Palestine Polytechnic University

College of Engineering

Upgrading A Stone Cutting Machine From Manual System To Automatic System

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إهداء

إلى معلمنا وقائدنا وحبيبنا وشفيعنا وقدوتنا محمد صلى الله عليه وسلم.

إلى من رسموا بدمائهم خارطة الوطن وطريق المستقبل وهندسوا بأجسادهم معاقل العزة والكرامة وإلى من هم أكرم منا جميعا شهداء الوطن الحبيب.

إلى الذين عشقوا الحرية التي تفوح منها رائحة الياسمين وتواروا خلف القضبان ليفسحوا لنا النور أسرانا البواسل.

إلى أبي الذي لم يبخل عليا يوما بشيء، وامي التي زودتني بالحنان والمحبة أقول لهم:

أنتم وهبتوني الحياة والأمل والنشأة على شغف الإطلاع والمعرفة.

إلى اخوتي وأسرتي جميعا.

إلى من كل من علمني حرفاُ أصبح سنا برقه يضيء الطريق أمامي.

إلى من ضاقت السطور لذكرهم فوسعتهم قلوبنا أصدقاءنا الأعزاء.

إلى كل من أضاء بعلمه عقل غيره، أو هدى بالجواب الصحيح حيرة سائليه، فأظهر بسماحتها تواضع العلماء، وبرحابته سماحة العارفين.

إلى من رسم معنا خطوات هذا النجاح الى من بذل جهده ووقته وكان لنا مرشداَ وناصحاً وأخاً مشرفنا الحبيب الأستاذ عبد القادر الزرو.

Abstract

Upgrading a stone cutting machine from manual system to automatic system.

Our project talks about how to convert this machine from the traditional system "manual" to Automated system using a controller to work automatic/manual with variable selections and alternatives.

The machine was working with relays and the controlling was complex as a lot of control was series (traditional control) and it was a big problem in case of any interrupt. Also there some problems that we will fix it later by adding the programming in system in general .

الملخص

تحويل منشار قص الحجر من النظام التقليدي الى النظام الاوتوماتيكي

مشروعنا يتحدث عن كيفيه تحويل المنشار من النظام التقليدي "يدوي " إلى النّظام الألي المؤتمت باستخدام وحده تحكم ، للعمل التلقائي مع اختيارات وبدائل معينة.

الماكينة كانت تعمل بواسطة الريليهات والتحكم كان معقد بوجود الكثير من التحكم التقليدي وهذه مشكلة كبيرة في حال حدوث أي عطل وايضا هناك بعض المشاكل التي سوف نقوم بحلها لاحقا بإضافة البرمجة في النظام بشكل عام.

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1.1 Introduction

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1.1Introduction:

The stone industry is the largest industry sectors in Palestine, because few sectors that provide the country's self-sufficiency of stones manufactured and exported out of the country with high quality and competitive nationwide.

This sector relies on thousands of factories throughout the country, these marble need heavy machinery for this process and productivity, and in order to get these stones carefully for human use must pass these stones in several stages, and it begin with explore the mountains, and it's good for the need we want or not. After exploration and extraction in the form of relatively large marble, marble cubes shaped between 2.5 m^3 or 2 m^3 or near these sizes.

After this process we transfer these cubes by transport vehicles and can tolerate these heavy weights, and they go to stone plants known as stone saws, who have dedicated machines for these operations that work on cutting the stones used in building the necessary session Such as buildings, streets and decoration in General.

And the last is important, we can't do anything without it to convert this marble to use humanitarian benefits and exploiting natural resources. Generally occur at this stage ; these cubes are entered at the factory specifically to this machine stone; a saw stone machine for each stone factory, where it converts the marble to usable stone ready for build .

Industry has begun to recognize the need for quality improvement and increase in productivity after second world war. Flexibility have also became a major concern (ability to change a process have quickly became very important in order to satisfy consumer needs).

There was always a huge electrical board for system controls, and not infrequently it covered an entire wall! Within this board there was a great number of interconnected electromechanical relays to make the whole system work. By word "connected" it was understood that electrician had to connect all relays manually using Wires! An engineer would design logic for a system, and electricians would receive a schematic outline of logic that they had to implement with relays. These relay schemas often contained hundreds of relays. The plan that electrician was given was called" schematic" Ladder displayed all switches, sensors, motors, valves, relays, etc. found in the system. Electrician's job was to connect them all together.

One of the problems with this type of control was that it was based on mechanical relays, Mechanical instruments were usually the weakest connection in the system due to their moveable parts that could wear out. If one relay stopped working, electrician would have to examine an entire system (system would be out until a cause of the problem was found and corrected).

The other problem with this type of control was in the system's break period when a system had to be turned off, so connections could be made on the electrical board. If a firm decided to change the order of operations.

But this machine where a lot of complexity and precise control system, containing nine motors at least and a lot of control and command devices that need to work consistently and accurately at the same time without conflict or problems occur.

This stone cutting machine which works manual clicks cubic pieces into smaller pieces of a specific request of the customer and this process happens every day in every stone factories, so we'll turn this machine from the traditional system of " manual " to the automated system based on a controller , to manage this machine automatically depending on the process .

Specifically we need for this process because of recurring maintenance and difficult access and repeated failures in the machine in order to reduce such disruptions and easy of maintenance, as well as to make such a machine less complex and sophisticated to keep up with current technology.

1.2 Operation of Machine:

This machine works step by step whether automatic or manual selection, well; The operator starts work on them by pressing the main power switch after confirming the arrival of electricity to the main panel and motors and the system in general , and later the calibration of starting point on the block was done to start the process of cutting and then enter the dimensions you want stone want to be and height of stone that are Actually taken from an Encoder that counts as standardized where usually 5 cm x 25 cm is placed through the screen and takes into consideration the distance that will the disc width take which it 6 mm approximately and later he running large and small disks without starting the process of cutting and this is the initiation of starting process of cutting and after the operator press on automatic or manual button that located on the front of the system board, and later

the cutting process is start after the arrival of water on shear discs this process begins at the beginning of the stone only.

Also there is a table that receives the stone block that we cutted from the big block , it motion is determined by limit switches that connected to PLC **(The Brain Of This Machine)** that we will controlled them by it by programming this computer with specific code that will get us a full process to take a perfect product that we need.

1.3 Problems:

1. Many of wire's in system.
2. Not good in maintenance process.
3. Many of components.
4. Not accuracy too much.
5. More complicated to detect the failures in system.
6. It take more time in process.

1.3 Importance:

1. Using controller in system will get the accuracy by the way.
2. Using controller will make us to detect the failures fast.
3. More effective.
4. More fast and it also will save money and time.

2

Literature view:

-Technology of exploitation for onyx stones with diamond wire saw and pilow :

They have set up the parallel of the existing equipment in some quarries and will be describe the technology of exploitation of dimension stones, dumping of strips and the devices. The paper will also give an account of latest equipment used in quarries.

In excavation (exploitation) of stone blocks (onyx) is one of the most important operations. Various devices and techniques are used depending on the kind of the mine, the capacity, properties of stone blocks and the efficiency of the equipment used in the quarry.

At the moment the exploitation of dimension stone are in use more different methods and techniques for turning down of strip.

The manufactures of this equipment have a lot of different products but which of techniques will be use depends of character of the open pit quarry, capacity and physical – mechanical characteristics of dimension stone.

-Implementation Of Programmable Logic Controller (PLC) :

Programmable Logic Controllers (PLCs) have a history that dates back to the 1960s, yet there are still many in the automation industry who've had little experience with them. When it conies to learning about these products, or making the jump from other areas of automation to applications that. involve PLCs, the transition can sometimes be difficult.

It's hard to know where to begin, and if you've been charged with the task of selecting one, **it** can be even harder to know which manufacturer or model to choose. To make the switch to PLCs, it's important to have a basic understanding of what they are, what they do, and which PLC is right for your application. This thesis motivates definition and history of PLC. it have collected then reference books have Training of Program on Programmable Logic Controller (PLC) [1].

-Automation of a foam cutting machine:

A foam manufacturing company is sponsoring a project for the automation of a cutting machine. The cutting machine cuts a block of foam into sheets of specified thicknesses ,the machine is a two degree of freedom machine which operates via a mechanical gear train this project consists of bypassing the mechanical gearing system by an automated positioning system[2].

-Study of cutting forces:

The study of cutting forces in granite processing is a field that has developed only recently segment cutting can be considered as abrasion at multiple contact points (diamond grains) at different passing depths ,only a few grains of diamond form part of the abrasion process on each pass.

A of factors influence this process, such as diamond grain concentration in the matrix, grain geometry, each diamond grain's protrusion out of the matrix.

The diamond segment is made up of sintered diamond grin in a matrix. As the diamond is stronger, it remains in view and the supporting matrix is eroded a way, wear on the matrix varies according to the attack face or the tail face of the diamond grain.

-Review on Design and Development of PLC Operated Cutting Machine:

It's reviews the PLC properties, different types of hacksaw used for cutting purposes, today there is lot of advancements in these fields as every industry is getting automated. For cutting materials for mass production conveyor systems are widely used.

There are two types of conveyor: Belt type and Roller type. Feed of cutting materials is also done with the help of conveyor. Pneumatic System is used for smooth operation of hacksaw[3].

-A Review of Automated Profile Cutting Machine using plc:

Global competitions and technological advances are forcing manufacturers, designers and engineers to constantly innovate new product manufacturing strategies in reducing product development cost and time. Contemporary manufacturers have the option of selecting optimum technologies or processes to suit their manufacturing environment.

CNC is one in which the functions and motions of a machine tool are controlled by means of a prepared program containing coded alphanumeric data. This technique is basically used for industrial application. This presents that how to work profile cutting machine by using PLC technique.[4]

3

Theory

3.1 Component table

3.2 PLC

3.3 Encoder

3.4 Three-phase Motors

3.5 Contactors

3.6 Limit Switch

3.7 Frequency Inverter

3.1 Some of component used in system :

The table is show some of component used in the system in general.

Photo	component	Function
	Marble	The input of the process
	3 phase motor	Each motor with specific function .
	PLC	Control the system

	Contactor	Connecting the power between network and motors
	Double acting cylinder	For reversing cut
	Limit switch	Limitation of motion
	invertor	Adjustment speed
	selector	Control the valve
	Encoder	Counting

Table **3**.1: some of component in the system

3.2 PLC controller:

Programmable Logic Controllers (PLC) is essential controller equipment in modern industrial control system. Though it is totally practical equipment it can be changed by the program of its operation that‘s why it is call Programmable Logic Controllers ,and the figure(3.1) below is show a one of types of PLC :

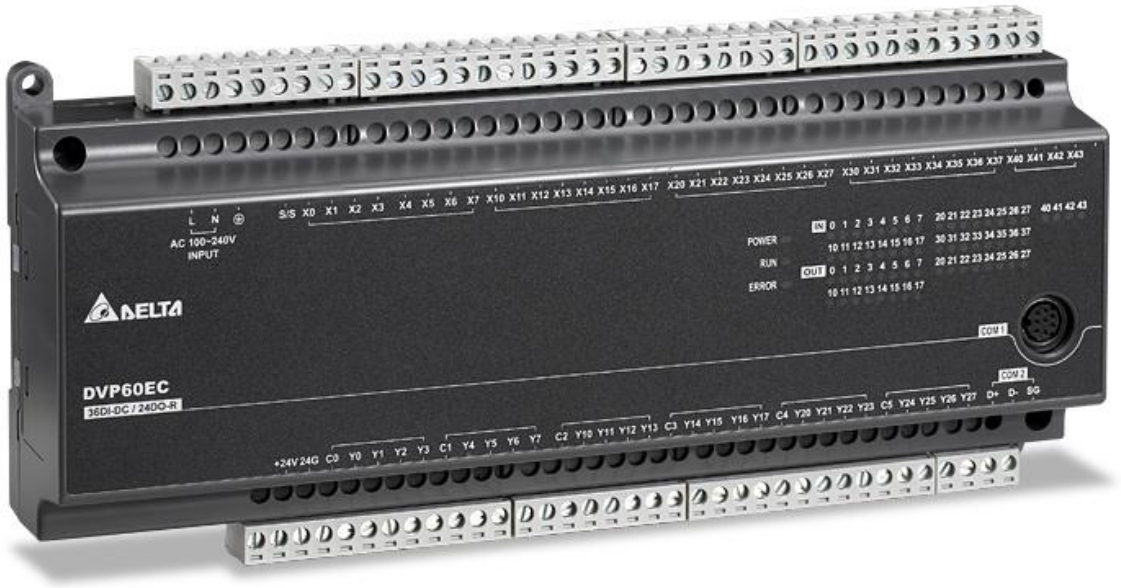


figure (3.1) : Delta PLC

Using of relay-based switches to implement basic logical expressions and some examples of logic-based industrial system control. This type of control system detects the status of inputs like switches and other on-off logical devices(e.g. position directors, liquid level detectors, etc.) and then uses relays, timers and counters to implement logic and drive outputs by energizing the output coil of some sort of valve or other actuator.

Introduction to PLC:

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

PLCs have been gaining popularity on the factory floor and will probably remain predominant for some time to come Most of this is because of the advantages they offer:

-Cost effective for controlling complex systems.

-Flexible and can be reapplied to control other systems quickly and easily.

-Computational abilities allow more sophisticated control.

-Trouble shooting aids make programming easier and reduce downtime.

-Reliable components make these likely to operate for years before failure.

Characteristic of PLC:

- Its Changeable operation.
- Processing element is used hear.
- Input & output signal Isolated as if PLC could not damage with electrical fault.
- Its reliability is high .

Functional Description of PLC:

PLC is actually an industrial microcontroller system where you have hardware and software specially adapted to industrial environment Special attention needs to be given to input and output. because in these blocks you find protection needed in isolating a CPU blocks from damaging influence that industrial environment can be bring to a CPU via input lines. Program unit is usually a computer used for writing a program (often in ladder diagram).

The control program can be entered into the PLC by using a simple from of high level language like ladder diagram, instruction code etc. The input device such as switch, push buttons, sensors and output device such as motors, relays, valves, lamps, etc. are connected to PLC the operator then enters a sequence of instructions (programs) into the memory of the PLC, the controller then monitors the inputs and outputs according to these programs and carries it out of the program.

power supply:

The electrical supply is used in bring electrical energy to central processing unit. Most PLC controllers work either at 24V DC or 220V AC , but " usually 24V DC" . On some PLC controllers you'll find electrical supply as a separate module. Those are usually bigger PLC controllers, while small and medium series already contain the supply module. User has to determine how much current to take from I/O module to ensure that electrical supply provides appropriate amount of current. Different types of module of modules use different amount of electrical current. This electrical supply is usually not used to start external inputs or outputs. User has to provide separate supplies in starting PLC controller inputs or outputs because than you can ensure so called " pure " supply for the PLC controller. With pure supply we mean supply where industrial environment can not affect it damagingly. Some of the smaller PLC controllers supply their inputs with voltage front a small supply source already incorporated into a PLC .

Memory:

System memory (today mostly implemented in FLASH technology) is used by a PLC for an process control system. Aside from this operating system it also contains a user program translated from a ladder diagram to a binary form. FLASH memory contents can be changed only in case Where user program is being changed.

PLC controllers were used earlier instead of FLASH memory and have had EPROM memory instead of FLASH memory which had to be erased with UV lamp and programmed on programmers. With the use of FLASH technology this process was greatly shortened. Reprogramming a program memory is done through a serial cable in a program for application development.

User memory is divided into blocks having special functions and some parts of a memory are used for storing input and output status. The real status of an input is stored either as "1" or as "0" in a specific memory bit also each input or output has one corresponding bit in memory. Other parts of memory are used to store variable contents for variables used in user program e.g timer value, or counter value would be stored in this part of the memory.

Central Processing Unit (CPU) :

The Central Processing Unit (CPU) is the brain of a PLC controller. CPU itself is usually one of the microcontrollers. It controls and processes all the operations within the PLC. It is supplied with a frequency of typically between 1 and 8 MHz This frequency determines the operating speed of PLC and provides the timing and synchronization for all elements in the system. A bus system carries information and data to and from the CPU.

