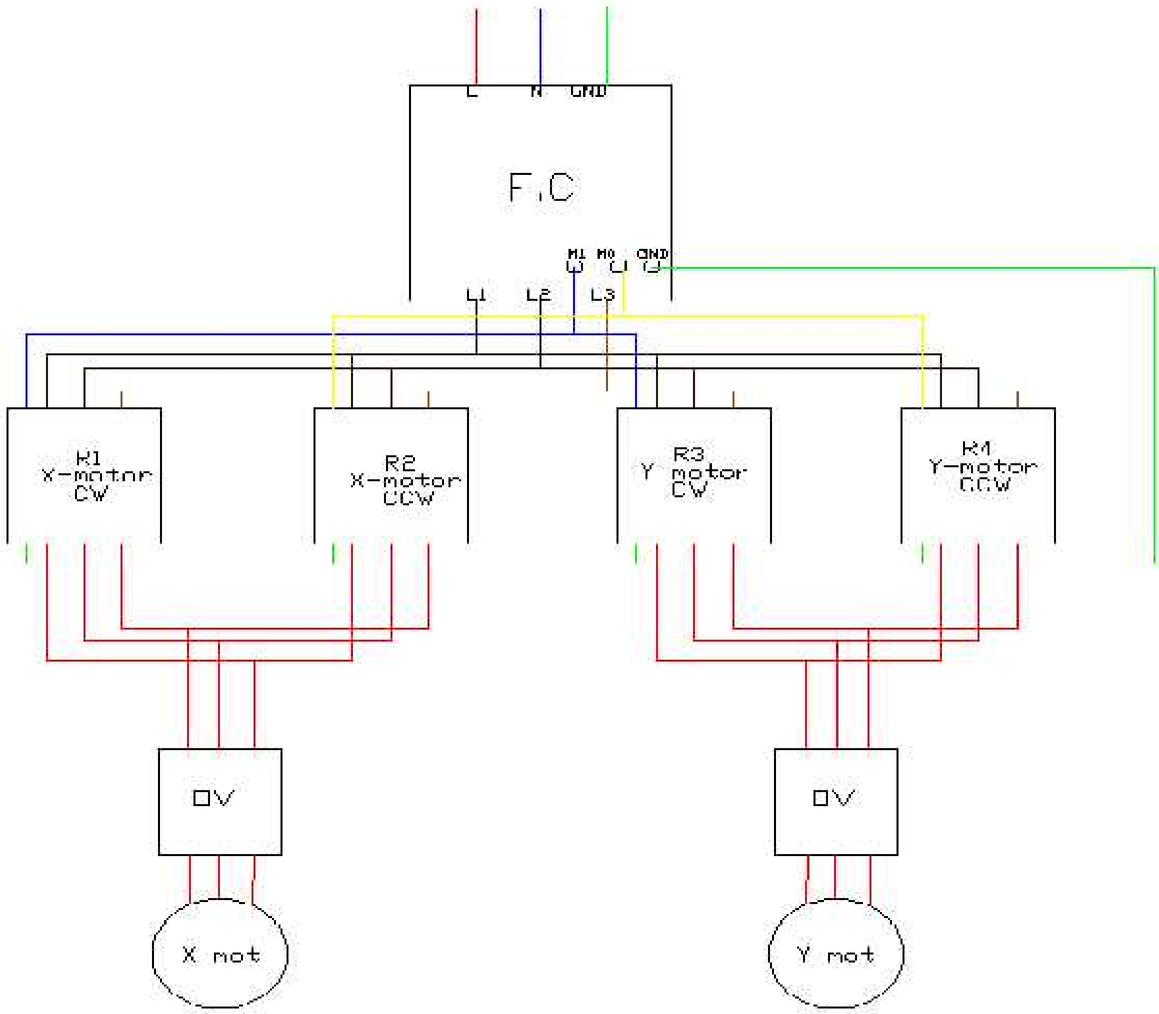


Fig 4.11 : The f.c connection with motor

In machine use two cylinder , the first to up head motor and the second to push stone under the head motor , and this figure show how connect the pneumatic system in machine .

