Abstract

229

Thyme Separating Machine

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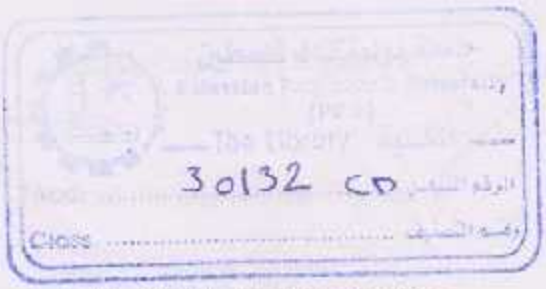

Palestine Polytechnic University

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[3] Gregory K. McMillan, Douglas M. Clonidine (Ed), Process/Industrial Instruments and Controls Handbook Fifth Edition, McGraw-Hill, 1999 ISBN 0-07-012582-1 Section 3 Controllers

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Abstract

Nowadays, we are facing many problems of manual separating thyme from stalk process. These problems are difficult to produce big amounts of thyme in a short time and lack of production and high cost. Because of these problems, our idea is to design full automatic system that works on separate thyme from stalk by using technology and modern techniques, to produce separated thyme high efficient and fast low cost production.

During this project it was running the most important part of the system and is (Zig-Zag Channel) and control via the logical control programmer (PLC) in addition to the construction of the electrical panel containing control circuits and power circuits, which will supply the machine needed for its energy.

There is a closed air flow cycle inside the system via the suction motors, the air glow is be controlled by controlling the speed of the suction motors by using the Variable Frequency Drivers (VFD).

الملخص

في الوقت الحاضر، نواجه العديد من المشاكل في عملية فصل الزعتر. تعمل هذه المشاكل في صعوبة انتاج كميات كبيرة من الزعتر في وقت قصير وعدم الوصول الى الكفاءة المطلوبة. وبسبب هذه المشاكل فكرتنا هي تصميم نظام اوتوماتيكي يعمل على فصل أوراق الزعتر عن ساقه من خلال استخدام التكنولوجيا والتقنيات الحديثة للحصول على كفاءة وسرعة في الإنتاج بأقل تكلفة.

خلال خذا المشروع تم العمل على تشغيل اهم جزء في النظام وهو (Zig-Zag Channel)والتحكم به من خلال وحدات التحكم المنطقي المبرمج (PLC) بالإضافة الى بناء لوحة كهربائية تحتوي دوائر التحكم و دوائر القدرة التي ستزود الماكينة بالطاقة اللازمة لعملها.

تم عمل دورة هواء مغلقة داخل الماكينة عن طريق محركات الشفط وتم التحكم في سرعة الهواء الخارج من محركات الشفط عن طريق التحكم في سرعة محركات الشفط من خلال ال (Variable Frequency Inverters).

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1.1 Overview

This chapter illustrates an introduction to the project, the objectives and motivation of the project.

This chapter also shows the methodology used to build and complete this system, the parts of the system is mentioned, some of risk management, results and problems are mentioned, the estimated cost is modified, after that, the control of the report is shown.

1.2 Introduction

Nowadays, industrial machine is very important in the daily life, get the task to be done very fast than before .thus; the production line for the product is given more and bigger. Now the intelligent computers and intelligent control system is introduced to a machine to increase its accuracy and safety when doing work, it is also important for the production process that is complicated to deal with.

Thyme machine, with its new design help the industrial companies to produce clean thyme with short time compared with a human work time. This new design decreases the number of workers to do the task.

1.3 Project Idea and Quality

The idea of the project is to design and implement a machine that produce a thyme by an automatic way and is controlled by a programming PLC.

In Palestine and other Arab world countries, there's need for machine that gives a high quality of thyme, our project will give higher quality than all current ways of traditional production methods, by using a modern method of production that will concerned cleanliness of the product and an elaborate form of the product.

According to the questionnaire, the machine must have the following features:

1. Low noise.
2. Ease for use.
3. High safety factor, safe for worker.
4. Keeps clean and healthy

1.4 Project Objectives

This project aims to achieve the following:

- Increase supplying thyme product to markets.
- To produce thyme leaves with high purity, with less impurities and crushed stems, by separating leaves out of stems using thyme Separation machine.
- Rid of traditional ways of thyme separation.
- Implement a new technology to the machine in order to increase its accuracy, safety, and reduce the losses.

1.5 Time schedule for the project

- Stage 1 : Select the Idea

Determine the idea of the project, the motivation and the main objectives that intend to be achieved.

- Stage 2 : preparing for the project and collecting data

In this stage, more and deeper determination of the tasks and steps are done, and more information about the project is prepared.

- Stage 3 :project Analysis

In this step, a study of all possible design option to determine the design process.

- Stage 4 : Determine the project requirement

After determine the project design scheme, the entire needed requirement detailed mathematical model for the system is specified, software and hardware and try to bring them to be ready for the implementation stage.

- Stage 5 : Documentation Writing

Documenting the project is beginning from the first stage to the last stage.

- Stage 6 : make the hardware available

In this stage, the needed hardware devices are brought for the next steps, motors, PLC, and gears.

- Stage 7 :build up the machine and finishing

All the machine equipment and devices bought it there is an available source in the market or if not, going to the lath to introduce the mechanical parts.

- Stage 8: testing the machine

Detect if there is an error occurred and making a report about that.

- Stage 9 : finishing the graduation final report

All documentation has made is to be checked and done in this stage, every change in it is to be added and to be noticed that something is changed.

- Stage 10 : preparing for the final presentation

The presentation will prepare to show the project and its parts

Table (1.1): Timing plant of the first semester

Task	W 1	W 2	W 3	W 4	W 5	W 6	W 7	W 8	W 9	W 10	W 11	W 12	W 13	W 14
Stage 1														
Stage 2														
Stage 3														
Stage 4														
Stage 5														

Table (1.2): Timing plant of the second semester

Task	W 16	W 17	W 18	W 19	W 20	W 21	W 22	W 23	W 24	W 25	W 26	W 27	W 28	W 29
Stage6														
Stage 7														
Stage 8														
Stage 9														
Stage 10														

1.6 Total cost for the project

Table (1.3): Total Cost

Components	Price(NIS)	Quantities	Total Cost(NIS)
Contactors	100	6	600
PLC(Fatek)	800	1	800
Overloads	150	5	750
Motors	300	5	1500
Suction Motors	600	2	1200
Inverter	600	2	1200
Gears	250	5	1250
switches	9	25	225
Cyclone	100	2	200
Pipe	150	5	150
Body	2000	-	2000
Other Components	800	-	800
		Total Cost=	10675 NIS

Chapter Two

Theory

2.1 Introduction

2.2 Zig-Zag Separator

2.3 Cyclone Air Separator

2.4 Electrical Components

2.4.1 PLC

2.4.2 Variable Frequency Drive (VFD).

2.4.3 Protection

2.4.4 Contactor

2.5 Gears.

2.6 Traditional Method of Sieving Thyme.

2.7 Automated Method of Production.

2.8 Block Diagram.

2.1 Introduction

In this chapter we will show all of main techniques it will used in the desired design, and it will be discuss the traditional ways of separation and sieving thyme. After using this technologies and knowing how the traditional ways working on separate thyme we will finally design our machine according on it.

2.2 Zig-Zag Separator

Zigzag air classification is a separation process in which particles are classified mainly according to their falling behavior in airflow. Figure 2.1 shows a zigzag air classifier. The channel consists of rectangular sections joined together at an angle to create a zigzag shape. A dispersion of particles is fed to this channel. The aerodynamically "light" particles are carried to the top by the airflow that is led through the classifier. The "heavy" particles fall to the bottom. In principle, many channel configurations are possible. Some of these have been patented. Differences in configuration are for instance. [1]

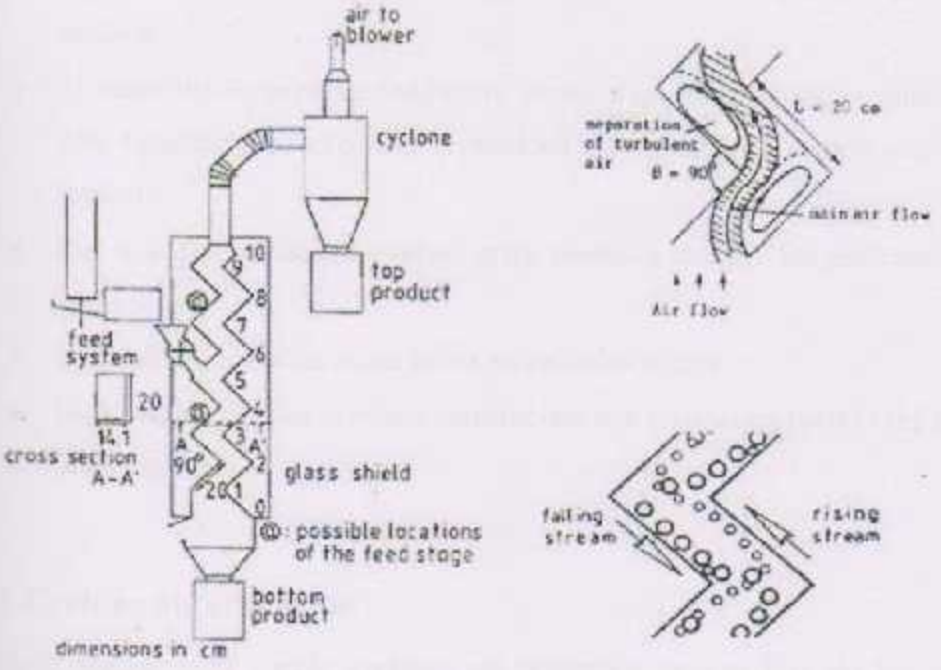


Figure (2.1): Geometry of 90 degree of zig-zag separator.

Zig-Zag air separator the feed material is conveyed onto an airproof item to the separator channel. According to the multiple-cross flow-separating process, light material is separated from heavy material. The airflow required for separation is blown through the separation channel from button to top. Light material is carried by the airflow. Heavy material is carried by the airflow. Heavy material falls through the airflow and is discharged through the separator base. The light material transported by the airflow to the cyclone is separated there and is discharged via rotary gate valve. Zig-Zag Air Separator Plants are usually operated in recirculation air mode, whereby the cleaned air is returned via blower to the separator base. In case of dusty or moist products the operation of the plant is also possible in partly air circulation or suction mode. A radial blower generates the required airflow and pressure.

Application of the Zig-Zag air separator:

- Very precise separation due to by multi-stage-cross-flow separation (8 to 15 separation stages).
- Based on arranged upon another separation steps and the consequential multiple impacts of the mass flow, the desagglomeration and release of product knots is ensured.
- To reach stable operating conditions, we use a special designed ventilator rotor disk. Constant product quality is provided via regulation of airflow and -control (option).
- Due to additional cleaning valves in the separator channel, the plant can be cleaned easily.
- In the air recirculation mode exists no emission source.
- High availability due to robust construction and no rotating parts in the separator.
- Sturdy design.

2.3 Cyclone air separator

Cyclone separators or simply cyclones are separation devices that use the principle of inertia to remove particulate matter from flue gases. Cyclone separators are part of a group of air pollution control devices known as recliners as they are generally used to roughly remove larger pieces of particulate matter. This prevents finer filtration methods from

having to deal with large, more abrasive particles later one. As well, several cyclone separators can operate in parallel, and when this is set up the system is known as a multi cyclone.

It is important to note that cyclones can vary drastically in their size. The size of the cyclone depends largely on how much flue gas must be filtered, and thus larger operations tend to need larger cyclones. For example, several different models of one cyclone type can exist, and the sizes can range from a relatively small 1.2-1.5 meters tall (about 4-5 feet) to around 9 meters or about 30 feet (which is about as tall as a three story building).

