Palestine Polytechnic University

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Enhancing the Quality of Stone Industry Through Using State of the Art Technology

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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.

نهدي مشروعنا هذا الى من ارواحهم صعدت الى السماء الى من فارقونا جراء جرائم ومجاور الاحتلال الى من قاومت بالصورة والصوت الى من عرفتها ازقة المخيمات والقرى والبلدات القديمة الى نجمة القدس الى الانسانة الملهمة الشهيدة شيرين أبو عاقلة والى ابطال الانفاق في غزة وفي جلبوع الى الصامدين والمرابطين في بيتا والقدس.

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

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

أنتم وهبتوني الحياة والأمل والنشأة على شغف الاطلاع والمعرفة.

إلى اخوتي وأسرتي جميعا.

إلى من كل من علمني حرفا 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 مرشدا وناصحا واخا مشرفنا الحبيب الدكتور سمير حنا.

Abstract

Stone cutting machine is one of the important machines in the current era, as it shapes stones for use in construction. This machine is found in some stone factories in Palestine, stone factories take the traditional method as a way to produce stones. This method has many drawbacks as it requires a lot of effort and time in the production process. Based on the field visits to the stone factories located in the Beit Fajjar area, and some factories owners demanded to solve some of the problems they face, the most important problem such as cutting inaccuracy due to frequently dimension adjustment and Difficulty in controlling the cutting speed required for stone formation, It can be solved using the latest technology (PLC , HMI) , in order to increase product quality, competitiveness, quantity and reduce human errors from reading to satiety, In this project we apply these techniques to our existing miniature stone scissors model.

الملخص

تعتبر آلة قص الحجارة من الآلات المهمة في العصر الحالي، حيث تقوم بتشكيل الأحجار لاستخدامها في البناء. توجد هذه الآلة في بعض مصانع الحجر في فلسطين، وتتخذ مصانع الحجر الطريقة التقليدية لإنتاج الأحجار. هذه الطريقة لها العديد من السلبيات حيث أنها تتطلب الكثير من الجهد والوقت في عملية الإنتاج.

بناءً على الزيارات الميدانية لمصانع الحجر الواقعة في منطقة بيت فجار، طالب بعض أصحاب المصانع بحل بعض المشاكل التي يواجهونها، فإن أهم المشاكل مثل عدم دقة القطع بسبب كثرة تعديل الأبعاد وصعوبة التحكم في سرعة القطع المطلوبة لتشكيل الحجر. يمكن حلها باستخدام أحدث التقنيات(وحدة التحكم المنطقية , شاشة التحكم)، من أجل زيادة جودة المنتج والقدرة التنافسية والكمية وتقليل الأخطاء البشرية من القراءة إلى الشبع، وفي مشروعنا هذا طبقنا هذه التقنيات على نموذج مقص حجر مصغر موجود لدينا.

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Chapter One: Introduction

1.1 Introduction.

1.2 Problem Formulate.

1.3 Motivation.

1.4 Importance.

1.5 Proposed Budget .

1.6 Timeline.

1.1 Introduction

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 Stone, Stone cubes shaped between 2.5 m^3 or 2 m^3 or near these sizes[1].

1.2 Problems

1. Limited and Reduced production due to slowdown process because of traditional methods.
2. Cutting inaccuracy due to frequently dimension adjustment.
3. Difficulty in controlling the cutting speed required for stone formation.
4. Energy cure reduced.

1.3 Motivation

1. Development of a stone cutting machine towared increase productivity.
2. Developing of a stone cutting machine so to be more safier and simple handed.
3. Energy saving by controlling energy consumption.
4. Introducing interaction screen in form of HMI(Human Machine Interface) at control the cutting speed according to stones type.

1.4 Importance

1. Implement state of the art technology to obtain high productivity rate and quality.
2. Providing the machine with updated troubleshooting and fault detection.
3. Increase of the Human machine communication technology's in simple data entry.
4. Increase product quality.

Task

Table (1. 1): The following ate the project tasks along first & second semester.

# of Task	**Task description**
T1	Project selection
T2	Identify the scope of the project
T3	Collection references from libraries & websites
T4	Select an initial design
T5	Conducting the needed adjustments and calibration on the design
T6	Writing the thesis chapters
T7	Prepare the 1st presentation (Introduction to project)
T8	Editing the thesis based on received committee revision
T9	Purchasing the electronic part
T10	Building project's prototype
T11	Conducted the needed programing and coding
T12	Testing the machine
T13	Calibration of testing prototype,,,
T14	Completing the thesis structure…
T15	Preparing the final presentation

1.5 Budget

Table (1. 2): Estimated cost for the machine ±15%:

#	Name of part	Quantity	Cost($)
1	Motors	5	1000
2	Contactors	10	100
3	Switches	10	80
4	Limit switch	7	100
5	Relay	3	70
6	Overload	5	80
7	VFD	1	300
8	PLC (Delta)	1	300
9	HMI (Human machine interface)	1	150
10	Encoder	2	300
11	Emergency Switch	1	10
	Total		**2490**

1.5 Timeline

Table (1. 3): illustrates the tasks that we did in First semester and how long it takes weekly for each task:

Task /weak	1	2	3	4	5	6	7	8	9	10	11	12	13	14
T1														
T2														
T3														
T4														
T5														
T6														
T7														
T8														

Table (1. 4): illustrates the tasks that we did in Second semester and how long it takes weekly for each task:

Task /weak	1	2	3	4	5	6	7	8	9	10	11	12	13	14
T9														
T10														
T11														
T12														
T13														
T14														
T15														
T16														
T17														

2

Literature Review

2.1 Introduction.

2.2 Stone Production Process.

2.3 Cutting Stone Machine.

2.4 Type of Stone in Palestine.

2.1 Introduction

Quarrying is a traditional industry in Palestine, although large-scale production only began after 1948. In 1965, there were 111 firms, constituting 2.9% of all industrial establishments. The industry was concentrated in the Nablus area where 53.2% of the firms were located, followed by the Jerusalem area (39.6%) and Hebron (7.2%). In 1965, 61 of these firms employed more than 10 workers; 59% were located in the Nablus area, 34.4% in the Jerusalem area and 6.6% in the Hebron area. The value of production of the industry was US $291 thousand in 1965. As with many industries in Palestine, the development of the quarrying and crushing industry was closely related to the Israeli occupation. After 1967, the Israeli authorities imposed a set of restrictive measures and policies that hindered economic development in general and industrial development in particular. of particular relevance to the quarrying and crushing industry were restrictive Israeli licensing policies and the confiscation of land and equipment. Regardless of these restrictive measures, the number of firms grew to 144 by 1989 [2].
According to the Federation of Stone and Marble Industry in Palestine, Figure (2.1) shows the distribution of factories in the country [3].

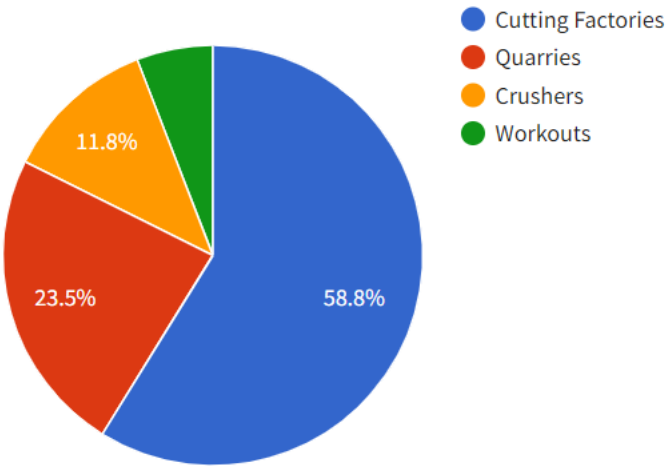

Figure (2.1): Distribution of companies per type

2.2 Stone Production Process

At first, the stone blocks are extracted from the mountains, then the quality of the stone blocks is checked if they are suitable for use or not. Then the cubes are cut into stone slabs. Finally, the stones are subsequently shaped to the appropriate and desired sizes as needed. Figure (2.2) shows the steps for extracting the stone.

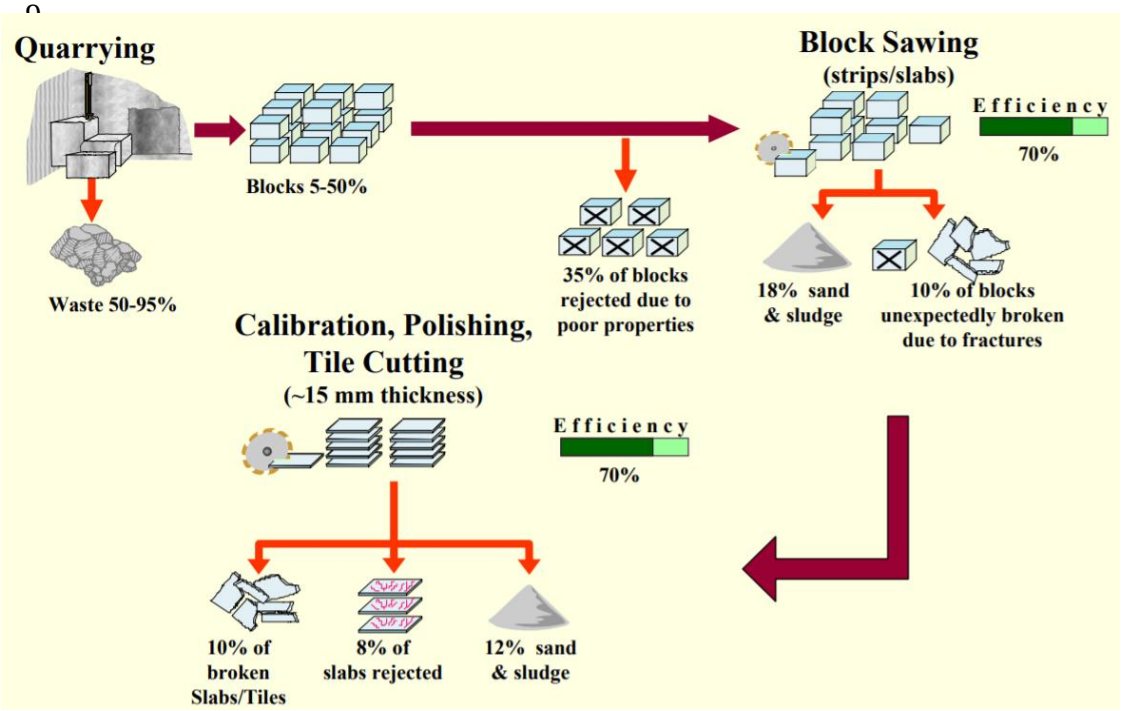

Figure (2.2): Stone production chain

2.3 Cutting Stone Machine

Stone cutting machine as show in Figure(2.3), The stone is placed on the machine table, then the stone cutting process begins with the large disc. After the cutting is completed, the cutting is repeated using the small disc during the reverse.