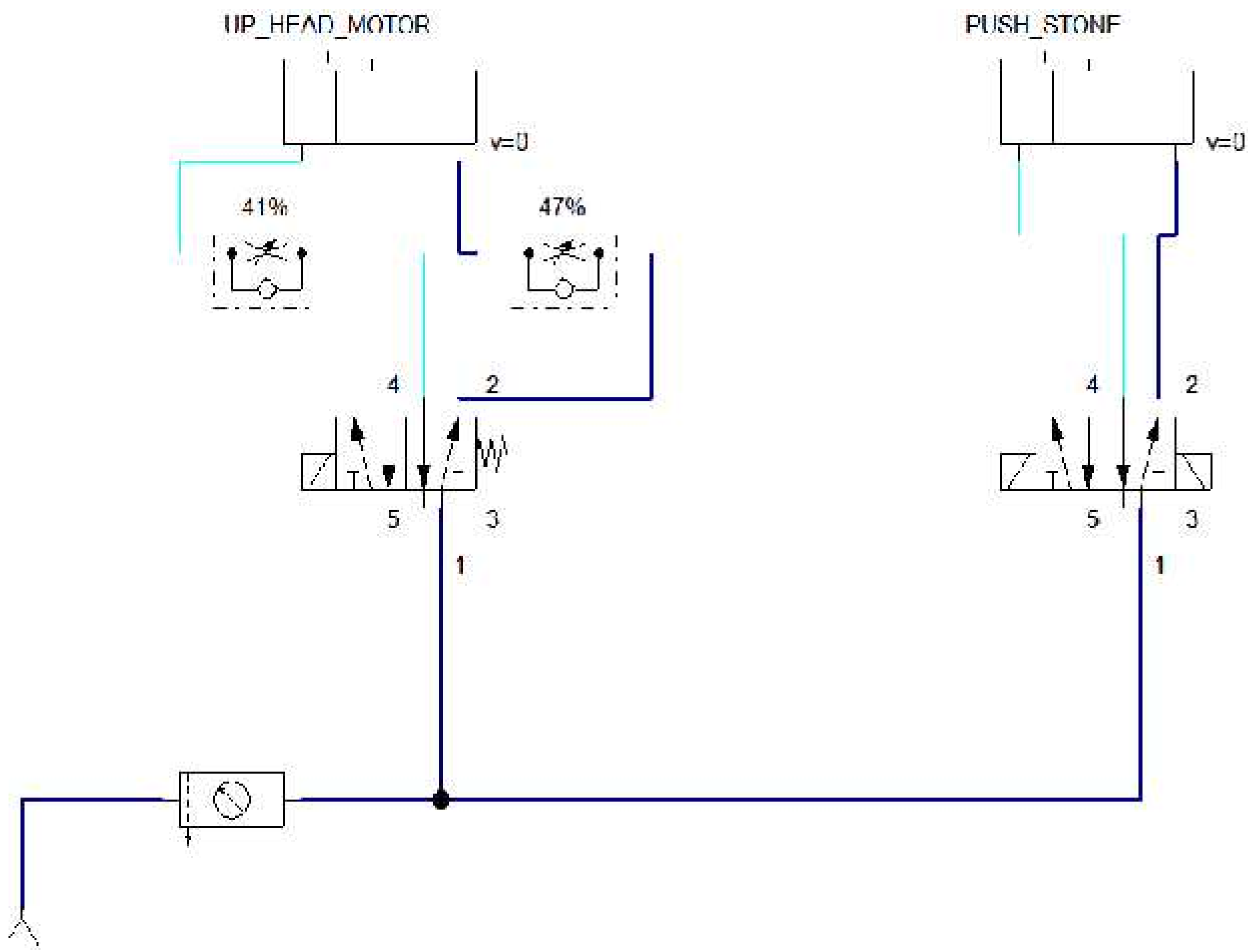


Fig 4.12 : The pneumatic system connection

CHAPTER

5 *CONCLUSION AND RECOMMENDATION*

Conclusion and Recommendation

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

Conclusion

According to our predetermined task is implemented design , the following can be extracted

1. The design is implemented and tested , where tie obtained results in for of forming the store surface fulfills the requirements.