How it works: In a cyclone separator, dirty flue gas is fed into a chamber. Inside this chamber exists a spiral vortex, similar to a tornado. This spiral formation and the separation are shown in Figure (2.2). The lighter components of this gas have less inertia, so it is easier for them to be influenced by the vortex and travel up it. Unlike these particles, larger components of particulate matter have more inertia and are not as easily influenced by the vortex. [2]

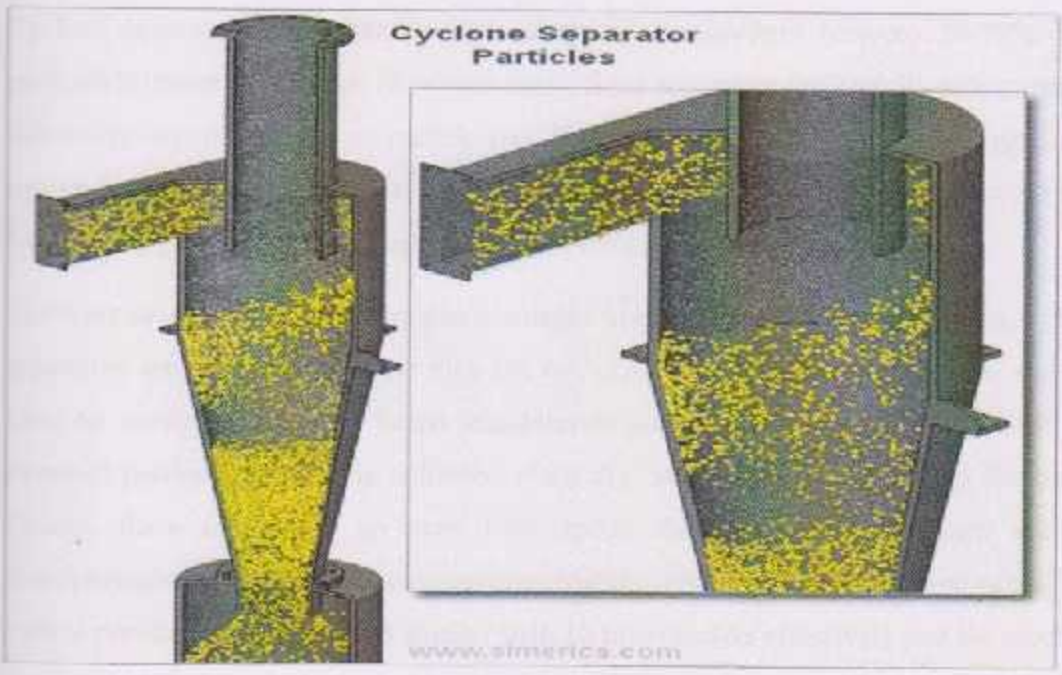


Figure (2.2): Cyclonic separator.

Because these larger particles have difficulty following the high-speed spiral motion of the gas and the vortex, the particles hit the inside walls of the container and drop down into a collection hopper. These chambers are shaped like an upside-down cone to promote the collection of these particles at the bottom of the container. The cleaned flue gas escapes out the top of the chamber.

Most cyclones are built to control and remove particulate matter than is larger than 10 micrometers in diameter. However, there do exist high efficiency cyclones that are designed to be effective on particles as small as 2.5 micrometers. As well, these separators are not effective on extremely large particulate matter. For particulates around 200 micrometers in size, gravity settling chambers or momentum separators are a better option.

Out of all of the particulate-control devices, cyclone separators are among the least expensive. They are often used as a pre-treatment before the flue gas enters more effective pollution control devices. So, cyclone separators can be seen as "rough separators" before they reach the fine filtration stages.

Cyclone separators are generally able to remove somewhere between 50-99% of all particulate matter in flue gas. How well the cyclone separators are actually able to remove this matter depends largely on particle size. If there is a large amount of lighter particulate matter, less of these particles can be separate out. Because of this, cyclone separators work best on flue gases that contain large amounts of big particulate matter.

There are several advantages and disadvantages in using cyclone separators. First, cyclone separators are beneficial because they are not expensive to install or maintain, and they have no moving parts. This keeps maintenance and operating costs low. As well, the removed particulate matter is collected when dry, which makes it easier to dispose of. Finally, these units take up very little space. Although effective, there are also disadvantages in using cyclone separators. Mainly, the standard models are not able to collect particulate matter that is smaller than 10 micrometers effectively and the machines are unable to handle sticky or tacky material well.

2.4 Electrical Components

This section contains the electrical component specifications (contactors, and frequency inverter) and electrical protection from failures.

2.4.1 Programmable Logic Controller (PLC):

A programmable logic controller (PLC) or programmable controller is a digital computer used for automation of electromechanical processes. PLC is designed for multiple inputs and output arrangements, extended temperature ranges, immunity to electrical noise and to vibration and impact.

PLC consists of:

- Central processing Unit (CPU).
- Power Supply Unit.
- Memory Unit.
- Input/output Interface
- Programming Device.

These components are shown in figure (2.3).

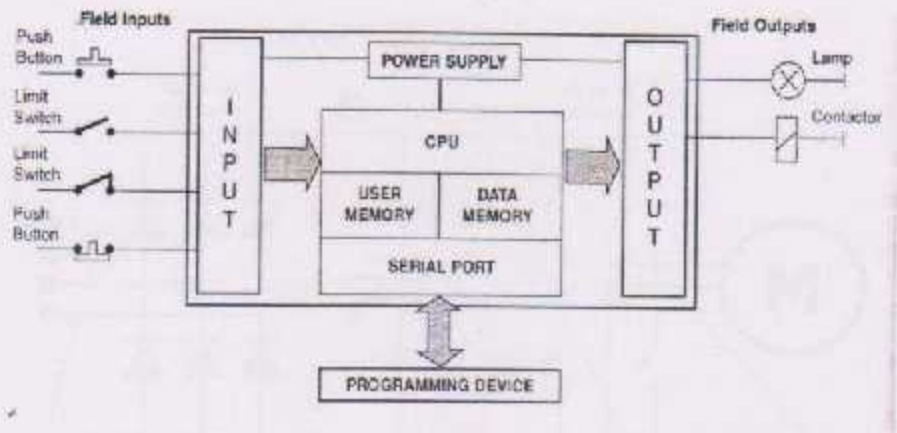


Figure (2.3): PLC Components.

2.4.2 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. Figure (5.2) shows the circuit of VFD and how finally gets a variable voltage and variable frequency. [3]

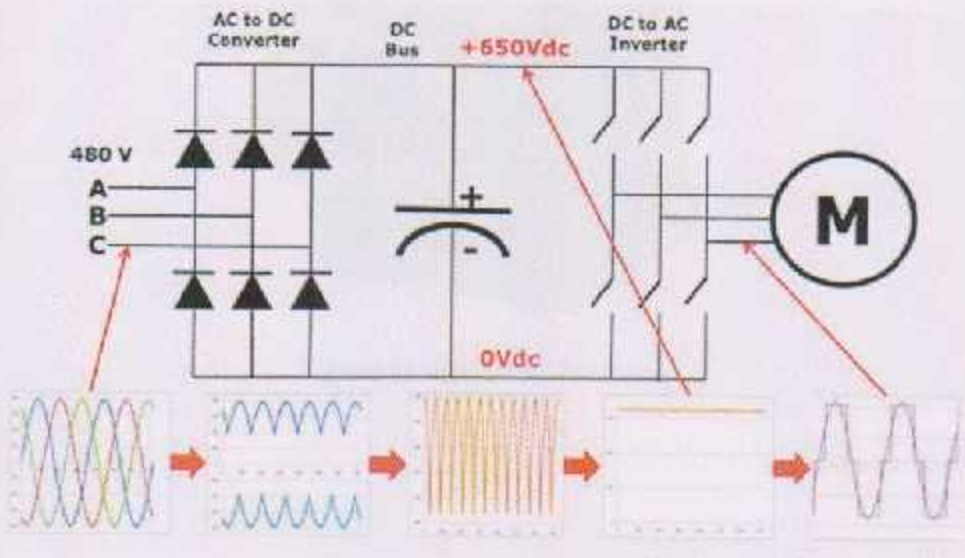


Figure (2.4): Convert from constant AC to variable AC.

2.4.3 Protection

Circuit Breaker (CB):

If a power surge occurs in the electrical wiring, the breaker will trip this means that a breaker that was in the on position will flip to the off position and shut down the electrical power leading from the breaker. Essentially, a circuit breaker is a safety device. When a circuit breaker is tripped it may prevent a fire to start in overloaded circuit, it can also prevent the destruction of the device that is drawing the electricity. As shown in figure (2.5).

Figure (2.5): Circuit breaker

Overload relay:

Overload relays shown in figure (2.6) are intended to protect motors, controllers and branch-circuit conductors against excessive heating due to prolonged motor over currents up to and including locked rotor currents. Protection of the motor and other branch-circuit components from higher currents, due to short circuits or grounds, is a function of branch-

circuit fuses, circuit breakers or motor short-circuits protectors. The system needs two overloads to protect the vibrations motors.

Figure (2.6): Overload relay.

Emergency-Stop Button:

Emergency-Stop Button is shown in figure (2.7) 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 (2.7): Emergency-Stop Button

Earth leakage:

An Earth-leakage shown in figure (2.8) is a safety device used in electrical installations with high earth impedance to prevent shock. It detects small stray voltages on the metal enclosures of electrical equipment, and interrupts the circuit if a dangerous voltage is detected. Once widely used, installations that are more recent instead use residual current circuit breakers that instead detect leakage current directly.

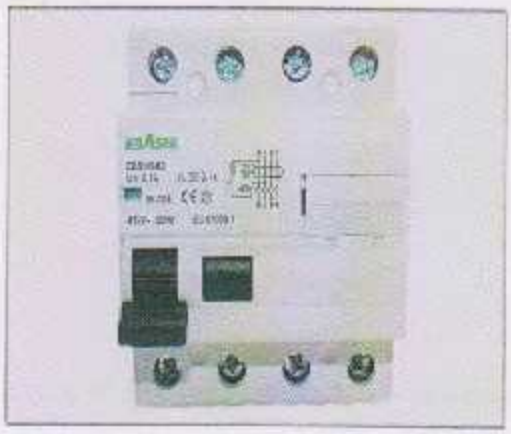


Figure (2.8): Earth leakage.

2.4.4 Contactors

Contactors are an electrically controlled switch used for switching a power circuit similar to a relay except with higher current ratings.

A contactor is controlled by a circuit that has a much lower power level than the switched circuit.

Contactors come in many forms with varying capacities and features. Unlike a circuit breaker, a contractor is not intended to interrupt a short circuit current, contactors range from several amperes to thousands of amperes. The physical size of contactors ranges from a device small enough to pick up with on hand to large device as shown in figure (2.9). In this project, we used two contactors for two vibrating motors.

Figure (2.9): Contactor.

2.5 Gears

A gear motor is a specific type of electrical motor that is designed to produce high torque while maintaining a low horsepower, or low speed, motor output. Gear motors can be found in many different applications, and are probably used in many devices in your home.

Gear motors are commonly used in devices such as can openers, garage door openers, washing machine time control knobs and even electric alarm clocks. Common commercial applications of a gear motor include hospital beds, commercial jacks, cranes and many other applications that are too many to list.

A gear motor shown in figure (2.10) can be either an AC (alternating current) or a DC (direct current) electric motor. Most gear motors have an output of between about 1,200 to 3,600 revolutions per minute (RPMs). These types of motors also have two different speed specifications: normal speed and the stall-speed torque specifications.

Gear motors are primarily used to reduce speed in a series of gears, which in turn creates more torque. This is accomplished by an integrated series of gears or a gearbox being attached to the main motor rotor and shaft via a second reduction shaft. The second shaft is then connected to the series of gears or gearbox to create what is known as a series of

reduction gears. Generally speaking, the longer the train of reduction gears, the lower the output of the end, or final, gear will be.[4]

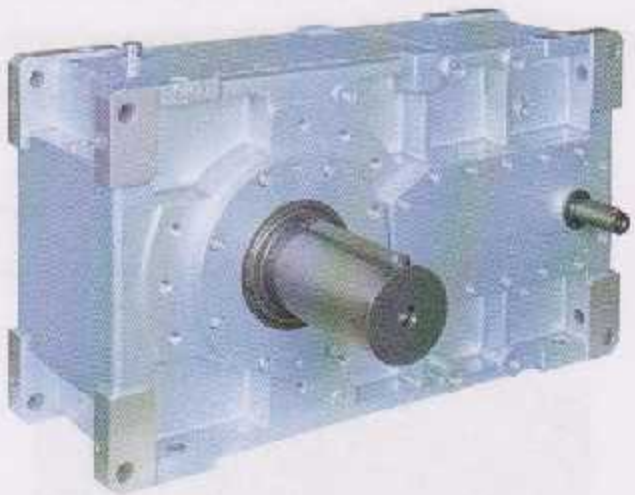


Figure (2.10): The Gear

2.6 Traditional method of sieving thyme.

The only way of sieving thyme is the traditional way, it's just a sieve as shown in figure (2.11) the thyme is put on it after that the sieving be shaken to get pure thyme (without stalk).

Figure (2.11): Traditional sieve.

This traditional way for sieving thyme has many drawbacks the most important is:

1. When it is required to produce a large amount of pure thyme the traditional way will fail, because the process will take long time to end the task.
2. Human drudgery: the thyme is sieve by a traditional sieve so its need many of workers. Therefore, this way increases human drudgery.
3. Low productivity: nowadays the population is increasing that is meaning the demand is rising. Therefore, this does not work in this case.