Figure (2.3): 2-D view of stone cutting machine

2.4 Types of Stone in Palestine

Stone industry in Palestine is considered one of the conventional and historic industries. Researches were in agreement with the fact that Palestine is one of those countries in which raw material for construction stone is available at commercial quantities, and distinguished for its type, quality and multicolor**.**

According to the test of physical requirements, Stones are divided into three main type:

- **Low-Density**
- **Medium-Density**
- **High-Density**

A distinction is made between stone types based on the American Society for Examination and Materials(ASTM) Standards. Table(2.1) shows the percentages adopted for determining the type of stone.

Table (2.1): Physical and mechanical properties of natural stone.

Physical Property	Low-density	Medium-density	High-density
Absorption by weight, max,%	**12**	**7.5**	**3**
Density, min[kg\m^3]	**110**	**135**	**160**
Compressiv strength, min[MPa]	**1800**	**4000**	**8000**

1. Low-Density.

Stone of Palestine is featuring by its high quality and excellent properties. There are no stones in Palestine that are low in density.

2. Medium-Density.

Shyoukh stone is one of the most Medium hardness stones in Palestine, Shyoukh stone is one the Palestinian limestones with white color. Some layers of Shyoukh stone is with red veins, others with yellow veins and other colors are with cream background. Shyoukh quarries are located in Shyoukh area in east direction of Hebron governorate and it is one of the famous quarries in Palestine. These quarries contain more than ten layers which can be used mainly for outside cladding with different finishes**.**

According to the experiments conducted by the Stone Center at Palestine Polytechnic University, Table(2.2) show the technical specifications of this type.

Table (2.2): Technical Specifications of Shyoukh stone.

Test	Standards	Results
Water Absorption(%)	**ASTM C 97 + EN 13755 + EN 1936**	**4.7**
Specific Gravity	**ASTM C 97 + EN 13755 + EN 1936**	**5.567**
Compressive Strength, (MPa) Dry , Perpendicular to Rift	**ASTM C 170 + EN 1926**	**140.3**

3. High-Density.

Alkherbah stone is one of the most hardness stones in Palestine, Alkherbah Stone is one of the Palestinian limestones with white cream color. Alkherbah quarries are located in Qabatia area in Jenin governorate. Alkherbah stone is with white – cream color and could be used for external and internal uses.

According to the experiments conducted by the Stone Center at Palestine Polytechnic University, Table (2.3) show the technical specifications of this type.

Table (2.3): Technical Specifications of Alkherbah stone.

Test	Standards	Results
Water Absorption(%)	**ASTM C 97 + EN 13755 + EN 1936**	**1.54**
Specific Gravity	**ASTM C 97 + EN 13755 + EN 1936**	**2.562**
Compressive Strength, (MPa) Dry , Perpendicular to Rift	**ASTM C 170 + EN 1926**	**80.9**

3

Brief Review on Machine Component

3.1 Machine Component.

3.2 Protection Devices.

3.1 Machine Components

1. Programming Logic Control (PLC).

Programmable logic controllers (PLC) are essential control equipment in the modern industrial control system. Although they are quite practical equipment, they can be changed through their driver which is why they are called Programmable Logic Controllers. There are 24 Inputs and 8 Output. Figure (3.1) below shows one of the types of PLC:

12

20

Figure (3.1): Front view of used PLC

2. HMI

It is very important to clarify control procedures to indicate the sequence of operations in the machine, and therefore this helps the worker or technician who deals with this machine to understand its work comfortably and this also helps engineers when performing maintenance operations, figure (3.2) show the HMI:

Figure (3.2): HMI

3. Relay

A Relay as shown in figure (3.4), is an electromechanical device that can be used to make or break an electrical connection. It consists of a flexible moving mechanical part which can be controlled electronically through an electromagnet, basically, a relay is just like a mechanical switch but you can control it with an electronic signal instead of manually turning it on or off. Again, this working principle of relay fits only for the electromechanical relay.

Figure (3.3): General View of Used Relay.

4. Variable Frequency Drive (VFD)

A VFD is a type of motor controller that drives an electric motor by varying the frequency and voltage supplied to the electric motor. Other names for a VFD are variable speed drive, adjustable speed drive, adjustable frequency drive, AC drive, micro-drive, and inverter.

Frequency (or hertz) is directly related to the motor's speed (RPMs). In other words, the faster the frequency, the faster the RPMs go. If an application does not require an electric motor to run at full speed, the VFD can be used to ramp down the frequency and voltage to meet the requirements of the electric motor's load. As the application's motor speed requirements change, the VFD can simply turn up or down the motor speed to meet the speed requirement.

By adjusting the frequency and voltage of the power entering the motor, the speed and the torque may be controlled. The actual speed of the motor, as previously indicated, is determined as Ns = ((120 x f) / P) x (1 - S) where: N = Motor speed; f = Frequency (Hz); P = Number of Poles; and S = Slip.

5. Electrical Switches.

They are electromechanical devices used in electrical circuits to control power, detect when the systems are outside their operating ranges, and signal control devices for the locations of machine members and work pieces, and provide a means for manual control and automatic control of the functions of electrical machinery and equipment, as shown in Figure (3.4).

Figure (3.4): Electrical Switches

6. Emergency Switch

Emergency Stop Button, as shown in Figure (3.5), provides safety for humans and the machine; it offers a wide range of safety components for the protection of humans, machine and production goods in emergency situations. It is the purpose of emergency-stop device to deflect or minimize the risk as quickly as possible and optimally in the event of an emergency arising.

Figure (3.5): Emergency Switch

7. Contactor

A contactor is an electrically-controlled switch used for switching an electrical power circuit. A contactor 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. The contactor view as shown in figure (3.6).

Figure (3.6): Contactor

3.2 Protection Devices

1. Circuit breaker(CB)

A circuit breaker is a switching device that interrupts the abnormal or fault current. It is a mechanical device that disturbs the flow of high magnitude (fault) current and in additions performs the function of a switch. The circuit breaker is mainly designed for closing or opening of an electrical circuit, thus protects the electrical system from damage, as shown in Figure (3.7)[5].

$$(CB) = \text{Next Standard}(1.25 \times In) \quad \textbf{3.1}$$

Figure (3.7): Circuit breaker

2. Overload (OL)

To protection the motor we used overload switches and it defined as overload relays are intended to protect motors against excessive heating due to long time motor over currents up to and including locked motor currents. Protection of the motor due to short circuits or grounds is a function of circuit breakers, or motor short-circuit protectors, as shown in Figure (3.8)[6].

Figure (3. 8): Overload

4

Electrical Design

4.1 Function Block Diagram.

4.2 The Final View of the Design.

4.3 Flow chart.

4.4 Power Circuit.

4.5 Control Circuit.

4.6 PLC Input-Output.

4.1 Functional Block Diagram

We will describe the project in terms of the product processing block diagram, figure (4.1) shows the production process:

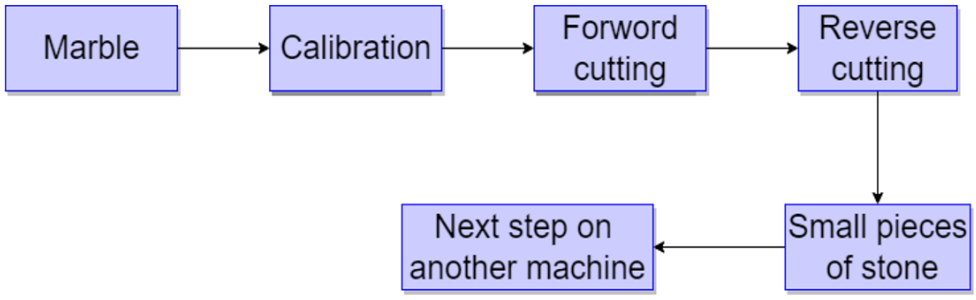

Figure (4.1): production process

Marble:

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

Calibration:

At this point we determine the starting point of the block, and take the lowest point to cut Marble on it to get the square shape during the process, and calibrate the required measurements.

Forward cutting:

We use motors designed to move the part containing the large disk to do this task you talk about vertical cutting with a finite span according to the process ends when it reaches the end point.

Reverse cutting:

After completing the cutting process, the reverse cutting process begins with a small disk starting from the point where the previous process ended.