2.In this project the problem is the long time is need to formation stone in traditional method , and the less quality in machine formation .

3. The solutions of this problems design machine decreased the time need to formation stone and in the same time must increased the quality .

4. In this machine use the lead screw to convert the rotational motion to linear motion , and the speed of lead screw depended on pitch where is increased it then the speed will decreased .

5. Between lead screw and nut high friction and this decrease the efficiency, and can increase the efficiency if put oil in thread of lead screw.

6. In this machine the distance will be crossing in Y and Z direction is constant , but the X direction is variable because the stone length is variable .

Recommendation

1. Can put motor to down and up the head motor .

2. Make conveyer to move the stone under the head motor .

3. Connect to frequency converter with to motor , the first with X-motor and the second with Y-motor .

References

[1]M. Awad, M. Tomazi, E. Shobaky; **Automatic Transferring Cut Stones;** PPU; 2000

[2] Gopal K. Dubey ; **Fundamentals of Electric Drives**; First reprint, New Delhi; Naosa Publishing House; 1995.

[3] Rakesh Parekh; **AC Induction Motor Fundamentals;** Microchip Technology Inc .

[4]Bhandari; **Design of Machine Elements,** Tata McGraw- Hill;2007

[5] Shigley, Joseph E., Mischke, Charles R.; Budynas, Richard Gordon, **Mechanical Engineering Design** (7th ed.), McGraw Hill; 2003.