✓ Traditional method process:

They get thyme from farmers as shown in this figure (2.12):

Figure (2.12): Thyme from farmers.

After that, they use big holes sieve to red of the large size of stalks as shown in figure (2.13)

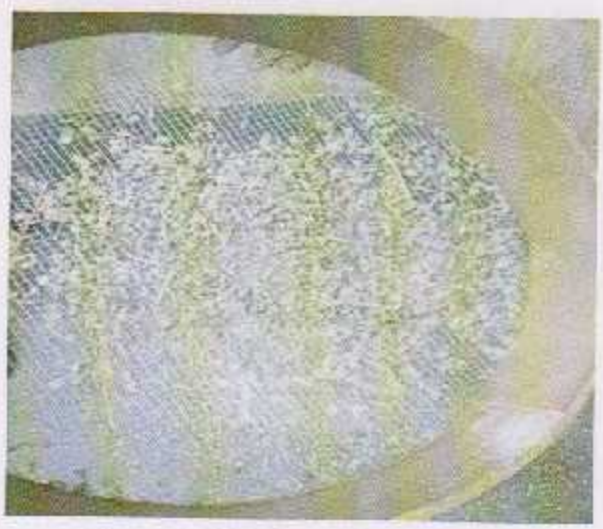


Figure (2.13): Removing large stalks.

And then they use thyme that get out from the first sieve process and put it inside the grinding machine to make the leaf softer sieve it by smaller holes sieve as shown

In figure (2.14) and figure (2.15), we can see the grinding machine and smaller sieve:

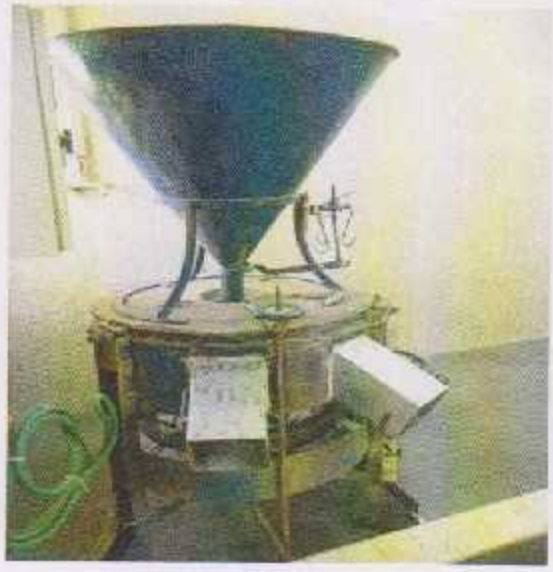


Figure (2.14): Grinding machine.

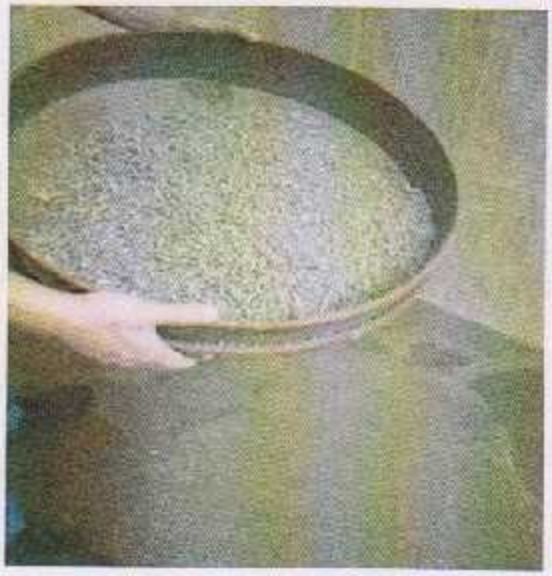


Figure (2.15): Smaller holes sieve.

As we describe before, they use the smaller holes sieve and repeat sieving thyme many times to get the pure thyme without any small stalks as shown in figure (2.16).

Figure (2.16): Pure thyme.

2.7 Automated Method of Production.

The airflow required for separation is blown through the separation channel from button to top. Light material is carried by the airflow up stream in to cyclone and through rotary sack in to sack on to the next conveyor. Heavy material cannot be carried by the airflow, falls through the airflow, and is discharged through the separator base.

The light material transported by the airflow to the cyclone is separated there and is discharged via rotary gate valve.

Zig-Zag Air Separator Plants are usually operated in recirculation air mode, whereby the cleaned air is returned via blower to the separator base. In case of dusty or moist products, the operation of the plant is also possible in partly air circulation or suction mode. A radial blower generates the required airflow and pressure. Shown in figure (2.17).

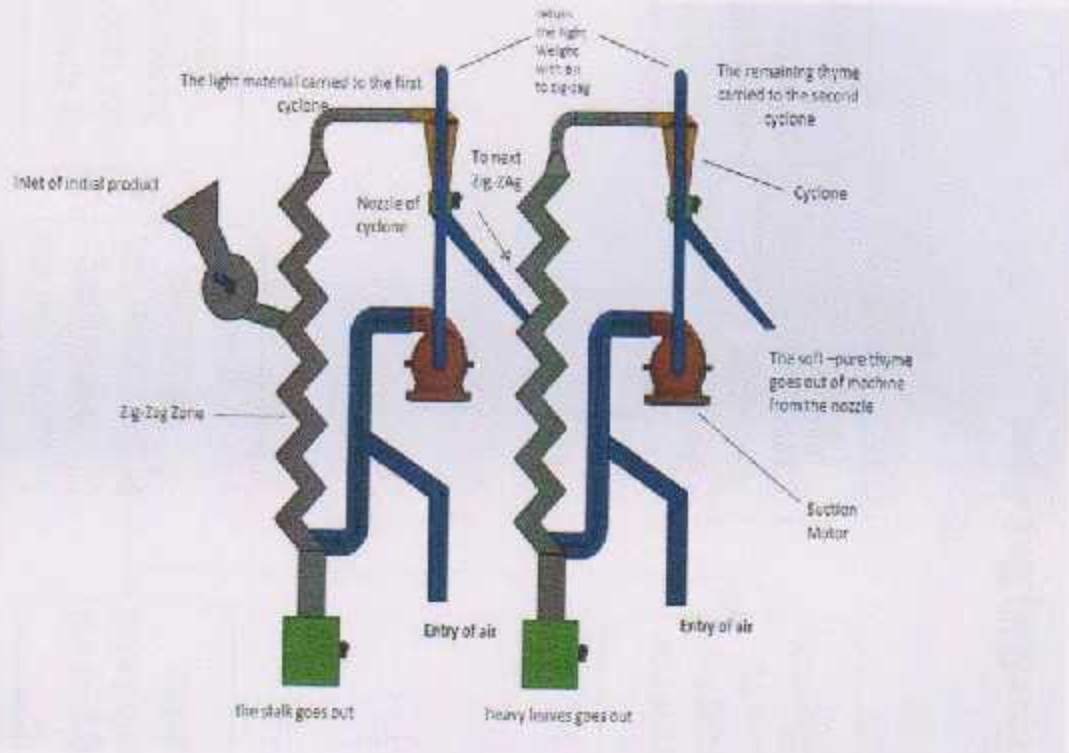


Figure (2.17): Principle of operation in our machine.

2.8 Block diagram

The block diagram as shown below explains how the thyme move inside the machine step by step into stages to reach the final destination. As shown in figure (2.18).

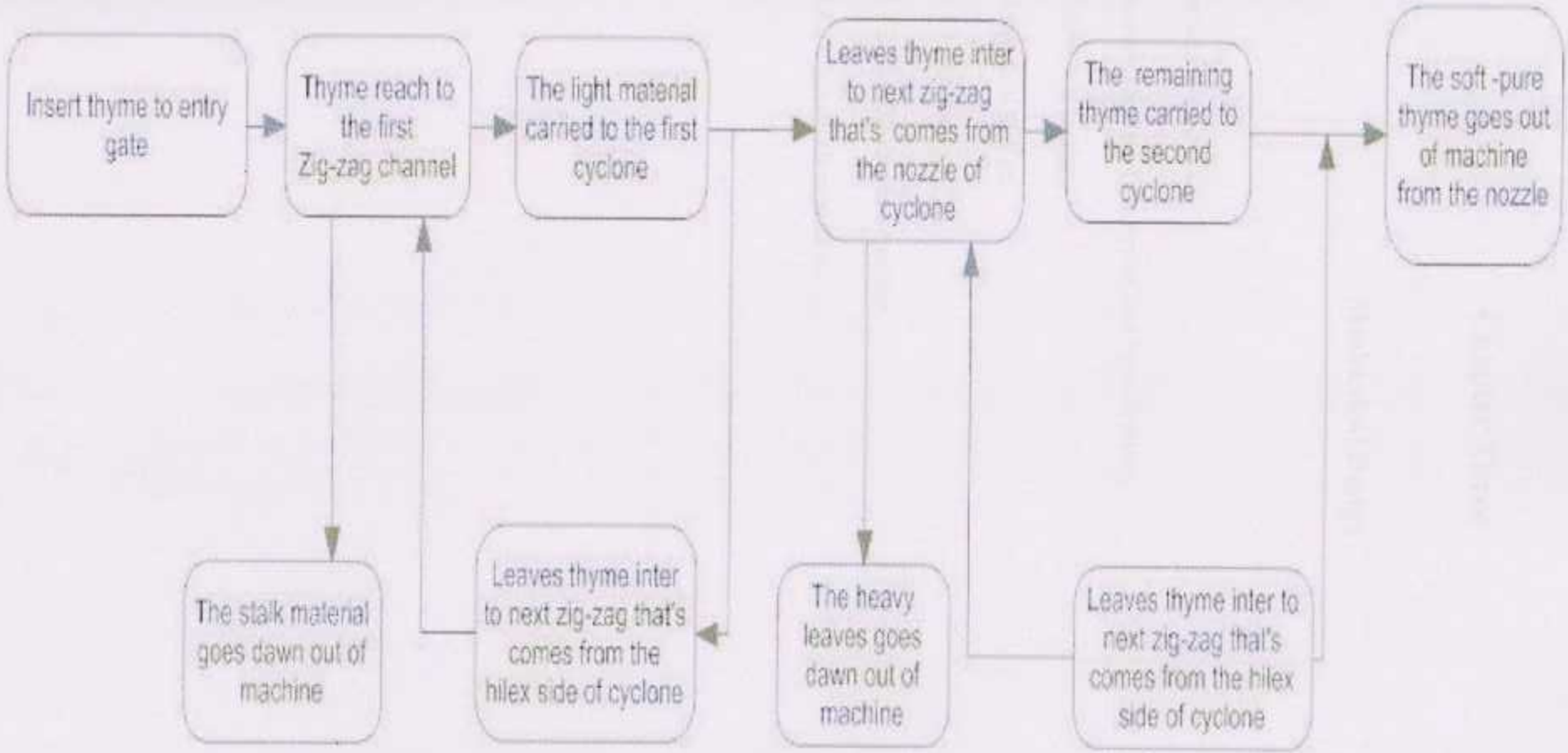


Figure (2.18) :Block diagram

Chapter Three

Mechanical Design

3.1 Introduction.

3.2 Proposed System Description and Specifications.

3.3 Conceptual Design.

3.4 Mechanical Design.

3.4.1 The gates.

3.4.2 The Zig-Zag air separator.

3.4.3 Cyclone air separator.

3.1 Introduction

In this chapter, we will talk about the mechanical parts, the elements used and the construction of the implementation method. Moreover, there are detailed dimensions of the whole elements used with directed positions.

The mechanical system in the project has major part, these parts are combined together to form mechanical units, in addition these units are combined together for forming the machine.

The proposed design depends on the sequence of mechanical movement in the machine, starting from entry gate passing through Zig-Zag channel and cyclone separator.

3.2 Proposed System Description and Specifications

This chapter demonstrate how to design the machine, and how to make a solution for current problem, in our project we will show the new technology in separating thyme using air cleaner and using a full automated machine programmed with a PLC, to ensure that the product will be pure (without stalk) as possible.

Machine is bind as shown in figure (3.1).

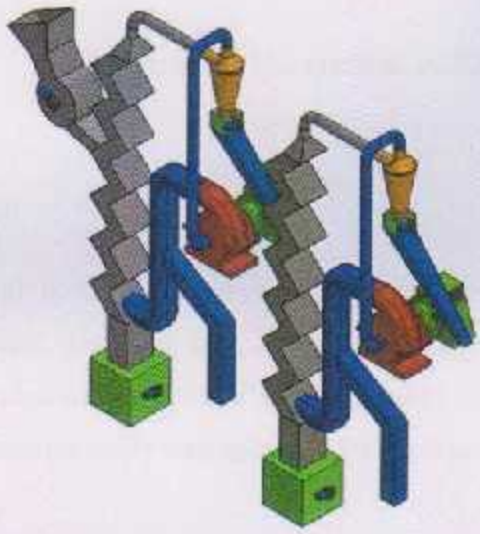


Figure (3.1): The machine in 3D.