Small pieces of stone:

After completing the cutting process, we get small pieces of stones that have the same required sizes.

Next step on another machine:

The formed stones are transferred to the next machine.

4.2 The Final View of the Machine

Figure(4.2) shows the final view of the prototype for the machine, and the mechanical components'.

Figure (4.2):final view of the machine

1. **Motor (1)**

The function of this motor is Vertical cutting while holding the saw that runs against the marble to cut it vertically and then comes back For the next process, start from the left front of the marble to the right.

In our prototype project, we will be using a 1 HP motor with a rated current of 1.77 A, powered by a 1HP inverter. And the free-start motor only needs to be stopped in an emergency and stopped manually.

2. **Motor (2)**

The function of this motor is the horizontal cutting. This motor carries the saw that runs on the marble to cut it horizontally and then back again for the next process, starting from the left front of the marble to the correct.

In our project for prototype we will use a motor of 0.25HP and the rated current is0.8A. it is also free start motor No need to stop only in emergency and stop manually.

3. **Motor (3)**

The function of the motor here is to move the "head" left and right and this head has the big disk and the small disk as shown in Figure (4.3), that's 0.25 hp 0.8 A. and it works when you need it.

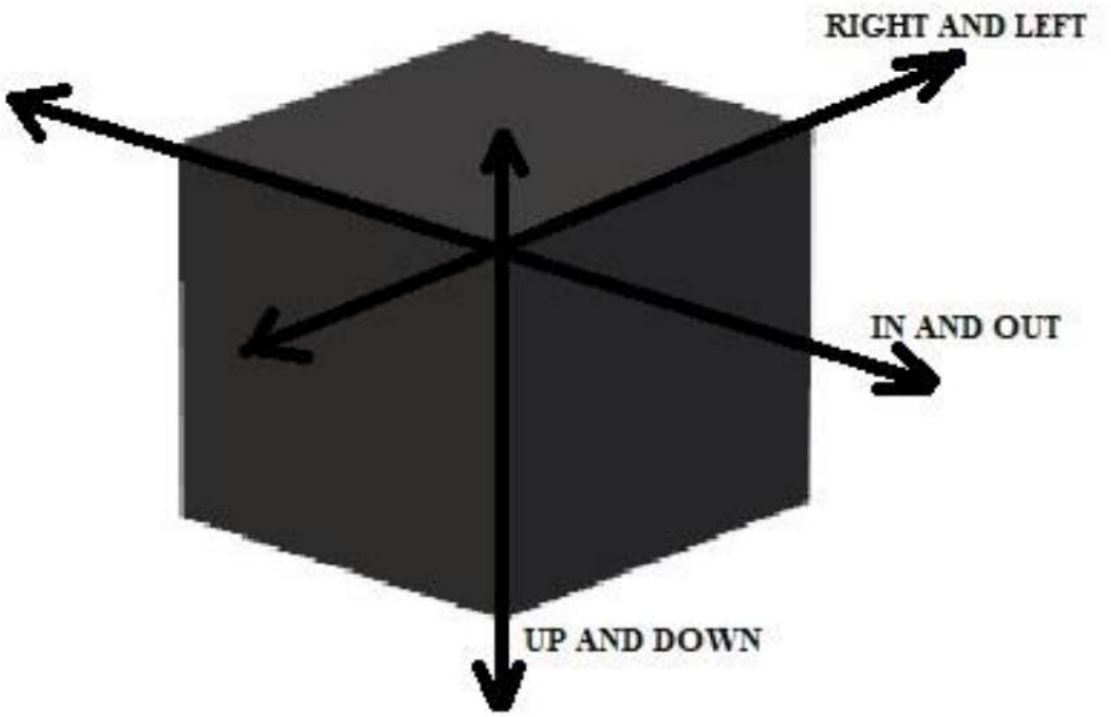

Figure (4.3): direction of working the motors

4. **Motor (4)**

The function of the motor here is to move the "head" up and down and this head has the big disk and the small disk as shown in Form (4.3), that's 0.25 HP 0.8 A, and it works when you need it.

5. **Motor (5)**

This motor takes the "table" in and out as shown in Figure (4.3), and this motor

With 0.25Hp and 0.8A current. This engine is powered by a 0.5HP inverter. and this motor only works when we need it.

Table (4.1) The following table shows the required values of Overload, Circuit breaker and Contactor for the system:

	Power (HP)	**Rated current (A)**	**Overload (A)**	**Circuit breaker (A)**	**Contactor (A)**
Motor1	**1**	**1.77**	**1.947**	**6**	**_**
Motor2	**0.25**	**0.8**	**0.88**	**6**	**9**
Motor3	**0.25**	**0.8**	**0.88**	**6**	**9**
Motor4	**0.25**	**0.8**	**0.88**	**6**	**9**
Motor5	**0.25**	**0.8**	**0.88**	**6**	**_**

The equations:

Overload(A) = 1.1 * Rated current(form name plate) **(4.1)**

Circuit breaker(A) = 1.25 * Rated current **(4.2)**

Contactor(A) = 1.5 * Rated current **(4.3)**

The Rated current form name plate

4.3 Flow Chart

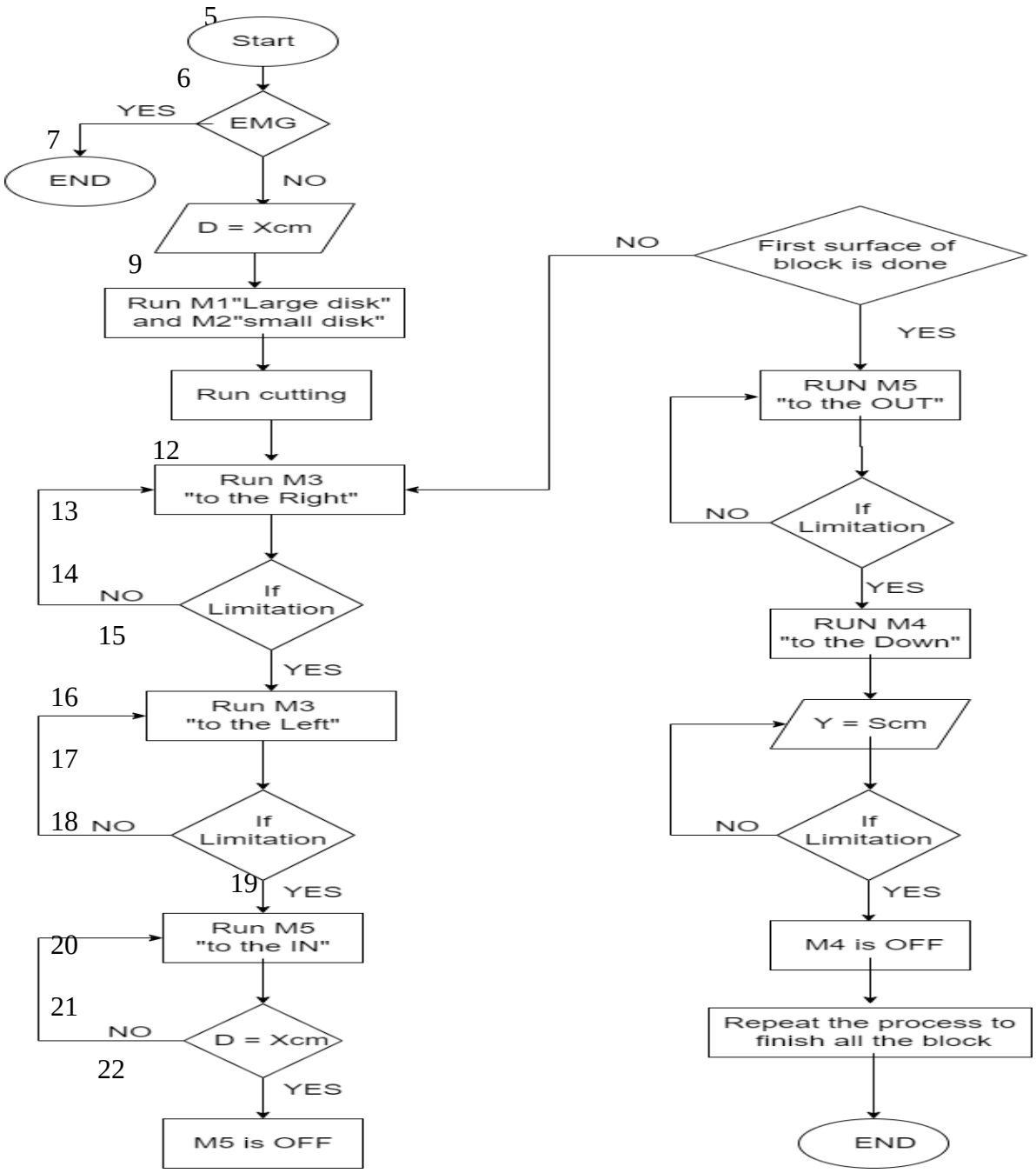

Figure (4.4): Flow chart of machine

4.4 Power Circuit

The power circuit as shown in Figure (4.5) , where two VFDs were used to control the speed of the motor responsible for the vertical cutting and to control the speed of the motor responsible for the Table.