Address bus :

Address bus is used select a certain memory location of a device ,when a particular address is selected by its address being placed on the address bus, only that location is open to communications from the CPU.

Data bus :

Data bus is used to transport a word to or from the CPU and the memory or the input output interface When address bus select a specific memory location then data of that location is available on data bus.

PLC controller inputs :

Intelligence of an automated system depends largely on the ability of a PLC controller to read signals from different types of sensors and input devices. Keys, keyboards and by functional switches are a basis for man versus machine relationship. On the other hand, in order to detect a working piece, view a mechanism in motion, check pressure or fluid level you need specific automatic devices such as proximity sensors, marginal switches, photoelectric sensors, level sensors, etc. Thus, input signals can be logical (on/off) or analogue. Smaller PLC controllers usually have only digital input lines while larger also accept analogue inputs through special writs attached to PLC controller. One of the most frequent analogue signals are a current signal of 4 to 20 mA and mV range voltage signal generated by various sensors. Sensors are usually used as inputs for PLCs. You can obtain sensors for different purposes. They can sense presence of some parts, measure temperature. pressure. or some other physical dimension, etc. (ex. inductive sensors can register metal objects).

Other devices also can serve as inputs to PLC controller. Intelligent devices such as robots, video systems. etc. often are capable of sending signals to PLC controller input modules (robot, for instance, can send a signal to PLC controller input as information when it has finished moving an object from one place to the other.

PLC Input Devices:

The figure (3.3) is show some example of inputs such as:

1. Push buttons.
2. Switches (limit switches, level switches, etc.) it shown in figure(3.2).
3. Sensors.
4. Etc.

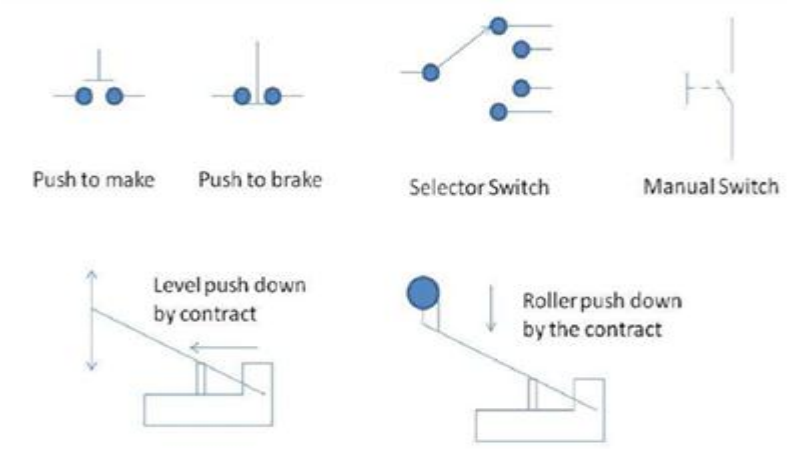
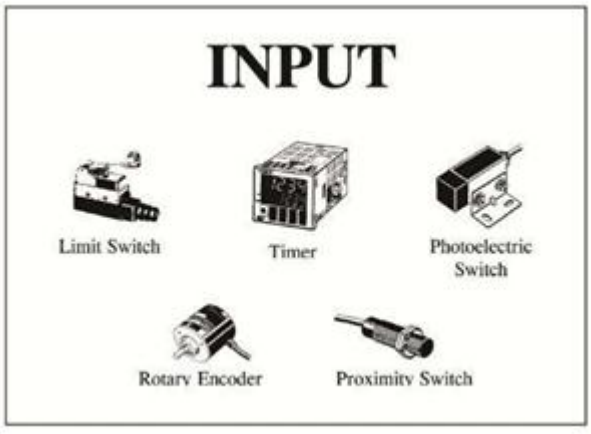


figure (3.2): switch



figure(3.3): some type of inputs

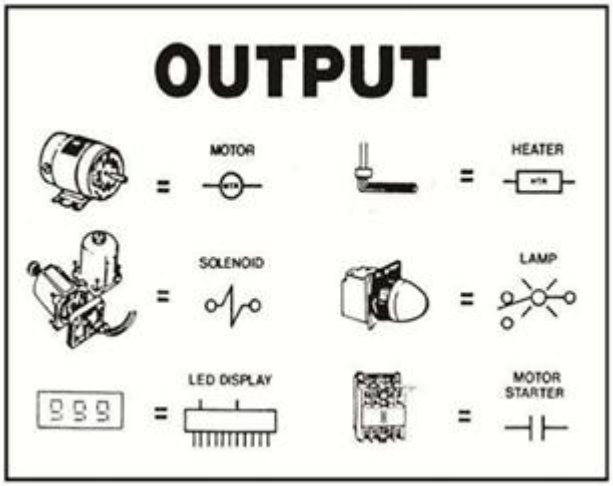
PLC controller output:

Automated system is incomplete if it is not connected with some output devices. Some of the most frequently used devices are motors, solenoids, relays, indicators, sound signalization and similar. By starting a motor, or a relay, PLC can manage or control a simple system such as system for sorting products all the way up to complex systems such as service system for positioning head of CNC machine. Output can be of analogue or digital type. Digital output signal works as a switch; it connects and disconnects line. Analogue output is used to generate the analogue signal ex: motor whose speed is controlled by a voltage that corresponds to a desired speed.

PLC Output Devices :

The figure (3.4) is show some example of outputs such as:

1. Relay contacts
2. Solenoid valves
3. Signal devices (such as lamps, alarms, etc.)
4. Motors
5. Etc.



figure(3.4): Output device.

PLC Input/output connection:

The figure (3.5) is show how the to connect the input and output in the PLC :

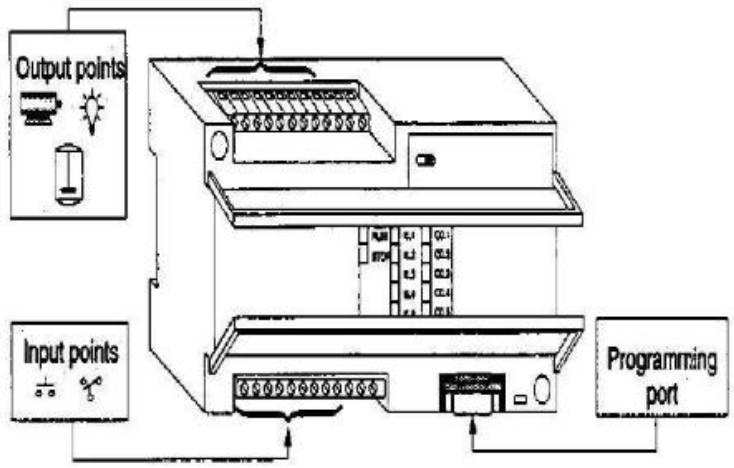


figure (3.5):PLC connection.

Programming a PLC controller :

PLC controller can be reprogrammed through a computer (usual way), but also through manual programs (consoles). This practically means that each PLC controller can programmed today's a computer if you have the software needed for programing. Today's transmission computers are ideal for reprograming a PLC controller in factory itself This is of great importance to industry.

Once the system is corrected, it is also important to read the right program into a PLC again It is also good to check from time to time whether program in a PLC has not changed. This helps to avoid hazardous situations in factory rooms (some automakers have established communication networks which regularly check programs in PLC controllers to ensure execution only of good programs).

Almost every program for programming a PLC controller possesses various useful options such as: forced switching on and off of the system inputs/outputs (I/O lines). program follow up in real time as well as documenting a diagram. This documenting is necessary to understand and define failures and malfunctions.

Programmer can add remarks. names of input or output devices, and comments that can be useful when finding errors. or with system maintenance. Adding comments and remarks enables any technician (and not just a person who developed the system) to understand a ladder diagram right away. Comments and remarks can even quote precisely part numbers if replacements would be needed This would speed up a repair of any problems that come up due to bad parts, The old way was such that a person who developed a system had protection on the program, so nobody aside from this person could understand how it was done, correctly documented ladder diagram allows any technician to understand thoroughly how system functions[5].

Programming Language of PLC :

PLC programming language refers to the method by which user communicates information to the PLC.

There are three most common languages:

1-Ladder Diagram Language :

The most common used by PLC language .

2-Boolean language :

The statements refers to the basic AND, OR and NOT logic gate functions.

3-Function chart system:

It is a method of programing a control system that uses a more structured approach.

3.2 Rotary Encoder:

A rotary encoder, also called a shaft encoder, is an electro-mechanical device that converts the angular position or motion of a shaft or axle to an analog or digital signal.

There are two main types: absolute and incremental (relative). The output of absolute encoders indicates the current position of the shaft, making them angle transducers. The output of incremental encoders provides information about the motion of the shaft, which is typically further processed elsewhere into information such as speed, distance and position.

Rotary encoders are used in many applications that require precise shaft unlimited rotation including industrial controls, robotics, special purpose photographic lenses, computer input devices (such as optomechanical mice and trackballs), and the figure (3.6) below is show the construction of it[6]:

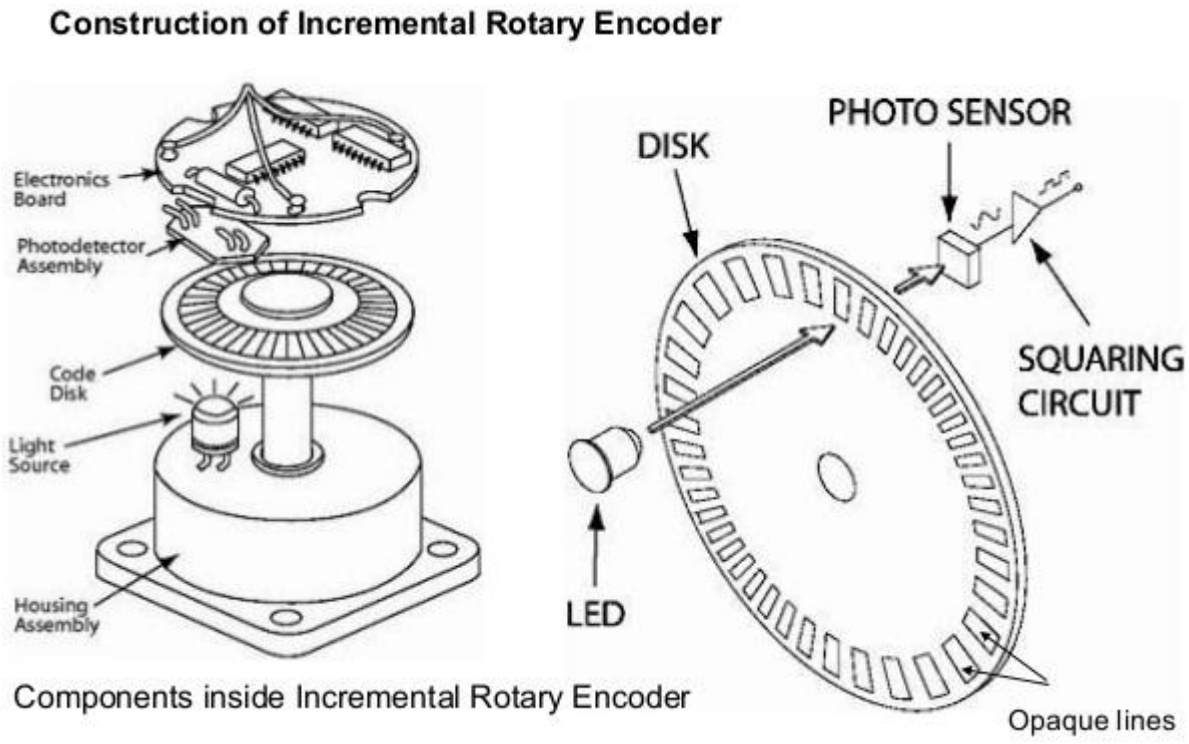


figure (3.6) : Rotary Encoder

3.4 Three-Phase Induction Motors:

An induction motor or asynchronous motor is an AC electric motor in which the electric current in the rotor needed to produce torque is obtained by electromagnetic induction from the magnetic field of the stator winding, an induction motor also can be made without electrical connections to the rotor, an induction motor's rotor can be either wound type or squirrel-cage type.

The three-phase squirrel-cage induction motors are widely used as industrial drives because they are rugged, reliable and economical. Single-phase induction motors are used extensively for smaller loads, such as household appliances like fans. Although traditionally used in fixed-speed service, induction motors are increasingly being used with variable-frequency drives (VFDs) in variable-speed service. VFDs offer especially important energy savings opportunities for existing and prospective induction motors in variable-torque centrifugal fan, pump and compressor load applications. Squirrel cage induction motors are very widely used in both fixed-speed and variable-frequency drive (VFD) applications.

Three phase induction motors have been a popular choice for many industrial applications for a number of reasons:

1. Non-complex construction – they don't require permanent magnets, brushes or windings on the rotor
2. They run directly off of the electric distribution grid
3. Low cost
4. Rugged and suitable for hazardous environments
5. Due to not having brushes, they are long lasting and require minimal maintenance

However, one of the main drawbacks of the 3-phase induction motor is that they have a small, load-dependent speed range this limits the types of applications induction motors can be used for, and the synchronous speed of induction motors is dependent on the number of poles of the motor and the frequency of the supply power ,simply by the equation (3.1):

$$ns = (120 \times f) / p \quad \text{.....} \quad \text{.....} \quad (3.1)$$

where n_s is the synchronous speed, f is the supply frequency and p is the number of motor poles. The actual motor speed will then be slightly less than the synchronous speed and will be dependent on the motor load [7].

3.5 Contactors:

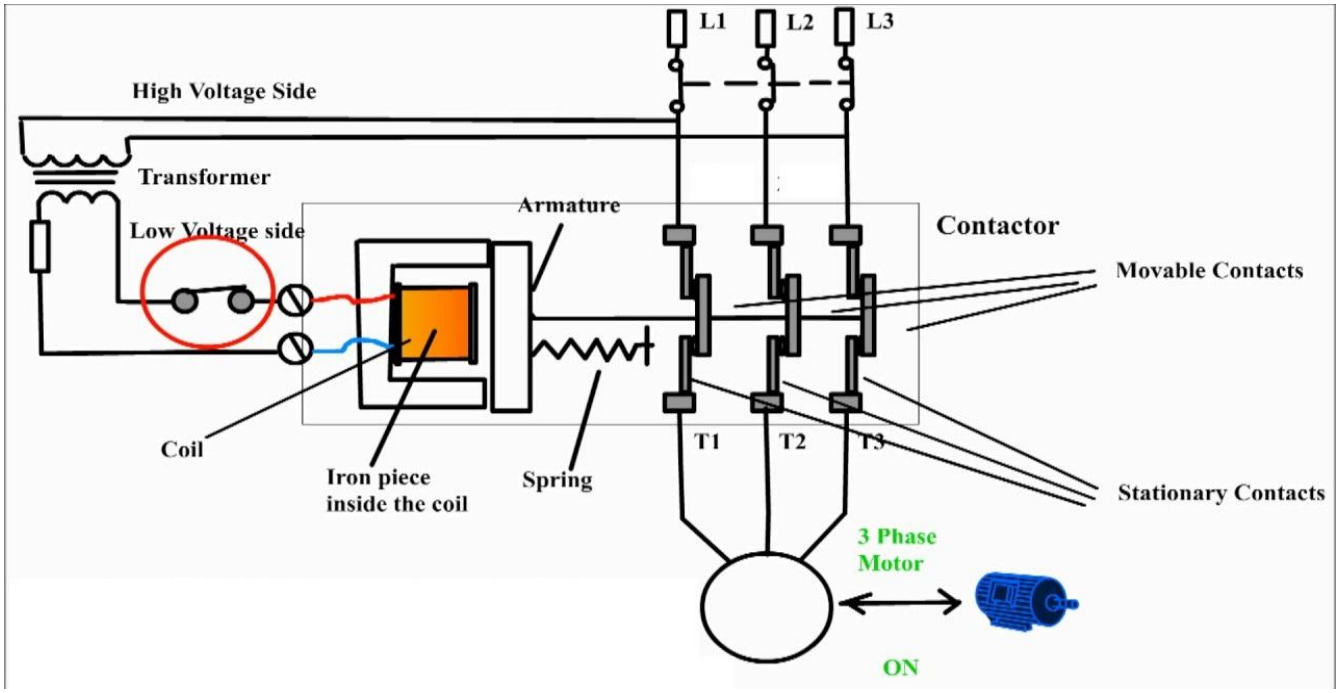
A contactor is an electrically controlled switch (relay) used for switching an electrical power circuit, also it is typically controlled by a circuit which has a much lower power level than the switched circuit, such as a 24-volt coil electromagnet controlling a 230-volt motor switch.