The dimensions of whole machine are 2.45m height and 3.44m width as shown in figure (3.2).

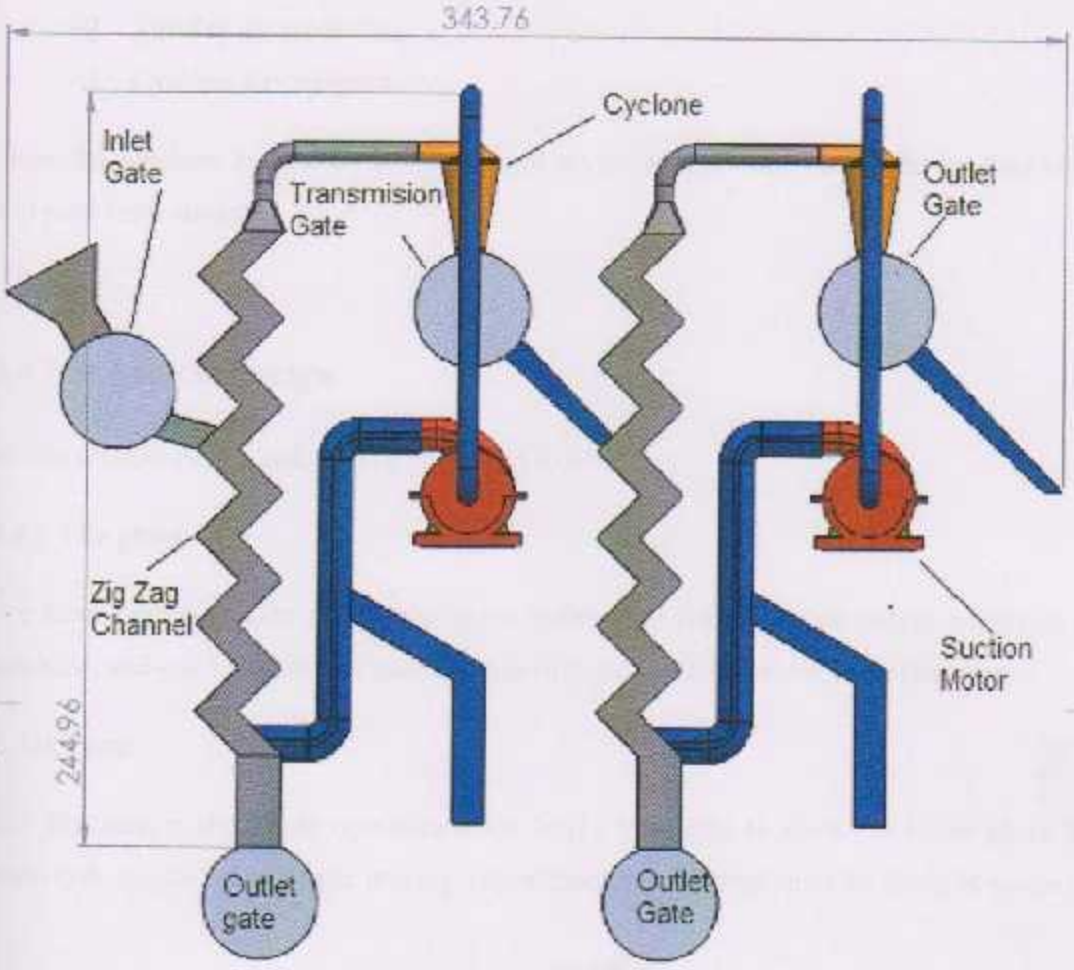


Figure (3.2): The machine in 2D.

3.3 Conceptual Design

It's desired to design and produce a thyme separator machine fully automated and controlled, the process starts when the user, After study many design and strategies of different machines and visited companies that's work in herbs and oregano production, so we reach to design that contains many strategies of sieving thyme to meet requirement of market.

In our design the machine is divided into two stages, every stage consist of two parts:

1. Thyme feed system.
2. Zig-Zag air separator.
3. Cyclone air separator.

Since the machine is used for production of thyme and in order to get the product clean and pure from stalks.

3.4 Mechanical Design

In this section, each block will be explained in details:

3.4.1 The gates.

We have one inlet gate for thyme, three outlet gate for deference output of thyme in machine, and one transmission gate that transmit the material between the two stages.

1. Inlet gate

The first step in the whole operation starts in the inlet gate as shown in figure (3.3), the main task of gate move thyme into zig-zag without any infiltration of air cycle in system.

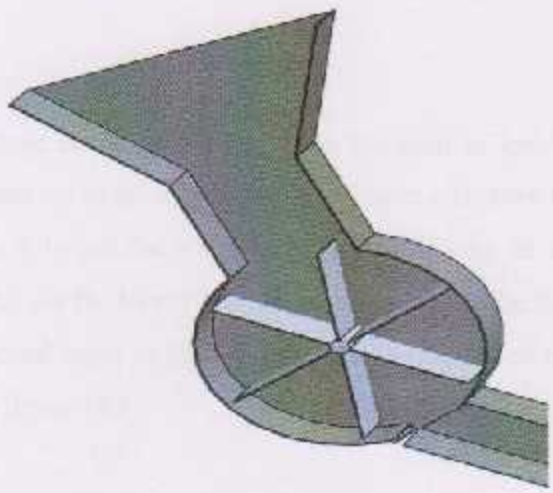


Figure (3.3): The inlet gate.

The demotions of the inlet gate are shown in figure (3.4).

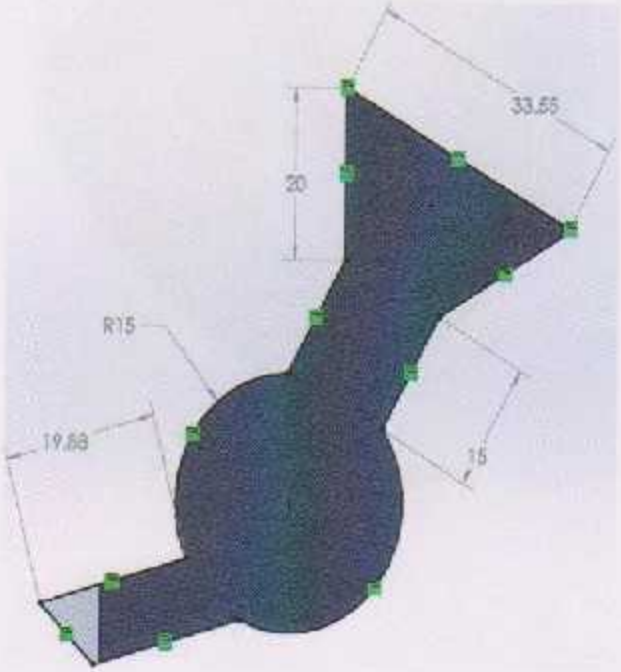


Figure (3.4): The dimensions of inlet gate.

2. Outlet gates:

In the machine there is three outlet gates, the main function to get the material out of machine without any infiltration of air cycle in system, each one have deferent output, the first one in the first stage it is get the stalk out, the second one in second stage at the bottom of second zig-zag to get the heavy leaves out of machine, the third one its position after the cyclone in the second stage to get the very-soft thyme out of machine. The shape of outlet gates is shown in figure (3.5).

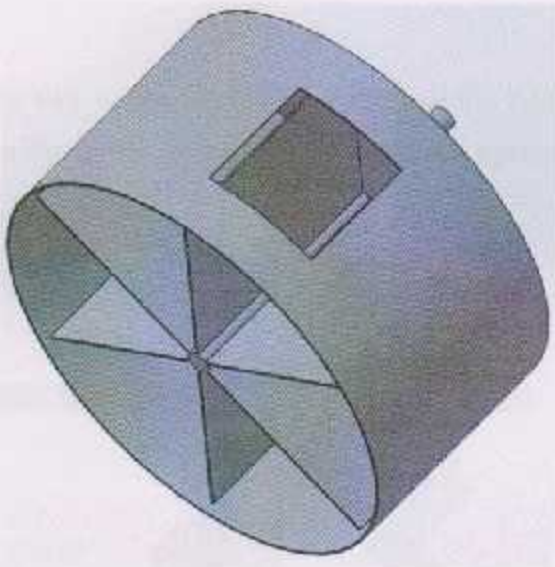


Figure (3.5): Outlet gates.

The outlet gates dimensions are shown in figure (3.6).

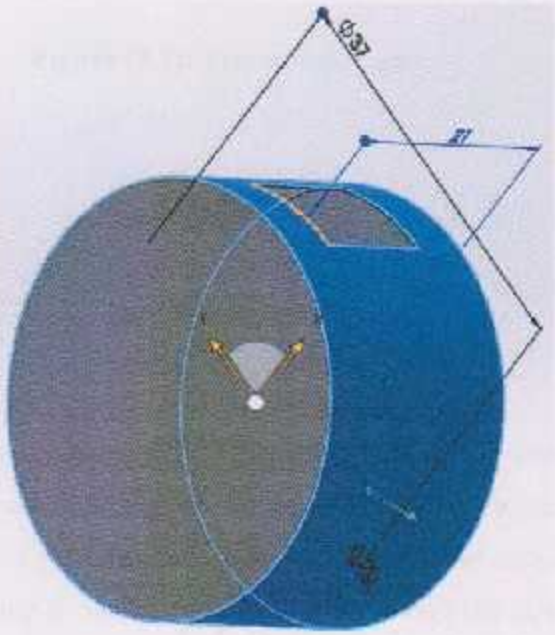


Figure (3.6): Outlet gates dimensions.

3. Transmission gate:

There is a gate between the two stages of zig-zag, its deliver the thyme comes from firs stage to the second stage without any infiltration of air in each cyclone. Shown in figure (3.7).

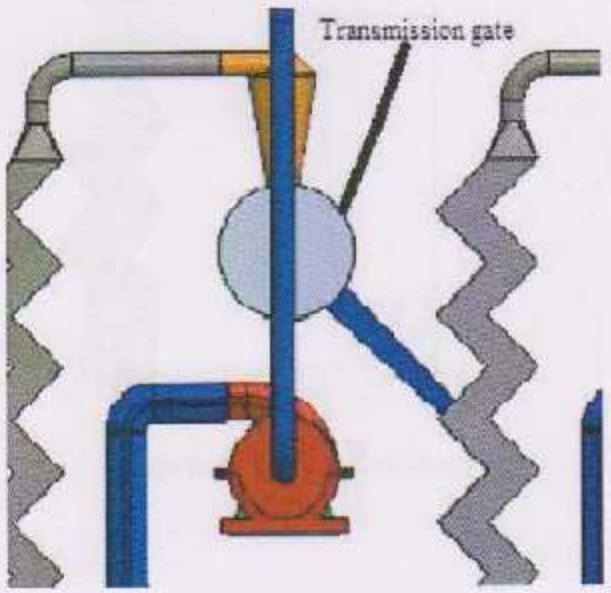


Figure (3.7): Transmission gate.

3.4.2 The Zig-Zag air separator.

In our project we have two symmetrical Zig-Zag channel each one consists of rectangular sections joined together at an angle is equal 90 degree to create a zigzag shapes shown in figure (3.8). A dispersion of particles is fed to this channel. The aerodynamically "light" particles are carried to the top by the air flow that is led through the classifier. The "heavy" particles fall to the bottom.

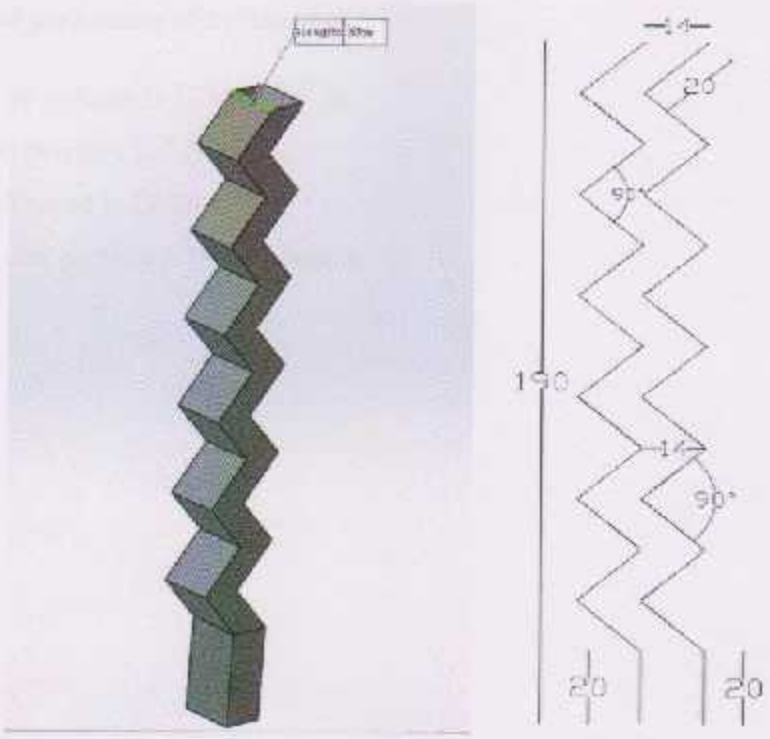


Figure (3.8): Zig-Zag Shape.

