Palestine Polytechnic University

College of Engineering

Design of a Prototyping Food Dehydration Machine

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Abstract

Food drying is an important procedure for dehydrating vegetables and fruits and keeping them suitable for consumption at any time of year, especially outside of the harvesting and picking season. It's also a procedure for keeping these materials from decaying and spoiling owing to moisture. This is the project's basic concept: to design a machine that automatically dries vegetables and fruits by removing moisture. This could be accomplished by placing vegetables or fruits in this machine and subjecting them to a specific atmospheric condition for a set period of time, known as a dehydration cycle, in which the temperature and air velocity are changed during the dehydration process. The advantages of adopting such a machine include increased production, the elimination of human errors in dehydration quality, and the protection of the material from environmental side effects or actors such as dust, dew, and rain. The proposed design is prototyping-friendly and can dehydrate 3 kg of material, but it can also be scaled up for businesses or large production.

الملخص

تعتبر عملية تجفيف الطعام عملية مهمة في تجفيف الخضار والفاكهة وحفظها لتكون مناسبة للاستهلاك في أي وقت من السنة بشكل رئيسي في خارج موسم الحصاد والقطف ، بالإضافة إلى أنها إجراء مهم لمنع هذه المواد من التعفن والفساد بسبب وجود الرطوبة. وهذه هي الفكرة الرئيسية للمشروع ، وهي تصميم آلة تجفف الخضار والفواكه تلقائيًا عن طريق إزالة الرطوبة. يمكن القيام بذلك عن طريق إدخال الخضار أو الفاكهة في هذا الجهاز وتعريض هذه المواد لظروف جوية معينة لفترة معينة تسمى دورة الجفاف عن طريق تغيير درجة الحرارة. فوائد استخدام هذه الآلة تزيد الإنتاجية بشكل كبير ، وتجنب الأخطاء البشرية في جودة الجفاف ، وتمنع المواد المجففة من الآثار الجانبية المحيطة أو العوامل الفاعلة مثل الغبار والندى والمطر. يتميز التصميم المقترح بطابع نموذجي يمكن استخدامه لتجفيف مادة 3 كجم ، يمكن أيضًا توسيع نطاقه للأعمال التجارية أو الإنتاج الكبير.

الاهداء

إلى معلمنا الاول ومعلم الناس الخير..... نبينا محمد صلى الله عليه و سلم

إلى من زرعوا فينا الطموح والمثابرة و االجتهاد.....آباؤنا الافاضل

إلى ينابيع المحبة و العطاء.....أمهاتنا العزيزات

إلى إخوتنا وأخواتنا

إلى معلمينا و معلماتنا

إلى الاصدقاء و الزملاء

إلى من ناضلوا من أجلنا شهدائنا وأسرانا وجرحانا

إلى هذه الارض التي نحب فلسطين

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1.1 Introduction

Drying has remained one of the popular methods for preserving food for many years. The drying process involves reducing water from the product to an acceptable level for marketing, storage, or processing. Given the absence of sufficient water, microorganisms are unable to grow and multiply. Many of the enzymes and bacteria that cause food spoilage cannot function without water.

The old method of food drying is executed by spreading the food material on the ground and exposing the food to sunlight. This method is practiced until today for certain products because of the advantages of simplicity and economy. However, open sun drying has some drawbacks. Open sun drying requires longer drying time and product quality is difficult to control because of inadequate drying, high moisture, fungal growth, encroachment of insects, birds and rodents and others. Open sun drying also requires a large space [1].

1.2 Problem Definition

1-Unavailability of vegetables and fruits throughout the year.

2-Part of the agricultural crops are damaged every year Because of excessing over the market need.

3- To prevent eventual marketing failure and product losses due to open market competency or severe weather conditions and traders suffered financial losses due to crop failure.

4- Traditional dehydration procedures suffering from long time duration with less quality need for a very long time to dry vegetables and fruits by traditional methods.

1.3 Project Motivation

1- Proposing a machine that converts fresh fruits & vegetable into draying status and to be used in seasons where it hard to find fresh fruits.
2- Creating new aspects for Palestinian agricultural sector for offering new products…Fresh and dry product.
3- Creating a machine of acceptable size and cost for both home and industrial use.

1.4 Project Objectives

Design a prototyping drying machine for few kinds of fruit and vegetable like Beets, Green beans, Okra , Corn and etc. That can be used for domestic and industrial scales.

1.5 Project Importance

1- Offering vegetables and fruits among the year.

2- Reducing the farmer and trading sector losses .

3- Reducing the storage space.

4- Processing of excess product during the harvesting season.

1.6 Formulated Tasks

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	Select the mechanical parts and accessories
T7	Writing the thesis chapters
T8	Prepare the 1st presentation (Introduction to project)
T9	Editing the thesis based on received committee revision
T10	Purchasing the mechanical and electronic part
T11	Building project's prototype
T12	Installing the mechanical and parts,,,
T13	Conducted the needed programing and coding
T14	Testing the machine
T15	Calibration of testing prototype,,,
T16	Completing the thesis structure…
T17	Preparing the final presentation

1.7 Time Schedule

Table (1. 2): 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. 3): 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														

1.8 Cost Estimation

Table (1. 4): shows the expected cost for the machine ±15%:

#	Name of part	Quantity	Cost
1	Project body	1	250$
2	Air suction unit	1	25$
3	Fan	1	30$
4	Heater	1	30$
5	Filter	1	10$
6	Induction motor	1	35$
7	VFD	1	150$
8	PLC (Delta)	1	150$
9	HMI (Human machine interface)	1	370$
10	Relays	4	10$
11	Overload	1	25$
12	Thermocouple	1	20$
13	Emergency Switch	1	4$
14	Ozone treatment	1	30$
15	Other electrical component	----	115$
	Total		**1254$**

Chapter 2:

Food Dehydration Technology and Methods

1) **Introduction.**
2) **Type of dehydration materials.**
3) **Methods for dehydration.**
4) **Proposed methods.**
5) **Summary about used method.**
6) **Type of materials that should be subject of present work.**

2.1 Introduction

Dehydrating foods until there isn't enough moisture to enable microbial growth is known as drying. Drying eliminates the water that bacteria, yeasts, and molds require to thrive. If properly dried and kept, it can last a long time (safe for storage at room temperature). The drying food preservation process is simple to use, safe, and suitable for a wide range of foods. Oven drying and dehydrating using an electric dehydrator are two of the simplest and most frequent methods that may be utilized in any environment. Air drying (in the shade during hot weather), sun drying (limited to desert conditions), solar drying (needs specially constructed dryer), and pit oven drying (helpful when other methods are unsuitable) are the other options [5].

2.2 Type of Dehydration Materials

Fruits and vegetables that can be dried using particular temperature, drying time, and method data are the target materials. Tables (2.1) and (2.2) list the ingredients for targeting, as well as the preparation time and final product [2].

Table (2. 1): Types of vegetables that are dried**.**

Food Drying Guide, Vegetables at **51** °C			
FOOD	PREPARATION	TIME	Final Product
Green beans	Wash, remove ends, cut into 1” pieces	9-12 hrs.	Crunchy
Beets	Remove 1/4” of the top, scrub thoroughly, steam blanch until tender. Peel and cut into 1/4” thick slices	9-12 hrs.	Pliable
Broccoli	Wash & trim. Cut stems into 1/4” pieces. Dry florets whole	10-14 hrs.	Crunchy
Cabbage	Wash & trim. Cut into 1/8” strips.	8-11 hrs.	Crunchy
Carrots	Wash & trim tops. Peel or scrape if desired. Cut into 1/8” thick slices	7-11 hrs.	Pliable
Corn	Shuck corn and trim silk. Steam until milk is set. Cut kernels from cob. and spread on	7-10 hrs.	Crunchy

	plastic screen. Stir several times during drying.		
Cucumber	Wash & trim. Cut into 1/8” slices.	4-8 hrs.	Pliable
Eggplant	Wash & peel. Cut into 1/4” slices	4-8 hrs.	Pliable
Mushroom	Wash and cut into 3/8” slices	4-7 hrs.	Pliable
Okra	Wash, remove ends, cut into 1” pieces	10-14 hrs.	Crunchy
Peppers	Wash and remove stems, seeds and white section. Pat dry. Cut into 1/4” thick strips or rings.	4-8 hrs.	Pliable
Potatoes	Use New Potatoes. Wash, peel if desired. Steam blanch 4-6 minutes. Cut French fry style. 1/4” slices, 1/8” thick circles or grate.	7-13 hrs.	Crunchy/Pliable
Tomatoes	Wash and remove stems. Slice into 1/4” circles. For cherry tomatoes, slice in half, dry skin side down.	5-9 hrs.	Pliable
Zucchini	Wash, peel if desired. Cut into 1/4” slices or chips.	7-11 hrs.	Crunchy

Table (2. 2): Types of Fruits that are dried**.**

Food Drying Guide, Fruits at **57** ° C			
FOOD	PREPARATION	TIME	Final Product
Apples	Wash, core, and peel if desired. Cut into 1/4" slices. Dust with cinnamon if desired.	7-15 hrs.	Pliable
Apricots	Wash, halve and remove pit. Slice if desired and dry skin side down.	21-29 hrs.	Pliable
Bananas	Wash, peel and slice into 1/8" slices	7-10 hrs.	Pliable
Figs	Wash, cut out blemishes, quarter. Dry skin side down	22-30 hrs.	Pliable
Kiwi	Wash, Peel and slice into 1/4" slices	8-15 hrs.	Crisp
Nectarines	Wash, halve and remove pit. Slice if desired and dry skin side down	8-17 hrs.	Pliable
Peaches	Wash, halve and remove pit. Slice if desired and dry skin side down	8-16 hrs.	Pliable
Pears	wash, core and peel if desired. Cut into 1/4" slices or quarter.	8-16 hrs.	Pliable
Pineapple	Peel, remove fibrous eyes, remove core. Cut into 1/4" slices or wedges.	11-18 hrs.	Pliable
Rhubarb	Wash, cut into 1" lengths.	6-10 hrs.	Pliable
Strawberries	Wash, cut out caps, slice 1/4" thick.	7-15 hrs.	Crisp
Watermelon	Cut off rind, cut into wedges and remove seeds	8-10 hrs.	Pliable & Sticky

2.3 Methods for Dehydration.

2.3.1 Natural Dehydration.

Sun dehydration is a traditional post-harvest practice that includes exposing the crops to the effects of sun and wind. The practice is usually managed by spreading the crops on the ground. Besides that, sun drying also includes spreading the crops in shade, as well as on raised surfaces (for instance panels that are placed on blocks). By placing the crop on a raised surface, a farmer can ensure better air circulation, and therefore improve the drying process

2.3.2 Fast Dehydration.

There are two methods of quick dehydration- :

2.3.2.1- Heat Dehydration(Oven dehydration)

This process is applied by directing the heat to the vegetables and fruits from all sides, and in most cases the regular kitchen oven is used by heating the vegetables and fruits directly.