[6] http://www.engineersedge.com

[7] http://en.wikipedia.org

Appendix

Appendix

Appendix A : Frequency Inverter

System overview

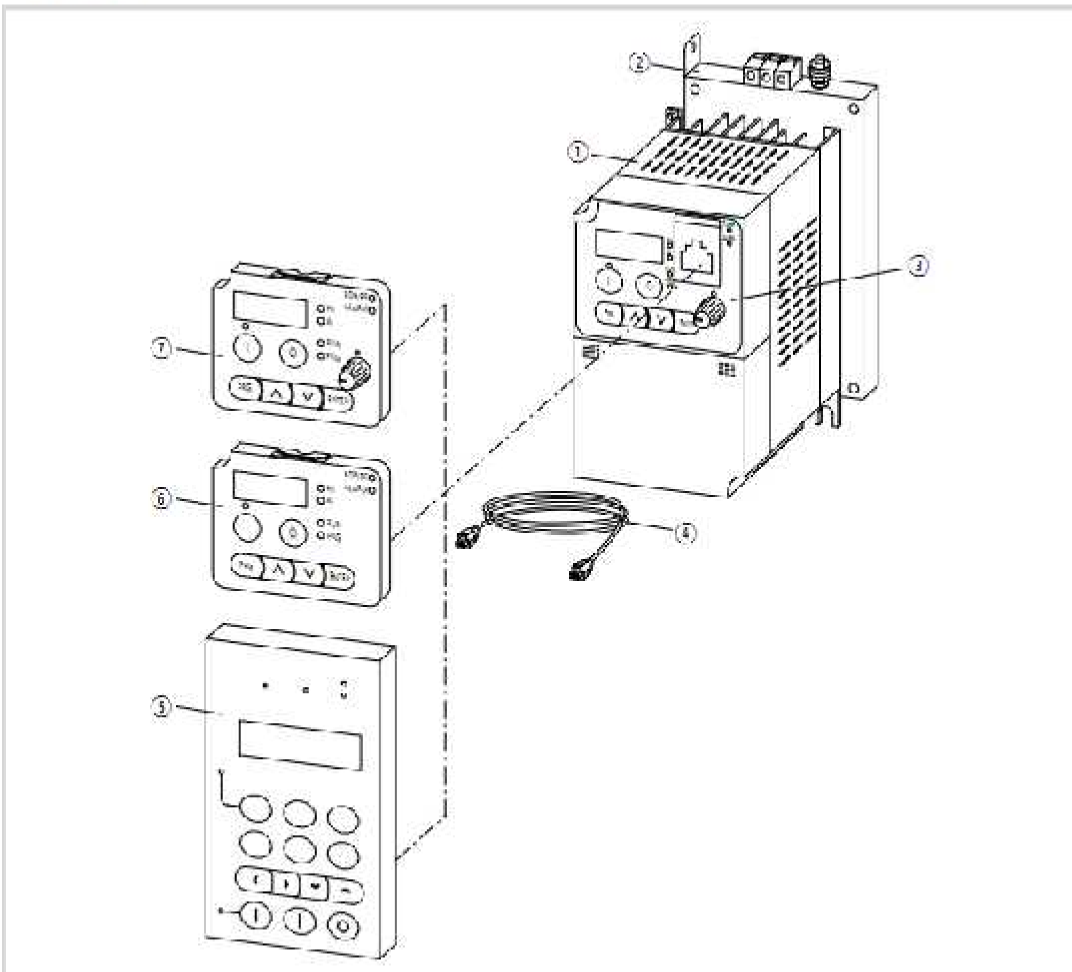


Figure 1: System overview

(1) DF51-... frequency inverter
(2) DE51-LZ... RFI filters
(3) Operator keypad with built in interface
(4) DEX CBL ... ICS connection cables
(5) DEX-DEY-10 external keypad
(6) DEX-DEY-61 external keypad
(7) DEX DEY 6 external keypad

Arrangement of the power terminals

The arrangement of power terminals depends on the size of the power section.

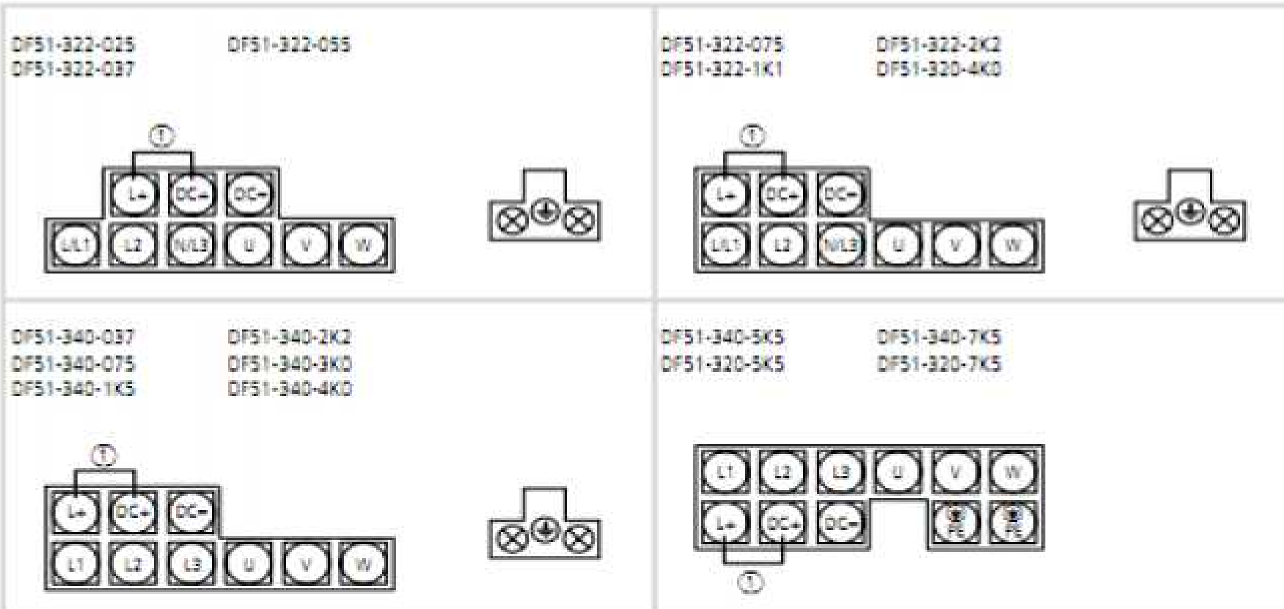
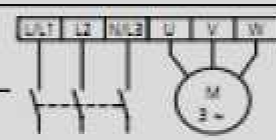