When a relay is used to switch a large amount of electrical power through its contacts, it is designated by a special name" **contactor**".

Contactors typically have multiple contacts, and those contacts are usually (but not always) normally-open, so that power to the load is shut off when the coil is de-energized, perhaps the most common industrial use for contactors is the control of electric motors.

And the figure(3.7) is show how it work , the top three contacts switch the respective phases of the incoming 3-phase AC power, the lowest contact is an “auxiliary” contact which has a current rating much lower than that of the large motor power contacts, but is actuated by the same armature as the power contacts.

The auxiliary contact is often used in a relay logic circuit, or for some other part of the motor control scheme, typically switching 120 Volt AC power instead of the motor voltage, also we have contactor may have several auxiliary contacts, either normally-open or normally-closed if required [8].



figure(3.7):contactors.work

3.6 LIMIT SWITCH :

In electrical engineering a limit switch is a switch operated by the motion of a machine part or presence of an object. They are used for controlling machinery as part of a control system, as a safety interlocks, or to count objects passing a point.

A limit switch is an electromechanical device that consists of an actuator mechanically linked to a set of contacts. When an object comes into contact with the actuator, the device operates the contacts to make or break an electrical connection.

Limit switches are used in a variety of applications and environments because of their ruggedness, ease of installation, and reliability of operation. They can determine the presence or absence, passing, positioning, and end of travel of an object. They were first used to define the limit of travel of an object; hence the name "Limit Switch".

Standardized limit switches are industrial control components manufactured with a variety of operator types, including lever, roller plunger, and whisker type. Limit switches may be directly mechanically operated by the motion of the operating lever. A reed switch may be used to indicate proximity of a magnet mounted on some moving part. Proximity switches operate by the disturbance of an electromagnetic field, by capacitance, or by sensing a magnetic field.

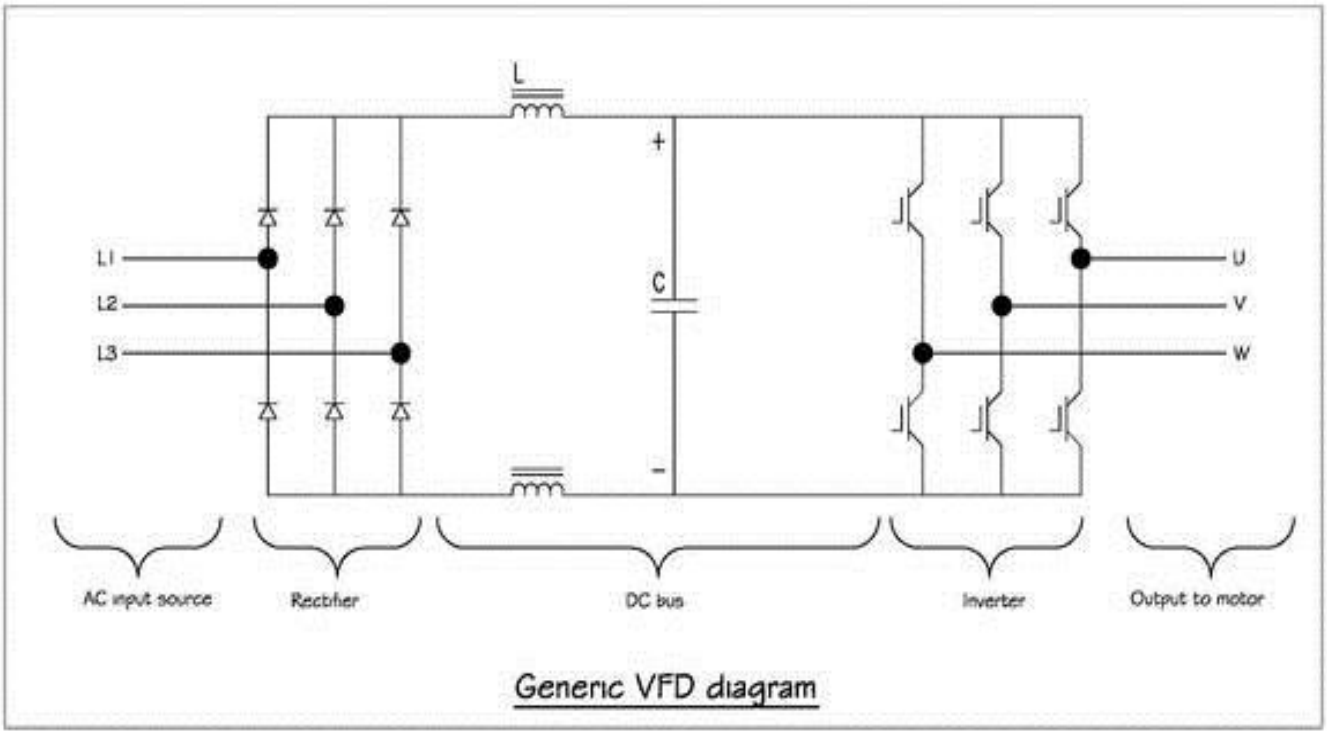
Rarely, a final operating device such as a lamp or solenoid valve will be directly controlled by the contacts of an industrial limit switch, but more typically the limit switch will be wired through a control relay, a motor contactor control circuit, or as an input to a programmable logic controller.

Miniature snap-action switch may be used for example as components of such devices as photocopiers, computer printers, convertible tops or microwave ovens to ensure internal components are in the correct position for operation and to prevent operation when access doors are opened. A set of adjustable limit switches are installed on a garage door opener to shut off the motor when the door has reached the fully raised or fully lowered position. A numerical control machine such as a lathe will have limit switches to identify maximum limits for machine**[9].**

3.7 Frequency Inverter :

A frequency inverter changes output voltage frequency and magnitude to vary the speed, power, and torque of a connected induction motor to meet load conditions. A typical frequency inverter consists of three primary sections:

The circuit in the figure (3.8) below is shown the variable frequency device and what consist of



figure(3.8):VFD circuit.

Although the exact configuration of each section of the frequency inverter may vary from manufacturer to manufacturer, the basic structure remains the same, and the rectifier section consists of an array of fast-acting switches that convert an incoming ac voltage supply to a pulsating dc voltage also the intermediate circuit consists of a dc bus and associated circuitry to stabilize and smooth the pulsating rectifier output. The dc bus voltage is roughly 1.414 times greater than the incoming ac supply voltage, depending on design type. This dc bus voltage is made available to the inverter section, which synthesizes an AC sine wave voltage output from the dc bus voltage.

The inverter section output is not a true sine wave but an approximation based on the principles of pulse width modulation (PWM), which is the predominant inverter technology. An array of fast-acting switches in inverter section produces voltage pulses at a constant magnitude proportional to the

dc bus voltage. In a 3-phase frequency inverter, there are six switches with a pair of switches for each phase. In each pair of switches, one switch generates the positive component of the sine wave and the second generates the negative component of the sine wave from the dc bus voltage. The longer that the switch is "on," the higher the output voltage; conversely, the longer that the switch is "off," the lower the output voltage. This duration of on-time for each pulse is called pulse width. The time duration/intervals of these positive and negative dc voltage pulses determine the synthesized ac output voltage and frequency.

The speed at which these switches can turn on and off is called the carrier frequency. When the carrier frequency is increased, the associated output can have much higher resolution, resulting in a smoother output waveform with less ripple/distortion. This smoother output can improve motor torque performance at low speed and decrease audible motor lamination noise. In addition, faster switching has the potential for better inverter output controllability with associated improved dynamic response[10].

4

Electrical Design

4.1 The Main Design Block Diagram:

4.2 Function Block Diagram

4.3 Flow Chart of Machine

4.4 Power circuit

4.5 Control circuit

4.6 Results

4.7 Recommendations

4.1 The Main Design Block Diagram:

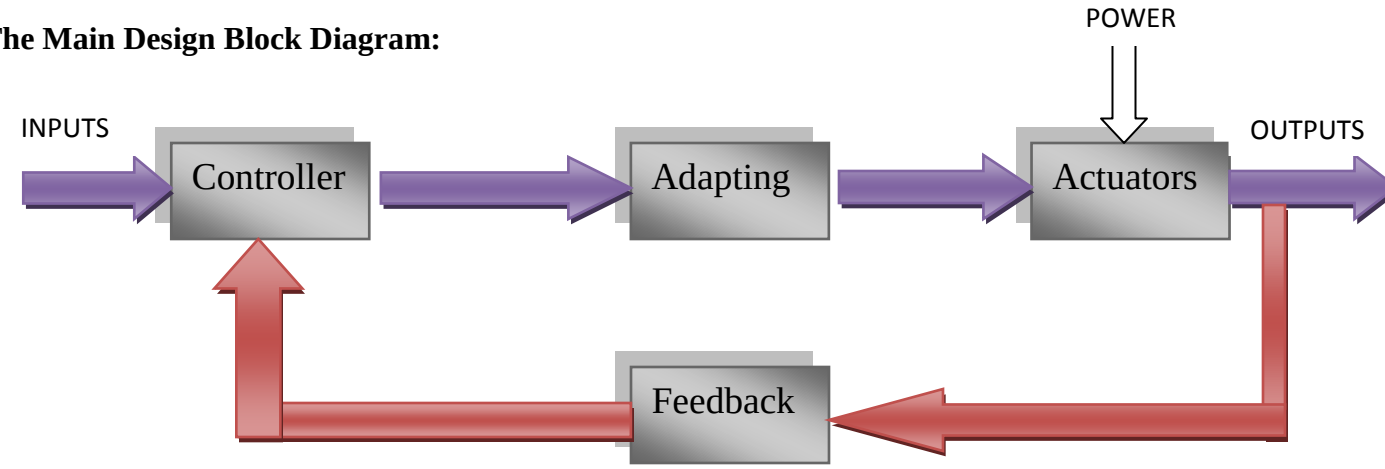


figure (4.1): Main design block diagram

The main work was on :

1-Programing PLC with LADDER LOGIC language as central controller.

2-Adapter between controller and actuator which need relays to switch the actuators and adjust the encoders.

3-The electrical main supply will feed the actuators with suitable need for power for each motor as designed .

4-Feedback the actual outputs with limit switches to take back to the PLC.

5-The comparator between the select inputs and the outputs process in the PLC.

4.2 Function Block diagram:

Here we will describe the project in terms of block diagram for product processing in figure (4.2).

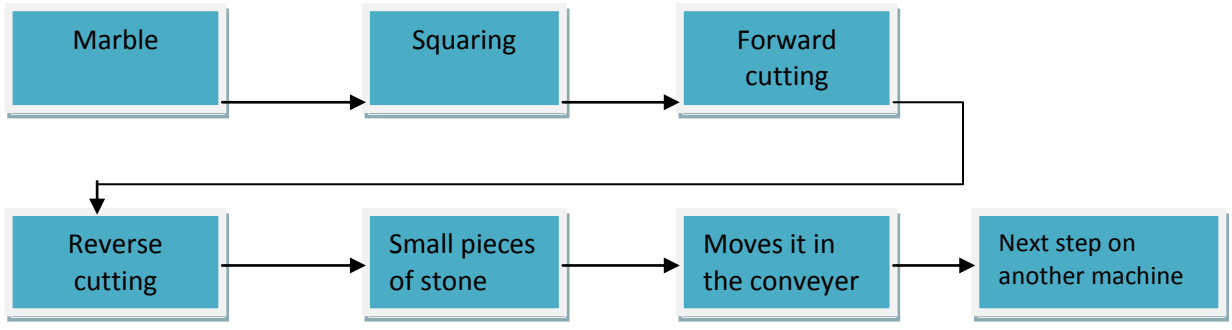


figure (4.2):function block diagram

Block 1: marble:

In the beginning we get the marble and put it in the stand of machine to start in the cutting process.

Block 2: Squaring**:**

In this stage we determine the start point of the block , and we take the lowest point to cut the marble above it to get the square shape during the process.

Block 3: Forward cutting:

In this stage we use the motors which designed to move the part that contain the large disk to do this mission which talk about vertical cutting with specific determined rang according to the process and it finish when it reach the end point .

Block 4: Reverse cutting:

This stage is look like the previous stage but with small disk that called Horizontal cutting , and it start when the past stage is done .

Block 5: Small pieces of stone:

After the cutting process, we get pieces of stone that have the same length as the stone surface.

Block 6 : Moves it in the conveyer:

When we get the pieces of stone , we have a conveyer that transport the stone to another process to make the pieces to another small size.

Block 7: Next step on another machine:

It another machine that receive the output from our machine to complete the production process of stone .