2.3.2.2 Hot Air Dehydration

There are two methods of Hot air drying:

1)Fluidized dehydration

The principle of the process is based on using the force of air through a perforated plate to dry the products in a horizontal chamber. The product is suspended in the air stream.

2) Convection of air

The air movement is controlled by fans, then will exposing the air to the fruits and vegetables, for example, fruits and vegetables are placed on the ground and exposed to the air coming from the fans.

2.3.3 Comparison of Types Dehydration

A comparison between the types of dehydration in terms of the type of food and its advantages and disadvantages as illustrated in table (2.3).

Table (2. 3): Comparison of types dehydration.

No	*Type of Drying*	*Type of Food*	*Advantages*	*Disadvantages*
1	Sun dehydration	All fruits and vegetables	cheap	Long drying times. poor product quality (excessive browning and casehardening) unhygienic.
2	Oven dehydration	All fruits and vegetables.	Ease of use Simple	Poor product quality (excessive browning and case hardening) unhygienic
3	Fluidized dehydration	Fruits and vegetables that can be linked	Low humidity, low energy needs, flexible and easy system	Too much undesirable dust Restriction on particle size
4	Convection of air	All fruits and vegetables	High productivity rates, low cost	Very large areas for drying A little slow

2.4 Proposed Method

Based on data mentioned in Table (2. 3) the proposed method that combines dehydration by heat and air drying and adding move the product to be dried.

2.5 Advantage about Used Method

This method contains a variable heat source to eliminate the disadvantages of thermal dehydration, the presence of a fan to move the existing hot air in order to eliminate the disadvantages of air dehydration, as well as the presence of a motor that moves the product in order to increase the efficiency and quality of the product.

2.6 Type of Materials that should Be the Subject of Present Work

It was suggested in this project that the peas and green beans be dried to test the machine's efficiency, with the correct manner determined by Table (2. 1) to finish the drying process as required.

2.6.1 How to Dehydrate Okra

According to Table (2.1) will proposing the best method to dehydrate okra using the dehydrate machine, started by cleaning okra then removing the ends of it then cutting the pods in 1 inch then the okra will be ready to entered the machine then the okra stay in the machine from 10 to 14 hours with temp of 51℃ after that in the final form have crunchy okra.

2.6.2 How to Dehydrate Green Beans

According to Table (2.1) will proposing the best method to dehydrate Beans using the dehydrate machine started by cleaning Beans then removing the ends of it then cutting into 1” pieces then the Beans will be ready to entered the machine then the Beans stay in the machine from 9 to 12 hours with temp of 51℃ after that in the final form have crunchy beans.

Chapter Three

Electromechanical Design

1) **Overview.**
2) **Functional block diagram.**
3) **Flowchart.**
4) **Electrical design.**
5) **Control element.**
6) **Protection Devices.**
7) **PLC input-output table.**
8) **Power circuit.**
9) **Information on mechanical parts.**
10) **PLC circuit**

3.1 Overview

This paragraph discusses how the drying machine works in general, as shown in Figure (3.1), where the material to be dried is selected by selecting it from the (HMI) screen, where the selection is from several, and after this process, the material to be dried is placed inside the cage in a specific amount and according to the drying principles that vary from one type to another, and after placing the machine's door, the machine dries. The drying time, temperature, and stirring speed are then determined using the (HMI) screen, and the machine is then turned on using the on-screen operation button (HMI). The temperature sensor is used to drive and control the heat source, and the PLC is used to switch on the fan to convey the hot air within the machine. At the same time, materials are conveyed using a motor controlled by a plc via a variable frequency drive (VFD), and after a period of operation, it operates on air suction to pull air. It is full of moisture, removing the water and returning the air to the inside of the device with the ability to add time and control the temperature from the (HMI) screen during the operation of the machine, and the sterilization process begins with ozone lighting after the drying process is completed.

Figure (3. 1): General view of the proposed machine.

3.2 Functional block diagram

Function block diagram of the proposed machine is displayed in figure (3.2) clarify machine stages.

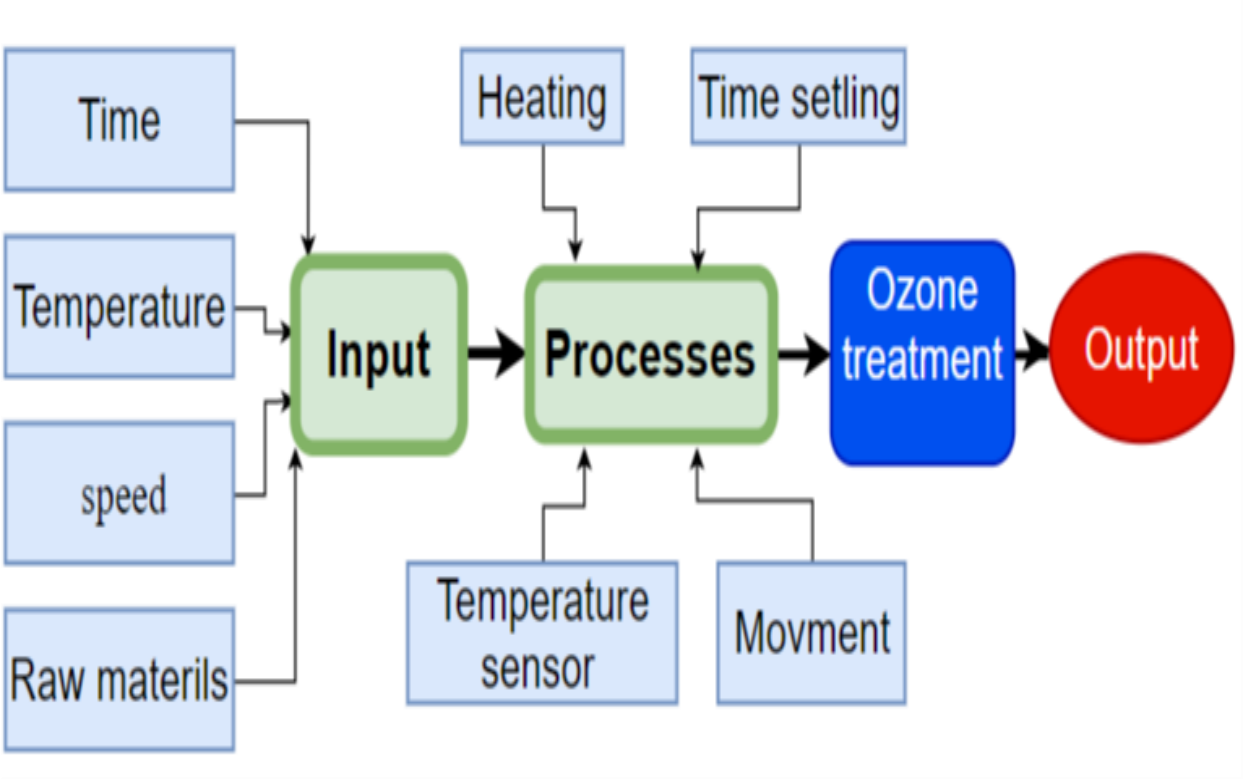


Figure (3. 2): Functional block diagram

Where:

Time :- The time required to complete the drying process .

Temperature ;- The temperature to be reached in the drying process .

Speed :- The motor's speed in drying process.

Row materials :- The kind of food will be dried .

Heating :- The work of the heaters in drying process.

Time stling :- The period of time that has passed since the drying process began.

Temperature sensor :- The read of the temperature sensor in side the machine .

Movement :- Motor movement during the drying process.

3.3 flowcharts

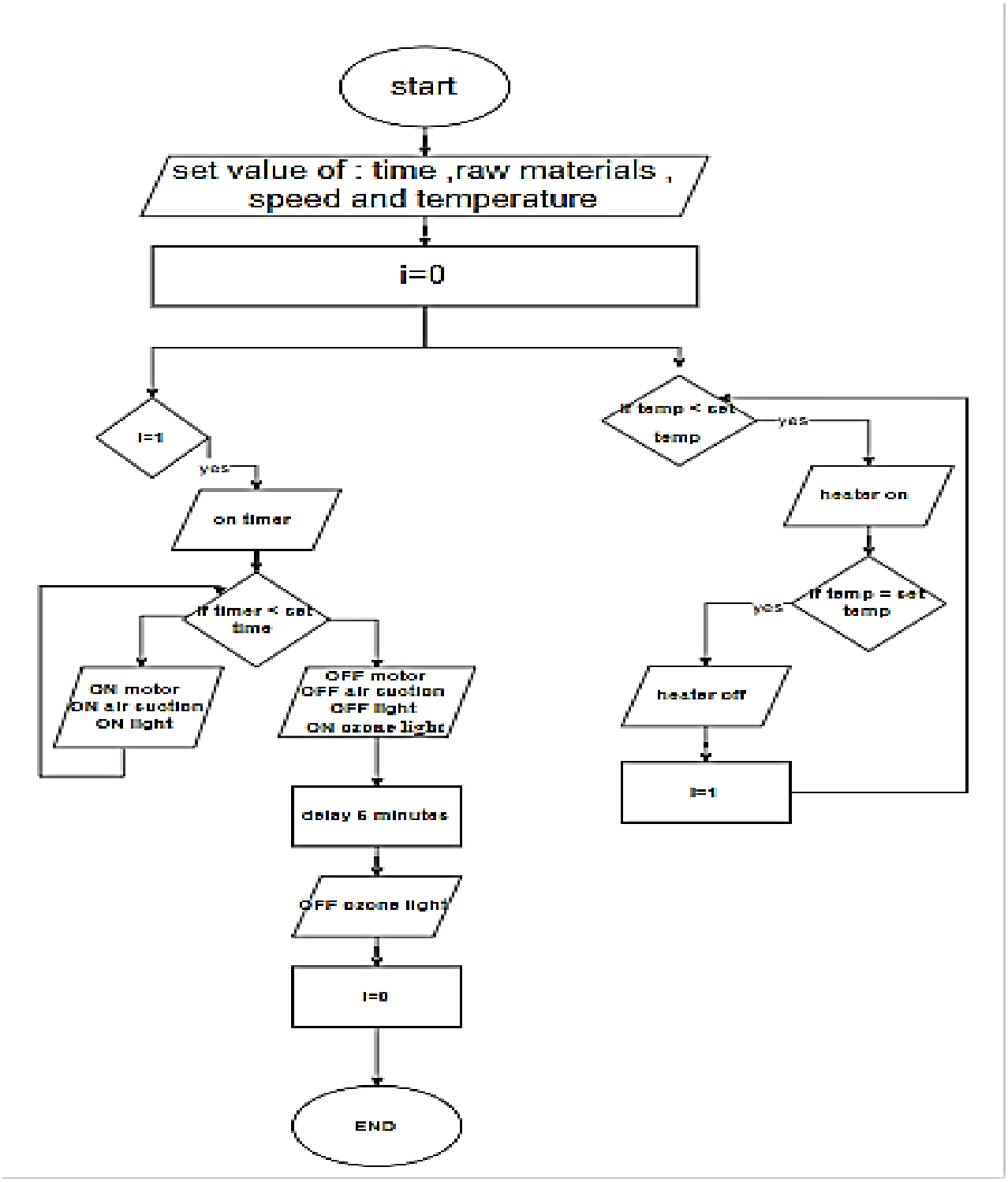


Figure (3. 3): flowcharts

3.4 Electrical Design

According to table (1.4), the proposed machine has the following electromechanical elements that to be designed individually then integrated together:-

- Electrical parts :HMI, PLC, temp sensor, ozone lamp, switch, wire, circuit breaker, VFD, relays, motor, heater, air suction and fan.
- Mechanical parts: Air intake pipe, screws, nuts.