Figure 6: Arrangement of the power terminals

① Internal connection. Remove if a DC link choke is used.

Table 1: Description of the power terminals

Terminal designation	Function	Description
L, L1, L2, L3, N	Supply voltage (mains voltage)	• Single-phase mains voltage: Connection to L and N • Three-phase mains voltage: Connection to L1, L2, L3
U, V, W	Frequency inverter output	Connection of a three-phase motor
L+, DC+	External direct voltage reactor	Terminals L+ and DC+ are bridged with a jumper. If a DC link choke is used, the jumper must be removed.
DC+, DC–	Internal DC link	These terminals are used for connecting an optional external braking resistor and for DC linking and supplying DC to multiple frequency inverters.
⏚, PE	Earthing	Enclosure earthing (prevents dangerous voltages on metallic enclosure elements in the event of a malfunction).



Appendix B : PLC Model

Electrical Specifications

General Electrical Specifications

	AC	DC
Power Supply Voltage	100 ~ 240VAC (-15% ~ 10%), 50/60Hz ±5%	24VDC (-15% ~ 20%)
Fuse Capacity	2A/250VAC	2A/250VAC
Spike Voltage Durability	1500VAC (Primary-secondary); 1500VAC (Primary-PE); 500VAC (Secondary-PE)	
Insulation Impedance	>5MΩ (all I/O point-to-ground: 500VDC)	
Noise Immunity	ESD: 8KV Air Discharge EFT: Power Line - 2KV Digital I/O 1KV Analog & Communication I/O 250V RS: 26MHz ~ 1GHz, 10V/m	
Earth	The diameter of grounding wire shall not be less than that of the wiring terminal of the power. (When many PLCs are in use at the same time, please make sure every PLC is properly grounded.)	
Operation/Storage	Storage: -25°C ~ 70°C (temperature); 5 ~ 95% (humidity) Operation: 0°C ~ 55°C (temperature); 50 ~ 95% (humidity); pollution degree 2	