4.3 Flow chart of machine:

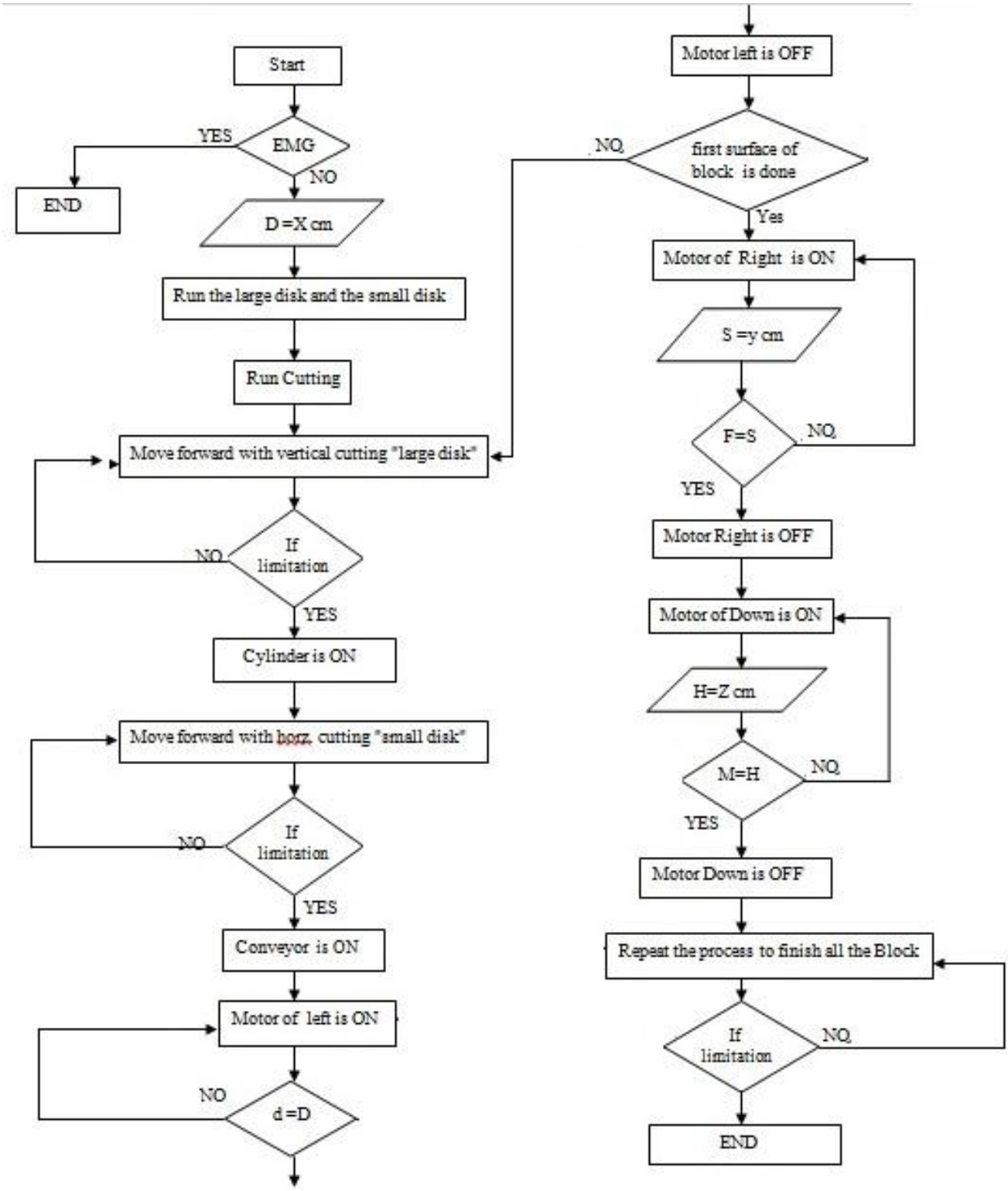
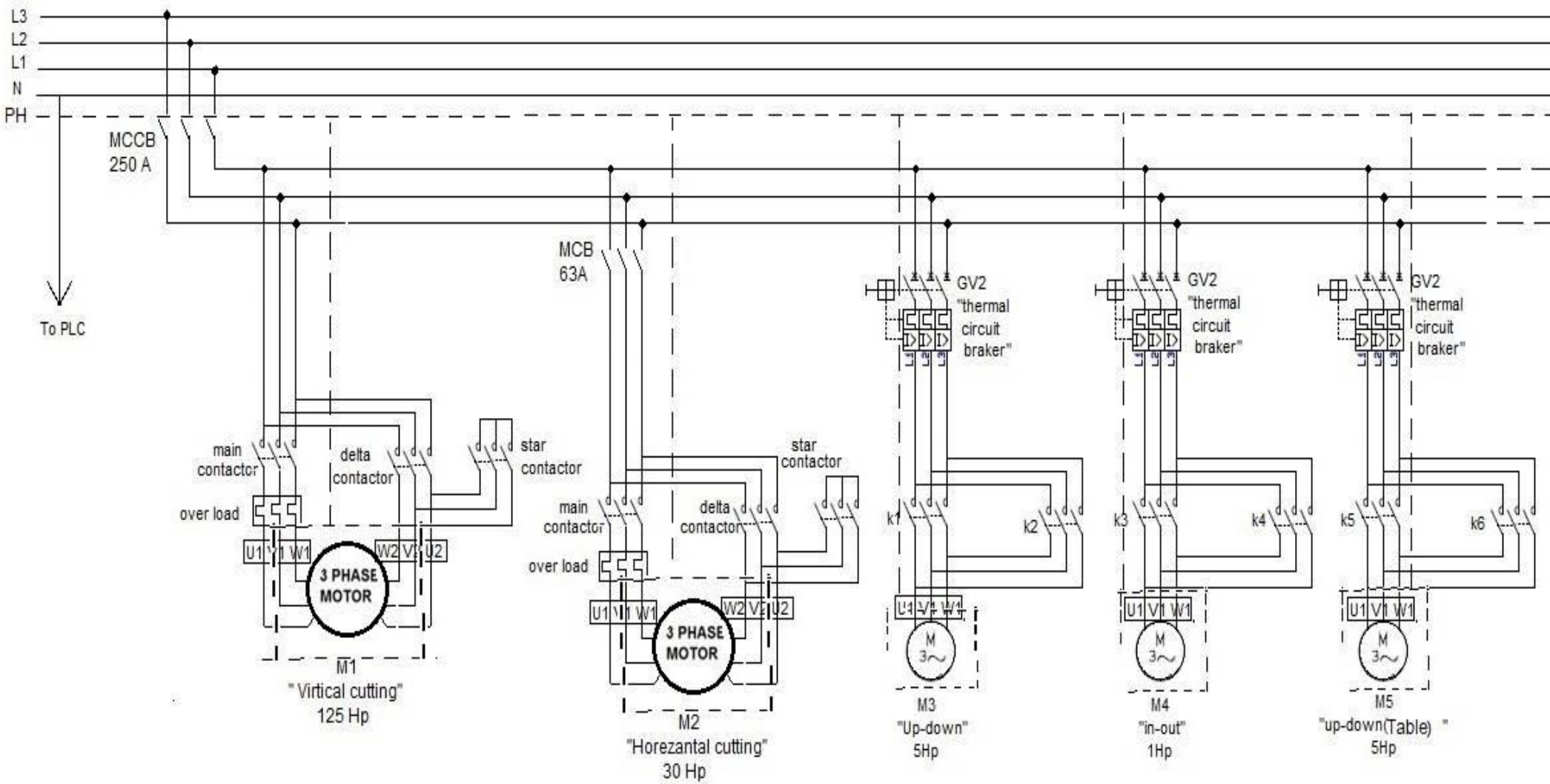


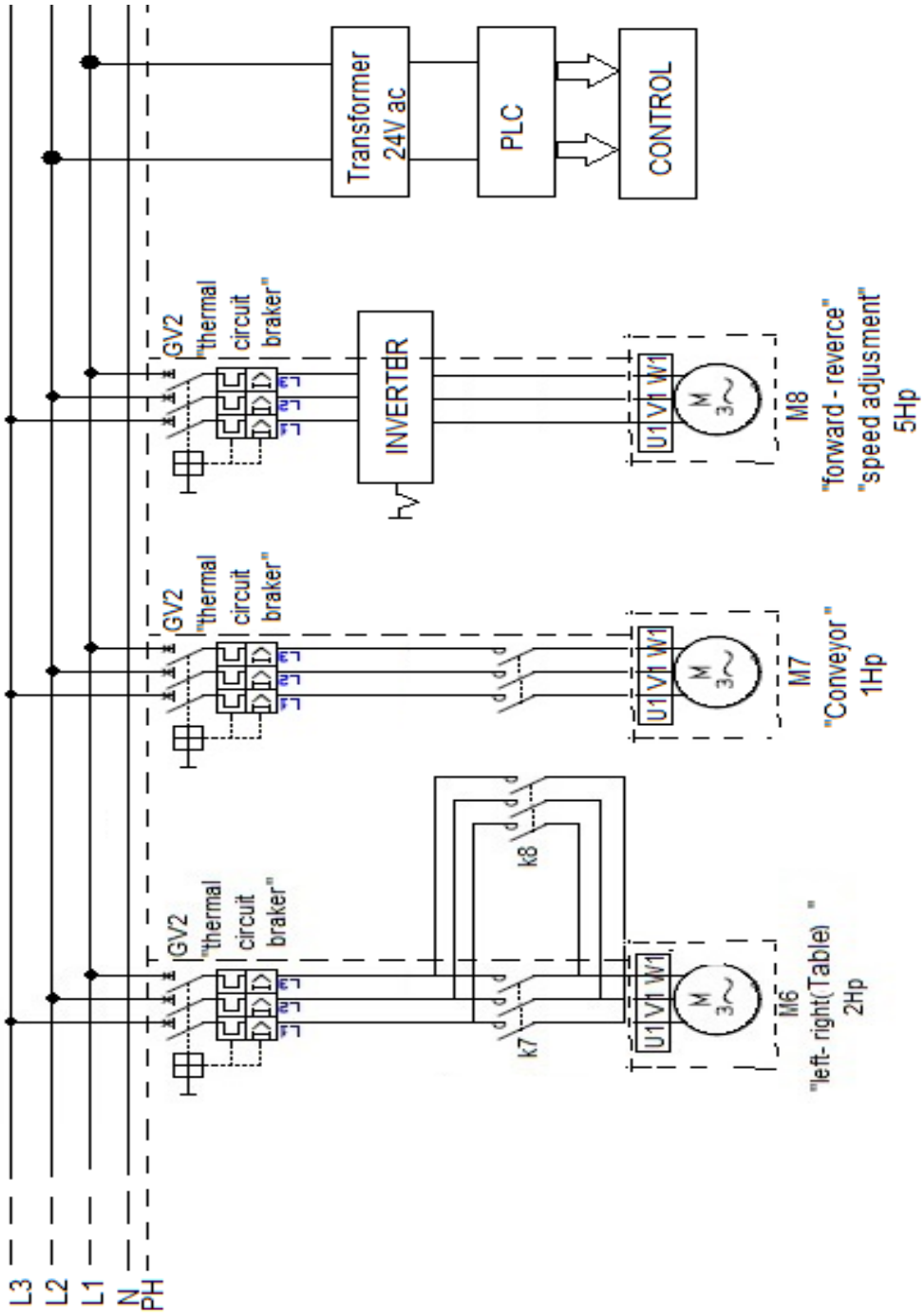
figure (4.3) :flow chart of machine.

4.4 Power Circuit:

The figures(4.4) and (4.5) are shows the power circuit of stone cutting machine. .



Figure(4.4):power circuit



Figure(4.5):power circuit

The description of this circuit :

1-**Motor M1** :

This motor is design with star delta connection due to heavy load and this motor function for vertical cutting and it carries the saw which run against the marble to cut it vertically then return back for next process ,it start from the left front of the marble to the right .

The size of this motor "main motor" 125Hp and the rated current is 165A with overload 100 A, also its free running motor no need to stop just in emergency and manually stop.

2-Motor M2:

This motor also with star delta connection due to heavy load and it function is for horizontal cutting by help with cylinder and this motor carries the saw which run against the marble to cut it horizontally then return back for next process , and it start from the left front of the marble to the right.

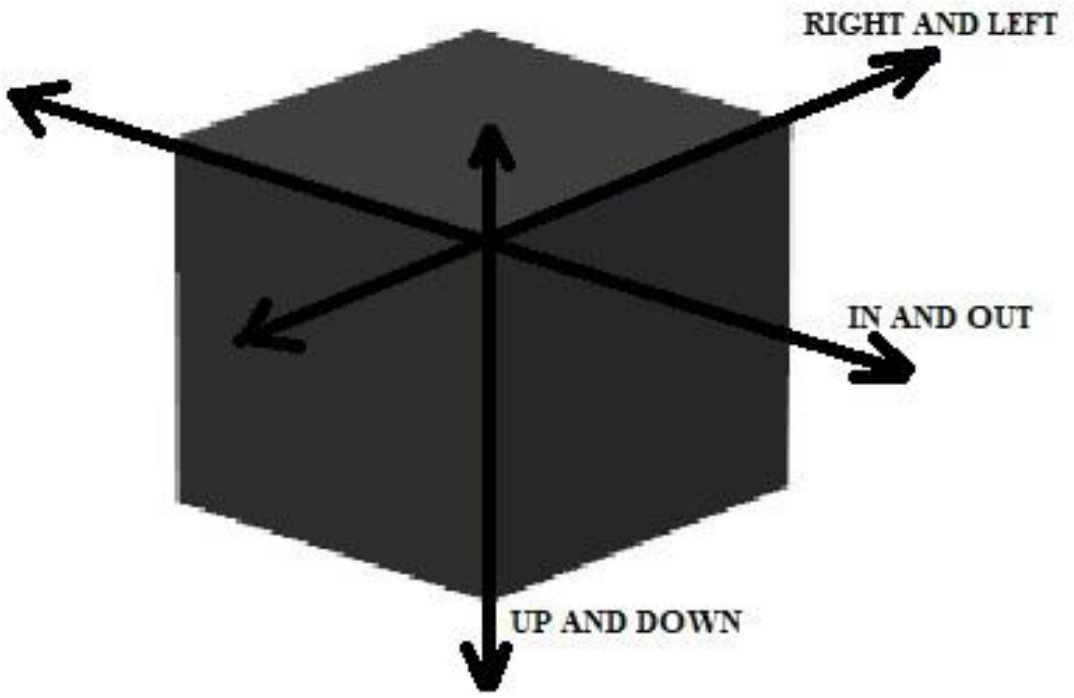
The size of the motor is 30 Hp and with rated current is 40A with circuit breaker 63A and overload 25A ,also it free running motor no need to stop just in emergency and manually stop.

3-Motor M3:

This motor is work to rise the machine up and down as the figure (4.6) is show , by adding extra contactor on it we can reverse the direction motion of this motor, and this motor power is 5Hp with running current 7.5A and GV2 "thermal circuit breaker with overload 6A to protect the motor, and this motor is work just when we need it.

4-Motor M4:

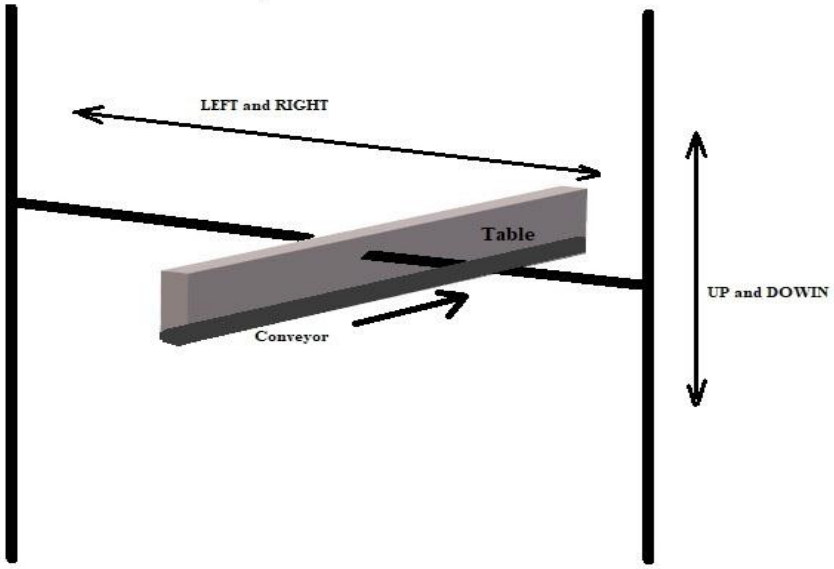
It work to entering the machine In ,and exiting it out to the left as the figure (4.6) is show, and this motor with 1Hp and current 1.5A , also with GV2 "thermal circuit breaker with overload 2A to protect the motor, and this motor is work just when we need it.



figure(4.6):direction of working the motors

5-Motor 5:

This motor to the take the "table" up and to down it as the figure (4.7) is show, and this motor with 5Hp and current 7.5A , also with GV2 "thermal circuit breaker with overload 6A to protect the motor, and this motor is work just when we need it.



figure(4.7): Table and conveyor movement

6- Motor 6:

It design to the take the "table" right and to left it as the figure (4.7) is show, and this motor with 2Hp and current 3A , also with GV2 "thermal circuit breaker with overload 4A to protect the motor, and this motor is work just when we need it.