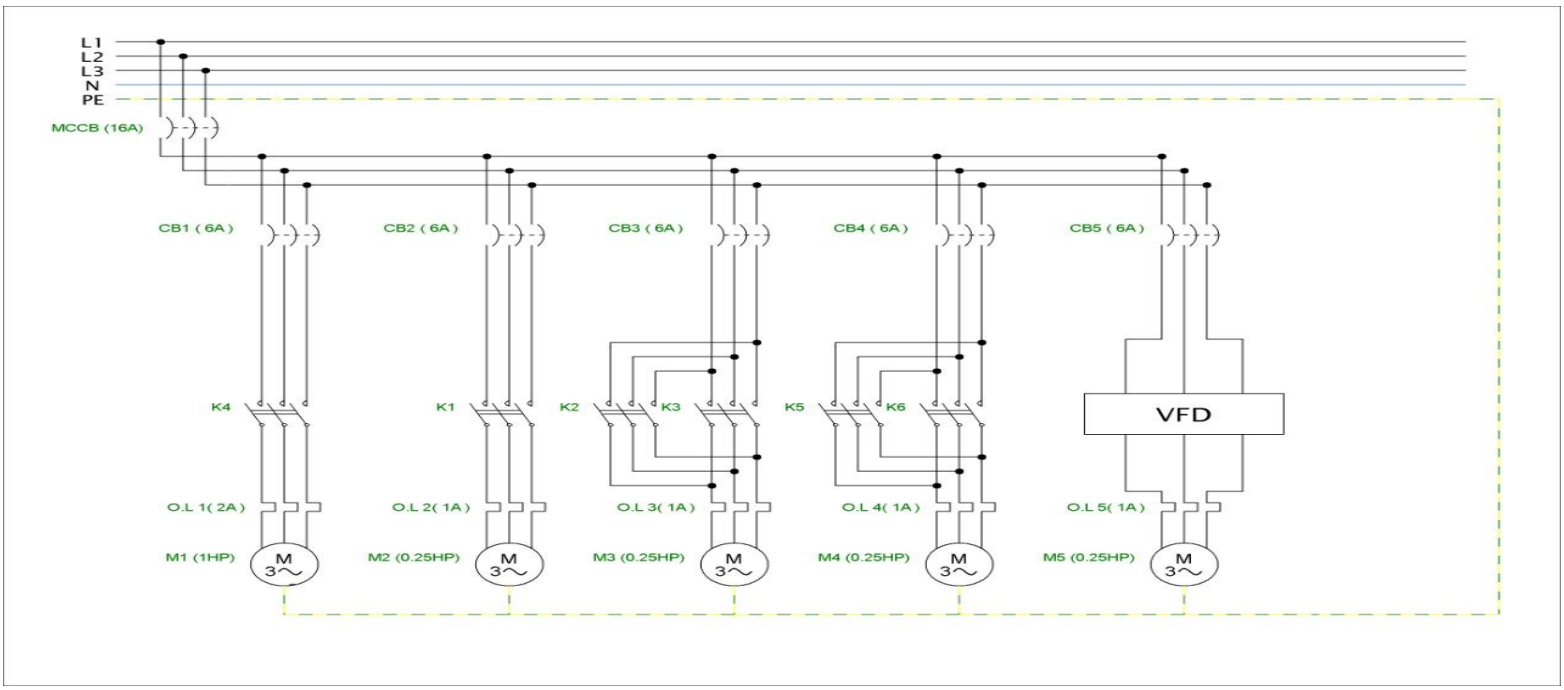

Figure (4.5): power circuit of machine

4.4 Control circuit

The control circuit as shown in Figure (4.6) , where two encoder were used to control dimensional value.

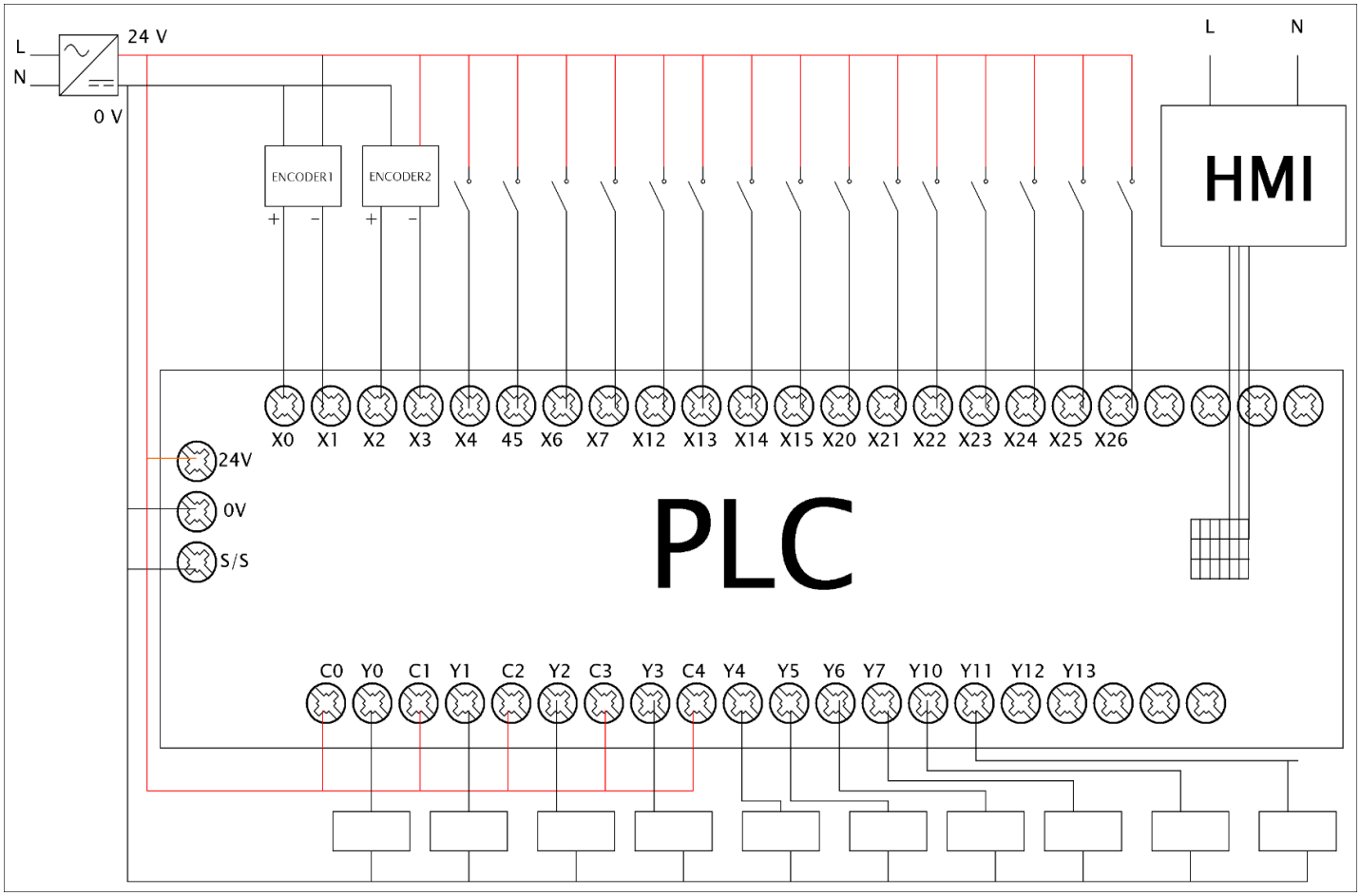

Figure (4.6): control circuit of machine

4.6 PLC Input-Output

Table (4.2): PLC Input-Output:

Input	Comment	Output	Comment
X0	**Encoder 1 (+)**	**Y0**	**Motor is vertical cutting**
X1	**Encoder 1 (-)**	**Y1**	**Motor is the horizontal cutting**
X2	**Encoder 2 (+)**	**Y2**	**Motor in of the machine**
X3	**Encoder 2 (-)**	**Y3**	**Motor out f the machine**
X5	**Down the machine**	**Y4**	**Motor of up the machine**
X26	**Up the machine**	**Y5**	**Motor of Down the machine**
X12	**Reverse the machine**	**Y11**	**Motor of In the Table**
X4	**Forward the machine**	**Y12**	**Motor of Out the Table**
X15	**In the machine**		
X21	**Out the machine**		
X13	**Stop the machine**		
X7	**Automatic**		
X23	**In the Table**		
X22	**Out the Table**		
X14	**Limit switch forward of the machine**		
X6	**Limit switch reverse of the machine**		
X20	**Limit switch In of the machine**		
X13	**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 in of the Table**		

4.7 Results

Taking into account the implemented design m the following results are achieved :

- The designed protype is completely operation with all functions in term of :
  1- Added variable speed operation for various stones types.
  2- Added HMI for simple and dynamic interference such as varying the dimensions, speed, process observation and emergency interference.
  3- Added new monitoring system for motors overloading aiming at preventing the system for eventual failure.
  4- 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.

4.8 Conclusion

1- The mentioned project aims and objected are realized in form of complete machine protype realized.
2- The data of the most existed three types of Stones in Palestine are added to the machine's database for fast and accurate selection such with respect to their density.
3- In order to protect the machine from eventual damage (cutting disk) the motor speed is regulated based the stone harness.
4- As Industrial student's the main program components were implemented in this project (PLC, SCADA, Machine's Control, programing and operational safety).

4.9 Recommendations

For further development and enhancement the machine's operation the project team proposes adding external documentation unit for data archiving and reporting.

Reference

[1]https://psmc.ppu.edu/sites/default/files/Techniques%20for%20the%20Stone%20Waste%20managements.pdf?fbclid=IwAR3PI6W7NDevTV5VPXBZ1fo_

[2] https://library.palestineeconomy.ps/public/files/server/20142511163038-1.pdf

[3]https://www.usmpal.ps/industry.php?lng=1&fbclid=IwAR0TEDziosSgfm8adgJSuetNMu4OxqBdrT78SBFRAGMGITwDyXx9aqKOFHE.