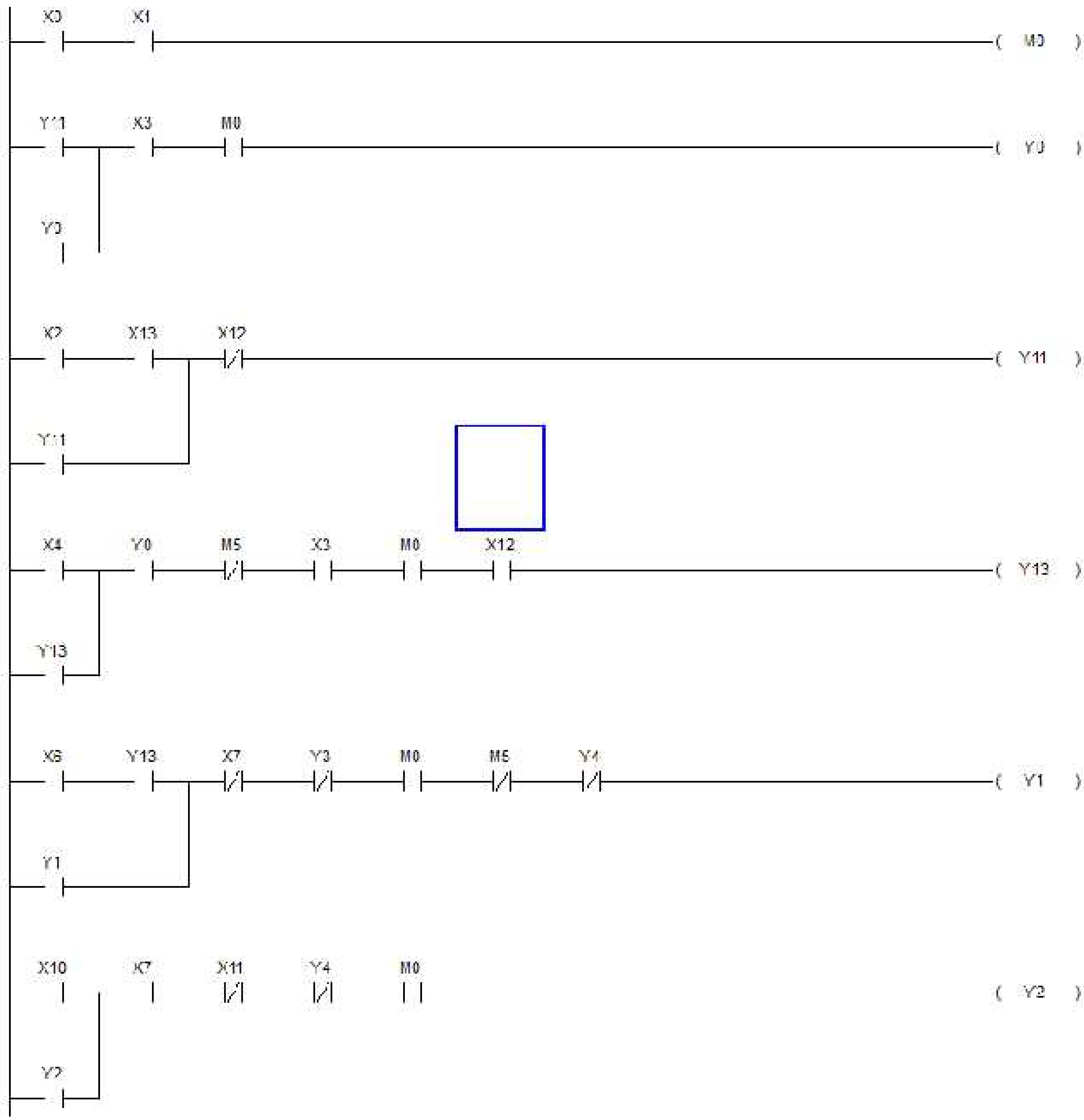
Input Point Specifications

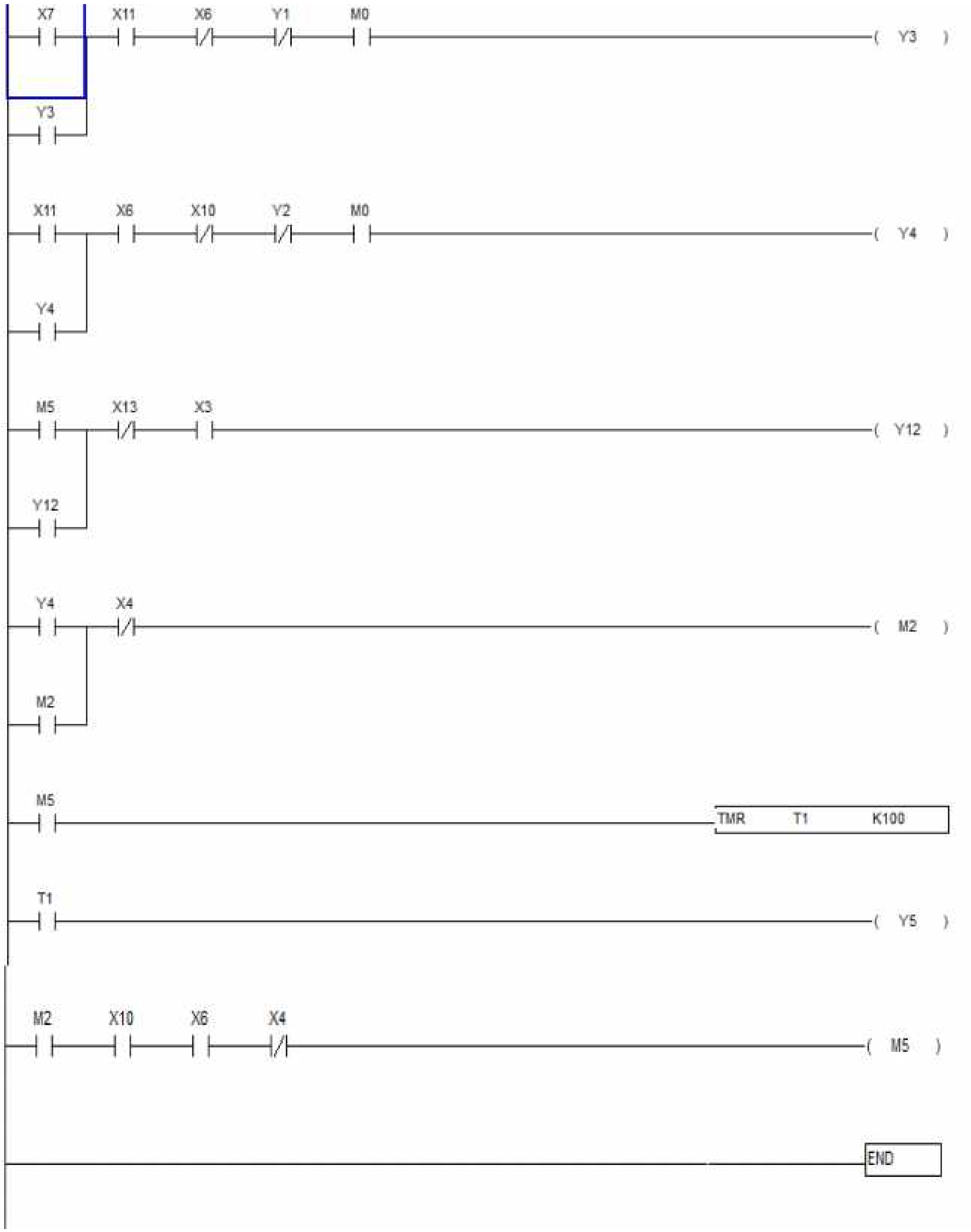
		Single Common Port Input		
		General Speed(10kHz)	Medium Speed(20kHz)	High Speed(100kHz/200kHz)
Input Signal Type		SINK / SOURCE		
Input Signal Voltage		24VDC ± 10% (5mA)		
Response time ES/EX SS/SA/SX SC EH2/SV		 0 ~ 15ms adjustable 0 ~ 20ms adjustable 0 ~ 20ms adjustable 0 ~ 60ms adjustable		 4.7µs 3µs
Motion Level	OFF->ON	>16.5VDC	>18.5VDC	>16.5VDC
	ON->OFF	<8VDC	<8VDC	<8VDC

Output Point Specifications

	Relay (R)	Transistor (T)	
		General Speed	High Speed
Max. Exchange (Working) Frequency	Load ON/OFF Control	10kHz	50kHz/100kHz/200kHz
Current Specification ES/EX SS SA/SX/SC EH2 SV	 2A 1.5A 1.5A 2A 1.5A	0.3A/1 point@40°C	<1kHz, 0.3A/1 point@40°C ≥1kHz, 30mA/1 point@40°C
Voltage Specification	250VAC/30VDC	30VDC	
Response Time	10ms	OFF->ON: 20µs ON->OFF: 30µs	EH2/SV 0.5µs SC 1µs SA/SX 2µs