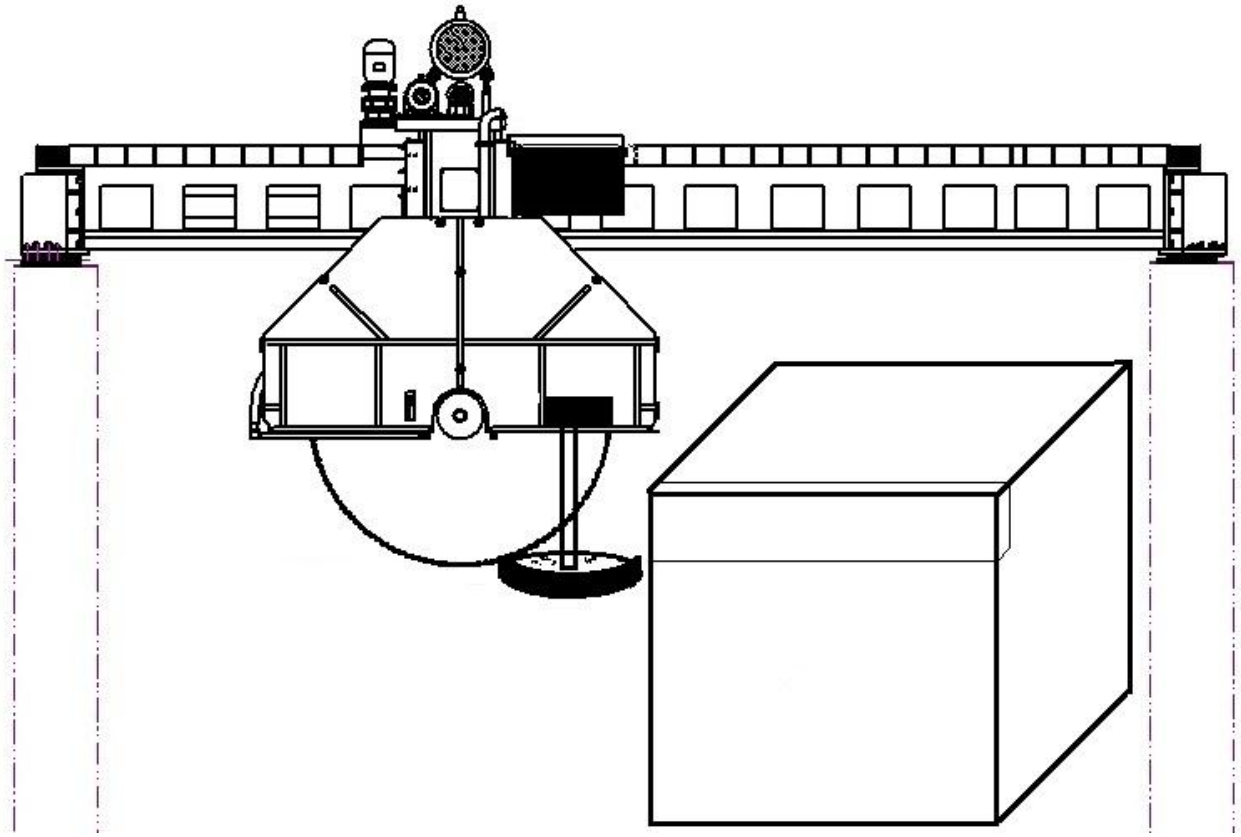
7- Motor 7:

This motor is design to move the conveyor which it carries the stone were we cut from the big marble block as the figure (4.7) is show , and this conveyor is move it to next machine with another process .

This motor here with 1Hp and 1.5 A ,also with GV2 "thermal circuit breaker with overload 2A to protect the motor, and this motor is work just when we need it.

8-Motor 8:

The motor function here is to move the "head" forward and reverse with adjustable speed by the frequency inverter , and this head is contain the large disk and small disk , as the show in the figure(4.8),and this motor with 5Hp and 7.5 A with GV2 and overload 6 A ,and free running all the process.



Figure(4.8): 2-D view of stone cutting machine without table .

4.4 Control Circuit:

The figure below is show the connection of PLC with input and output **:**

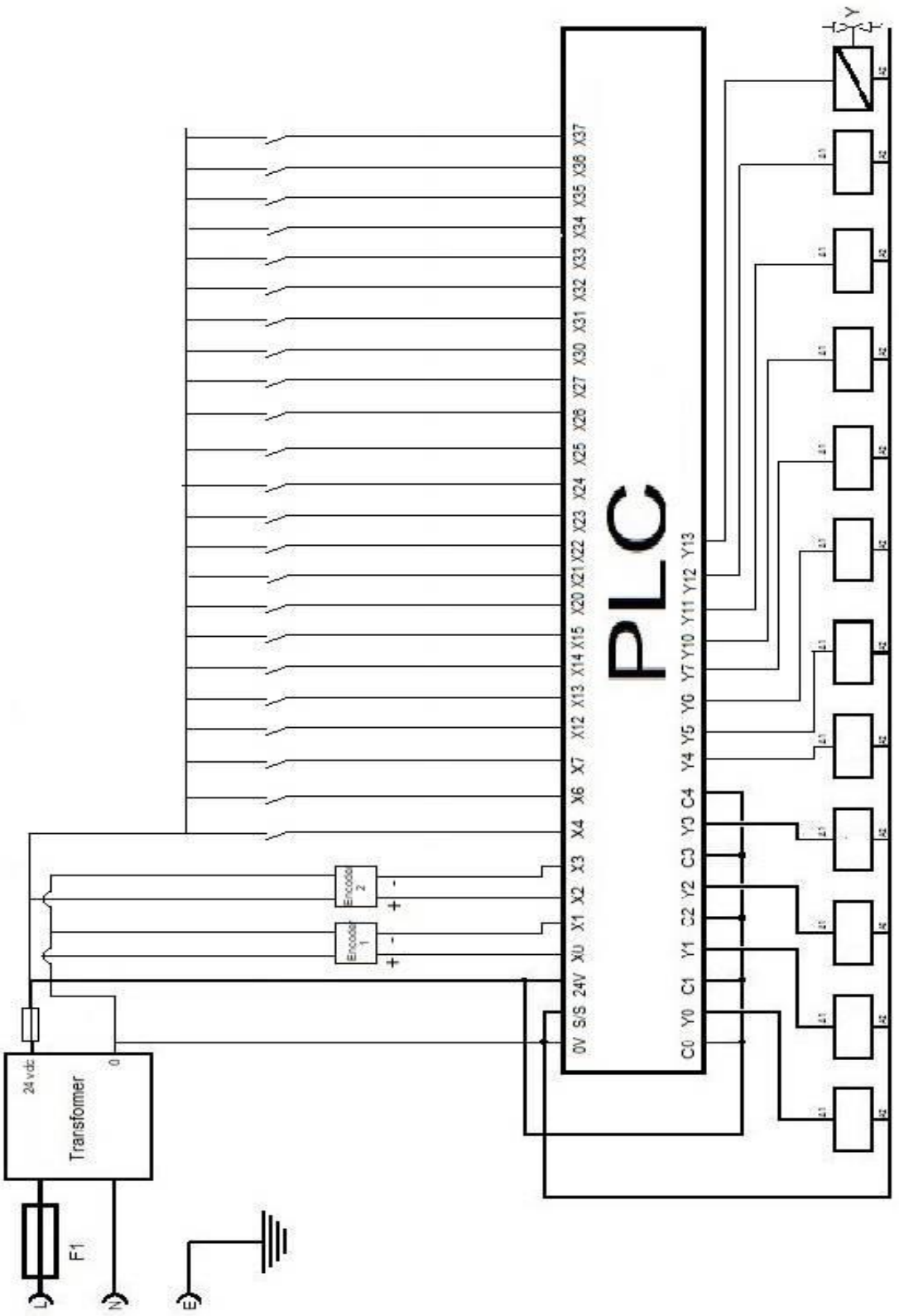


Figure 4.9 : Control Circuit

The table below is show the addresses and the descriptions of each inputs and outputs on PLC:

Address	Description
INPUT	
X0	Encoder 1 (+)
X1	Encoder 1 (-)
X2	Encoder 2 (+)
X3	Encoder 2 (-)
X22	Down the machine
X26	Up the machine
X12	Reverse the machine
X4	Forward the machine
X15	In the machine (inverter)
X21	Out the machine (inverter)
X13	Stop the machine
X7	Automatic (machine)
X30	Up the Table
X32	Down the Table
X34	In the Table
X36	Out the Table
X27	Conveyer
X14	Limit Switch forward of the Machine
X6	Limit Switch reverse of the Machine(actuate the selector)
X20	Limit Switch In of the Machine
X21	Limit Switch Out of the Machine
X25	Limit Switch up of the Machine
X24	Limit Switch down of the Machine
X35	Limit Switch In of the Table
X37	Limit Switch Out of the Table
X31	Limit Switch up of the Table
X33	Limit Switch down of the Table
OUTPUT	
Y0	Motor of forward (inverter)
Y1	Motor of reverse (inverter)
Y2	Motor In of the machine(with counting)
Y3	Motor Out of the machine(with counting)
Y4	Motor of up the machine
Y5	Motor of down the machine
Y6	Motor of Conveyer
Y7	Motor of up the Table
Y10	Motor of down the Table
Y11	Motor of In the Table
Y12	Motor of Out the Table
Y13	selector (air)

Table 4.1: PLC Address

5.6 Result:

The machine was working with relays and the controlling was complex as a lot of control was series (traditional control) and it was a big problem in case of any interrupt .

We Appling our project step by step carefully to take as many as good results after it done; by doing the motions of the head and table very well and make full system to control this machine using limit switches and encoders and inverter then all lines of control become series as PLC becomes the central process which make any interrupt easy to deal with .

It work such as the operation that we need to take the production with high quality and better time during the process and as the operator want.

5.7 Recommendations:

1-Recommendation to added the select of speed from manually to automatic with calcification the type of the stone and the hardness of it to select and adjust the proper speed .

2-With the differences of the highest of the marble block it need every time to adjust manually the encoder , the recommendation added the starting point for the encoder .

3-The stand for the carriage table working manual by the worker , and to change it automatically .

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[3]http://www.grdjournals.com/uploads/article/GRDJE/V03/I02/0018/GRDJEV03I020018

[4]http://ijdacr.com/uploads/papers/31000-15-008 .

[5] http://oro.open.ac.uk/54687/1/594090.

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[7]https://www.groschopp.com/three-phase-induction-motors/.

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[9] https://en.wikipedia.org/wiki/Limit_switch .

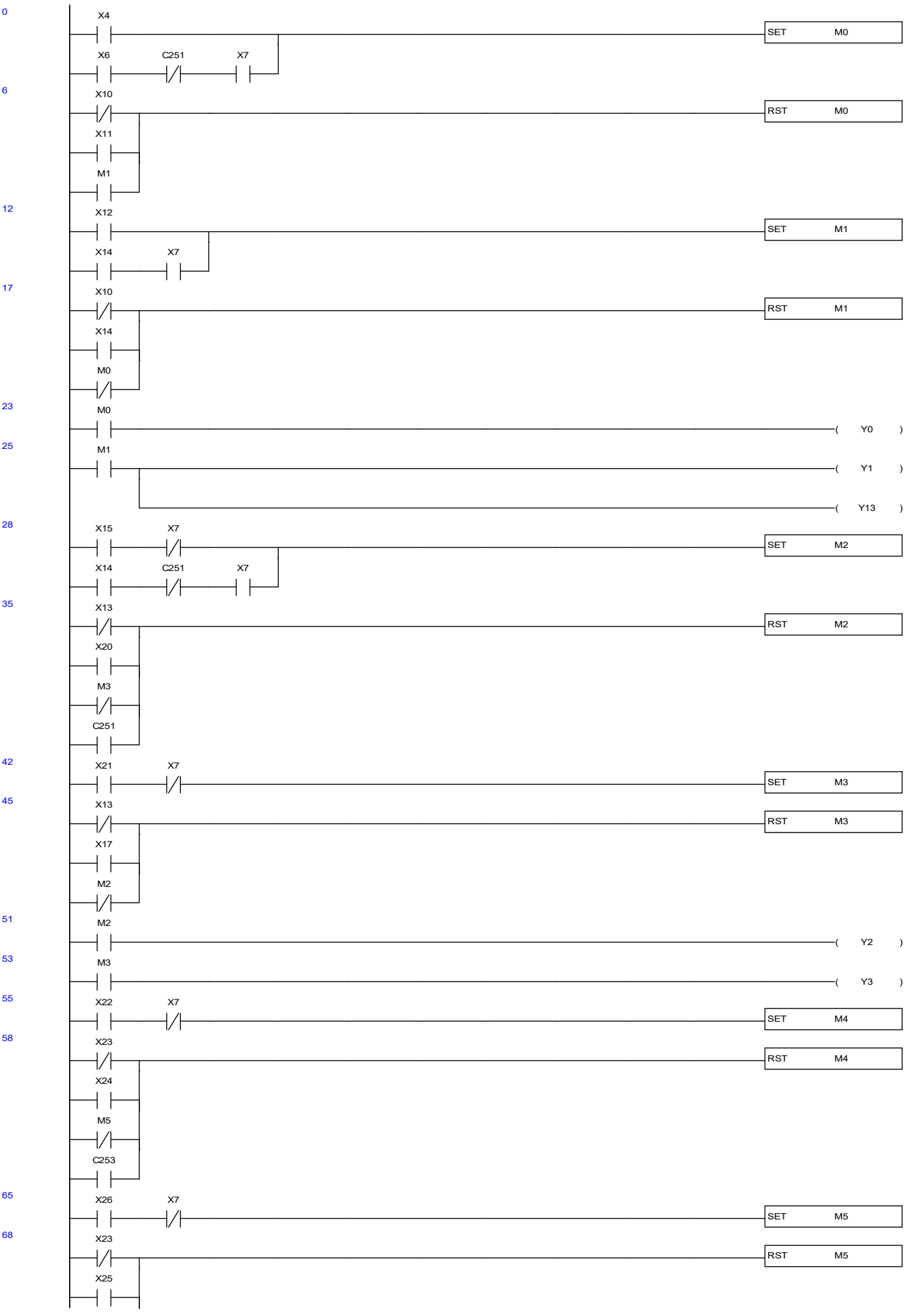
[10]https://www.vfds.com/5hp-230v-teco-n3-vfd-n3205cu.

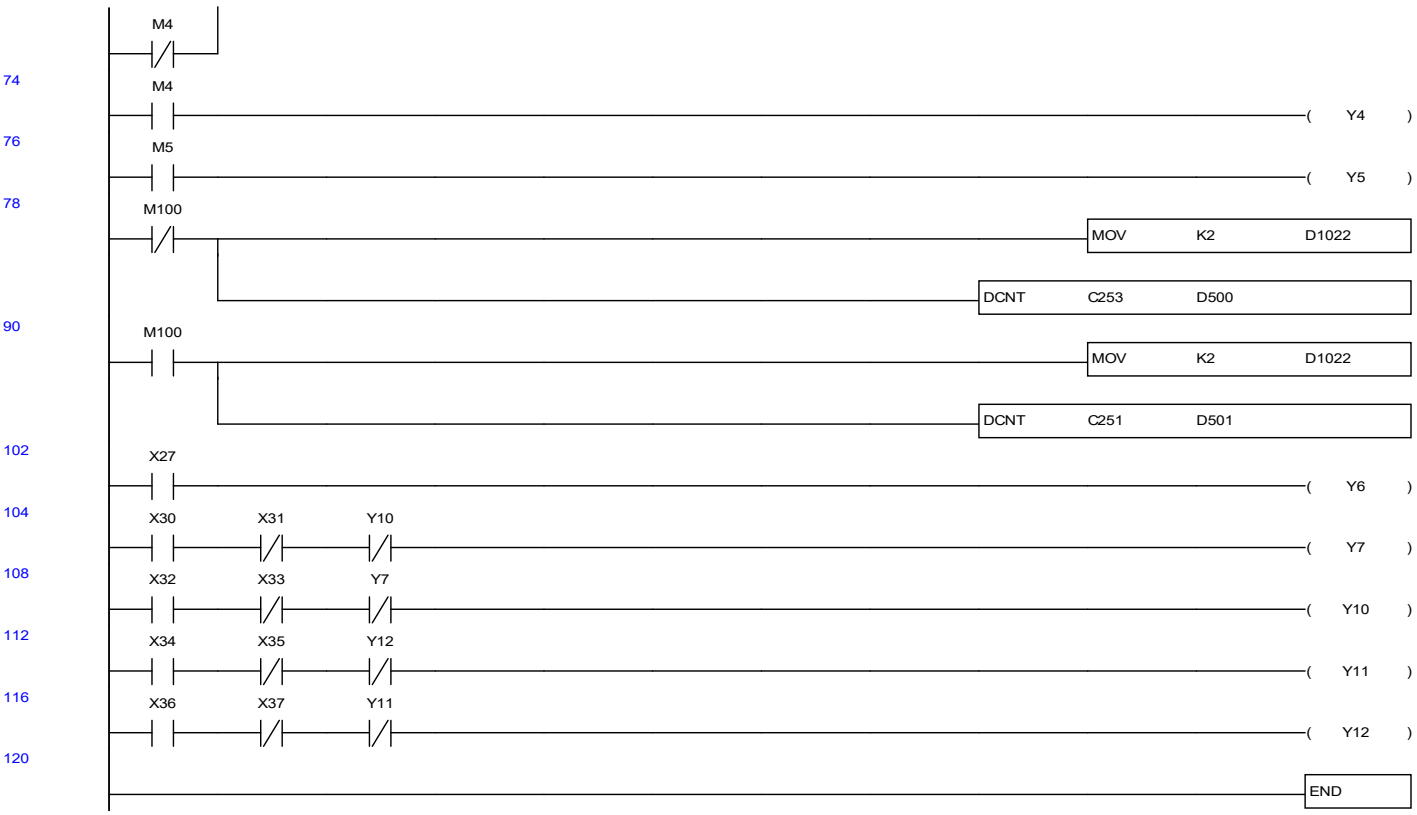
Appendix A

Appendix B

Appendix C

Appendix D


0
X4
SET M0
X6 C251 X7
6
X10
RST M0
X11
M1
12
X12
SET M1
X14 X7
17
X10
RST M1
X14
M0
23
M0
(Y0)
25
M1
(Y1)
(Y13)
28
X15 X7
SET M2
X14 C251 X7
35
X13
RST M2
X20
M3
C251
42
X21 X7
SET M3
45
X13
RST M3
X17
M2
51
M2
(Y2)
53
M3
(Y3)
55
X22 X7
SET M4
58
X23
RST M4
X24
M5
C253
65
X26 X7
SET M5
68
X23
RST M5
X25