3.4.1Motor and Gear calculations

An electric motor is an electrical machine that converts electrical energy into mechanical energy. In this section, the specifications of the electric motor will be explained, which includes the AC motor, where the motor move **3 kg** of vegetables and fruits to be dried, and the machine has been chosen for use in industrial and domestic facilities.

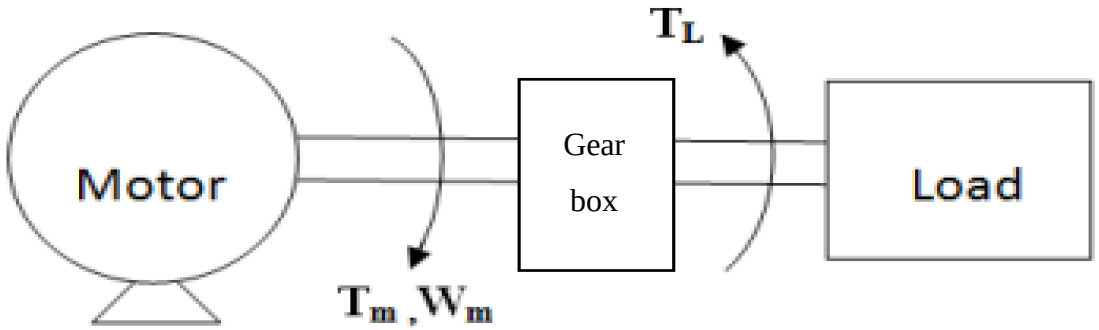


Figure (3. 4): Mechanical circuit

- The gear box ratio :-

  Ratio = acual speed / speed pefor gear box = 1450/30 = 48.33 (3.1)

Table (3.1) : Gear box data

Ratio	1/50

- The force:

$$F = m*r*\omega^2 = 8*0.15*(3.14)^2 \quad \textbf{(3.2)}$$

$$= 11.8N$$

Where:

r: radius of the basket

m:the mass of basket and the product.

ω:the speed of the motor

- The torque of load (T_L):

$$T_L = F * r = 11.8 * 0.15 = 1.77 \text{ Nm} \quad \textbf{(3.3)}$$

- Mechanical Power (Pm):

$$Pm = T_L * \omega \quad \textbf{(3.4)}$$

$$= 1.77* 3.14$$

$$=5.55 \text{ W}$$

Based on Equation (3.4), the motor specification a motor with standard specification is selected as stated in table (3.2)

The Motor Data sheet is attached In Appendix A

Table (3. *2*): Selected Motor MMSTD:

Name	Phase	Type	P/W	V/V	I/A	n/RPM	F/Hz
Motor Gear	1Ø	**Induction**	**15**	**220**	**0.2**	**30**	**50**

3.4.2 Heater Element

A typical heating element is usually a coil or tape (straight or corrugated) or a strip of wire, as shown in Figure (3.5), that emits heat like a filament for a lamp. When an electric current flow through it, it glows red and converts the electrical energy that passes through it into heat that radiates in all directions and gives a higher temperature than what is required, so Thermocouples sensor, as shown in Figure (3.9) were used to control the temperature.

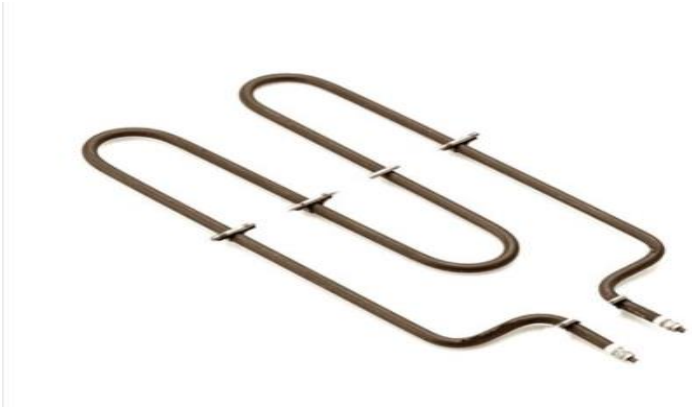


Figure (3. 5): Heater Element.

- We will be using 1 heating elements distributed on the sides of the machine.

$$P_{total} = V * I \quad (3.6)$$

$$= 220 * 9$$

$$= 1.98 \ KW$$

Where

V: Voltage (V)

I: Current (A)

The value of the current at a temperature rise of one degree.

$$A = I / C^{\circ} \quad (3.7)$$

$$= 9 / 280 = 0.032 \ A/ C^{\circ}$$

The Heater Data sheet is attached In Appendix B

Table (3. 3): Selected Heater Element Airex:

Name	Phase	P/KW	V/V	T/C°	I/A	F/Hz
Heater	**1∅**	**1.98**	**220**	**280**	**9**	**50**

3.4.3 Fan calculations.

For circulating the air inside the drying room fans are installed inside the room, fan can run at its maximum speed a 1.51 m/s air velocity [3].

$$Q = A * v \quad (3.8)$$

Where,

A : cross section area for fan, m^2.

v : Air velocity, m/s.

Q: Air flow, m^3/s

$$Q = A * v \quad (3.8)$$

$$= 0.292 * 1.51$$

$$= 0.44\ m^3/s$$

The Fan Data sheet is attached In Appendix C

Table (3.4): Selected Fan Nameplate:

Name	Air Flow(m^3/s)	Type of protection	P/W	V/V	I/A	n/RPM	F/Hz
Fan	**0.458**	**IP54**	**85**	**220**	**0.21**	**1350**	**50**

And this a suitable value for air speed in this application.

3.4.4. Air suction unit

The air suction unit is used to draw high-humidity air inside the machine, to filter the air from the water and return to the machine, and this air suction is selected at a speed equal to the speed of the rotating fans $v = 1.51$ m / s.

$$Air\ Flow = A * v \quad (3.9)$$

$$= (0.05^2 * \pi) * 1.51$$

$$= 0.0119\ m^3/s$$

And this a suitable value for air speed in this application.

3.4.5Ozone treatment

Ozone lamp is used to sterilize vegetables and fruits from germs, bacteria and viruses on vegetables and fruits after the completion of the drying process [4].

3.5 Control Element.

The control panel is based on PLC, HMI, and contains relay, VFD, Electrical Switches, Thermocouples sensor, and Emergency switch.

3.5.1 PLC

A programmable logic controller (PLC) is a microprocessor-based piece of hardware that is specifically designed to operate in the industrial environment. The PLC type that will be used is DELTA-DVP20EX2 that has 8 digital inputs and 6 digital outputs and 4 analog input and 2 analog output. We chose delta PLC because of its good quality, it is easy to be programmed, has accepted price and meet the required purpose. As shown on Figure (3.6).

The PLC DELTA-DVP20EX Data sheet is attached In Appendix D

The PLC code is attached In Appendix F

Figure (3.6): Front view of used PLC**.**

3.5.2HMI

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. As shown in Figure (3.7).

The type of HMI that will be used is “Delta B03S211 -Standerd HMI” The HMI Data sheet is attached in the Appendix E.

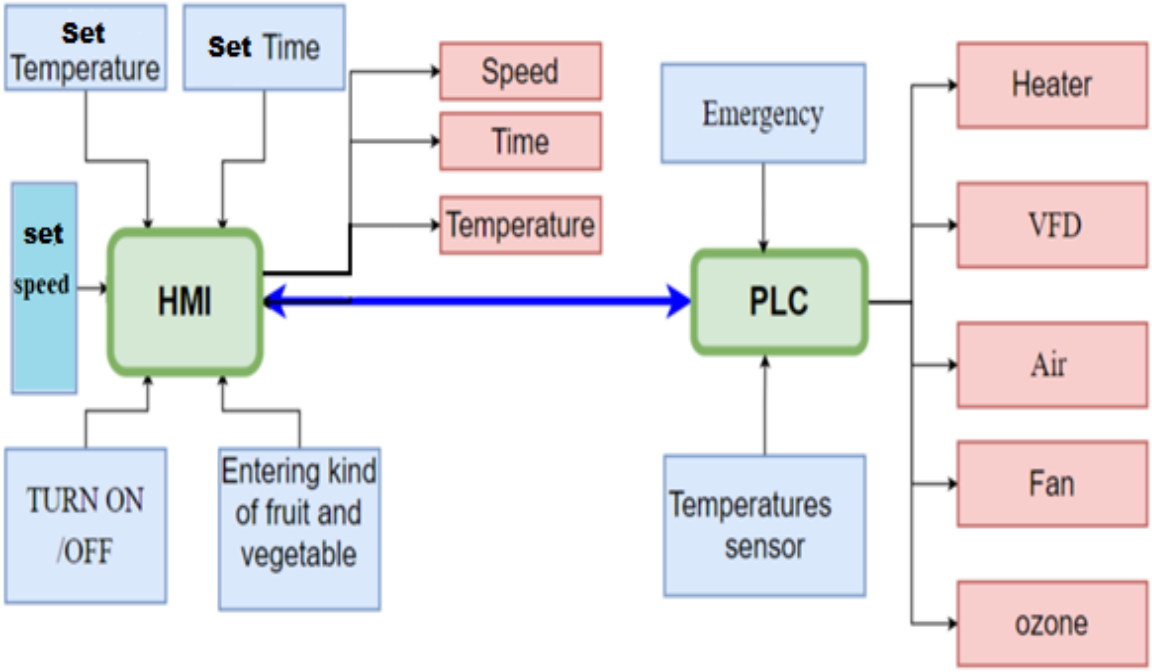


Figure (3.7): HMI control procedures

Where

Heater :-on the heater inside the machine.