3.4.3 Cyclone air separator.

We have two corresponding cyclones in each stage, the Inside of cyclone make a spiral vortex similar to a tornado the function of cyclone is separate the particles without using any filters. The cyclone is shown in figure (3.9) with its dimensions, since the cyclone sustains until 1.5hp.

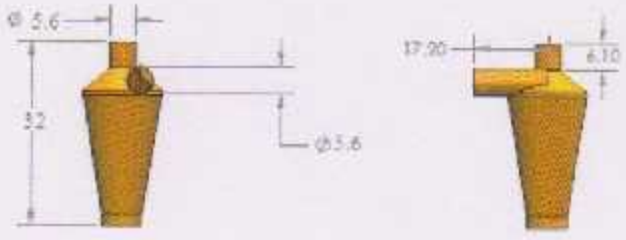


Figure (3.9): The Cyclone.

The technical parameters of cyclone are:

1. The air volume is 174-280 m^3/m.
2. Wind pressure is 2.5-22 kpa.
3. Wind speed is 18-28 m/s.
4. The dust particle is 0.3μm-40mm.

Chapter Four

PLC Programming

4.1 Introduction.

4.2 PLC Programming.

4.2.1 PLC Characteristic.

4.2.2 PLC in State Graph.

4.3 Ladder code

4.1 Introduction

The separating thyme System is controlled system and the process is performed sequentially, this can be achieved by using PLC (Programmable Logic Controller). This made adding automation capability and safety precautions possible.

The PLC is chosen to be used on the system rather than the Microcontroller because the first one has an operating system and user program you can change its program easily, in PLC the inputs and outputs are scanned in each cycles each part of program is executed separately, but in Microcontroller run from first line to the end. Table (3.1) is showing a comparison between PLC and Microcontroller.

And this chapter contains the electrical component specification (motors, sensors, and transformer), control and power circuit, and protection.

Table (4.1): PLC VS Microcontroller.

	PLC	Microcontroller
Less initial cost	**NO**	**YES**
Less total cost	**YES**	**NO**
Build in modules	**YES**	**NO**
Faster response	**NO**	**YES**
Ease in programming	**YES**	**NO**
Work at 220 V	**YES**	**NO**

4.2 PLC Programming

In this section, we will show the PLC program in manual operation and automatic, in ladder and state graph programming and connection, we will explain each symbol in program, and the PLC Characteristic.

4.2.1 PLC Characteristic

Programmable Logic Controller (PLC) is a digital computer used for automation of electromechanical process, such as control of machinery on factory assembly lines. PLCs are used in many industries and machines. Unlike general-purpose computers, the PLC is designed for multiple inputs and output arrangement, extended temperature range, immunity to electrical noise, and resistance to vibration and impact. Programs to control machine operation are typically stored in battery-backed-up non-volatile memory. A PLC is an example of a hard real time system since output results must be produced in response to input conditions within a limited time, otherwise unintended operation will result.

In our controlling design it is desirable to use a PLC with 8 input and 9 outputs mention in the table (4.2) below, it must be compatible to use with220 volt.

Table (4.2): Logic Allocation.

input	Symbol	Address	Logic allocation
Pb(start)	start	X0	Start the operation
Pb(stop)	Stop	X1	Stop all operation
Select switch	AUTOMATIC	X2	If the select switch in the right position the operation mode is Automatic.
Select switch	Manual	X3	If the select switch in the left position the operation mode is manual

Emergency switch(NC)	EMG	X4	Turn off all process.
Switch1	Motor_1 Motor_2	X5	Turn on motor_1=1and motor_2=1. Turn on motor 1 and motor2
Switch 2	Motor_3 Motor_4	X6	Turn on motor_3=1 and motor_4=1. Turn on motor 3 and motor4
Switch3	Motor_5	X7	Turn on motor_5=1 Turn on motor 5

output	Symbol	Address	Logic allocation
Motor 1	Motor_1	Y0	Motor1 run
Motor2	Motor_2	Y1	Motor2 run
Motor3	Motor_3	Y2	Motor3 run
Motor4	Motor_4	Y3	Motor 4 run
Motor5	Motor_5	Y4	Motor 5 run
Lamp 1	H1	Y5	H1 on when start operation
Lamp 2	H2	Y6	H2 on when select Automatic
Lamp3	H3	Y7	H3 on when select Manual
Lamp4	H4	Y8	H4 on when stop operation

The "Fatek FBs-24MCR2" PLC has 14 digital inputs, with 10 digital outputs. This device is good for our application because we don't need more inputs or outputs. We used five inputs to control the operation with eight outputs to turn on the contactors & to turn on the lamps in front of the electrical board [6] .Shown in figure (4.1).

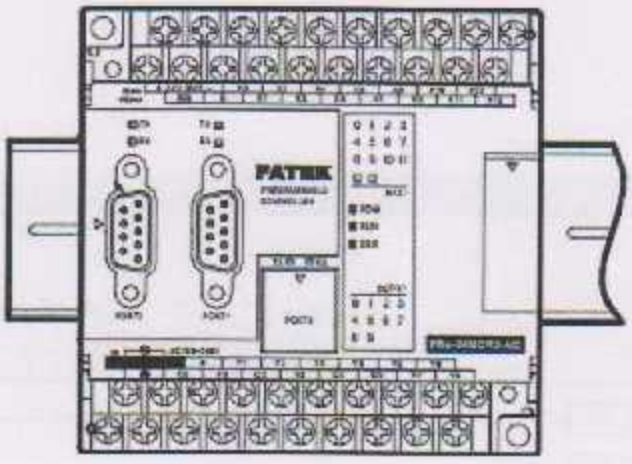


Figure (4.1): PLC Hardware.

Power Supply has an input of 220V AC and an output of 24V DC. We will use this power supply to protect the PLC & to provide enough power for the coils of the contactors.shown figure(4.2).

Figure(4.2): Power supply.

The software for "Fatek FBs-24MCR2" Winproladder Programming software as Shown in the figure (4.3).

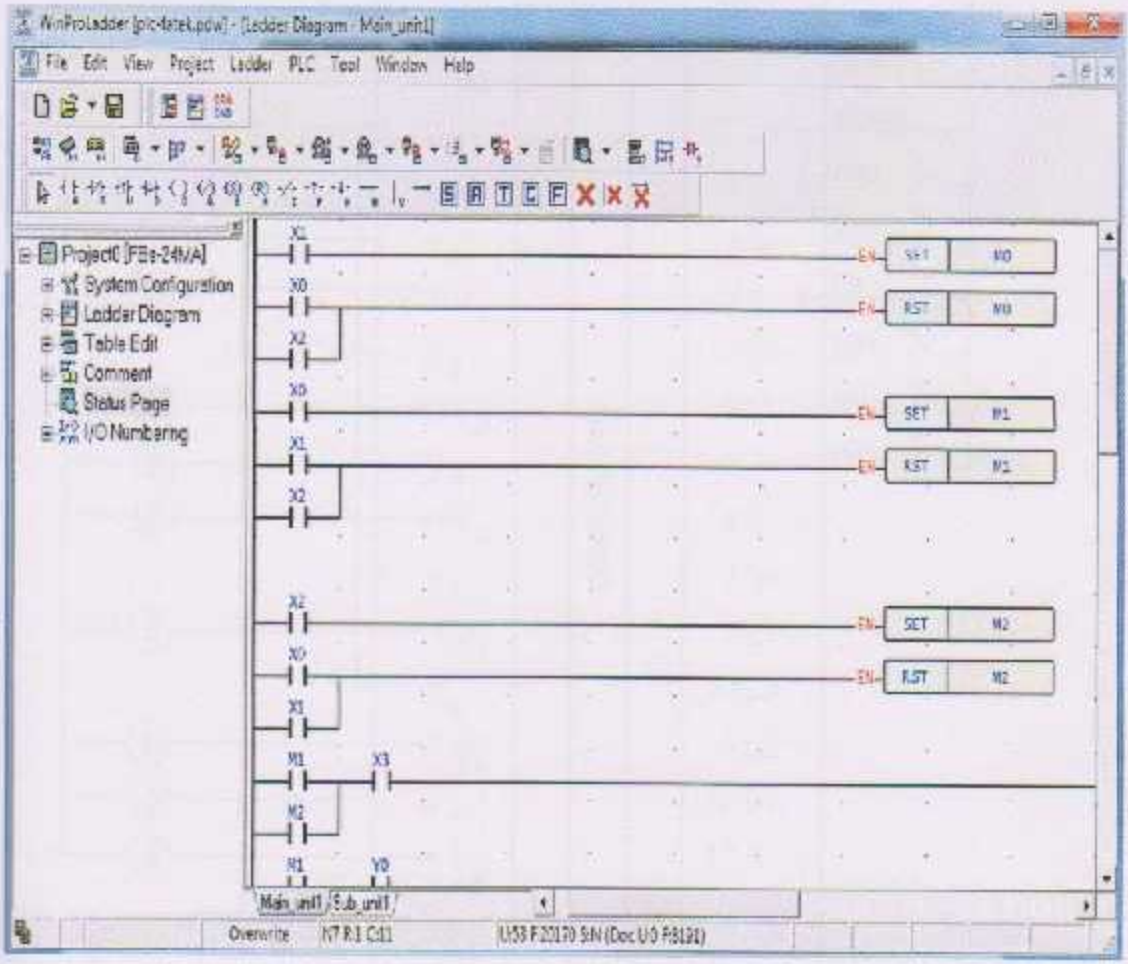


Figure (4.3): Winproladder Programming software.

The PLC connections inputs and outputs are shown in the figure (4.4).

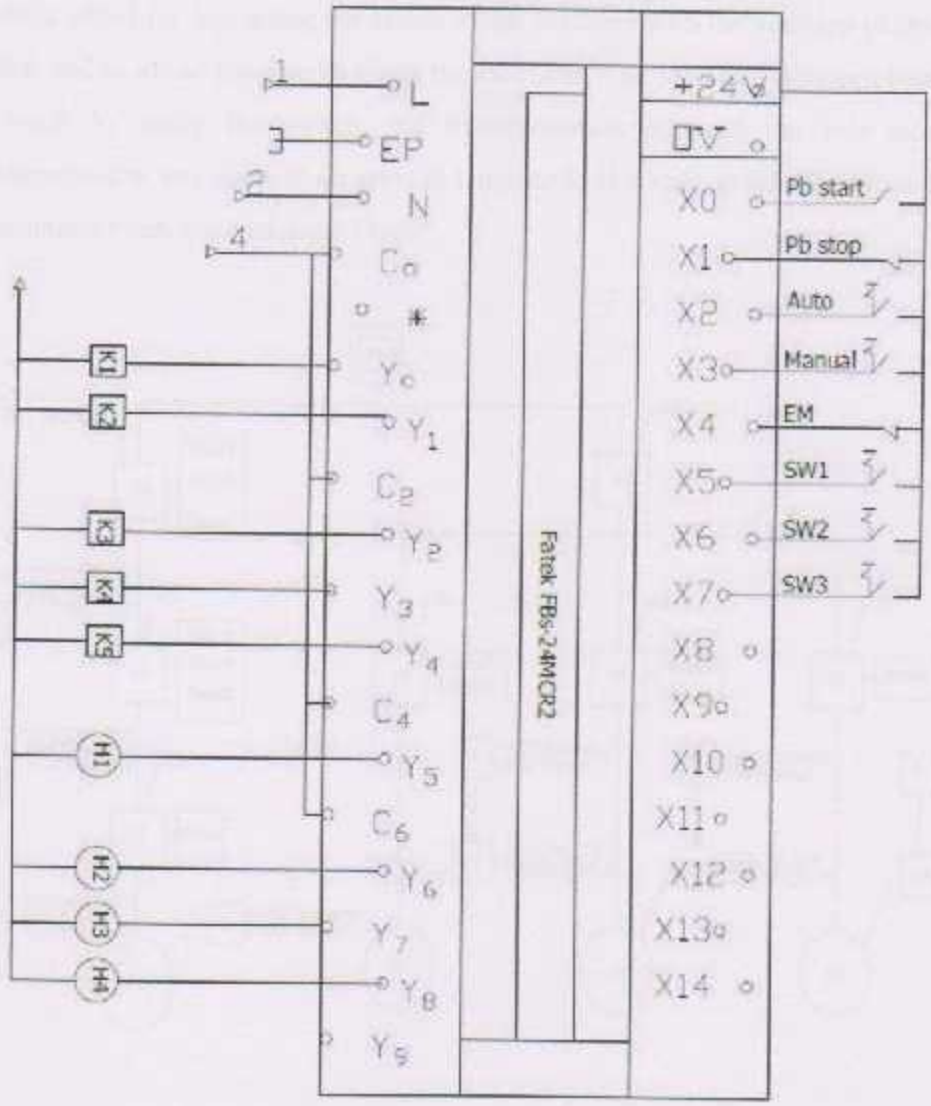


Figure (4.4): PLC connections.