M4
74
M4
Y4
76
M5
Y5
78
M100
MOV K2 D1022
DCNT C253 D500
90
M100
MOV K2 D1022
DCNT C251 D501
102
X27
Y6
104
X30 X31 Y10
Y7
108
X32 X33 Y7
Y10
112
X34 X35 Y12
Y11
116
X36 X37 Y11
Y12
120
END

Three Phase Squirrel Cage Induction Motors

MAA SERIES
63 - 160 SIZES

FKI Energy Technology

MarelliMotori

ASI.CT.039.1 GB

FKI Energy Technology

RATED OUTPUT	MOTOR TYPE	SPEED	PERFORMANCE AT RATED OUTPUT				POWER FACTOR	EFFICIENCY (LOAD) 3 / 4	FOR D.O.L STARTING		BREAKDOWN TORQUE	SOUND PRESSURE LEVEL	MOMENT OF INERTIA	WEIGHT IM 1001 (IM B3)
			TORQUE	CURRENT (400 V)	EFFICIENCY h CLASS									
kW		rpm min^{-1}	Tn Nm	In A	eff	%	cosj -	h %	Is/In p.u.	Ts/Tn p.u.	Tmax/Tn p.u.	LpA dB(A)	J kgm^2	Approx. kg
3000 min^{-1} = 2 poles - 50 Hz														
0,18	MAA 63 MA2	2710	0,63	0,55	n.c.	63,0	0,75	62,1	4,1	2,6	2,7	53	0,00020	4,0
0,25	63 MB2	2710	0,88	0,71	n.c.	65,0	0,78	64,5	4,2	2,6	2,7	53	0,00023	4,4
0,37	63 MC2*	2710	1,30	1,05	n.c.	65,0	0,78	64,5	4,2	2,6	2,5	53	0,00030	4,9
0,37	71 MA2	2730	1,29	0,97	n.c.	70,0	0,79	69,5	4,8	2,5	2,4	58	0,00040	5,6
0,55	71 MB2	2760	1,90	1,42	n.c.	71,0	0,79	71,0	4,8	2,5	2,4	58	0,00045	6,1
0,75	71 MC2*	2730	2,62	1,83	n.c.	72,0	0,82	72,0	5,7	3,0	2,4	59	0,00057	7,0
0,75	80 MA2	2770	2,59	1,77	n.c.	73,0	0,84	73,0	6,1	2,5	3,0	58	0,00083	9,1
1,1	80 MB2	2770	3,79	2,51	2	76,2	0,83	76,2	6,4	2,5	3,0	58	0,00097	10,2
1,5	80 MC2*	2800	5,12	3,32	2	78,5	0,83	79,0	7,0	2,5	3,1	58	0,00120	11,7
1,5	90 S2	2840	5,05	3,28	2	78,5	0,84	78,5	6,0	2,8	2,7	61	0,0016	12,0
2,2	90 L2	2840	7,40	4,61	2	81,0	0,85	80,6	6,5	2,8	2,7	61	0,0022	15,0
3	90 LB2*	2840	10,09	6,10	2	82,6	0,86	81,2	7,0	2,8	2,9	61	0,0028	18,5
3	100 LA2	2840	10,09	6,03	2	82,6	0,87	81,9	7,5	2,2	2,5	69	0,0050	22,3
4	100 LB2*	2850	13,41	7,88	2	84,2	0,87	83,5	7,8	2,8	2,9	69	0,0063	25,2
4	112 M2	2880	13,27	7,88	2	84,2	0,87	84,0	7,2	2,4	2,6	69	0,0063	26,7
5,5	112 MB2*	2880	18,25	10,53	2	85,7	0,88	85,5	7,5	2,4	2,6	69	0,0078	30,2
5,5	132 SA2	2900	18,12	10,53	2	85,7	0,88	85,1	7,5	2,1	3,1	70	0,016	38,5
7,5	132 SB2	2920	24,54	14,14	2	87,0	0,88	86,8	7,5	2,1	3,1	70	0,019	42,2
9,2	132 MB2*	2930	30,00	17,25	2	88,0	0,89	87,4	7,5	2,1	3,1	70	0,023	51,4
11	132 MC2*	2930	35,87	19,96	2	88,4	0,90	88,1	7,5	2,1	3,1	70	0,028	58,8
15	132 MD2*	2905	49,33	29,00	n.c.	88,0	0,85	88,0	7,5	2,8	3,2	70	0,028	62,0
11	160 MA2	2940	35,75	19,19	2	88,4	0,90	88,1	7,5	2,0	2,2	78	0,030	75,0
15	160 MB2	2940	48,75	26,61	2	89,4	0,91	89,2	7,5	2,0	2,2	78	0,035	88,0
18,5	160 L2	2940	60,12	32,60	2	90,0	0,91	89,5	7,5	2,0	2,2	78	0,040	99,0
1500 min^{-1} = 4 poles - 50 Hz														
0,12	MAA 63 MA4	1350	0,85	0,47	n.c.	57,0	0,84	52,6	3,4	2,0	2,1	45	0,00025	3,9
0,18	63 MB4	1350	1,27	0,68	n.c.	59,0	0,85	57,7	3,4	2,0	2,1	45	0,00030	4,3
0,25	63 MC4*	1350	1,77	0,91	n.c.	60,0	0,86	58,7	3,5	2,1	2,2	46	0,00040	4,8
0,25	71 MA4	1350	1,77	0,84	n.c.	60,0	0,72	59,2	3,8	2,0	2,1	49	0,00050	5,4
0,37	71 MB4	1370	2,58	1,11	n.c.	65,0	0,74	64,5	4,1	2,4	2,2	49	0,00060	6,2
0,55	71 MC4*	1380	3,81	1,60	n.c.	66,0	0,75	65,5	4,1	2,5	2,2	49	0,00076	7,3
0,55	80 MA4	1370	3,84	1,58	n.c.	67,0	0,75	67,0	4,2	2,0	2,2	50	0,00130	9,0
0,75	80 MB4	1380	5,19	1,93	n.c.	72,0	0,78	72,0	4,7	2,2	2,2	50	0,00160	10,0
1,1	80 MC4*	1390	7,56	2,67	2	76,2	0,78	76,2	5,1	2,3	2,3	50	0,00190	12,3
1,1	90 S4	1400	7,51	2,64	2	76,2	0,79	77,3	4,8	2,2	2,3	50	0,0033	12,1
1,5	90 L4	1400	10,24	3,45	2	78,5	0,80	79,1	5,9	2,2	2,4	50	0,0040	14,6
2,2	90 LB4 *	1400	15,01	4,90	2	81,0	0,80	81,4	6,1	2,8	2,6	50	0,0048	18,3
2,2	100 LA4	1420	14,80	4,84	2	81,0	0,81	81,5	5,9	2,1	2,4	52	0,0073	21,0
3	100 LB4	1420	20,18	6,47	2	82,6	0,81	83,6	6,4	2,2	2,4	52	0,0090	24,7
4	100 LC4	1430	26,72	8,36	n.c.	84,2	0,82	85,2	7,0	2,2	2,3	52	0,0110	29,0
4	112 M4	1430	26,72	8,26	2	84,2	0,83	84,8	6,6	1,9	2,7	57	0,012	30,5
5,5	112 MS4	1440	36,49	11,16	2	85,7	0,83	84,9	6,6	1,9	2,9	57	0,013	34,8
5,5	132 SA4	1450	36,24	11,03	2	85,7	0,84	86,1	7,4	1,7	2,8	68	0,024	40,4
7,5	132 MA4	1450	49,42	14,64	2	87,0	0,85	87,3	7,6	1,8	3,0	68	0,030	49,6
9,2	132 MB4*	1460	60,20	17,85	2	87,5	0,85	87,5	8,0	2,0	3,0	68	0,034	56,6
11	132 MD4*	1460	71,98	20,88	n.c.	88,4	0,86	88,4	8,0	2,2	3,0	68	0,040	64,0
11	160 M4	1460	71,98	20,64	2	88,4	0,87	88,5	7,4	1,5	2,7	68	0,063	78,0
15	160 L4	1460	98,16	28,15	2	88,4	0,87	88,5	7,5	1,6	2,7	68	0,075	98,0
18,5	160 LB4	1460	121,06	34,50	2	88,4	0,85	88,5	7,5	1,8	2,8	68	0,092	113,0

*n.a. - Rated output not part of CEMEP agreement - * Not included in IEC 60072-1 standards - Tmax = Breakdown torque, Ts = Starting torque, Is = Starting current.*

The motors illustrated are asynchronous three phase, low-voltage and suitable for industrial applications.

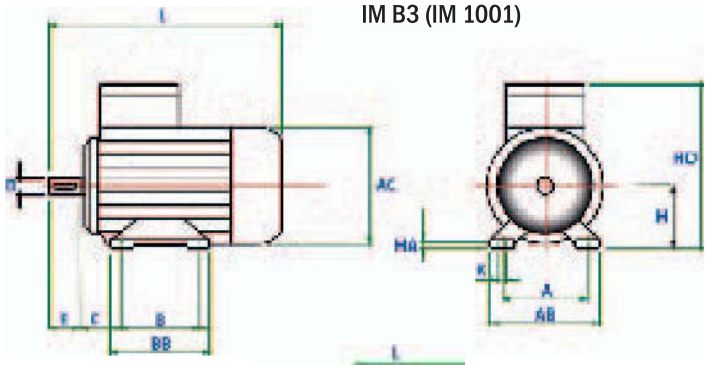
TECHNICAL CHARACTERISTICS

- International standards IEC 60034.
- Rated outputs and frame sizes in accordance with EN 50347 standards, where applicable.
- Continuous duty (S1) with sufficient thermal margins, to withstand short overloads.
- Motors designed according to the rules given by IEC 60034 group and the EC's harmonised ones.
- Protection degree IP 55.
- Insulation class F.
- Temperature rise compatible with class B.
- Maximum ambient temperature: +40°C.
- Installation ≤1000 m a.s.l.
- Normal noise level less than 80db(A) for 4 or more poles.

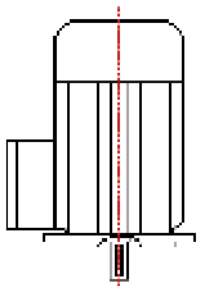
CONSTRUCTION MATERIALS

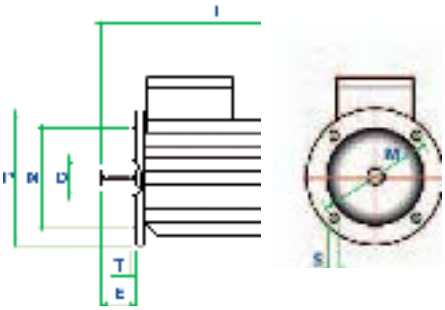
- Frame - Aluminium.
- Endshields - Aluminium.
- Fan cowl - Steel.
- Fan - Plastic.
- Terminal box - Aluminium.

IM B3 (IM 1001)

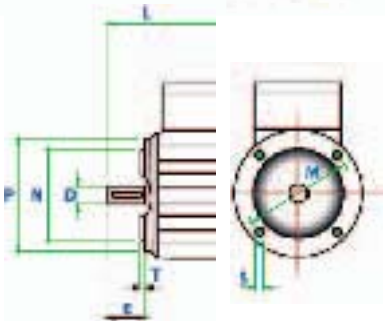


IM V1 (IM 3011)

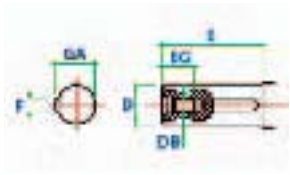




IM B5 (IM 3001)



IM B14 (IM 3601)



SHAFT EXTENSION

DIMENSIONS																														
FRAME SIZE													FLANGE B5 - V1					B14						SHAFT EXTENSION						
IEC	POLES	A	AB	AC	B	BB	C	H	HA	HD	K	L	M	N	P	S	T	M	N	P	LA	S	T	D	TOLL.	E	F h9	GA	DB	EG
63	2-8	100	120	122	80	100	40	63	7	173	7	215	115	95	140	9	3	75	60	90	10	M5	2,5	11	j6	23	4	12,5	M4	10
71	2-8	112	132	137	90	110	45	71		188		254	130	110	160		3,5	85	70	105		M6		14		30	5	16	M5	12,5
80	2-8	125	160	158	100	125	50	80	8	217	9	290	165	130	200	11	3,5	100	80	120	10	M6	3	19	j6	40	6	21,5	M6	19
90 S	2-8	140	175	177	100	155	56	90	10	235		310						115	95	140		M8	3	24		50	8	27	M8	19
90 L	2-8				125							365																		
100	2-8	160	196	197	140	180	63	100	12	252	11	386	215	180	250	14	4	130	110	160	11	M8	3,5	28	j6	60	8	31	M10	22
112	2-8	190	220				70	112		292		395																		
132 S	2-8	216	252	253	140	226	89	132	15	325	11	436	265	230	300	14	4	165	130	200	17	M10	3,5	38	k6	80	10	41	M12	28
132 M	2-8				178							500																		
160 M	2-8	254	290	314	210	296	108	160	20	390	14,5	640	300	250	350	18	5							42		110	12	45	M16	36
160 L	2-8				254																									

ENERGY SAVING

Marelli Motori have undersigned the voluntary agreement with the CEMEP which, in co-operation with the European Commission, designated energy efficiency classes for three phase squirrel cage induction motors, TEFC, 1.1 to 90kW, 2 and 4 poles, rated for 400V, 50Hz, S1 duty in standard design. These classes are identified as eff1, eff2 and eff3 in descending order. The replacement of standard motors with these new designs will lead to the following benefits:

- Increased lifetime of the motor and its bearings, due to reduced operating temperatures.
- Better capability of the motor to run under voltage variations, poor voltage and current wave shapes.
- Increased resistance to handle overload conditions.