Appendix C: PLC Connection




X7
X11
X6
Y1
M0
Y3
Y3
X11
X6
X10
Y2
M0
Y4
Y4
M5
X13
X3
Y12
Y12
Y4
X4
M2
M2
M5
TMR T1 K100
T1
Y5
M2
X10
X6
X4
M5
END

Appendix D **:** Circuit Breaker

FAZ Branch Circuit Breakers

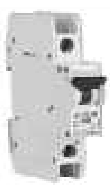
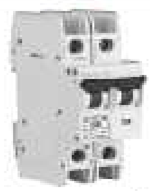
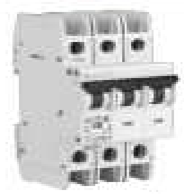
Trip Characteristic C

- UL Approved (UL489) and CSA Certified (CSA C22.2 No. 5-02) as Branch Circuit Breakers
- Interrupting capacity: 10kA UL/CSA; 15kA IEC 60947
- Trip characteristic C: Response time of instantaneous trip: 5 – 10 x I_n current rating
- Current limiting device

Type C Characteristics

Suitable for applications where medium levels of inrush current are expected. Instantaneous trip is 5 to 10 x rating of device (I_n). Applications include small transformers, lighting, pilot devices, control circuits, and coils. Medium magnetic trip point.

Trip Characteristic C – ***Designed for inductive loads***

	1 pole		2 poles		3 poles	
						
Rated Current I_n (A)	Type	Price	Type	Price	Type	Price
0.5	FAZ-C0,5/1-NA	34	FAZ-C0,5/2-NA	78	FAZ-C0,5/3-NA	120
1	FAZ-C1/1-NA	34	FAZ-C1/2-NA	78	FAZ-C1/3-NA	120
1.5	FAZ-C1,5/1-NA	34	FAZ-C1,5/2-NA	78	FAZ-C1,5/3-NA	120
2	FAZ-C2/1-NA	34	FAZ-C2/2-NA	78	FAZ-C2/3-NA	120
3	FAZ-C3/1-NA	34	FAZ-C3/2-NA	78	FAZ-C3/3-NA	120
4	FAZ-C4/1-NA	34	FAZ-C4/2-NA	78	FAZ-C4/3-NA	120
5	FAZ-C5/1-NA	34	FAZ-C5/2-NA	78	FAZ-C5/3-NA	120
6	FAZ-C6/1-NA	34	FAZ-C6/2-NA	78	FAZ-C6/3-NA	120
7	FAZ-C7/1-NA	34	FAZ-C7/2-NA	78	FAZ-C7/3-NA	120
8	FAZ-C8/1-NA	34	FAZ-C8/2-NA	78	FAZ-C8/3-NA	120
10	FAZ-C10/1-NA	34	FAZ-C10/2-NA	78	FAZ-C10/3-NA	120
13	FAZ-C13/1-NA	34	FAZ-C13/2-NA	78	FAZ-C13/3-NA	120
15	FAZ-C15/1-NA	34	FAZ-C15/2-NA	78	FAZ-C15/3-NA	120
16	FAZ-C16/1-NA	34	FAZ-C16/2-NA	78	FAZ-C16/3-NA	120
20	FAZ-C20/1-NA	34	FAZ-C20/2-NA	78	FAZ-C20/3-NA	120
25	FAZ-C25/1-NA	34	FAZ-C25/2-NA	78	FAZ-C25/3-NA	120
30	FAZ-C30/1-NA	34	FAZ-C30/2-NA	78	FAZ-C30/3-NA	120
32	FAZ-C32/1-NA	34	FAZ-C32/2-NA	78	FAZ-C32/3-NA	120
35	FAZ-C35/1-NA	34	FAZ-C35/2-NA	78	FAZ-C35/3-NA	120
40	FAZ-C40/1-NA	34	FAZ-C40/2-NA	78	FAZ-C40/3-NA	120

See Trip Curve chart on page 11