4.2.2 PLC in state Graph

The machine will has two operation mode manual mode and automatic mode. The Manual mode is added for increasing the safety of the machine with the addition of the emergency switch and to allow the user to clean the machine. The selection between two modes can be made by using the switch; the transformation between the two modes can be implemented at any stage if an error is happened. The state graph Shown in figure (4.5), "Automatic mode "and Manual Mode".

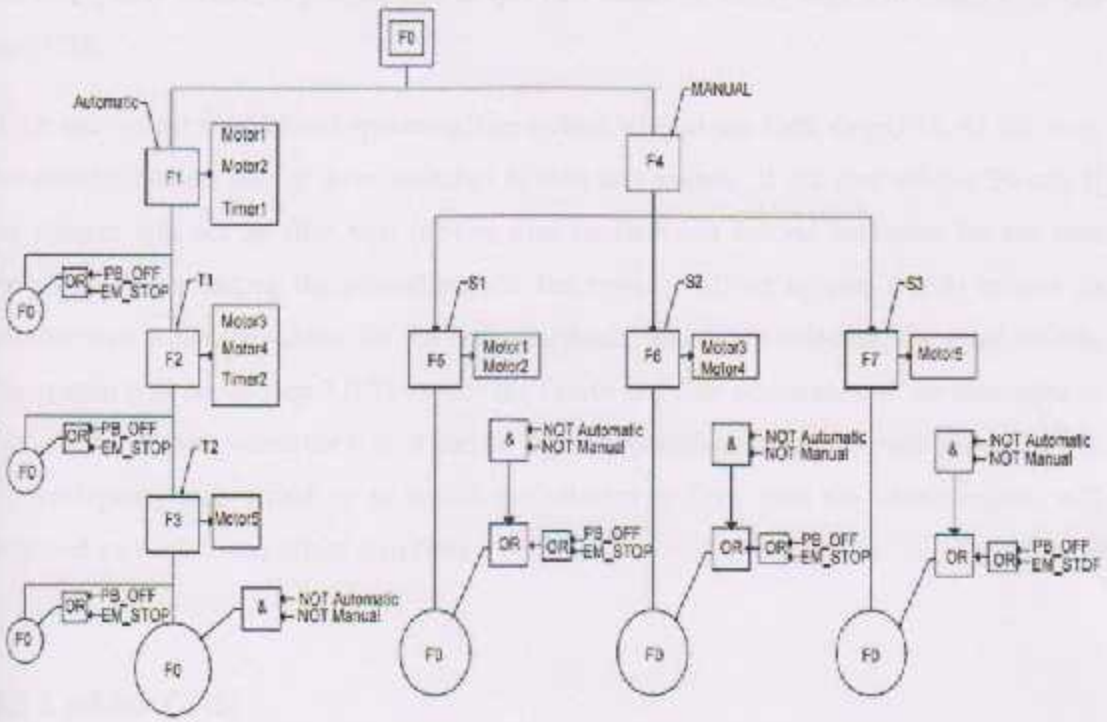


Figure (4.5): The state graph.

The initial step (F0) comes after pressing the (Start) push button Depends on the user of choosing between two kinds of operating, automatic operating or manual operating. If the user choose automatic operating the system will activate first step (F1) to turn on first contactor, second contactors & first timer. The system will continue and after the delay from timer 1 (T1), it will activate second step (F2) to turn on third and fourth contactor beside first two contactors with a second timer. After the delay from timer 2 (T2), it will activate third step (F3) to turn on five contactor beside first two contactors & the third contactor. There is a possibility to stop any action by pressing the (Stop) push button or the emergency switch, if pressed one of this two switches, the system will return to initial step (F0).

If the user select the Manual operating, the system will set the forth step (F4). At this step, the user will select one of three switches to start any system. If the user selects Switch 1, the system will set up fifth step (F5) to turn on first and second contactor for the first system. When selecting the second switch, the system will set up step 6 (F6) to turn on another two contactors alone for the second system. But when selecting the third switch, the system will set up step 7 (F7) to turn the fourth and fifth contactors. If the user want to turn off the system wherever it is, it can be done by pressing the (Stop) push button, active the emergency stop switch or to switch the selector to Zero, then the whole system will stop and go back to the initial step (F0).

4.3 Ladder Code

To build program for this system we used LDR language or ladder logic is widely used to program PLCs, where sequential control of process or manufacturing operation is required. Ladder logic is useful for simple but critical control systems or for reworking old hard-wired relay circuits. The ladder code is shown in figure (4.6).

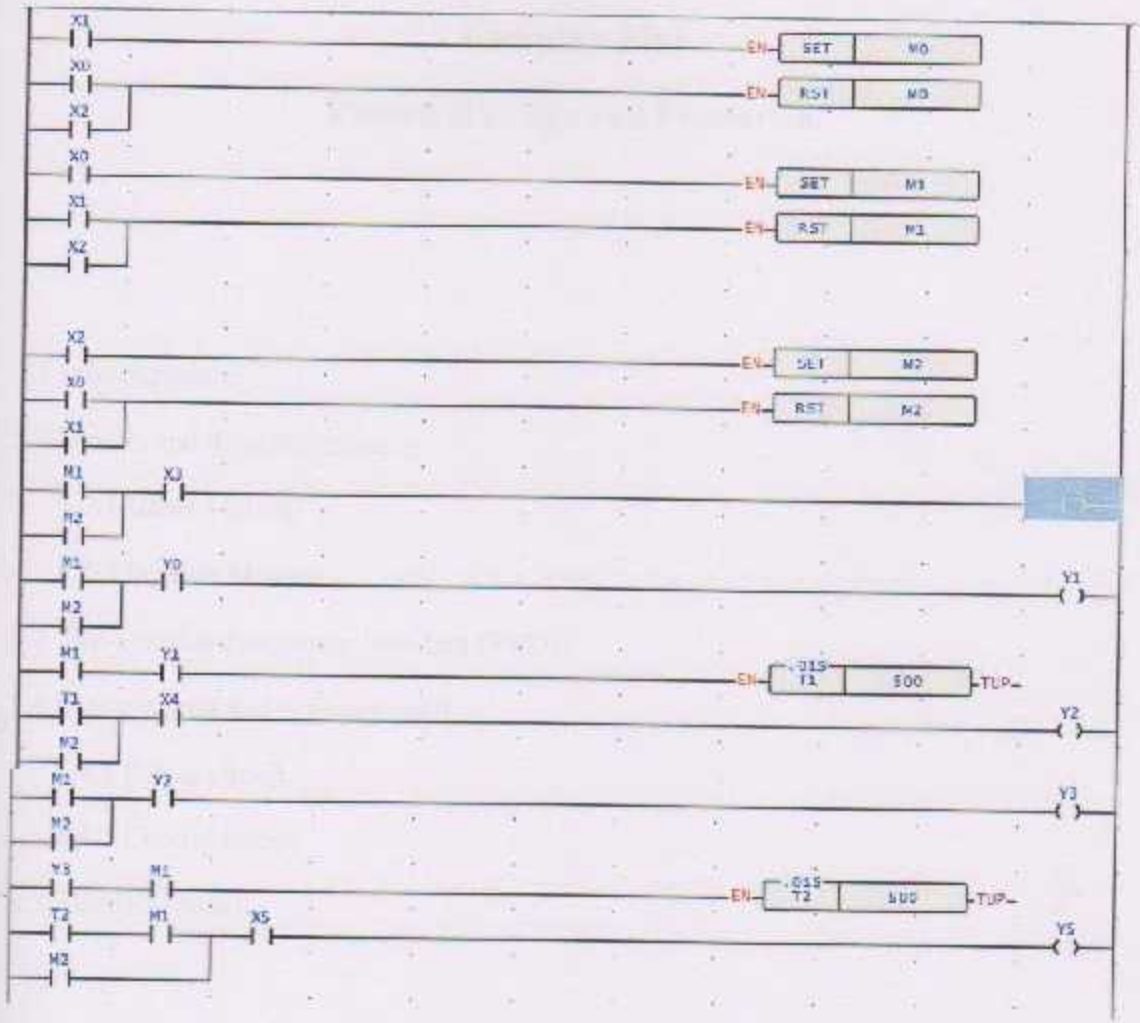


Figure (4.6): Ladder code.

Chapter Five

Electrical design and Protection.

5.1 Introduction.

5.2 Motors and its calculations.

5.2.1 Gates Motors.

5.2.2 Suction Motors.

5.3 The Variable Frequency Inverters (VFDs).

5.4 Power circuit and control circuit.

5.4.1 Power circuit.

5.4.2 Control circuit.

5.5 Electrical panel.

5.1 Introduction.

This chapter electrical component specifications (overload, earth leakage, circuit breaker, etc.), contain motor and its calculation power and control circuit, and protection.

5.2 Motors and its calculations.

5.2.1 Gates motors.

We have five motors for the gates, the motors are similar so we will calculate for one motors.

We need the speed of gates is 50 rpm therefore the calculations as follow:

a= Output speed/ Input speed..... (1)

Where:

a: is the gear ratio.

a= 50/ 1500

a= 0.033.

$w = \frac{2\pi N}{60}$ ..... (2)

Where:

w: is the motor speed in rad/s.

N: is the motor speed in rpm.

$w = (2*\pi*1500)/60$

$w = 157.08$ rad/s.

F = m*g..... ... (3)

Where:

m: the mass (k.g).

g: Gravity acceleration (9.807m/s^2).

$m = m_{slides} + m_{rod}$.

m= 1.8+1.57

m = 3.37k.g

F = 3.37*9.807

F = 33.04 N

$T_L = F*r$ ..... (4)

Where:

T_L: the torque load (N.m)

F: is the force (N)

r: is the radius of rod

$T_L = 33.04*0.018$

$T_L = 0.59$ N.m

$T_{IN} = (T_L*a)/efficiency$ ..... (5)

Where the efficiency of the gear is 0.7

So,

$T_{IN} = (0.59*0.33)/0.7$

$T_{IN} = 0.278$ N.m

$P_{out} = T_{IN}* w$ ..... (6)

$P_{out} = 0.278*157.08$

$P_{out} = 43.66$ watt

The safety factor is 1.13. So, the P_{out} equal:

$P_{out} = P_{out}*SF$ ..... (7)

$P_{out} = 43.66*1.13$

$P_{out} = 49.4$ watt

$P_{out} = 0.067$ hp.

So the power of the motor must be at least 0.067 hp. So we select the motors single phase 1500 rpm and 0.25 hp for the gates motors.

5.2.2 Suctions Motors

The machine has two suction motors; one motor for each stage the suction motor gives a suitable air flow in the channel of zig-zag and in the cyclone to make the separation process, the motor is 2800 rpm and 1hp. As shown in figure (5.1).

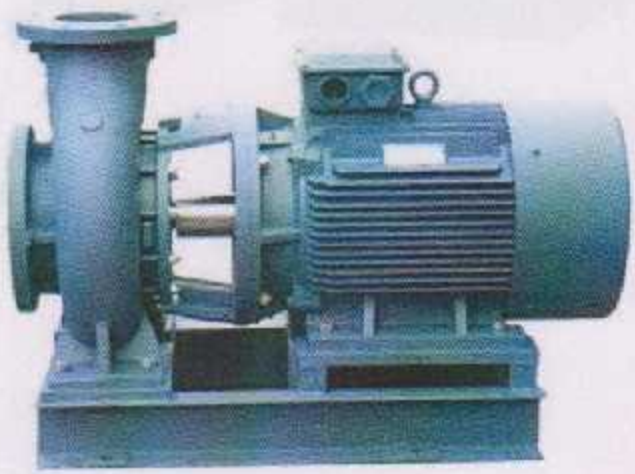


Figure (5.1): Suction Motor.