RATED OUTPUT	MOTOR TYPE	SPEED	PERFORMANCE AT RATED OUTPUT				POWER FACTOR	EFFICIENCY (LOAD) 3 / 4	FOR D.O.L STARTING		BREAKDOWN TORQUE	SOUND PRESSURE LEVEL	MOMENT OF INERTIA	WEIGHT IM 1001 (IM B3)
			TORQUE	CURRENT (400 V)	EFFICIENCY h CLASS									
kW		rpm min^{-1}	Tn Nm	In A	eff	%	cosj -	h %	Is/In p.u.	Ts/Tn p.u.	Tmax/Tn p.u.	LpA dB(A)	J kgm^2	Approx. kg
1000 min^{-1} = 6 poles - 50 Hz														
0,09	MAA 63 MA6*	840	1,02	0,51	n.c.	42,0	0,61	38,1	3,0	2,0	2,0	50	0,00025	4,2
0,12	63 MB6*	850	1,35	0,62	n.c.	45,0	0,62	41,1	3,5	2,0	2,0	50	0,00030	4,8
0,18	71 MA6	880	1,95	0,70	n.c.	56,0	0,66	52,5	3,0	1,6	1,7	52	0,0005	6,0
0,25	71 MB6	900	2,65	0,87	n.c.	59,0	0,70	55,3	3,0	2,0	2,2	52	0,0006	6,5
0,37	71 MC6	890	3,97	1,27	n.c.	61,0	0,69	57,2	3,5	2,0	2,1	52	0,0009	7,2
0,37	80 MA6	900	3,93	1,23	n.c.	62,0	0,70	59,4	4,0	1,9	1,9	53	0,0024	8,2
0,55	80 MB6	900	5,84	1,65	n.c.	67,0	0,72	64,6	4,0	2,0	2,3	53	0,0027	9,9
0,75	80 MC6	900	7,96	2,21	n.c.	68,0	0,72	66,0	4,0	2,0	2,3	53	0,0036	11,3
0,75	90 S6	920	7,79	2,18	n.c.	69,0	0,72	67,9	4,1	1,9	2,2	56	0,0037	11,7
1,1	90 L6	925	11,36	3,02	n.c.	72,0	0,73	70,4	4,5	2,2	2,2	56	0,0050	15,1
1,5	100 LA6	945	15,17	3,85	n.c.	74,0	0,76	72,3	4,8	2,1	2,3	58	0,010	19,1
2,2	112 M6	955	22,01	5,36	n.c.	78,0	0,76	76,7	5,0	2,2	2,2	58	0,015	25,4
3	132 SA6	960	29,86	7,21	n.c.	79,0	0,76	77,6	6,0	2,0	2,0	60	0,030	36,1
4	132 MA6	960	39,81	9,44	n.c.	80,5	0,76	80,1	6,5	2,0	2,0	60	0,038	45,0
5,5	132 MB6	960	54,74	12,42	n.c.	83,0	0,77	82,5	6,5	2,0	2,0	60	0,046	55,5
7,5	132 MC6	960	74,64	16,54	n.c.	85,0	0,77	84,4	6,5	2,0	2,0	60	0,062	60,0
7,5	160 M6	960	74,64	15,73	n.c.	86,0	0,80	86,7	6,5	2,0	2,2	62	0,087	72
11	160 L6	960	109,47	22,97	n.c.	87,5	0,79	87,7	6,5	2,0	2,2	62	0,110	92
750 min^{-1} = 8 poles - 50 Hz														
0,09	MAA 71 MA8	680	1,3	0,48	n.c.	48,0	0,56	45,4	2,7	1,5	1,7	50	0,0005	6,0
0,12	71 MB8*	690	1,7	0,58	n.c.	51,0	0,59	48,2	2,8	2,0	2,5	50	0,0006	6,8
0,18	80 MA8	680	2,5	0,84	n.c.	51,0	0,61	48,3	2,8	1,5	1,7	52	0,0024	9,9
0,25	80 MB8	680	3,5	1,06	n.c.	56,0	0,61	53,3	2,7	1,6	2,0	52	0,0027	10,9
0,37	80 MC8	680	5,2	1,35	n.c.	63,0	0,63	59,9	2,8	1,6	1,8	53	0,0035	14,8
0,37	90 S8	680	5,2	1,37	n.c.	59,3	0,66	56,5	3,0	1,9	2,0	56	0,0037	13,4
0,55	90 L8	680	7,7	1,85	n.c.	66,0	0,65	62,6	3,0	1,6	1,8	56	0,0050	17,2
0,75	100 LA8	710	10,1	2,45	n.c.	66,0	0,67	65,1	3,5	1,7	2,1	58	0,0090	17,5
1,1	100 LB8	710	14,8	3,20	n.c.	72,0	0,69	70,8	3,5	1,7	2,1	58	0,0120	19,7
1,5	112 MA8	710	20,2	4,30	n.c.	74,0	0,68	74,0	4,2	2,0	2,4	58	0,0170	25,6
2,2	132 SA8	720	29,2	5,96	n.c.	75,0	0,71	75,5	4,2	1,7	2,0	60	0,0380	35,5
3	132 MA8	720	39,8	7,70	n.c.	77,0	0,73	77,9	4,4	1,7	2,3	60	0,0460	45,0
4	160 MA8	730	52,4	9,89	n.c.	80,0	0,73	79,1	5,0	1,9	2,1	61	0,080	60,0
5,5	160 MB8	720	73,0	12,85	n.c.	83,5	0,74	82,6	5,5	2,0	2,1	61	0,092	72,0
7,5	160 L8	720	99,5	17,00	n.c.	85,0	0,75	84,6	6,0	1,9	2,2	62	0,110	92,0

*n.a. - Rated output not part of CEMEP agreement - * Not included in IEC 60072-1 standards - Tmax = Breakdown torque, Ts = Starting torque, Is = Starting current.*

MarelliMotori

TERMINAL BOX AND CABLE ENTRY

The terminal boxes of MAA series motors are placed on top of the electrical machine (considering IM 1001 - B3 as reference) and are normally equipped with 6 terminals.
The motors from 100 up to 160 frame size included allow the user to mount the terminal box either on the right side or the left one, as seen from the D-end side. The terminal box can be rotated in steps of 90° on motors up to 160 frame size included.

FRAME SIZE	CLEARANCE HOLES FOR METRIC CABLEGLANDS	TYPE OF TERMINAL	TERMINAL SCREW THREAD
63	1xM16	THREADED TERMINALS	M4
71 - 90	1xM20	THREADED TERMINALS	M4
100	2xM20	THREADED TERMINALS	M5
112 - 132	2xM25	THREADED TERMINALS	M5
160	2xM32	THREADED TERMINALS	M6

PERFORMANCES AT 50 Hz & 60 Hz

The motors wounded for V=230/400V and V=400V - 50Hz, when operating at the voltage and frequency values shown below, have performances which can be obtained by considering the following table.

MOTOR TYPE 2 - 4 POLES	VOLTAGE AND FREQUENCY OF THE WINDINGS	SUPPLY VOLTAGE CONNECTION AND FREQUENCY		RATED OUTPUT	RATED SPEED	RATED TORQUE AT THE FREQUENCY OF THE NETWORK Tn	STARTING TORQUE Ts/Tn	BREAKDOWN TORQUE Tmax/Tn
MAA 63-160	230 / 400 Volt Δ / Y 50 Hz	220 V	Δ 50 Hz	1	1	1	0,9	0,9
		240 V					1,1	1,1
		380 V	Y 50 Hz				0,9	0,9
		415 V					1,1	1,1
		440 V	Y 60 Hz	1,1	1,2	0,9	0,8	0,9
		460 V					0,9	1
		480 V		1,2		1	1	1

TECO

L510

Compact V/F Control Drive

TAIWAN EXCELLENCE 2011

L510 Series
Compact V/F Control Drive

TAIWAN EXCELLENCE 2011

Received prestigious Taiwan Excellence Award 2011 for outstanding design and unique features.

MAIN FEATURES

- 32 bit CPU design provides high performance, faster A/D conversion and torque compensation.
- Output frequency up to 650Hz.
- Built-in Modbus RS485 communication for one to one and one to many control.
- Communication interface modules for Profibus/ DeviceNet/ Ethernet(TCP/IP)/ CANopen.
- Built-in digital display and keypad including speed adjustment potentiometer.
- RJ45 interface for PC and copy module.
- Built-in EMI filter. For interference suppression in compliance with (IEC) EN61800-3.
- Compact space saving design for side by side installation. Plus optional Din rail mounting kit.
- Cooling without fan design for frame 1. Effectively lower the probability of unknown objects entering and prolong the product life.
- PID functionality
- Auto run. 7 programmable sequences (single cycle or repeated cycles)
- Auto Carrier frequency change to limit inverter over temperature.
- Full protective functions.

Power Rating	0.2kW 0.25HP	0.4kW 0.5HP	0.75kW 1HP	1.5kW 2HP	2.2kW 3HP
L510	100V 1-phase				
	200V 1-phase				
	200V 3-phase				
			400V 3-phase		

BASIC SPECIFICATIONS

Model	100V Class: Single-phase		
	L510-□□□-H1-N □*		
	1P2	1P5	101
Horse Power (HP)	0.25	0.5	1
Suitable Motor Capacity (KW)	0.2	0.4	0.75
Rated Output Current (A)	1.8	2.6	4.3
Rated Capacity (KVA)	0.68	1.00	1.65
Input Voltage Range(V)	Single-phase 100~120V,50/60HZ		
Allowable Voltage Fluctuation	-15%~+10%		
Output Voltage Range(V)	Three-phase 0~240V		
Input Current (A)	9.5	13	19
Allowable Momentary Power Loss Time (Sec.)	1.0		1.0
Enclosure	IP20		
Frame Size	1		2

Model	200V Class: Single-phase				
	L510-□□□-H1-N □* L510-□□□-H1F-P □*				
	2P2	2P5	201	202	203
Horse Power (HP)	0.25	0.5	1	2	3
Suitable Motor Capacity (KW)	0.2	0.4	0.75	1.5	2.2
Rated Output Current (A)	1.8	2.6	4.3	7.5	10.5
Rated Capacity (KVA)	0.68	1.00	1.65	2.90	4.00
Input Voltage Range(V)	Single-phase 200~240V,50/60HZ				
Allowable Voltage Fluctuation	-15%~+10%				
Output Voltage Range(V)	Three-phase 0~240V				
Input Current (A)	4.9	7.2	11	15.5	21
Allowable Momentary Power Loss Time (Sec.)	1.0			2.0	
Enclosure	IP20				
Frame Size	1			2	

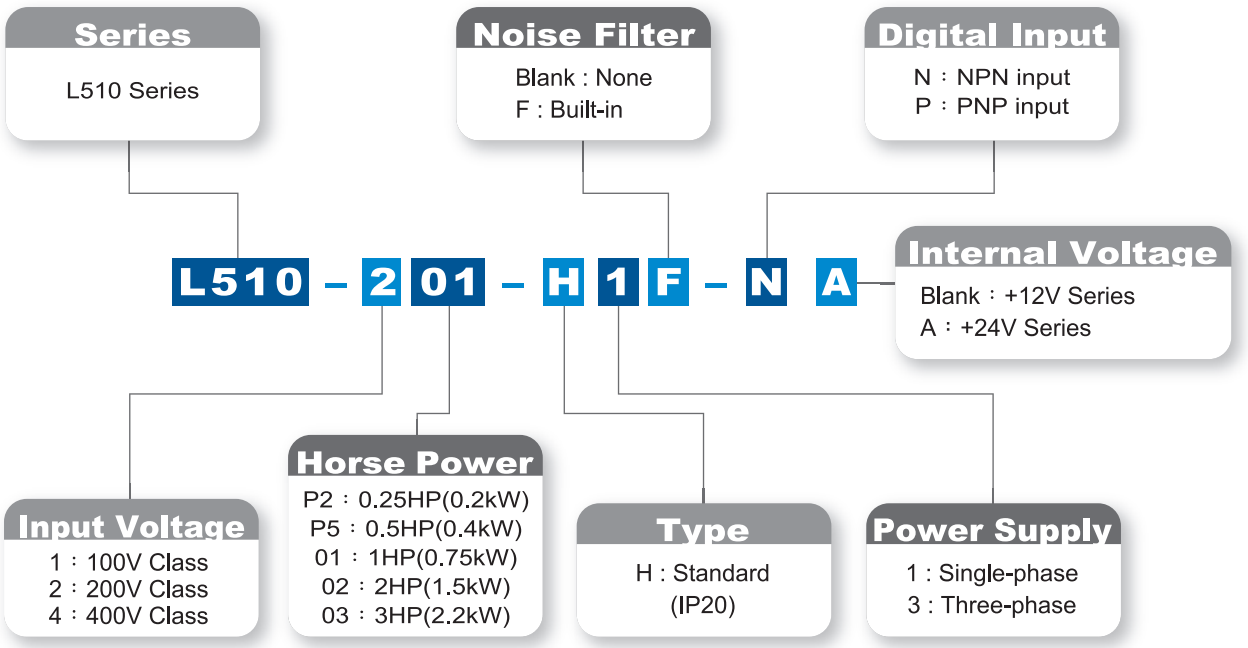
Model	200V Class: Three-phase				
	L510-□□□-H3-N □*				
	2P2	2P5	201	202	203
Horse Power (HP)	0.25	0.5	1	2	3
Suitable Motor Capacity (KW)	0.2	0.4	0.75	1.5	2.2
Rated Output Current (A)	1.8	2.6	4.3	7.5	10.5
Rated Capacity (KVA)	0.68	1.00	1.65	2.90	4.00
Input Voltage Range(V)	Three-phase 200~240V,50/60HZ				
Allowable Voltage Fluctuation	-15%~+10%				
Output Voltage Range(V)	Three-phase 0~240V				
Input Current (A)	3.0	4.0	6.4	9.4	12.2
Allowable Momentary Power Loss Time (Sec.)	1.0			2.0	
Enclosure	IP20				
Frame Size	1			2	

*If the model is marked A, it means that it is built-in the power supply of 24V; if not, then it is built-in the power supply of 12V.

Model	400V Class: Three-phase		
	L510-□□□-H3-N A* L510-□□□-H3F-P A*		
	401	402	403
Horse Power (HP)	1	2	3
Suitable Motor Capacity (KW)	0.75	1.5	2.2
Rated Output Current (A)	2.3	3.8	5.2
Rated Capacity (KVA)	1.7	2.9	4.0
Input Voltage Range(V)	Three-phase 380~480V,50/60HZ		
Allowable Voltage Fluctuation	-15%~+10%		
Output Voltage Range(V)	Three-phase 0~480V		
Input Current (A)	4.2	5.6	7.3
Allowable Momentary Power Loss Time (Sec.)	2.0	2.0	2.0
Enclosure	IP20		
Frame Size	2		

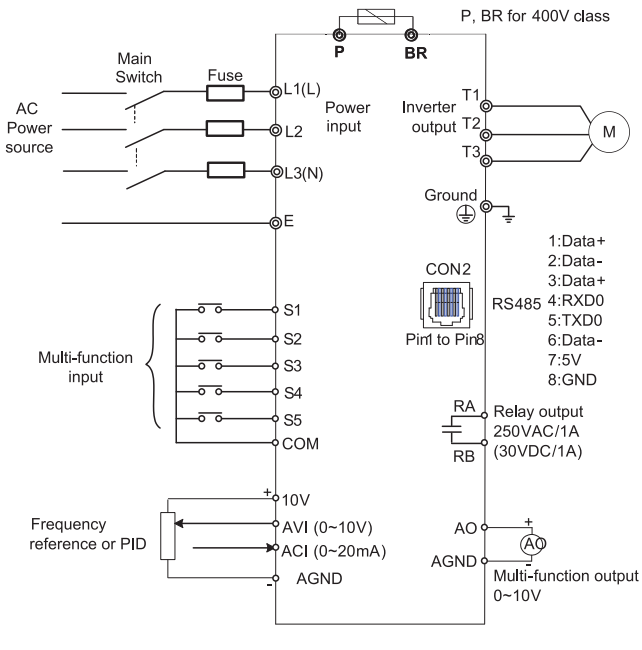
*Models of 400V machines are all marked A, built-in the power supply of 24V.