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[5] What is Circuit Breaker? Working Principle & Types of Circuit Breakers - Circuit Globe

[6]] Overload Relay | What is Overload Protection? - c3controls

Appendix A

Table of abbreviations:

abbreviation	Text
HMI	Human Machine Interface
PLC	Programming Logic Control
VFD	Variable Frequency Drive
CB	Circuit Breaker
OL	Over Load
A	Ampere
HP	Hours Power

Appendix B

Standard PLC DVP-ES3 / ES2 / EX2 Series and Extension Modules

The Most Profitable Solution for Sequential Control

reddot design award winner 2010

DVP-ES3 / ES2

Model Name	Specifications
DVP16ES200R	
DVP16ES200T	
DVP20ES200RE	E
DVP20ES200TE	E
DVP24ES200R	
DVP24ES200T	
DVP32ES200R	
DVP32ES200T	
DVP32ES211T	
DVP32ES200RC	C
DVP32ES200TC	C
DVP32ES200RE	E
DVP32ES200TE	E
DVP32ES311T New	C E
DVP40ES200R	
DVP40ES200T	
DVP40ES200RE	E
DVP40ES200TE	E
DVP60ES200R	
DVP60ES200T	
DVP60ES200RE	E
DVP60ES200TE	E
DVP80ES200R	
DVP80ES200T	

AC power supply · DC power supply · Inputs · Outputs · Transistor output · Relay output · Ethernet · CANopen

DVP-EX2

Model Name	Specifications
DVP20EX200R	4AI/2AO
DVP20EX200T	4AI/2AO
DVP30EX200R	3AI/1AO
DVP30EX200T	3AI/1AO

AC power supply · DC power supply · Inputs · Outputs · Transistor output · Relay output

Digital I/O Modules

- **Input Point Extension**
  DVP08XM211N
  DVP16XM211N
- **Output Point Extension**
  DVP08XN211R/T
  DVP16XN211R/T
  DVP24XN200R/T
- **Input/Output Point Extension**
  DVP08XP211R/T
  DVP16XP211R/T
  DVP24XP200R/T
  DVP32XP200R/T

Analog I/O Modules

- **Input Point Extension**
  DVP04AD-E2
- **Output Point Extension**
  DVP04DA-E2
  DVP02DA-E2
- **Input/Output Point Extension**
  DVP06XA-E2

Temperature Measurement Modules

DVP04PT-E2 DVP06PT-E2 DVP04TC-E2

Resolver Modules

DVP10RC-E2*1

DVP-ES2 Series Extension Cable Modules

DVPAEXT01-E2

*1. Contact your sales representative for the official launch date of the DVP10RC-E2 module.

DELTA

Specifications

Electrical Specifications

	AC	DC
Power Supply Voltage	100~240 V_{AC} (-15%~10%), 50/60Hz ±5%	24 V_{DC} (-15%~20%)
Fuse Capacity	2A/250 V_{AC}	ES: 2A/250 V_{AC}; SV: 2.5A/30 V_{DC}
Spike Voltage Durability	1500 V_{AC} (Primary-secondary); 1500 V_{AC} (Primary-PE); 500 V_{AC} (Secondary-PE)	
Insulation Impedance	> 5 MΩ (all I/O point-to-ground: 500 V_{DC})	
Noise Immunity	ESD: 8 kV Air Discharge EFT: Power Line, 2 kV Digital I/O: 1 kV Analog & Communication I/O: 1 kV RS: 26 MHz~1 GHz, 10 V/m	
Earth	The diameter of grounding wire shall not be shorter than that of the power supply cable. (When many PLCs are in use at the same time, please make sure every PLC is properly grounded.)	
Storage/Operation	Storage: -25 °C~70 °C (temperature); 5%~95% (humidity) Operation: 0 °C~55 °C (temperature); 5%~95% (humidity); pollution degree 2	

Input Specifications*1

Max. Input Frequency		10 kHz	20 kHz	100 kHz	200 kHz
Input Signal Type		NPN (Sink)/PNP (Source)			
Input Signal Voltage		24 V_{DC} ±10% (5 mA)			
Response time*2	**DVP-EH3/SV2/PM**	OFF→ON: 20 µs ON→OFF: 50 µs	ES/EX/SX/SS2/SX2 OFF→ON: 3.5 µs ON→OFF: 20 µs	ES2/EX2/SA2/SX2 OFF ON: 2.5 µs ON→OFF: 5 µs	ES3/EH3/SV2/PM OFF→ON: 0.15 µs ON→OFF: 3 µs
	DVP-ES3/ES2/EX2				
	DVP-ES/EX				
	DVP-SX				
	DVP-SS2				
	DVP-SA2/SX2/SE				

*1. For more detailed specifications, see the "Specification" section in the instruction sheet of each model.

*2. When the input point on PLC conducts only general input functions, use D1020 or D1021 to adjust the response time (default: 10ms).

Output Specifications*1

		Relay-R	Transistor-T		
			General-speed	High-speed	
Max. Exchange (working) Frequency		1Hz*2	10 kHz	100 kHz	200 kHz
Current spec.	**DVP-EH3/SV2/PM**	2A/1 Point	0.3A/point @40 °C	SA2/SX2/ES2/EX2/SE Resistive: 0.5A/point (4A/COM) Conductive: 12 W (24 V_{DC}) Light bulb: 2 W (24 V_{DC})	ES3/EH3/SV2/PM Resistive: 0.5A/point (4A/COM) Conductive: 12 W (24 V_{DC}) Light bulb: 2 W (24 V_{DC})
	DVP-ES3/ES2/EX2				
	DVP-ES/EX				
	DVP-SX	1.5A/1 Point			
	DVP-SS2/SA2/SX2/SE				
Voltage Spec.		250 V_{AC}/30 V_{DC}	30 V_{DC}		
Response Time		10 ms	OFF→ON: 20 µs ON→OFF: 30 µs	OFF→ON: 2 µs ON→OFF: 3 µs	OFF→ON: 0.5 µs ON→OFF: 2.5 µs

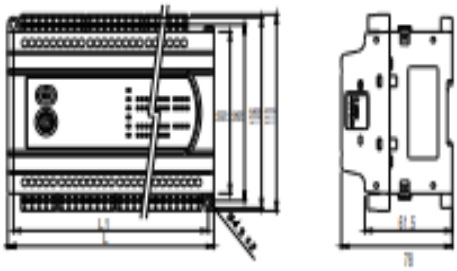
*1. For more detailed specifications, see the "Specification" section in the instruction sheet of each model.

*2. Relay life: Resistive load more than 200,000 times; conductive load more than 80,000 times.

Dimensions (unit: mm)

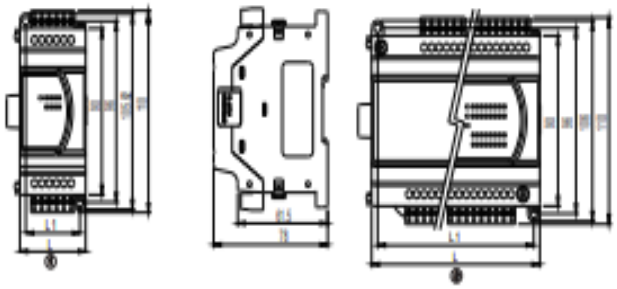
DVP-ES3/ES2/EX2 Series

Model Name (mm)	L	L1
DVP16ES200R/T	105	97
DVP20ES200RE	125	117
DVP20ES200TE	125	117
DVP24ES200R/T	125	117
DVP32ES200R/T	145	137
DVP32ES200RC	145	137
DVP32ES200TC	145	137
DVP32ES200RE	165	157
DVP32ES200TE	165	157
DVP32ES211T	145	137
DVP40ES200R/T	165	157
DVP40ES200RE	194	186
DVP40ES200TE	194	186
DVP60ES200R/T	225	217
DVP60ES200RE	255	247
DVP60ES200TE	255	247
DVP80ES200R/T	302	294
DVP20EX200R/T	145	137
DVP30EX200R/T	165	157
DVP32ES311T New	165	157



DVP-ES3/ES2/EX2 Series

Model Name (mm)	L	L1	Type
DVP08XM211N	45	37	①
DVP08XP211R/T	45	37	①
DVP08XN211R/T	45	37	①
DVP16XM211N	70	62	②
DVP16XP211R/T	70	62	②
DVP16XN211R/T	70	62	②
DVP24XP200R/T	145	137	②
DVP24XN200R/T	145	137	②
DVP32XP200R/T	145	137	②
DVP04AD-E2	70	62	②
DVP02DA-E2	70	62	②
DVP04DA-E2	70	62	②
DVP06XA-E2	70	62	②
DVP04PT-E2	70	62	②
DVP06PT-E2 New	70	62	②
DVP04TC-E2	70	62	②
DVP10RC-E2	70	62	②

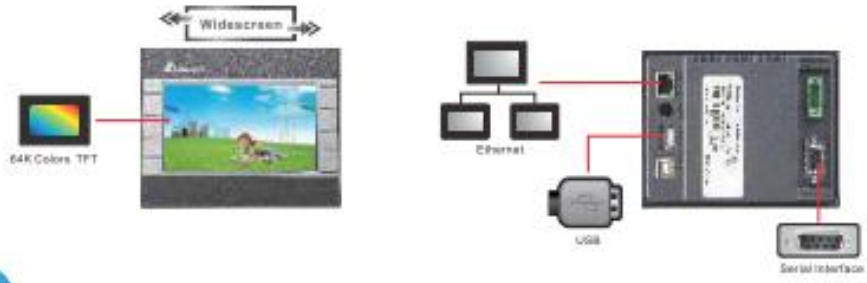


Appendix C

Specifications

B03 High Resolution Widescreen

Model Name	Display Size	Display Type	Resolution	ROM	Ethernet	USB Host	USB Client	Memory Card	Audio Output
DOP-B03S211	4.3-inch	65536 Colors TFT	480x272	128MB	N/A	v1.1 * 1	V2.0 * 1	N/A	N/A
DOP-B03E211	4.3-inch	65536 Colors TFT	480x272	128MB	10/100 Base-T	v1.1 * 1	V2.0 * 1	N/A	N/A