5.3 The Variable Frequency Inverters (VFDs)

Frequency converters are used to change the frequency and magnitude of the constant grid voltage to a variable load voltage. Frequency converters are especially used in variable frequency AC motor drives.

VFD007E21T Delta VFD-E input 1 phase 220 V output 3phase 0-380V 4.2A 0.1-600HZ

0.75KW 1hp inverter VFD AC motor drive with keypad .The VFD is shown in figure (5.2).

Figure (5.2): Variable Frequency Drive.

5.4 power circuit and control circuit

In this section we will take about the power and control circuit designed for our machine.

5.4.1 Power circuit

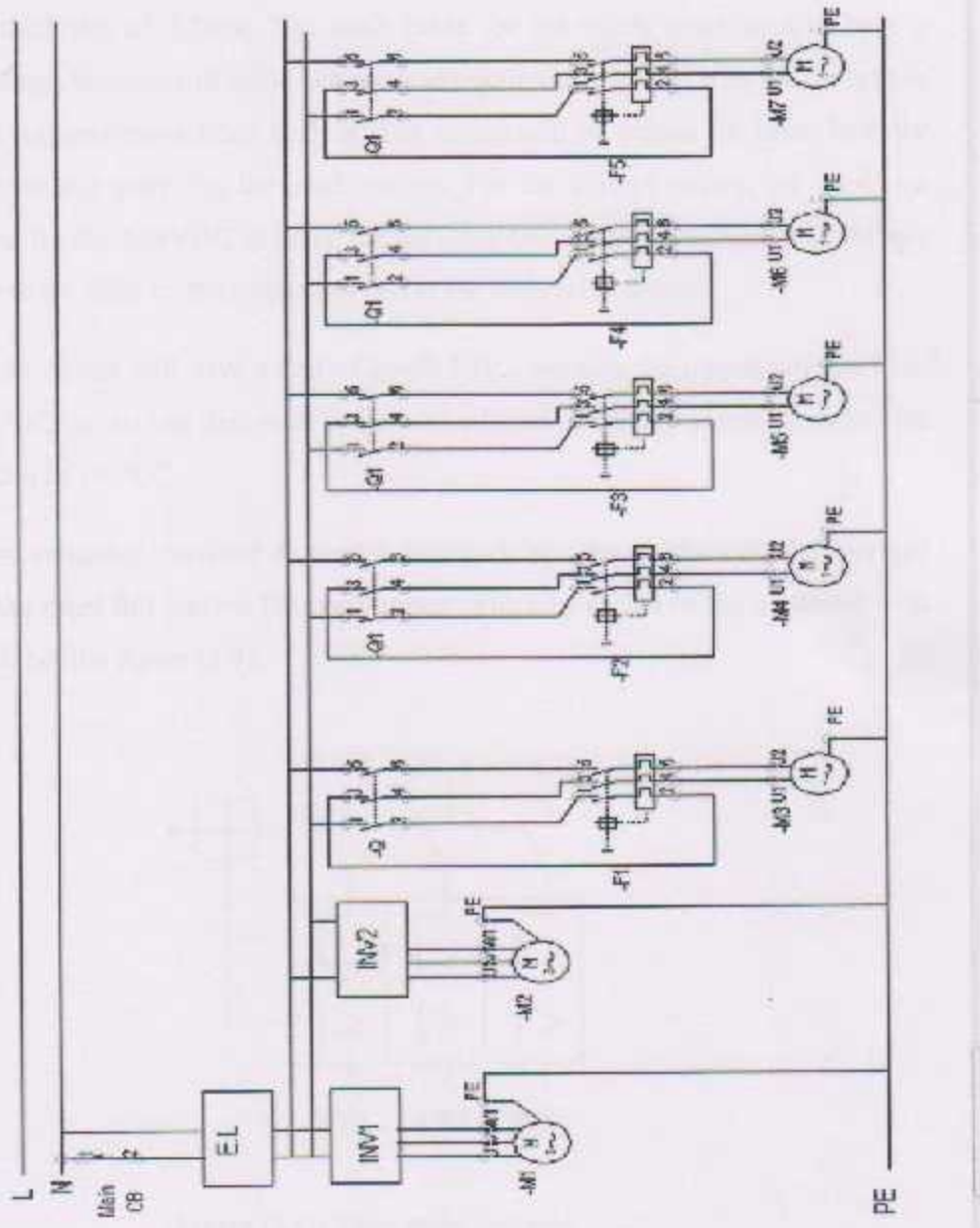


Figure (5.3): Power Circuit.

Since there is two suction motors are three phase, we will use frequency converters to control the speed of airflow of motors. Depending on the full load rated currents of all the motors we will use a 16A circuit breaker as a main circuit breaker. Then there comes the residual current device, which is a two pole breaker, it is important to protect the user if there is any leakage in the circuit or in the motor's coils. If the leakage is more than 30mA it will switch off & the whole circuit will stop working.

In our panel, since we have a power circuit with a control circuit, we used five colors of cables with a thickness of 1.5mm. The main cable for the whole machine will have a thickness of 2.5mm, because this cable can carry as maximum 16A and with all motors are turned on with the maximum rated current. The colors will be brown for Line, blue for Neutral & yellow and green for the earth system. For the control circuit, we used two colors only. Red for the +24VDC & black for the Zero DC. These two cables will deliver the DC voltage to the coils of the contactors and to the dedication lamps.

Contactors in our circuit will have a coil of 20-60 VDC, because the output voltage from the PLC is 24VDC, so we can deal with contactors without using any external device like a relay with a coil of 24VDC.

Overload, it has a thermal overload & current overload. We choose the suitable overload depending on the rated full current for every motor. The connection of the contactor with an overload will be like figure (5.4).

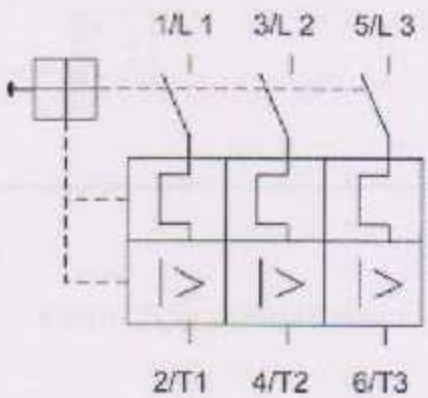


Figure (5.4): Three phase overload.

5.4.2 Control circuit design

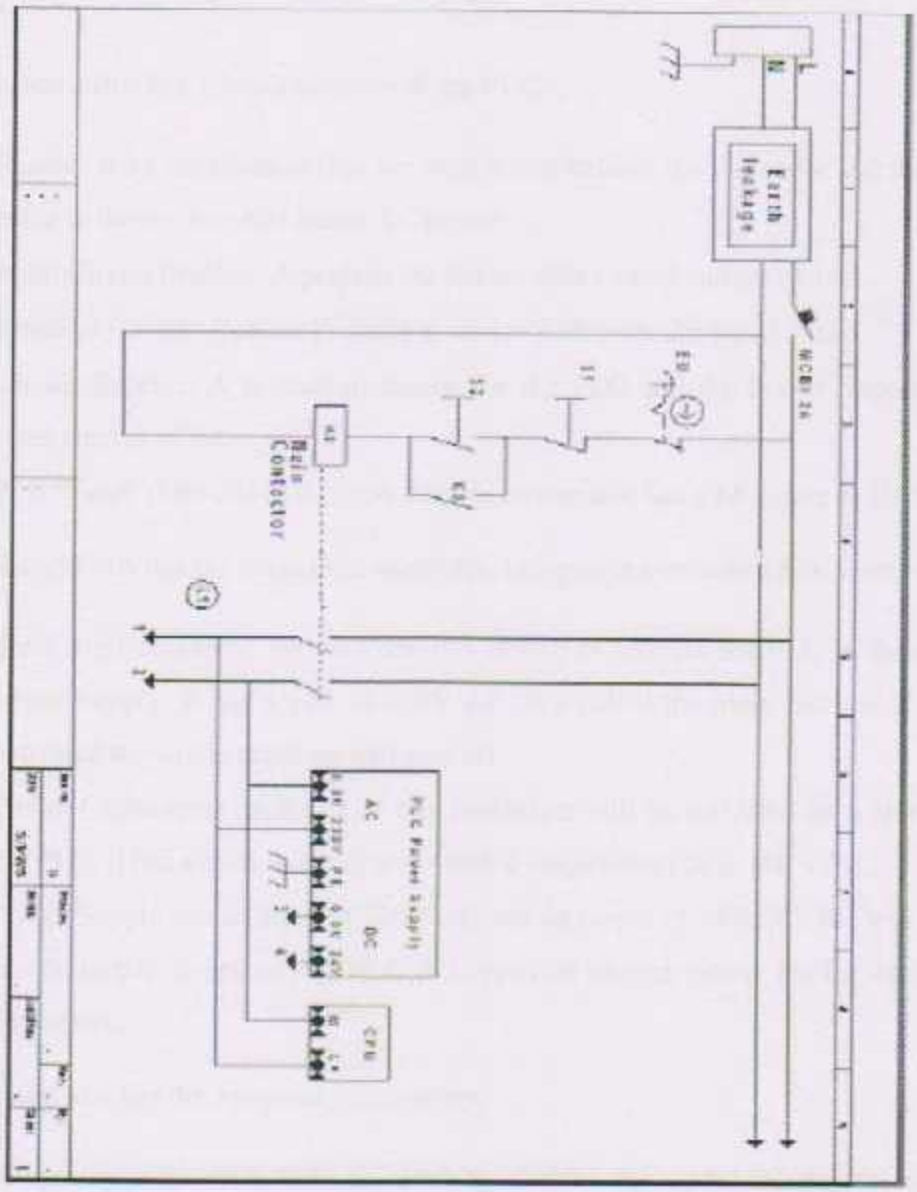


Figure (5.5): Control Circuit

5.5 Electrical panel

Inside the electrical board there are 5 rows, in order to arrange similar devices in a single row.

First row has a Bus bar, Circuit breakers & the PLC.

- Busbar: It's a distribution line. we used it to distribute the line cable and the neutral cable to the devices that needs AC power.
- Main Circuit Breaker: A protectrion device with a rated current of 16A.
- Residual Current Device: Protection device with a sensitivity of 30mA.
- Circuit Breaker: A protection device for the PLC and the Power Supply with a rated current of 6A.
- PLC "Fatek (FBs-24MAR2)": A Control device that has a 14 inputs & 10 outputs.

Second row has the main mini-contactor, two power contactors & a power supply.

- Main mini-contactor: We will use this device to activate the PLC & the external power supply. It has a coil of 220V AC. It's called the main because if it's not activated the whole machine will stay off.
- Power Contactors: Each one of this contactors will be activated by a signal from the PLC, it has a coils that can work with a range from (20 to 60) VDC.
- Power Supply has an input of 220V AC and an output of 24V DC. We will use this power supply to protect the PLC & to provide enough power for the coils of the contactors.

Third row has the Frequency converters.

- Frequency converters will be used to control the speed of the motors. The frequency converters will have a rated power of 2 horse power for the for the two suction motors.

Fourth row has theoverloads for the motors

- Overloads: We will use the GV2 overloads, because it has a Thermal Overload and a Current overload in the same device. This kind of overloads has a wide range and we can choose the overload depending on the rated current of each motor. Its much better than putting a thermal overload alone because it can be evaluated at the rated

current of the motor, so we don't need to put a another circuit breaker for each motor.

Fifth row has a Terminal Connectors.

- This connectors will be used to connect the main cable & the motor's cables.

Outside the electrical board there are another 4 rows.

First row has a four detection lamps.

- First lamp will turn on when the PLC is active.
- Second lamp will turn on when motor1 and motor2 on.
- Third lamp will turn on when motor 3 and motor 4 on.
- Fourth lam will turn on when motor 5 on.

Second row has a selection switches.

- First Selector is a three position selection switch, it can let the user select the type of operating, Manual operation, Automatic operation or stays at Zero.
- Second selector is a two position selection switch, it will be used in the manual operation to activate motor 1 and motor 2.
- Third selector is a two position selection switch, it will be used in the manual operation to active motor 3 and motor 4
- Fourth selector is a two position selection switch, it will be used in the manual operation to active motor 5.

Third row has 2 push buttons.

- First push button (Green) is a normally open button, when the user push this button the PLC will turn on.
- Second push button (Red) is a normally closed button, it will turn off the machine if the user pushs it.

Fourth row has the emergency button only. When this button is pressed, it will turn off the PLC and the power supply.