VFD :- Variable Frequency Drive who control the speed of the motor .

Air:- on the air suction inside the machine.

Fan:- on of the fan inside the machine

Ozone:- Product sterilization using ozone treatment .

3.5.3 Relay

A Relay, as shown in figure (3.8), 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. 8): General view of used relay**.**

3.5.4 Variable Frequency Drive (VFD)

A Variable Frequency Drive (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. circuit of VFD and how finally gets a variable voltage and variable frequency.

3.5.5 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 (3.9).

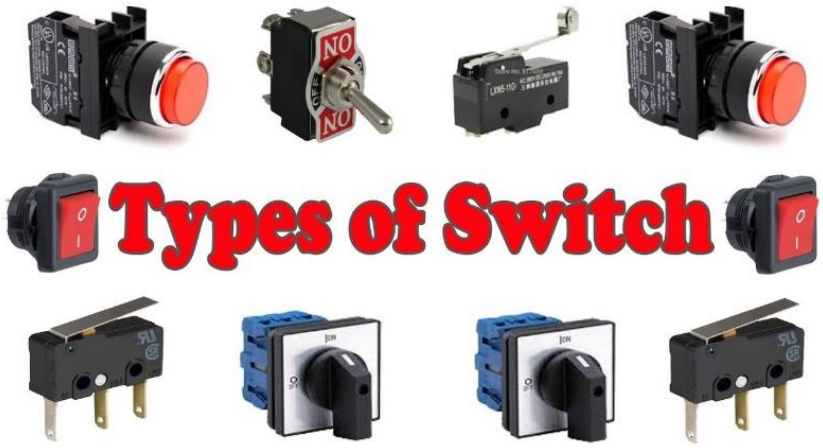


Figure (3. 9): Electrical Switches.

3.5.6 Thermocouples sensor

The Thermocouple sensor as shown in Figure (3.10) consists of two electrical conductors made of different metals that are joined at one end. Changes in temperature at the measurement junction induce a change in voltage between the other ends [6].

Figure (3.10): Thermocouples sensor.

Thermocouple are two groups, the base metal thermocouples J, K, T, E and N, and the precious metal thermocouples R, S and B.

In each type has a characteristic voltage against temperature curve and application range, as shown in Figure (3.11).

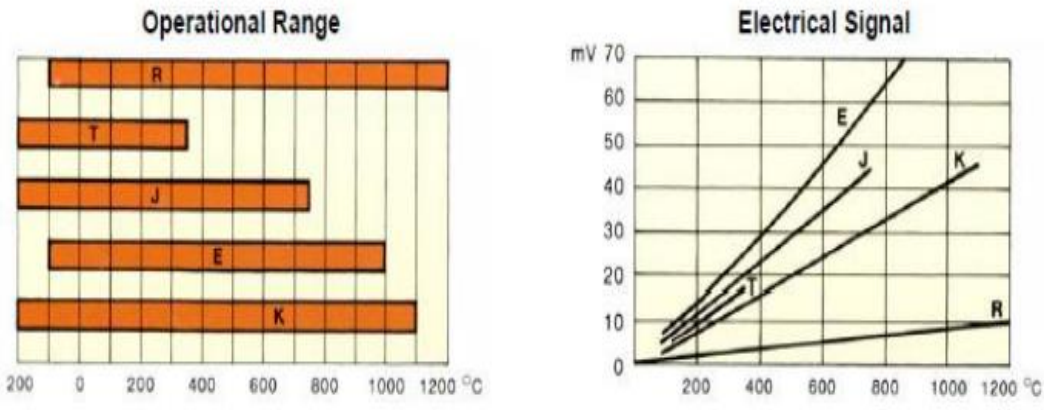


Figure (3.11): Thermocouple Characteristic Curve.

A thermocouple sensor will be used to measure a temperature. The output voltage value of this thermocouple is fed into the PLC input port. To close the temperature control loop.

3.5.7 Emergency Switch

Emergency Stop Button, as shown in Figure (3.12), 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 (3.12): Emergency switch.

3.6 Protection Devices

1. Circuit breaker:

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 (3.13) [7] .

- Circuit Breaker

CB= Next Standard$(1.25 \times In)$

Figure (3.13): Circuit breaker.

2. Overload:

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 (3.14) [8].

Figure (3. 14): Overload.

- Overload

OL=In

Table (3. 5): Selected Protection Components Ratings:

Name	Current (A)	Overload size(A)	CB size(A)
Motor	**5.3**	**5.3**	**6.6**
Heater Element	**9**	**-**	**11.25**
Fun	**0.21**	**-**	**0.26**

3.7 PLC Input-Output (LAD)

Table (3. *6*): PLC Input-Output:

Symbol	Function	Address
Inputs		
S0	Start\ stop	**X0**
EM	Emergency Switch	**X1**
TS	Thermocouple sensor	**AD1**
Output		
VFD	VFD	**DA1**
H	Heater	**Y1**
F	Fun	**Y2**
AS	Air suction	**Y3**
O	Ozone	**Y4**

3.8 Power circuit

This is the electrical diagram that shows the electrical parts used and on which the protection currents were selected. As shown in the figure. (3.15)

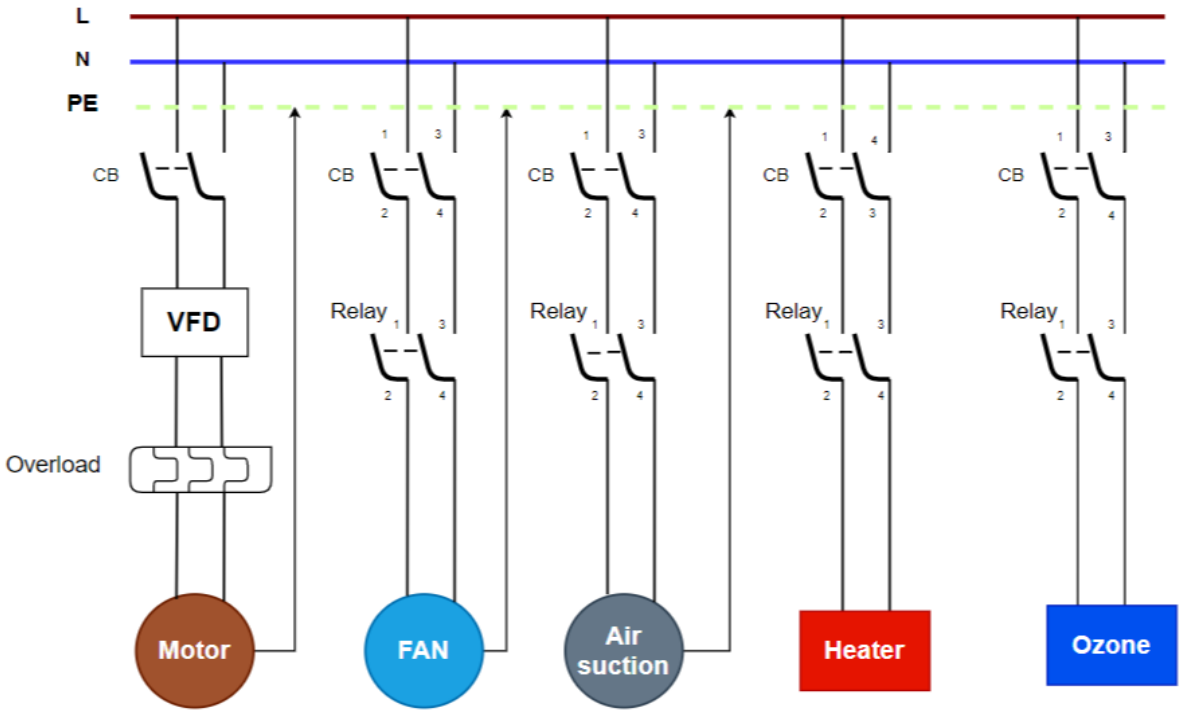


Figure (3. 15): Power Circuit.

3.9 Information on mechanical parts

Machine body and size: The machine is made entirely of stainless steel 304 and size 1 m3 and has a cylindrical basket made of stainless steel 304 with dimensions of 30 cm width and 50 cm length, the screws and nuts used are of Steel Self Tapping Screw and Stainless-Steel Hex Socket Cap Head Bolts Screws Nuts M3 M4 M5 Durable Use.

3. 10 PLC circuit

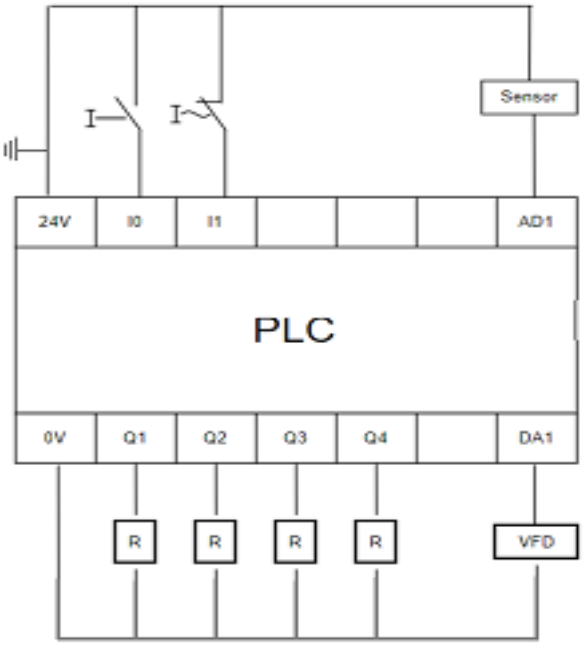


Figure (3. *16*): PLC Circuit

Chapter Four

Experimental Result & Recommendations

1- Introduction

2- Experimental Result

3- Recommendations

4.1 Introduction

The experimental results and some recommendations from the work learned for this project are presented in this chapter. In this chapter, we'll go through several goals that we aim to achieve or at the very least keep in mind.