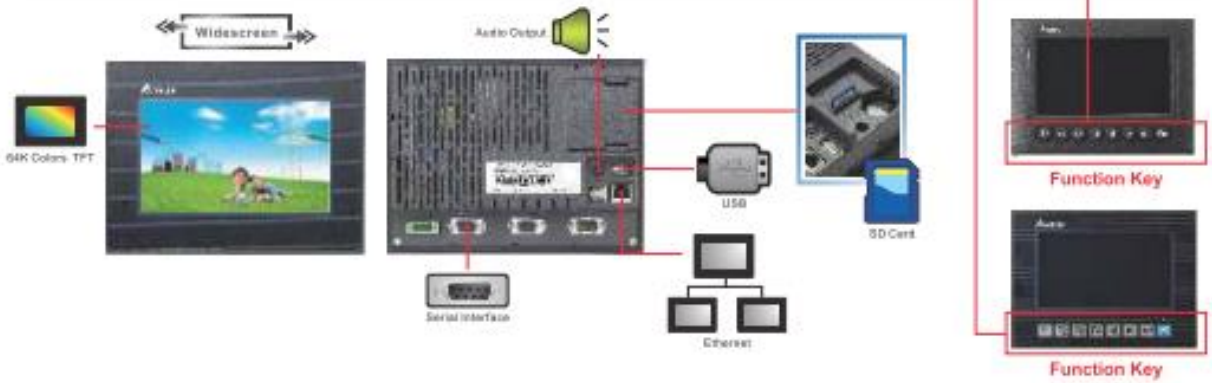


B05 Standard

Model Name	Display Size	Display Type	Resolution	ROM	Ethernet	USB Host	USB Client	Memory Card	Audio Output
DOP-B05S111	5.6-inch	65536 Colors TFT	320x234	128 MB	N/A	v1.1 * 1	v2.0 * 1	N/A	N/A

B07 High Resolution Widescreen

Model Name	Display Size	Display Type	Resolu-tion	ROM	Ethernet	USB Host	USB Client	Memory Card	Audio Output	Function Key	Delta Professional Integration Function
DOP-B07S411	7-inch	65536 Colors TFT	800x480	128MB	N/A	v1.1 * 1	V2.0 * 1	N/A	N/A	N/A	N/A
DOP-B07S401K	7-inch	65536 Colors TFT	800x480	128MB	N/A	v1.1 * 1	V2.0 * 1	N/A	N/A	8	N/A
DOP-B07S411K	7-inch	65536 Colors TFT	800x480	128MB	N/A	v1.1 * 1	V2.0 * 1	N/A	N/A	8	N/A
DOP-B07S415	7-inch	65536 Colors TFT	800x480	128MB	N/A	v1.1 * 1	V2.0 * 1	SD	N/A	N/A	N/A
DOP-B07E415	7-inch	65536 Colors TFT	800x480	128MB	10/100 Base-T	v1.1 * 1	V2.0 * 1	SD	YES	N/A	N/A
DOP-B07PS415	7-inch	65536 Colors TFT	800x480	128MB	N/A	v1.1 * 1	V2.0 * 1	SD	N/A	N/A	YES

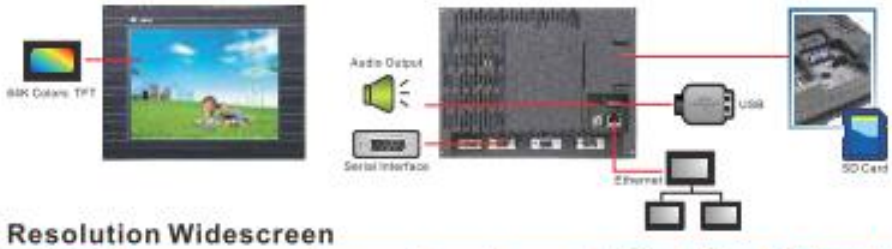


B07 High Resolution

Model Name	Display Size	Display Type	Resolution	ROM	Ethernet	USB Host	USB Client	Memory Card	Audio Output	Delta Professional Integration Function
DOP-B07S515	7-inch	65536 Colors TFT	800x600	128MB	N/A	v1.1 * 1	V2.0 * 1	SD	N/A	N/A
DOP-B07E515	7-inch	65536 Colors TFT	800x600	128MB	10/100 Base-T	v1.1 * 1	V2.0 * 1	SD	YES	N/A
DOP-B07PS515	7-inch	65536 Colors TFT	800x600	128MB	N/A	v1.1 * 1	V2.0 * 1	SD	N/A	YES

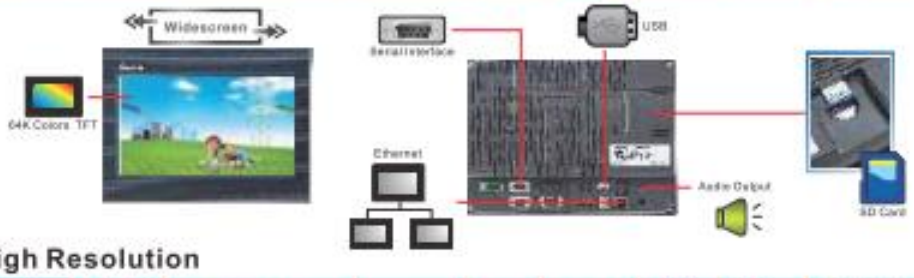
B08 High Resolution

Model Name	Display Size	Display Type	Resolution	ROM	Ethernet	USB Host	USB Client	Memory Card	Audio Output
DOP-B08S515	8-inch	65536 Colors TFT	800x600	128MB	N/A	v1.1 * 1	V2.0 * 1	SD	N/A
DOP-B08E515	8-inch	65536 Colors TFT	800x600	128MB	10/100 Base-T	v1.1 * 1	V2.0 * 1	SD	YES



B10 High Resolution Widescreen

Model Name	Display Size	Display Type	Resolution	ROM	Ethernet	USB Host	USB Client	Memory Card	Audio Output
DOP-B10S411	10.1-inch	65536 Colors TFT	800x480	128MB	N/A	v1.1 * 1	V2.0 * 1	N/A	N/A
DOP-B10S615	10.1-inch	65536 Colors TFT	1024x600	128MB	N/A	v1.1 * 1	V2.0 * 1	SD	N/A
DOP-B10E615	10.1-inch	65536 Colors TFT	1024x600	128MB	10/100 Base-T	v1.1 * 1	V2.0 * 1	SD	YES



B10 High Resolution

Model Name	Display Size	Display Type	Resolution	ROM	Ethernet	USB Host	USB Client	Memory Card	Audio Output
DOP-B10S511	10.4-inch	65536 Colors TFT	800x600	128MB	N/A	v1.1 * 1	V2.0 * 1	N/A	N/A
DOP-B10E515	10.4-inch	65536 Colors TFT	800x600	128MB	10/100 Base-T	v1.1 * 1	V2.0 * 1	SD	YES

Appendix D

Datasheet VFD-EL

Type number key

VFD 007 EL 43 A

- A: Version number — A=standard
- 43: Input voltage — 21=230VAC 1ϕ 23=230VAC 3ϕ 43=400VAC
- EL: VFD-EL: series
- 007: Power — 007=0.75kW 022=2.2kW etc
- VFD: Delta Variable Frequency Drive

230V single phase 0.2 ~ 2.2kW

Type number VFD		002EL21A	004EL21A	007EL21A	015EL21A	022EL21A
Rated power	kW	0.2	0.4	0.75	1.5	2.2
Rated output current	A RMS	1.6	2.5	4.2	7.5	11
Current limit	%	150% 60s				
Rated output capacity	kVA	0.6	1	1.6	2.9	4.2
Rated input current	A RMS	4.9	6.5	9.7	15.7	24
Mains fuse (for UL: Bussmann)		JJN-10	JJN-15	JJN-20	JJN-30	JJN-50
Dimensions HxWxD	mm	174x72x136			174x100x136	
Size ****		A			B	
Weight	kg	1.1			1.9	
Section of power cables	mm^2	0.8 ~ 3			0.8 ~ 8	
Cooling		Convection		Fan		
Carrier frequency	kHz	2 ~ 12				
EMC-Filter		Built-in				
DC-Choke		No				
DC-Bus connection		Yes				
Brake chopper		No				
Recommended brake resistor	Ω/W	250/200 **		150/200 **	85/300 **	50/600 ***
Minimum brake resistor value	Ω	200 **	100 **	80 **	80 **	25 ***