MODEL IDENTIFICATION

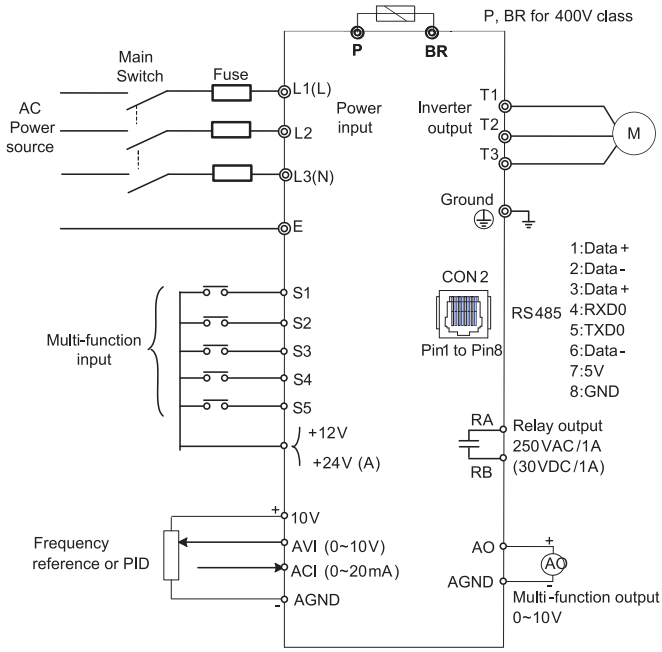


WIRING DIAGRAM

▪ NPN Input



▪ PNP Input



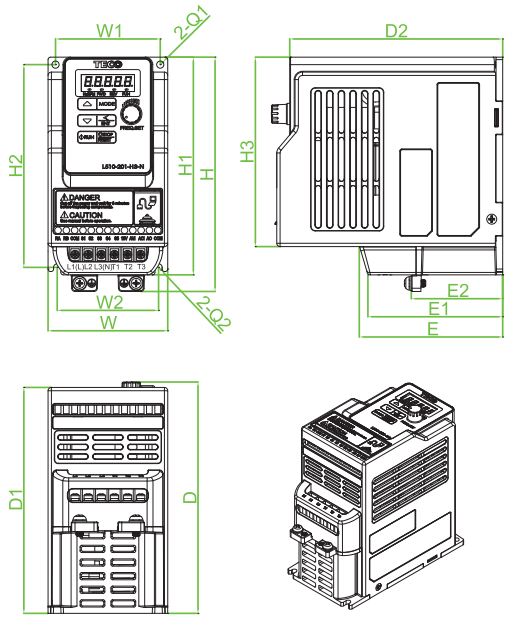
Wiring (AC Input)	Model	Power Input Terminal
NPN	100V / 200V (Single-Phase)	L1 (L) ; L3 (N)
	200V (Three-Phase)	L1(L) ; L2 ; L3 (N)
	400V (Three-Phase)	L1 ; L2 ; L3
PNP	200V (Single-Phase)	L1 (L) ; L3 (N)
	400V (Three-Phase)	L1 ; L2 ; L3

GENERAL SPECIFICATIONS

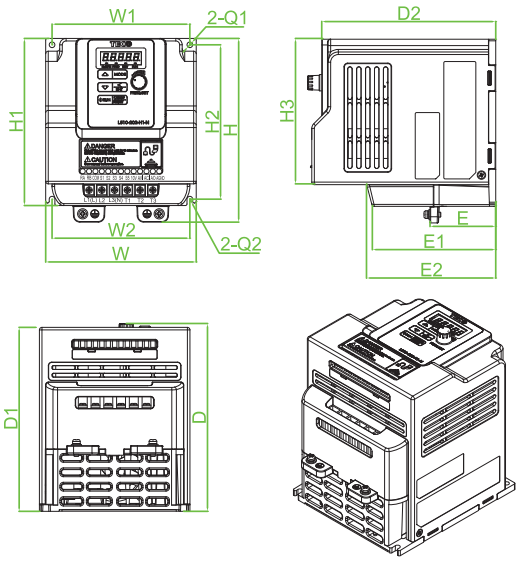
Item		L510
Control Mode		V/F control + Torque compensation function
Frequency	Range	0.01～650.00Hz
	Setting resolution	Digital input : 0.01Hz Analog input : 0.06Hz/60Hz
	Setting	Keypad : Set directly with▲▼ keys or the VR on the keypad External terminal: AVI(0-10V/2-10V),ACI(0-20mA/4-20mA) input Up/down function by multifunction inputs and also by communication method
	Frequency limit	Lower & Upper frequency limits and 3 Skip frequencies
Run	Operation Set	Panel : run, stop button control External terminal : Multi-operation-mode2 / 3 wire selection / Jog operation Communication operation
Main Control functions & Features	V/F Curve Setting	6 fixed curves and one customized curve
	Carrier Frequency	1-16KHz(default 5KHz)
	Acceleration and deceleration control	2 sections of acceleration/ deceleration time setting (0.1~3600.0 Sec.) 4 sections of S curve setting
	Multifunction Input	19 functions
	Multifunction output	14 functions
	Multifunction Analog Output	5 functions
	Other features	Overload detection, 8 preset speeds, auto-run, two Acc/Dec presets, Main/Alt run and frequency selections, PID control, Torque boost, V/F start frequency and fault reset
Display	LED	Display: parameter, parameter value, frequency, line speed, DC voltage, output voltage, output current, PID feedback, input and output terminal status, Heat sink temperature, Program Version, Fault Log
	Status Indicator	HZ/RPM, Forward/Reverse & FUN (function display)
Protective Functions	Overload Protection	Integrated motor overload protection
	Over Voltage	100/200V class: > 410V, 400V class: > 820V
	Under Voltage	100/200V class: < 190V, 400V class: < 380V
	Momentary Power Loss Restart	Restart in a short time once running into momentarily power loss
	Stall Prevention	Stall prevention for Acceleration/ Deceleration and also during Continuous run
	Short-circuit output terminal	Electronic Circuit Protection
	Grounding Fault	Electronic Circuit Protection
	Other protection features	Heat sink over temperature, Auto carrier frequency reduction due to temperature, Fault output, Reverse disable, Direct start on power up disable, Parameter access lock
Communication Control		Built-in RS485 Modbus, One to one or One to many control
Environment	Operating Temperature	-10~40°C(-10~50°C with fan)
	Storage temperature	-20～60°C
	Humidity	95% RH or less (no condensation)
	Shock	1.0G, in compliance with IEC 60068-2-6
	Enclosure	IP20

DIMENSIONS

Frame1



Frame2



Unit: mm (inch)

Frame 1	W	W1	W2	H	H1	H2	H3	D	D1	D2	E	E1	E2	Q1	Q2
L510-1P2-H1 ☐	72 (2.83)	63 (2.48)	61 (2.40)	141 (5.55)	131 (5.16)	122 (4.80)	114 (4.49)	139.2 (5.48)	136 (5.35)	128.2 (5.05)	86.3 (3.40)	81.1 (3.19)	55 (2.17)	4.3 (0.17)	2.2 (0.086)
L510-1P5-H1 ☐															
L510-2P2-H1(F) ☐															
L510-2P5-H1(F) ☐															
L510-201-H1(F) ☐															
L510-2P2-H3 ☐															
L510-2P5-H3 ☐															
L510-201-H3 ☐															

Frame 2	W	W1	W2	H	H1	H2	H3	D	D1	D2	E	E1	E2	Q1	Q2
L510-101-H1 ☐	118 (4.65)	108 (4.25)	108 (4.25)	144 (5.67)	131 (5.16)	121 (4.76)	114 (4.49)	147.3 (5.80)	144.2 (5.68)	136.4 (5.37)	101.3 (3.99)	96.7 (3.81)	51.5 (2.03)	4.3 (0.17)	2.2 (0.086)
L510-202-H1(F) ☐															
L510-203-H1(F) ☐															
L510-202-H3 ☐															
L510-203-H3 ☐															
L510-401-H3(F) A															
L510-402-H3(F) A															
L510-403-H3(F) A															

Note:

1. F：Built-in noise filter.
2. The dimension of NPN and PNP types are the same.

TYPICAL APPLICATIONS

- Fans & Pumps
- Conveyers
- Package Machines
- Textile Machines
- Automatic Door Control
- Feeder Machines
- Winding Machines
- PCB Automation

Package Machines

Conveyers

Automatic door control

PCB Automation

ACCESSORIES

Copy Unit (JN5-CU)

※Duplicating parameters setting in one Inverter to another Inverter.

※As a remote keypad to be used.

※Using RJ45 line to connect inverter.

RJ45 to USB (JN5-CM-USB)

※Using the TECO exclusive PC-software line.

Distributor

TECO

TECO ELECTRIC & MACHINERY CO., LTD.

TECO GO ECO

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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.

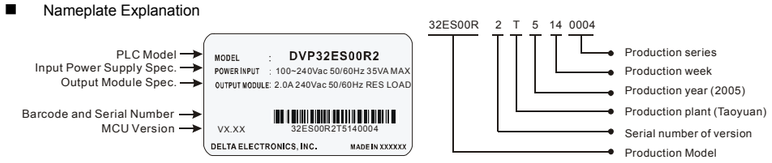
Never connect the AC main circuit power supply to any of the input/output terminals, as it will damage the PLC. Check all the wiring prior to power up. To avoid any electromagnetic noise, make sure the PLC is properly grounded ⏚. Do NOT touch terminals when power on.

2 INTRODUCTION

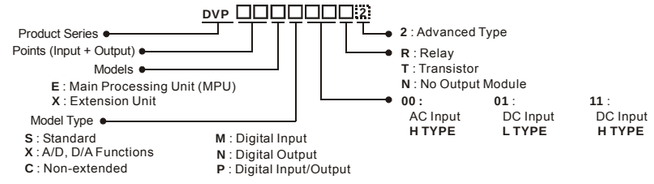
2.1. Model Name Explanation and Peripherals

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



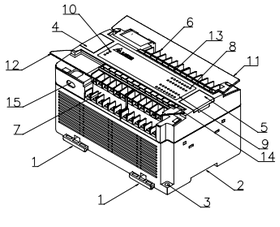
■ Model/Serial Number Explanation



■ 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

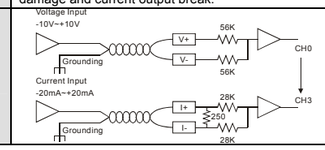
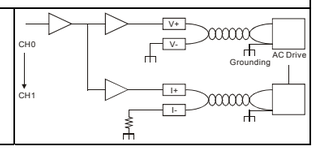
Item \ Model	DVP-14ES00 □	DVP-24ES00 □	DVP-32ES00 □	DVP-40ES00 □	DVP-60ES00 □	DVP-20EX00 □	DVP-14ES01 □	DVP-24ES□□ □	DVP-32ES01 □	DVP-20EX11□
Power Supply Voltage	100~240VAC (-15%~10%), 50/60Hz ± 5%						24VDC (-15%~10%)			
Operation Specification	The PLC start to operate at power supply of 95~100VAC. 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

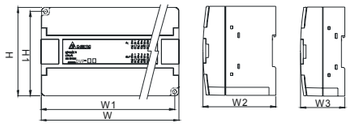
Items	Analog Input (A/D)		Analog Output (D/A)	
	Voltage Input	Current Input	Voltage Output	Current Output
Analog I/O Range	±10V	±20 mA	0 ~ 10V	0 ~ 20 mA
Digital Conversion Range	-512~+511	-512~+511	0 ~ 255	0 ~ 255
Resolution	10 bits(1_{LSB}=19.53125 mV)	10 bits (1_{LSB}=39.0625 μA)	8 bits(1_{LSB}=39.0625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

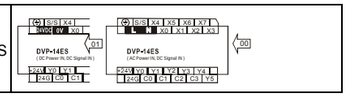
4 INSTALLATION & WIRING

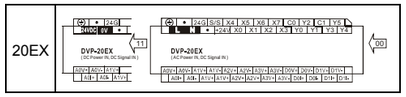
■ Dimensions

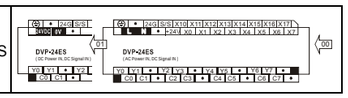
Model Name (mm)	H	H1	W	W1	W2 (H Type)	W3 (L Type)
DVP14ES00(01)[11]R2/T2	100	95	99	104	82	50
DVP24ES00(01)[11]R2/T2	100	95	150	155	82	50
DVP32ES00(01)[11]R2/T2	100	95	150	155	82	50
DVP40ES00R2/T2	100	95	150	155	82	-
DVP60ES00[11]R2/T2	90	85.5	180.5	185	89.6	-
DVP20EX00[11]R2/T2	100	95	150	155	82	-

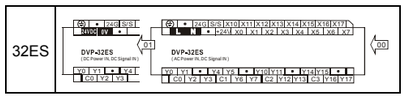


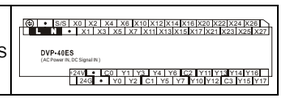
■ Terminal Wiring

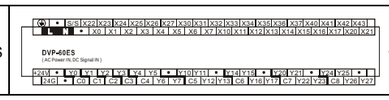
14ES


20EX


24ES


32ES


40ES


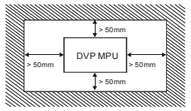
60ES


■ PLC Mounting Arrangements and Installation Notes

■ DIN Rail Installation

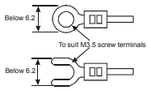
The DVP-PLC can be secured to a cabinet by using the DIN rail that is 35mm high with a depth of 7.5mm. When mounting the PLC on the DIN rail, ensure to use the end bracket to stop any side-to-side motion of the PLC, thus to reduce the chance of the wires being pulled loose. On the bottom of the PLC is 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.

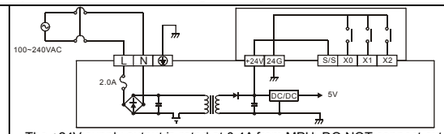
1. Do not mount the PLC in a location subjected to corrosive or flammable gases, liquids, or airborne dust or metallic particles.
2. Do not mount the PLC in a location where temperatures and humidity will exceed specification.
3. Do not mount the PLC in a location where vibration and shock will exceed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

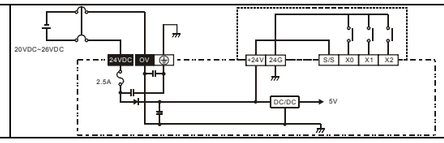
AC Input Type



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.

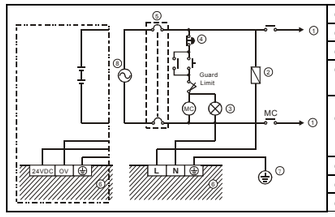
5. When DC voltage is supplied to the PLC, ensure the power is at terminals 24VDC and 0V (power range is 20.4VDC~26.4VDC). When the voltage is lower than 17.5VDC, PLC will stop operating, all outputs will turn OFF and the ERROR LED will flash continuously.

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:

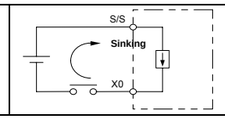
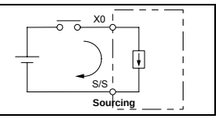


①	Power supply for AC loads
②	Fuse for circuit protection (3A Limit)
③	Power On pilot indicator
④	Emergency stop: PLC must provide a quick manual method to disconnect all system power.
⑤	Circuit isolation device (System Power Disconnect): Utilize the electromagnetic contactor and the relay to be the 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

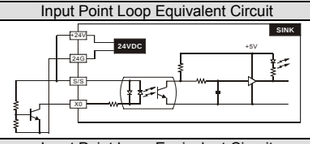
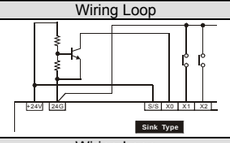
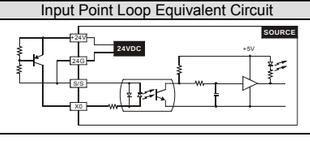
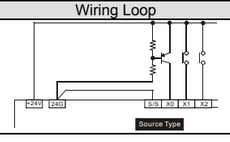
■ Input Point Wiring

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:

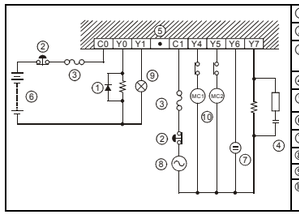
◎ Definition

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

◎ Wiring

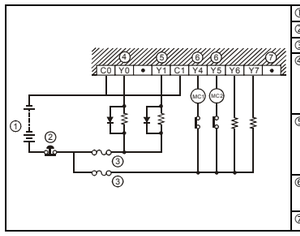
	Input Point Loop Equivalent Circuit	Wiring Loop
DC Type (DC Signal IN) SINK Mode		
DC Type (DC Signal IN) SOURCE Mode		

◎ 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.