Figure (4. *1*): Machine

Figure (4. *2*): The electrical panel

4.2 Experimental Result

We performed some tests on various aspects of our project, and the following are some of the results:

1- The initial machine operation procedure has been confirmed, and the procedure has been compared to the needed procedure.
2- In the second stage, green beans were added, and the drying process was completed, however the final product was slightly moist due to mechanical defects that enabled hot air to seep from the machine to the outside, affecting the final product.
3- Due to the variable nature of the materials to be dried from some of them, the basket that was built does not fit all types of materials, such as materials that are soft before the drying process.
4- Due to heat loss to the outside, the heater worked for longer than expected.

4.3 Recommendations

Finally, we have a number of recommendations that could add to the project's improvement, but we didn't have the time to implement them and didn't have the necessary financial support. The following are some of the main points of these recommendations:

1- The use of specialized materials in the machine body design to solve the problem of heat leaking from the machine to the outside, and the customized materials can protect the atmosphere inside the machine from the outside.
2- Adding a VFD to control the speed of moving the product inside the basket, which leads to an increase in the final product's efficiency, because the products differ in the stage of moving the product during the drying process, and the required speed can be controlled due to the type and condition of the product.
3- Adding a moisture sensor to control the humidity inside the machine will improve the final product's efficiency.
4- Adding a temperature sensor module to the PLC to regulate the temperature via PLC, other than that the temperature change in each product change process to match the required product temperature.

References:

[1] S. Misha., S. Mat., M.H. Ruslan., K. Sopian.and E. Salleh. (2013). Review on the Application of a Tray Dryer System for Agricultural Products. World Applied Sciences Journal 22 (3): 424-433, 2013, ISSN 1818- 4952.

[2] L.E.M. Products, Inc.107 May Drive, Harrison, OH 45030 • PH: 877-536-7763 • www.lemproducts.com

[3]D. Kumar, S. Prasad and G. S. Murthy , Optimization of microwave-assisted hot air drying conditions of okra using response surface methodology, Journal of Food Science and Technology,51 (2014), pp.221–232. https://link.springer.com/article/10.1007/s13197-011-0487-9

[4] A. Natha*, K. Mukhimb, T. Swerb, Debashis Duttaa, N. Vermaa, B.C. Dekab and B. Gangwara , A Review on Application of Ozone in the Food Processing and Packaging ,1(2014), pp07-21.

[5]https://medcraveonline.com/MOJFPT/drying-and-dehydration-technologies-a-compact-review-on-advance-food-science.html

[6]https://l.facebook.com/l.php?u=http%3A%2F%2Fwww.hyper-sense.com.tw%2Ffront%2Fbin%2Fdownload.phtml%3FPart%3DThermocouple%26Nbr%3D61247%26Category%3D0%26fbclid%3DIwAR0tgATF-W72Bzs1Pufcf6aGouMf-ZxznLbqTvwAfmLShV69jeg__0BRab8&h=AT2iqu7-Tbc5x1QkGZDHFOlps3QhH-w6FpGGHLtaPEB0IJ0XH1QClkIIXL1YGC5cob8qxxXDboOFTcK9VRAfwMirc8lMexHlJbtdZUxFGyQnKh0L8X251lQdGS4qDJc9qSHdeg

[7]https://circuitglobe.com/circuit-breaker.html?fbclid=IwAR3tbyEav_v5JI1l5W7B6bJFC-kynIoLUwtRQFv0y5benv93PcSejwez_LY

[8]https://www.c3controls.com/white-paper/what-is-overload-protection/?fbclid=IwAR2ZdmEjimmMyJES7foBmHaYKZbGaWGDxtcb2RpQGl-X2iSmAQF3gB7t4x0

Appendix A

Variable Speed Motor / Single Phase Reversible

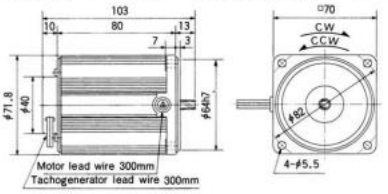
變速馬達單相感應馬達
가변속 모타 단상 인덕션 모타

Motor

Scale 1/4 Unit mm

70 mmSQ, 15W

M7RA15GV4L 4P 15W 100V
M7RA15GV4Y 4P 15W 200V
M7RA15GV4Q 4P 15W 110V
M7RA15GV4W 4P 15W 220V

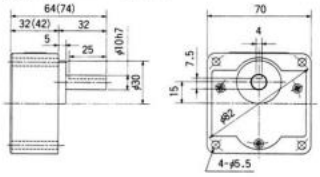


Weight 1.14kg
helical gear
module 0.5
number of teeth 10

Gear Head

Scale 1/4 Unit mm

M7GA□M (metal bearing type) weight0.54kg
M7GA□B (ball bearing type)



Note : The value in "( )" is for gear ratio of 1/20 or larger.

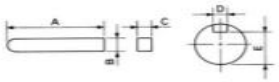
E

Connecting Diagram

See page 155 to page 157 for wiring connections

Key and Key Slot

M7GA□M(B)
M8GA□M(B)



Type	A	B	C	D	E
M7GA□M(B)	25	$4^{0}_{-0.030}$	$4^{0}_{-0.030}$	$4^{+0.060}_{+0.010}$	$7.5^{0}_{-0.15}$
M8GA□M(B)	25	$4^{0}_{-0.030}$	$4^{0}_{-0.030}$	$4^{+0.060}_{+0.010}$	$7.5^{0}_{-0.15}$

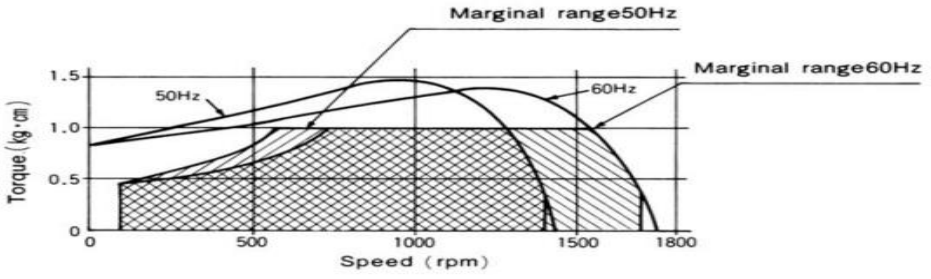
■Specifications

Size mmsq.	Type	poles	Output (W)	Voltage (V)	Frequency (Hz)	Duty	Variable speed range (rpm)	Allowable torque (kg-cm) 1200 (rpm)	Allowable torque (kg-cm) 90 (rpm)	Starting Current (A)	Starting Torque (kg-cm)	Condenser Capacitor μF(V)	Speed controller	Applicable gearhead type Metal	Ball	Decimal
70	M7RA15GV4L	4	15	100	50	30min	90~1400	1.0	0.47	0.59	0.82	6(200V)	—	M7GA□M	M7GA□B	M7GA10XM
					60		90~1700			0.52	0.82					
70	M7RA15GV4Y	4	15	200	50	30min	90~1400	1.0	0.47	0.30	0.82	1.5(400V)	—			
					60		90~1700			0.29	0.82					
80	M8RA20GV4L	4	20	100	50	30min	90~1400	1.2	0.50	0.67	1.1	7(200V)	—	M8GA□M	M8GA□B	M8GA10XM
					60		90~1700			0.67	1.1					
80	M8RA20GV4Y	4	20	200	50	30min	90~1400	1.2	0.50	0.34	1.1	1.8(400V)	—			
					60		90~1700			0.34	1.1					

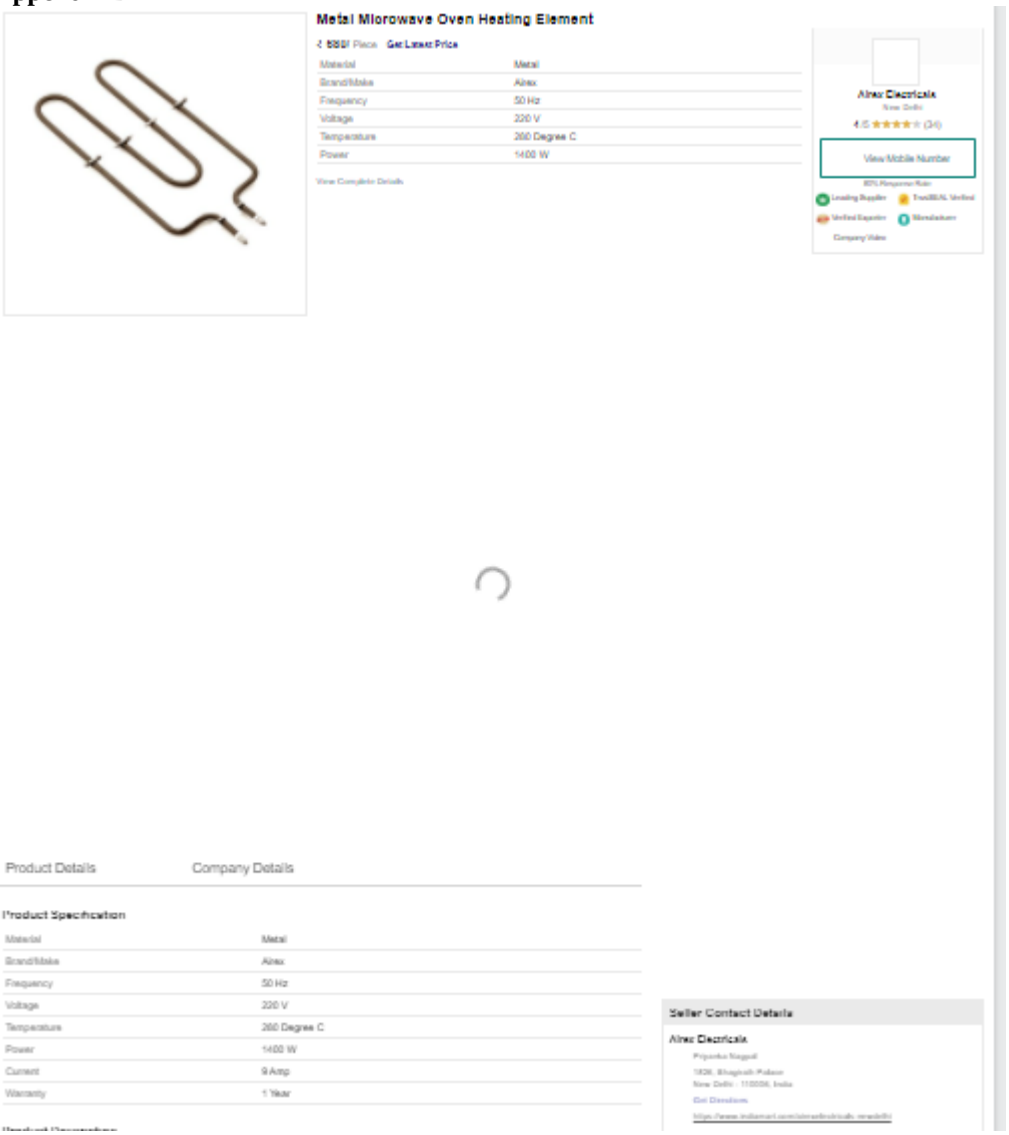
135

Speed-Torque Curve

M7RA15GV4Y



Appendix B



Metal Microwave Oven Heating Element

₹ 888/ Piece Get Latest Price

Material	Metal
Brand/Make	Alrex
Frequency	50 Hz
Voltage	220 V
Temperature	260 Degree C
Power	1400 W