** With external BUE20015 brake chopper

*** With external BUE20037 brake chopper

**** See dimensional drawing on Page 2.

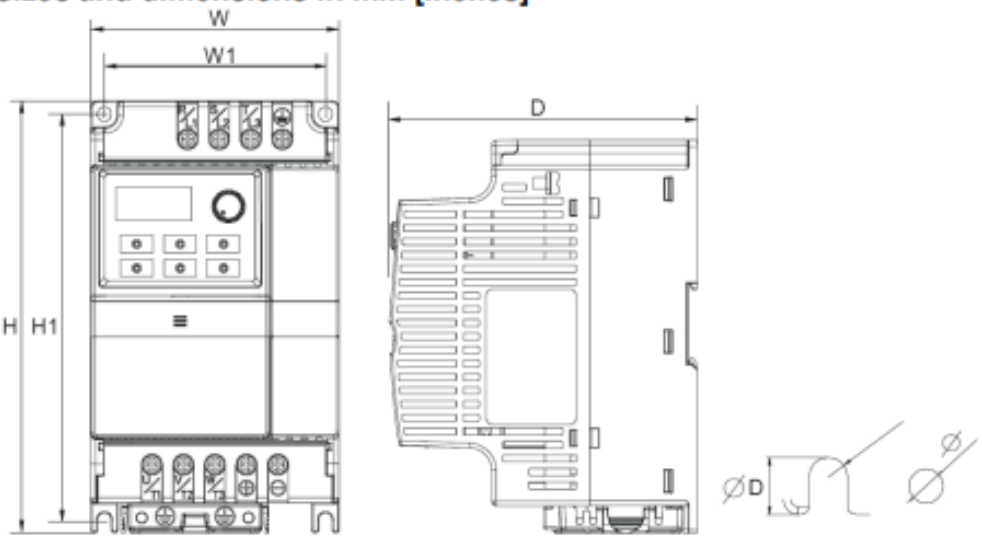
400V 0.4 ~ 3.7kW

Type number	VFD	004EL43A	007EL43A	015EL43A	022EL43A	037EL43A
Rated power	kW	0.4	0.75	1.5	2.2	3.7
Rated output current	A RMS	1.5	2.5	4.2	5.5	8.2
Current limit	%	150% 60s				
Rated output capacity	kVA	1.2	2	3.3	4.4	6.8
Rated input current	A RMS	1.9	3.2	4.3	7.1	11.2
Mains fuse (for UL: Bussmann)		JJS-6	JJS-6	JJS-10	JJS-15	JJS-20
Dimensions HxWxD	mm	174x72x136			174x100x136	
Size ****		A			B	
Weight	kg	1.2			1.9	
Section of power cables	mm^2	0.8 ~ 3			0.8 ~ 8	
Cooling		Convection		Fan		
Carrier frequency	kHz	2 ~ 12				
EMC-Filter		Built-in				
DC-Choke		No				
DC-Bus connection		Yes				
Brake chopper		No				
Recommended brake resistor	Ω/W	400/300 **		300/400 **	200/600 ***	
Minimum brake resistor value	Ω	400 **	200 **	160 **	100 ***	

** With external BUE40015 brake chopper
*** With external BUE40037 brake chopper

**** See dimensional drawing below.

Sizes and dimensions in mm [inches]



Frame	W	W1	H	H1	D	Ø	ØD
A	72.0[2.83]	59.0[2.32]	174.0[6.86]	151.6[5.97[	136.0[5.36]	5.4[0.21]	2.7[0.11]
B	100.0[3.94]	89.0[3.50]	174.0[6.86]	162.9[6.42]	136.0[5.36]	5.4[0.21]	2.7[0.11]

Programming

Group 00-xx **User Parameters**
Drive ID, Software version, Password, Parameter reset, User-defined display, etc.

Group 01-xx **Basic Parameters**
V/f-curve, Acc/Dec times, Jogging, S-curve, etc.

Group 02-xx **Operation Method Parameters**
Source of frequency/operation, Carrier frequency, 2-3 Wire operation, Motor direction inhibit, Stop method, etc.

Group 03-xx **Output Function Parameters**
Function and setting of analogue and digital outputs and relay, Count values, Fan control, Brake control, etc.

Group 04-xx **Input Function Parameters**
Function and setting of analogue and digital inputs, Index function, Debounce time, Digital input status, etc.

Group 05-xx **Multi-step Speed Parameters**
15 Speed steps.

Group 06-xx **Protection Parameters**
Protection settings, Fault memory, etc.

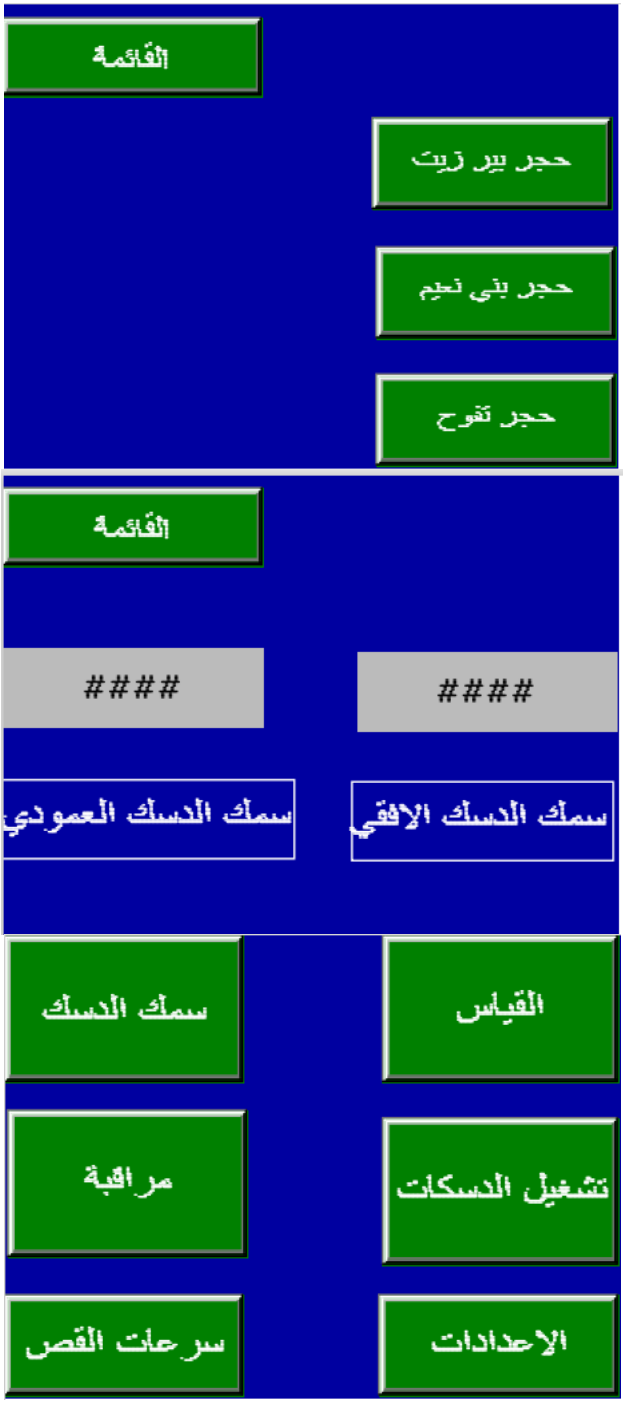
Group 07-xx **Motor Parameters**
Setting of motor parameters, Slip&Torque Compensation, PTC-function.

Group 08-xx **Special Parameters**
DC-Braking, 3 Skip frequencies, Speed search, AVR, Auto energy saving, Auto reset, etc.

Group 09-xx **Communication Parameters**
Protocol, Address, Transmission speed, etc.

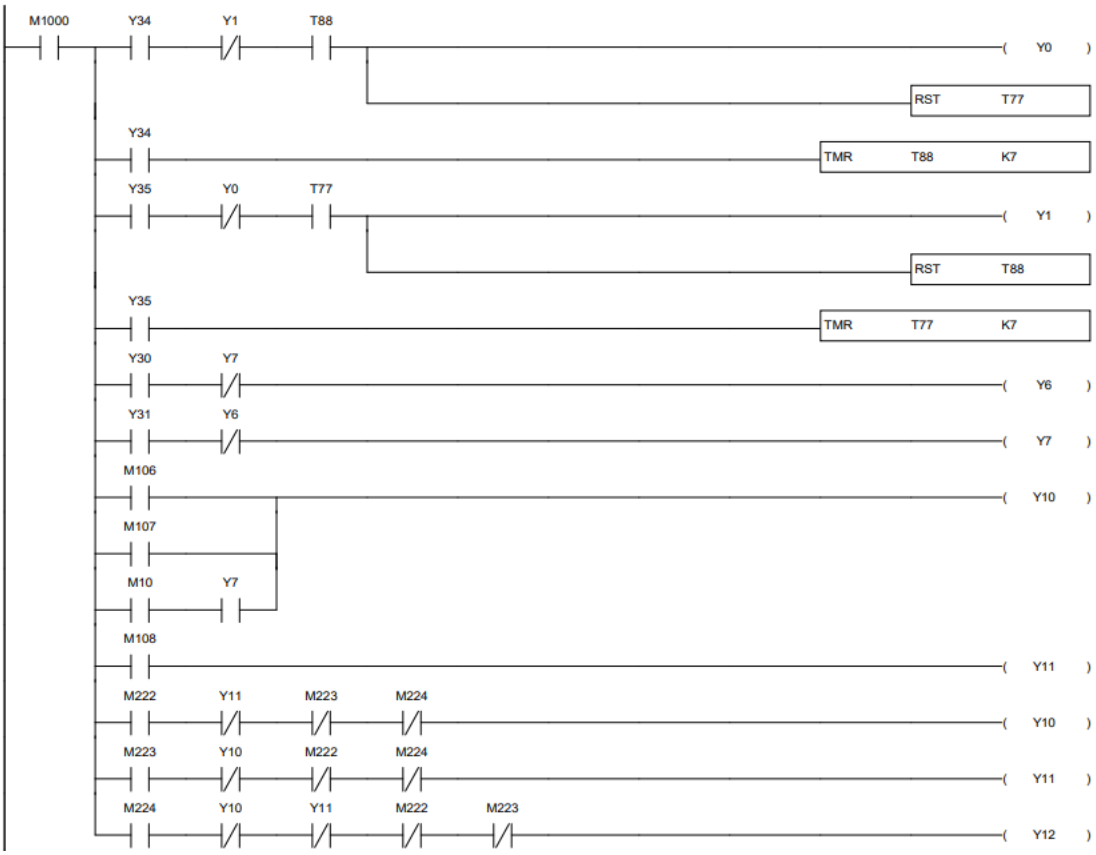
Group 10-xx **PID Control Parameters**
PID settings, Sleep and Wake-up, etc.