View Complete Details

Alrex Electricals

New Delhi

View Mobile Number

Product Details Company Details

Product Specification

Material	Metal
Brand/Make	Alrex
Frequency	50 Hz
Voltage	220 V
Temperature	260 Degree C
Power	1400 W
Current	9 Amp
Warranty	1 Year

Seller Contact Details

Alrex Electricals

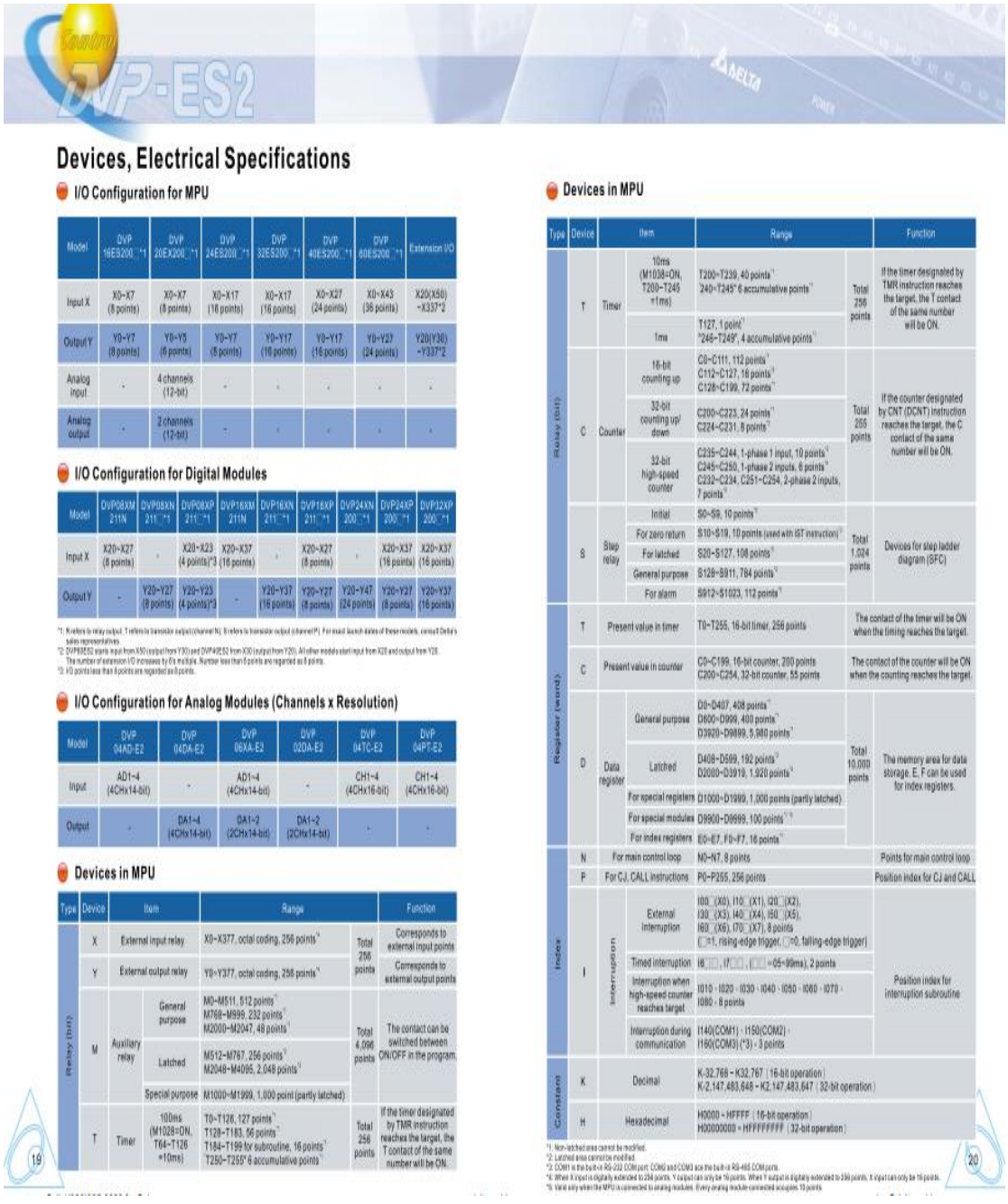
Appendix C

Power:	85W	**Rated Speed:**	1350RPM
Air Flow:	1650m³/h	**Rated Current:**	0.21A
Rated Voltage:	220VAC	**Frequency:**	50HZ
High Light:	**ac axial cooling fan, axial flow exhaust fan**		

Air-Conditioning Fans Extractor Fan With Ka-4m-300 For Eshaust Ventilation

Model Number:KA-4t-300
Rated Voltage:380V
Rated Speed:1350RPM
Power:85w
Rated Current:0.21A
Air Flow: 1650m³/h
S Series
Material:Sheet steel
Type of protection: IP54
Approvals: CCC CE
Insulation class:B
Ball bearing:NSK

Appendix D



Devices, Electrical Specifications

I/O Configuration for MPU

Model	DVP 16ES200□*1	DVP 20EX200□*1	DVP 24ES200□*1	DVP 32ES200□*1	DVP 40ES200□*1	DVP 60ES200□*1	Extension I/O
Input X	X0~X7 (8 points)	X0~X7 (8 points)	X0~X17 (16 points)	X0~X17 (16 points)	X0~X27 (24 points)	X0~X43 (36 points)	X20(X50) ~X337*2
Output Y	Y0~Y7 (8 points)	Y0~Y5 (6 points)	Y0~Y7 (8 points)	Y0~Y17 (16 points)	Y0~Y17 (16 points)	Y0~Y27 (24 points)	Y20(Y30) ~Y337*2
Analog input	-	4 channels (12-bit)	-	-	-	-	-
Analog output	-	2 channels (12-bit)	-	-	-	-	-

I/O Configuration for Digital Modules

Model	DVP08XM 211N	DVP08XN 211□*1	DVP08XP 211□*1	DVP16XM 211N	DVP16XN 211□*1	DVP16XP 211□*1	DVP24XN 200□*1	DVP24XP 200□*1	DVP32XP 200□*1
Input X	X20~X27 (8 points)	-	X20~X23 (4 points)*3	X20~X37 (16 points)	-	X20~X27 (8 points)	-	X20~X37 (16 points)	X20~X37 (16 points)
Output Y	-	Y20~Y27 (8 points)	Y20~Y23 (4 points)*3	-	Y20~Y37 (16 points)	Y20~Y27 (8 points)	Y20~Y47 (24 points)	Y20~Y27 (8 points)	Y20~Y37 (16 points)

*1: N refers to relay output, T refers to transistor output (channel N), S refers to transistor output (channel P). For exact launch dates of these models, consult Delta's sales representatives.
*2: DVP16ES2 starts input from X50 (output from Y30) and DVP40ES2 from X30 (output from Y20). All other models start input from X20 and output from Y20. The number of extension I/O increases by 8's multiple. Number less than 8 points are regarded as 8 points.
*3: I/O points less than 8 points are regarded as 8 points.

I/O Configuration for Analog Modules (Channels x Resolution)

Model	DVP 04AD-E2	DVP 04DA-E2	DVP 06XA-E2	DVP 02DA-E2	DVP 04TC-E2	DVP 04PT-E2
Input	AD1~4 (4CHx14-bit)	-	AD1~4 (4CHx14-bit)	-	CH1~4 (4CHx16-bit)	CH1~4 (4CHx16-bit)
Output	-	DA1~4 (4CHx14-bit)	DA1~2 (2CHx14-bit)	DA1~2 (2CHx14-bit)	-	-

Devices in MPU

Type	Device	Item		Range		Function
Relay (bit)	X	External input relay		X0~X377, octal coding, 256 points*1	Total 256 points	Corresponds to external input points
	Y	External output relay		Y0~Y377, octal coding, 256 points*1		Corresponds to external output points
	M	Auxiliary relay	General purpose	M0~M511, 512 points*2 M768~M999, 232 points*1 M2000~M2047, 48 points*1	Total 4,096 points	The contact can be switched between ON/OFF in the program.
			Latched	M512~M767, 256 points*2 M2048~M4095, 2,048 points*1		
			Special purpose	M1000~M1999, 1,000 point (partly latched)		
	T	Timer	100ms (M1028=ON, T64~T126 =10ms)	T0~T126, 127 points*1 T128~T183, 56 points*2 T184~T199 for subroutine, 16 points*1 T250~T255* 6 accumulative points*1	Total 256 points	If the timer designated by TMR instruction reaches the target, the T contact of the same number will be ON.