Appendix E


القائمة
حجر بير زيت
حجر بني نعيم
حجر تفوح
القائمة
####
####
سمك الدسك العمودي
سمك الدسك الافقي
سمك الدسك
القياس
مراقبة
تشغيل الدسكات
سرعات القص
الاعدادات


القائمة
####
####
ارتفاع القطعة
سمك القطعة
القائمة
تشغيل الدسك الافقي
تشغيل الدسك العمودي
ايقاف الدسك الافقي
ايقاف الدسك العمودي
القائمة
1234
تصفير
السماكة
القائمة
Y axis encoder factor
####
Z axis encoder factor
#.####
Y axis ramping down
####

Appendix F


M1000
Y34
Y1
T88
Y0
RST T77
Y34
TMR T88 K7
Y35
Y0
T77
Y1
RST T88
Y35
TMR T77 K7
Y30
Y7
Y6
Y31
Y6
Y7
M106
Y10
M107
M10
Y7
M108
Y11
M222
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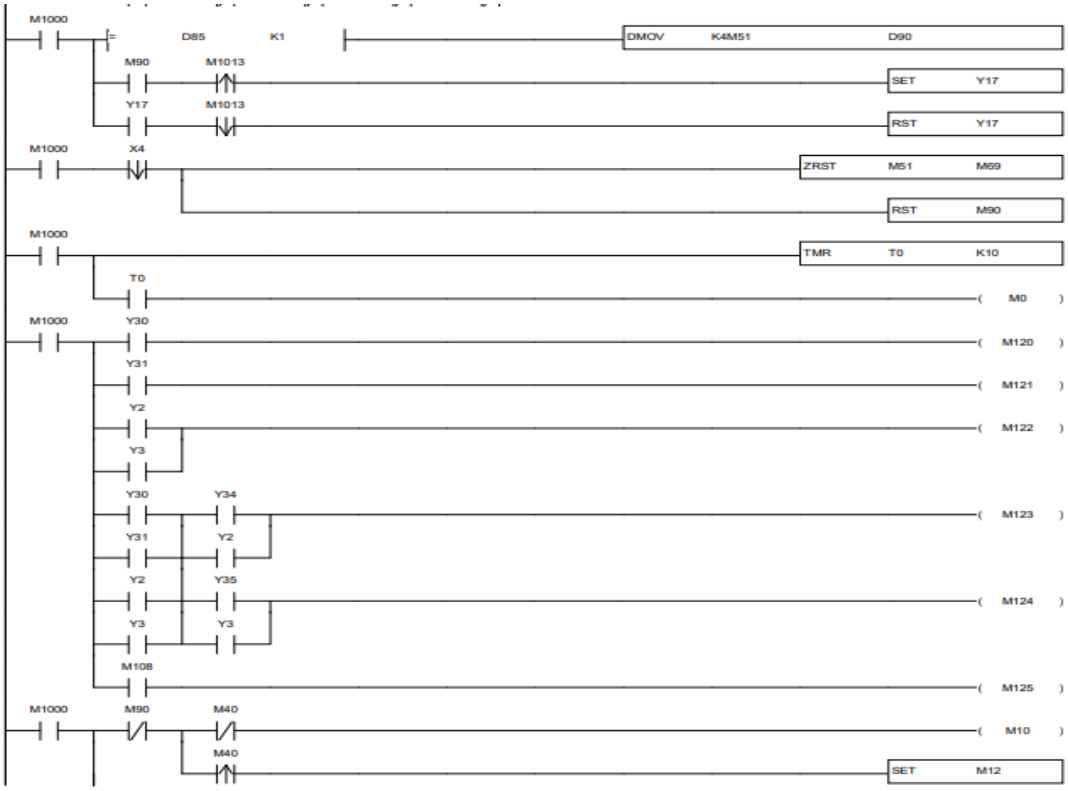
Y11
M224
Y10
Y11
M222
M223
Y12


M1000
D85 K1
DMOV K4M51 D90
M90
M1013
SET Y17
Y17
M1013
RST Y17
M1000
X4
ZRST M51 M69
RST M90
M1000
TMR T0 K10
T0
M0
M1000
Y30
M120
Y31
M121
Y2
M122
Y3
Y30
Y34
M123
Y31
Y2
Y2
Y35
M124
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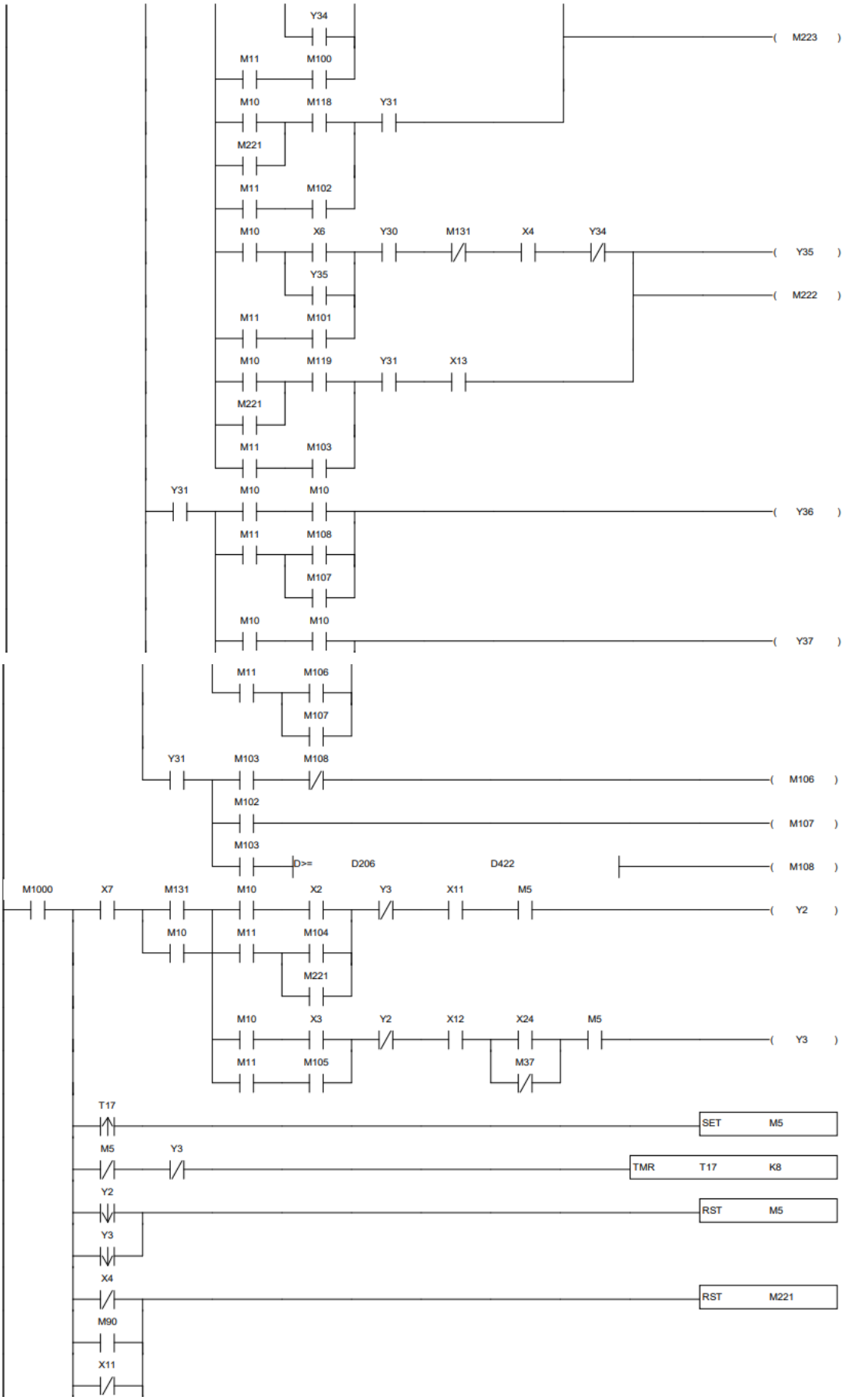
Y3
M108
M125
M1000
M90
M40
M10
M40
SET M12


Y34
M223
M11
M100
M10
M118
Y31
M221
M11
M102
M10
X6
Y30
M131
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Y34
Y35
Y35
M222
M11
M101
M10
M119
Y31
X13
M221
M11
M103
Y31
M10
M10
Y36
M11
M108
M107
M10
M10
Y37
M11
M106
M107
Y31
M103
M108
M106
M102
M107
M103
D>=
D206
D422
M108
M1000
X7
M131
M10
X2
Y3
X11
M5
Y2
M10
M11
M104
M221
M10
X3
Y2
X12
X24
M5
Y3
M11
M105
M37
T17
SET
M5
M5
Y3
TMR
T17
K8
Y2
RST
M5
Y3
X4
RST
M221
M90
X11