Devices in MPU

Type	Device	Item			Range		Function
Relay (bit)	T	Timer	10ms (M1038=ON, T200~T245 =1ms)		T200~T239, 40 points*1 *240~T245* 6 accumulative points*1	Total 256 points	If the timer designated by TMR instruction reaches the target, the T contact of the same number will be ON.
			1ms		T127, 1 point*1 *246~T249*, 4 accumulative points*1		
	C	Counter	16-bit counting up		C0~C111, 112 points*1 C112~C127, 16 points*2 C128~C199, 72 points*1	Total 255 points	If the counter designated by CNT (DCNT) instruction reaches the target, the C contact of the same number will be ON.
			32-bit counting up/ down		C200~C223, 24 points*1 C224~C231, 8 points*2		
			32-bit high-speed counter		C235~C244, 1-phase 1 input, 10 points*1 C245~C250, 1-phase 2 inputs, 6 points*1 C232~C234, C251~C254, 2-phase 2 inputs, 7 points*1		
	S	Step relay	Initial		S0~S9, 10 points*2	Total 1,024 points	Devices for step ladder diagram (SFC)
			For zero return		S10~S19, 10 points (used with IST instruction)*2		
			For latched		S20~S127, 108 points*2		
			General purpose		S128~S911, 784 points*2		
			For alarm		S912~S1023, 112 points*1		
Register (word)	T	Present value in timer			T0~T255, 16-bit timer, 256 points		The contact of the timer will be ON when the timing reaches the target.
	C	Present value in counter			C0~C199, 16-bit counter, 200 points C200~C254, 32-bit counter, 55 points		The contact of the counter will be ON when the counting reaches the target.
	D	Data register	General purpose		D0~D407, 408 points*2 D600~D999, 400 points*1 D3920~D9999, 5,980 points*1	Total 10,000 points	The memory area for data storage. E, F can be used for index registers.
			Latched		D408~D599, 192 points*2 D2000~D3919, 1,920 points*2		
			For special registers		D1000~D1999, 1,000 points (partly latched)		
			For special modules		D9900~D9999, 100 points*3*4		
			For index registers		E0~E7, F0~F7, 16 points*5		
Index	N	For main control loop			N0~N7, 8 points		Points for main control loop
	P	For CJ, CALL instructions			P0~P255, 256 points		Position index for CJ and CALL
	I	Interruption	External interruption		I00□(X0), I10□(X1), I20□(X2), I30□(X3), I40□(X4), I50□(X5), I60□(X6), I70□(X7), 8 points (□=1, rising-edge trigger, □=0, falling-edge trigger)		Position index for interruption subroutine
			Timed interruption		I6□□, I7□□, (□□=05~99ms), 2 points		
			Interruption when high-speed counter reaches target		I010 · I020 · I030 · I040 · I050 · I060 · I070 · I080 · 8 points		
			Interruption during communication		I140(COM1) · I150(COM2) · I160(COM3) (*3) · 3 points		
Constant	K	Decimal			K-32,768 ~ K32,767 (16-bit operation) K-2,147,483,648 ~ K2,147,483,647 (32-bit operation)		
	H	Hexadecimal			H0000 ~ HFFFF (16-bit operation) H00000000 ~ HFFFFFFFF (32-bit operation)		

*1: Non-latched area cannot be modified.
*2: Latched area cannot be modified.
*3: COM1 is the built-in RS-232 COM port. COM2 and COM3 are the built-in RS-485 COM ports.
*4: When X input is digitally extended to 256 points, Y output can only be 16 points. When Y output is digitally extended to 256 points, X input can only be 16 points.
*5: Valid only when the MPU is connected to analog modules. Every analog module connected occupies 16 points.

Power Consumption

Model name	Max. power consumption	24VDC supply current (power)
DVP16ES200R/T	30VA	500mA (12W)
DVP24ES200R/T		
DVP32ES200R/T		
DVP40ES200R/T		
DVP60ES200R/T		
DVP20EX200R/T		
DVP24XN200R/T	20VA	100mA (2.4W)
DVP24XP200R/T		
DVP32XP200R/T	R:25VA T: 20VA	
DVP08XM211N	1.2W	無
DVP08XP211R/T	R: 1.2W T: 1W	
DVP08XN211R/T	R: 1.2W T: 0.5W	
DVP16XM211N	2.4W	
DVP16XP211R/T	R: 2.4W T: 1.6W	
DVP16XN211R/T	R: 2.4W T: 1W	
DVP04AD-E2	1W	
DVP02DA-E2	1.5W	
DVP04DA-E2	3W	
DVP06XA-E2	2.5W	
DVP04PT-E2	1.5W	
DVP04TC-E2	1.2W	

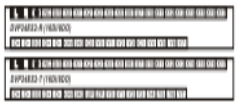
Example:
When the system is composed of 32ES200R + 08XP211R + 16XP211R + 16XN211R, the ES2 MPU can only supply 12 (1.2+2.4+2.4) = 6W.

Dimensions

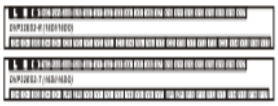
MPU I/O Terminal Layout

DVP16ES200R/T

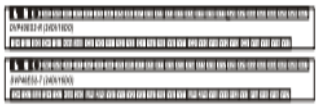
DVP24ES200R/T



DVP32ES200R/T

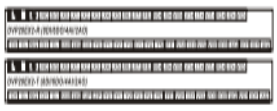


DVP40ES200R/T

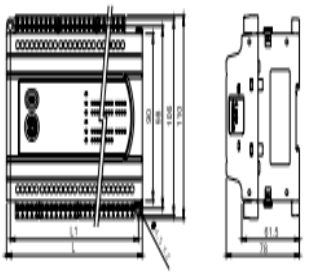


DVP60ES200R/T

DVP20EX200R/T

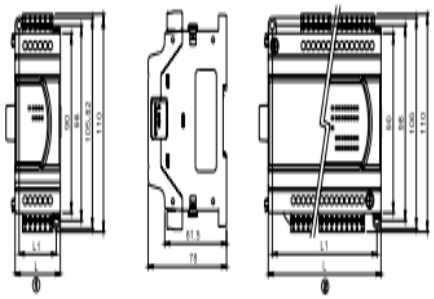


DVP-ES2/EX2 Series MPU



Model name	16ES200R/T	24ES200R/T	32ES200R/T	40ES200R/T	60ES200R/T	20EX200R/T
L	105	125	145	165	225	145
L1	97	117	137	157	217	137

DVP-ES2/EX2 Series Extension Modules



Model name	08XM2 11N	08XP2 11R/T	08XN2 11R/T	16XM2 11N	16XP2 11R/T	16XN2 11R/T	24XP2 00R/T	24XN2 00R/T	32XP2 00R/T
L	45			70			145		
L1	37			62			137		
Type	○			○			○		

Model name	04AD-E2	02DA-E2 04DA-E2	06XA-E2	04PT-E2	04TC-E2
L	70				
L1	62				
Type	○				

Ordering Information

MPU

Product name	Model name	Specification	Output method	Input points	Output points	Certificates
DVP-ES2 series Standard MPU	DVP16ES200R	Power range: 100~240VAC Max. I/O points: 272 Program capacity: 16k steps Data register: 10k words High-speed input: 2 points of 100kHz; 6 points of 10kHz Pulse output: 2 points of 100kHz; 2 points of 10kHz (Transistor output models) COM port: Built-in 1 RS-232 port and 2 RS-485 ports; compatible with Modbus ASCII/RTU protocol; can be Master or Slave	Relay	8	8	
	DVP16ES200T		Transistor	8	8	
	DVP24ES200R		Relay	16	8	
	DVP24ES200T		Transistor	16	8	
	DVP32ES200R		Relay	16	16	
	DVP32ES200T		Transistor	16	16	
	DVP40ES200R		Relay	24	16	
	DVP40ES200T		Transistor	24	16	
	DVP60ES200R		Relay	36	24	
	DVP60ES200T		Transistor	36	24	
DVP-EX2 series Analog MPU	DVP20EX200R	Power range: 100~240VAC Max. I/O points: 272 Program capacity: 16k steps Data register: 10k words High-speed input: 2 points of 100kHz; 6 points of 10kHz Pulse output: 2 points of 100kHz; 2 points of 10kHz (Transistor output models) COM port: Built-in 1 RS-232 port and 2 RS-485 ports; compatible with Modbus ASCII/RTU protocol; can be Master or Slave Analog I/O: Built-in 12-bit 4AD/2DA	Relay	8	6	
			Analog	4	2	
	DVP20EX200T		Transistor	8	6	
			Analog	4	2	

Basic instruction execution time: 0.35 ~ 1μs
MOV (data movement) instruction execution time: 3.4μs
DMUL (32-bit multiplication) instruction execution time: 11.4μs
DEMUL (32-bit floating point multiplication) instruction execution time: 10.3μs

Digital I/O Modules (AC Power Supply)

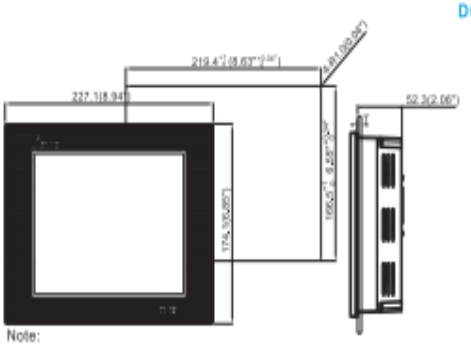
Product name	Model name	Specification	Output method	Input points	Output points	Certificates
DVP-ES2/EX2 series Digital I/O Modules	DVP24XN200R	Power range: 100~240VAC	Relay	-	24	
	DVP24XN200T		Transistor	-	24	
	DVP24XP200R		Relay	16	8	
	DVP24XP200T		Transistor	16	8	
	DVP32XP200R		Relay	16	16	
	DVP32XP200T		Transistor	16	16	

Extension Modules (24VDC Power Supply)

Product name	Model name	Output method	Input points	Output points	Certificates
DVP-ES2/EX2 series Digital I/O Modules	DVP08XM211N	-	8	-	
	DVP08XN211R	Relay	-	8	
	DVP08XN211T	Transistor	-	8	
	DVP08XP211R	Relay	4	4	
	DVP08XP211T	Transistor	4	4	
	DVP16XM211N	-	16	-	
	DVP16XN211R	Relay	-	16	
	DVP16XN211T	Transistor	-	16	
	DVP16XP211R	Relay	8	8	
	DVP16XP211T	Transistor	8	8	
DVP-ES2/EX2 series Analog I/O Modules	DVP04AD-E2	■ 4 points of analog voltage (±10V, ±5V)/current (±20mA, 0~20mA, 4~20mA) input ■ Resolution: 14-bit (-32,000~+32,000) ■ Digital/analog photocoupler isolation; no isolation between channels.			
	DVP04DA-E2	■ 4 points of analog voltage (-10V~+10V)/current (0~20mA, 4~20mA) output ■ Resolution: 14-bit (-32,000~+32,000)/(0~+32,000) ■ Digital/analog photocoupler isolation; no isolation between channels.			
	DVP02DA-E2	■ 2 points of analog voltage (-10V~+10V)/current (0~+20mA, 4~20mA) output ■ Resolution: 14-bit (-32,000~+32,000)/(0~+32,000) ■ Digital/analog photocoupler isolation; no isolation between channels.			
	DVP06XA-E2	■ 4 points of analog voltage (±10V, ±5V)/current (±20mA, 0~20mA, 4~20mA) input ■ Input resolution: 14-bit (-32,000~+32,000) ■ 2 points of analog voltage (-10V~+10V)/current (0~20mA, 4~20mA) output ■ Output resolution: 14-bit (-32,000~+32,000)/(0~+32,000) ■ Digital/analog photocoupler isolation; no isolation between channels.			
DVP-ES2/EX2 series Temperature Measurement Modules	DVP04PT-E2	■ 4 points of platinum RTD resistance (Pt100, Pt1000, Ni100, Ni1000) temperature sensor input/0~300Ω resistance input ■ Resolution: 16-bit ■ Digital/analog photocoupler isolation; no isolation between channels. ■ Built-in PID temperature control			
	DVP04TC-E2	■ 4 points of thermocouple (J, K, R, S, T, E, N Type) temperature sensor input/-80mV~+80mV voltage input ■ Resolution: 16-bit ■ Digital/analog photocoupler isolation; isolations between channels. ■ Built-in PID temperature control			

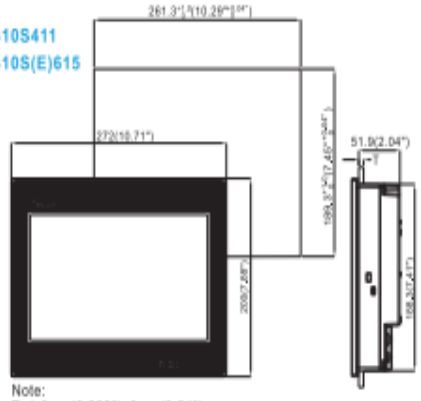
Appendix E

● DOP-B08S(E)515



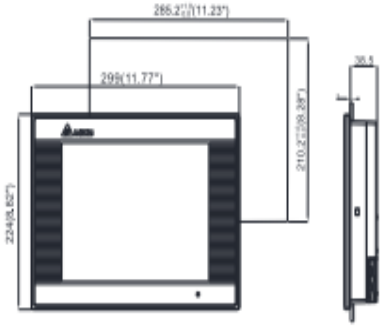
Note:
T=1.6mm(0.06") ~5.0mm(0.19")

● DOP-B10S411
DOP-B10S(E)615



Note:
T=1.6mm(0.063")~6mm(0.24")

● DOP-B10S511
DOP-B10E515



Note:
T=1.6mm(0.063")~6mm(0.24")

Ordering Information

DOP - B 07 S 4 15 K

[Production Name]
DOP: Delta Operation Panel

[Series] B: B Series HMI

[Display Size]
03: 4 3 inches / 05: 5.6 inches
07: 7 inches / 08: 8 inches
10: 10.1 inches

[Type] S: Standard Type /
E: Ethernet Type / PS: Professional Type

[Resolution] 1: QVGA 2: WQVGA
4: WVGA 5: SVGA 6: WXGA

[Version Code]

[Function Key]

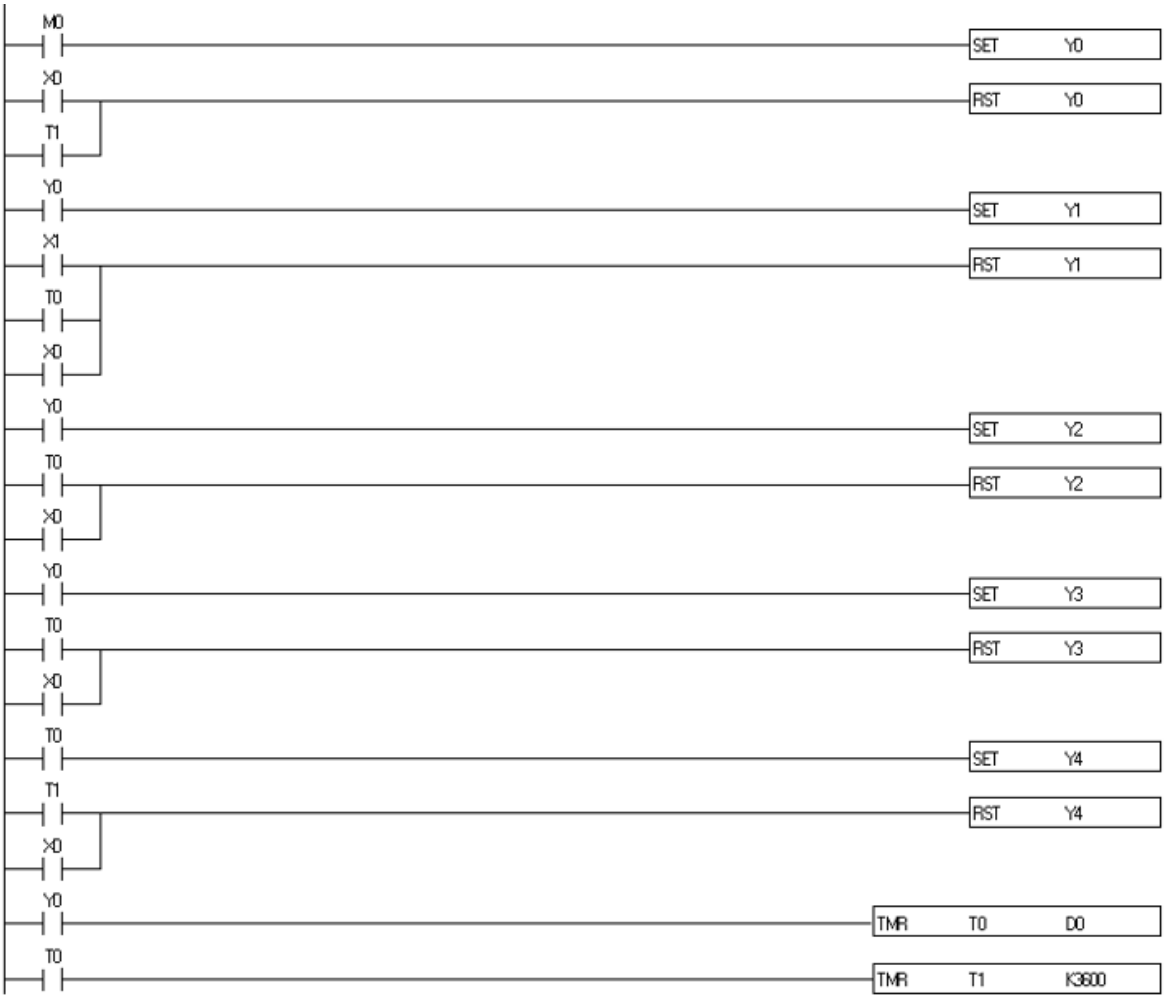
16

DELTA

Specifications

MODEL		DOP-B03S211	DOP-B03E211	DOP-B05S111	DOP-B07S411	DOP-B07S401K DOP-B07S411K	DOP-B07S415 DOP-B07PS415	DOP-B07E415
LCD MODULE	Display Type	4.3" TFT LCD (65536 colors)		5.6" TFT LCD (65536 colors)	7" Widescreen TFT LCD (65536 colors)			
	Resolution	480 x 272 pixels		320 x 234 pixels	800 x 480 pixels			
	Backlight	LED Back Light (less than 20,000 hours half-life at 25°C)[Note 1]						
	Display Size	95.04 x 53.856mm		113.28 x 84.70mm	154.08 x 85.92mm		152.4 x 91.44mm	
Operating System		Delta Real Time OS						
MCU		32-bit RISC Micro-controller						
Flash ROM		Flash ROM 128 MB(OS System: 30MB / Backup: 16MB / User Application: 82MB)						
SDRAM		64Mbytes						
Backup Memory		16Mbytes						
Sound Effect Output	Buzzer	Multi-Tone Frequency (2K ~ 4K Hz) / 85dB						
	AUX	N/A	N/A	N/A	N/A	N/A	N/A	Stereo output
Ethernet Interface		N/A	IEEE 802.3, IEEE 802.3u 10/100 Mbps Auto-sensing (has built-in isolated power circuit[Note 4])	N/A	N/A	N/A	N/A	IEEE 802.3, IEEE 802.3u 10/100 Mbps Auto-sensing (has built-in isolated power circuit[Note 4])
Memory Card		N/A	N/A	N/A	N/A	N/A	SD card (support SDHC)	
USB		1 USB Host[Note 2] Ver 1.1 / 1 USB Client Ver 2.0						
Serial COM Port	COM1	RS-232 (Supports hardware flow control) / RS-485		RS-232 (supports hardware flow control)				
	COM2	RS-422 / RS-485		RS-232 / RS-485			RS-232 / RS-422 RS-485	RS-232 / RS-422 RS-485 (has built-in isolated power circuit[Note 3])
	COM3	N/A		RS-422 / RS-485			RS-232 / RS-422 RS-485	RS-232 / RS-422 RS-485(has built-in isolated power circuit[Note 3])
Function Key		N/A				8	N/A	
Perpetual Calendar(RTC)		Built-in						
Cooling Method		Natural air circulation						
Safety Approval		CE / UL[Note 6] / KCC[Note 6]						
Waterproof Degree		IP65 / NEMA4						
Operation Voltage[Note 5]		DC +24V(-10% ~ +15%) (please use isolated power supply)						DC +24V (-10% ~ +15%) (has built-in isolated power circuit[Note 5])
Voltage Endurance		AC500V for 1 minute (between charging DC24 terminal and FG terminals)						
Power Consumption[Note 6]		2.64W	2.64W	3.8W	4W	4W	5W	7.5W
Backup Battery		3V lithium battery CR2032 x 1						
Backup Battery Life		It depends on the temperature used and the conditions of usage, about 3 years or more at 25°C						
Operation Temp		0°C ~ 50°C						
Storage Temp		-20°C ~ +60°C						
Ambient Humidity		10% ~ 90% RH [0 ~ 40°C], 10% ~ 55% RH [41 ~ 50°C], Pollution Degree 2						
Vibration / Shock		IEC 61131-2 compliant 5Hz ~ 8.3Hz = Continuous: 3.5mm, 8.3Hz ~ 150Hz = Continuous: 1.0g IEC 60068-2-27 compliant 15g peak for 11 ms duration, X, Y, Z directions for 6 times						
Dimensions (W) x (H) x (D) mm		129 x 103 x 39	129 x 103 x 39	184 x 144 x 50	215 x 161 x 50	215 x 161 x 50	215 x 161 x 50	215 x 161 x 50
Panel Cutout (W) x (H) mm		118.8x 92.8	118.8x 92.8	172.4 x 132.4	196.9 x 142.9	196.9 x 142.9	196.9 x 142.9	196.9 x 142.9
Weight		Approx. 236g	Approx. 264g	Approx. 678g	Approx. 826g	Approx. 820g	Approx. 970g	Approx. 976g

Appendix F


M0
SET Y0
X0
RST Y0
T1
Y0
SET Y1
X1
RST Y1
T0
X0
Y0
SET Y2
T0
RST Y2
X0
Y0
SET Y3
T0
RST Y3
X0
T0
SET Y4
T1
RST Y4
X0
Y0
TMR T0 D0
T0
TMR T1 K3600