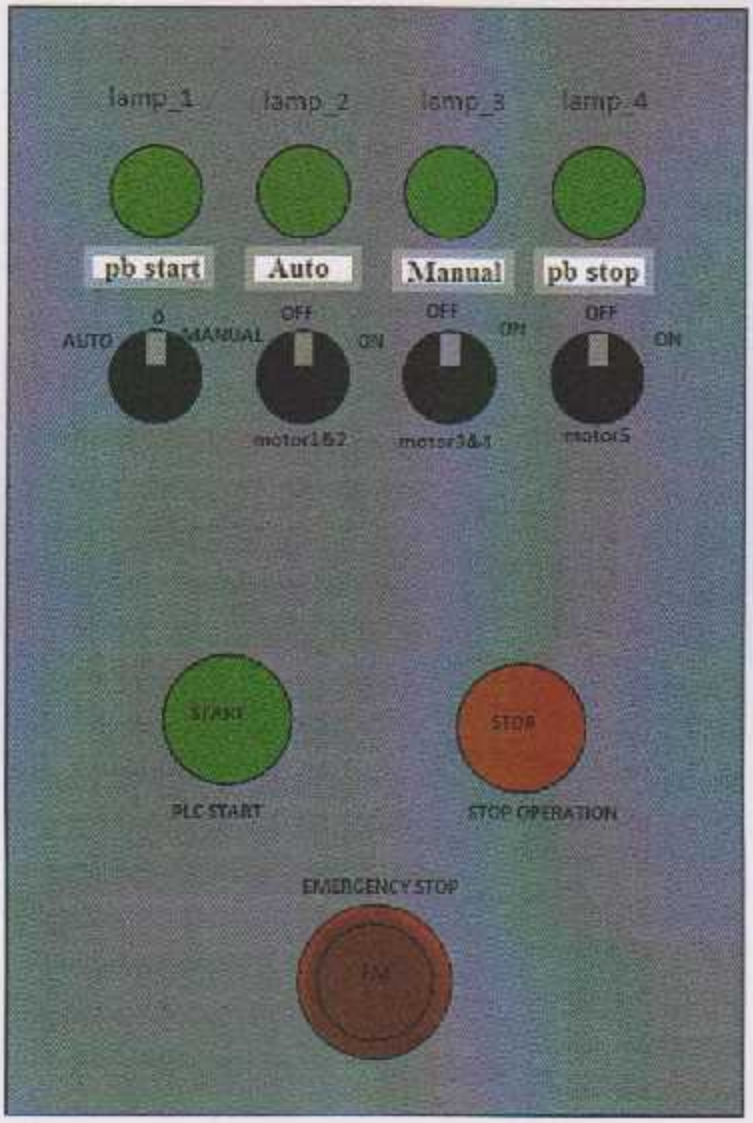


Figure (5.6): Exterior design of the panel electric.

Chapter Six

Experimental Result & Recommendations

6.1 Introduction

6.2 Experimental Result

6.3 Recommendations

6.1 Introduction

This chapter provides experimental result and some recommendations from the work learn for this project. In this chapter we are listing some goals hope to be accomplished or at least under attention.

Figure (6.1): The final machine.

6.2 Experimental Result

We made some experiments on parts of our project and these are some of results:

1. We tried to check the first stage and see how the air flow into machine with small amount of thyme, the air cycle move correctly.
2. The air flow is not enough to move the thyme into cyclone in the first stage because the Zig-Zag channel is tall due to suction motors that used.
3. There is some losses of air flow that lost in pipes and cyclones. So we couldn't reach the desired results.

6.3 Recommendations

These recommendations are recorded to people who can create opportunities for student to make something new and useful, in order to make difference in our country Palestine:

1. Such projects should be handled among different departments according to the project nature (we had lots of mechanical problems that might solve without having enough previous knowledge).
2. The Zig-Zag must be suitable with cyclone and the air flow.
3. The machine must not infiltrate any amount of air to ensure getting the required flow.

References

[1] A.H.Stebbins, USA Patent 1,650,727, 28-9-1926.

[2] https://en.wikipedia.org/wiki/Cyclonic_separation

[3] http://www.vfds.com/blog/what-is-a-vfd

[4] http://www.doityourself.com/stry/how-a-gear-motor-works

[5] https://ar.aliexpress.com/item/free-shipping-High-quality-cyclone-dust-collector-1pc/32244091377.html?spm=2114.010208.3.20.re25Aq&ws_ab_test=searchweb0_0,searchweb201602_1_116_10065_117_10068_114_115_113_10084_10083_10080_10082_10081_10060_10061_10062_10056_10055_10054_10059_10099_10078_10079_427_10103_10073_10102_10096_10052_10050_10051,searchweb201603_4&btsid=aa3b7868-9659-4e45-8589-be7f90d28095

[6] hp ://www.fatek.com/en/technical.php?act=manual&catId=11

APPENDIX

APPENDIX

A

APPENDIX A

Ladder Language

Ladder logic was originally a written method to document the design and construction of relay racks as used in manufacturing and process control. Each device in the relay rack would be represented by a symbol on the ladder diagram with connections between those devices shown. In addition, other items external to the relay rack such as pumps, heaters, and so forth would also be shown on the ladder diagram. See relay logic.

Ladder logic has evolved into a programming language that represents a program by a graphical diagram based on the circuit diagrams of relay logic hardware. Ladder logic is used to develop software for programmable logic controllers (PLCs) used in industrial control applications. The name is based on the observation that programs in this language resemble ladders, with two vertical rails and a series of horizontal rungs between them. While ladder diagrams were once the only available notation for recording programmable controller programs, today other forms are standardized in IEC 61131-3 (For example, as an alternative to the graphical ladder logic form, there is also a more assembly language like format called Instruction list within the IEC 61131-3 standard.).

Overview

Part of a ladder diagram, including contacts and coils, compares, timers and constable multivibrators

Ladder logic is widely used to program PLCs, where sequential control of a process or manufacturing operation is required. Ladder logic is useful for simple but critical control systems or for reworking old hardwired relay circuits. As programmable logic controllers became more sophisticated it has also been used in very complex automation systems. Often the ladder logic program is used in conjunction with an HMI program operating on a computer workstation.

The motivation for representing sequential control logic in a ladder diagram was to allow factory engineers and technicians to develop software without additional training to learn a language such as FORTRAN or other general-purpose computer language. Development, and maintenance, was simplified because of the resemblance to familiar relay hardware systems.[2] Implementations of ladder logic have characteristics, such as sequential execution and support for control flow features, that make the analogy to hardware somewhat inaccurate. This argument has become less relevant given that most ladder logic programmers have a software background in more conventional programming languages.

Ladder logic can be thought of as a rule-based language rather than a procedural language. A "rung" in the ladder represents a rule. When implemented with relays and other electromechanical devices, the various rules "execute" simultaneously and immediately. When implemented in a programmable logic controller, the rules are typically executed sequentially by software, in a continuous loop (scan). By executing the loop fast enough, typically many times per second, the effect of simultaneous and immediate execution is achieved, if considering intervals greater than the "scan time" required executing all the rungs of the program. Proper use of programmable controllers requires understanding the limitations of the execution order of rungs.

Example of a simple ladder logic program

The language itself can be seen as a set of connections between logical checkers (contacts) and actuators (coils). If a path can be traced between the left side of the rung and the output, through asserted (true or "closed") contacts, the rung is true and the output coil storage bit is asserted (1) or true. If no path can be traced, then the output is false (0) and the "coil" by analogy to electromechanical relays is considered "de-energized". The analogy between logical propositions and relay contact status is due to Claude Shannon.

Ladder logic has contacts that make or break circuits to control coils. Each coil or contact corresponds to the status of a single bit in the programmable controller's memory. Unlike electromechanical relays, a ladder program can refer any number of times to the status of a single bit, equivalent to a relay with an indefinitely large number of contacts.

So-called "contacts" may refer to physical ("hard") inputs to the programmable controller from physical devices such as pushbuttons and limit switches via an integrated or external input module, or may represent the status of internal storage bits, which may be generated elsewhere in the program.

Each rung of ladder language typically has one coil at the far right. Some manufacturers may allow more than one output coil on a rung.

Rung Input: Checkers (contacts)

— [ ] — normally open contact, closed whenever its corresponding coil or an input which controls it is energized. (Open contact at rest)

— [/] — normally closed ("not") contact, closed whenever its corresponding coil or an input, which controls it, is not energized. (Closed contact at rest)

Rung Output: Actuators (coils)

— ( ) — normally inactive coil, energized whenever its rung is closed. (Inactive at rest)

— (/) — normally active ("not") coil, energized whenever its rung is open. (Active at rest)

The "coil" (output of a rung) may represent a physical output which operates some device connected to the programmable controller, or may represent an internal storage bit for use elsewhere in the program.

A way to recall these is to imagine the checkers (contacts) as a push button input, and the actuators (coils) as a light bulb output. The presence of a slash within the checkers or actuators would indicate the default state of the device at rest.

Logical AND

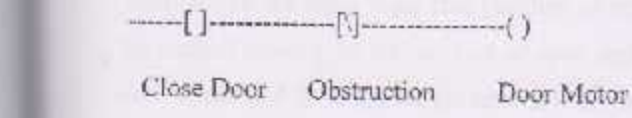
```
------[ ]----------[ ]----------( )
```

Key Switch 1 Key Switch 2 Door Motor

The above realizes the function: Door Motor = Key Switch 1 AND Key Switch 2

This circuit shows two key switches that security guards might use to activate an electric motor on a bank vault door. When the normally open contacts of both switches close, electricity is able to flow to the motor, which opens the door.

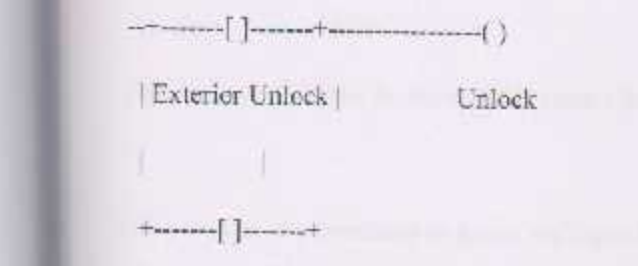
Logical AND with NOT



The above realizes the function: Door Motor = Close door AND NOT (Obstruction).

This circuit shows a push button that closes a door, and an obstruction detector that senses if something is in the way of the closing door. When the normally open push button contact closes and the normally closed obstruction detector is closed (no obstruction detected), electricity is able to flow to the motor, which closes the door.

Logical OR



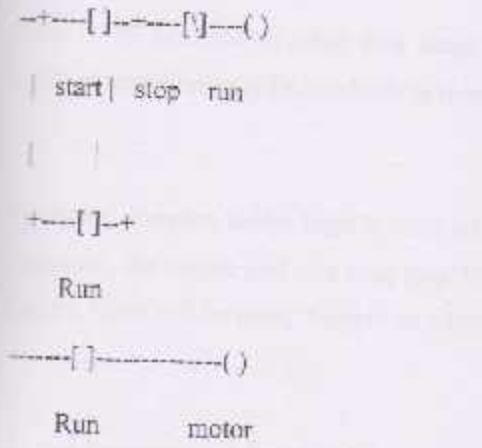
The above realizes the function: Unlock = Interior Unlock OR Exterior Unlock

This circuit shows the two things that can trigger a car's power door locks. The remote receiver is always powered. The unlock solenoid gets power when either set of contacts is closed.

Industrial STOP/START

In common industrial latching start/stop logic we have a "start" button to turn on a motor contactor, and a "stop" button to turn off the contactor.

When the "start" button is pushed the input goes true, via the "stop" button NC contact. When the "run" input becomes true the seal-in "run" NO contact in parallel with the "start" NO contact will close maintaining the input logic true (latched or sealed-in). After the circuit is latched, the "stop" button may be pushed causing its NC contact to open and consequently the input to go false. The "run" NO contact then opens and the circuit logic returns to its inactive state.

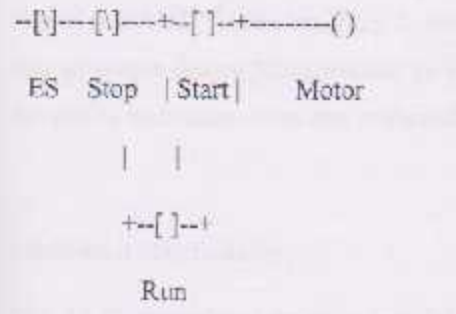


The above realizes the function: run = (start OR run) AND (NOT stop)

Note the use of parenthesis to group the logical OR function before evaluating the logical AND function (which has a higher order of operation priority). Also, note the use of NOT to represent the "stop" NC contact logic.

This latch configuration is a common idiom in ladder logic. In ladder logic, it is referred to as seal-in logic. The key to understanding the latch is in recognizing that "start" switch is a momentary switch (once the user relenses the button, the switch is open again). As soon as the "run" solenoid engages, it closes the "run" NO contact, which latches the solenoid on. The "start" switch opening up then has no effect.

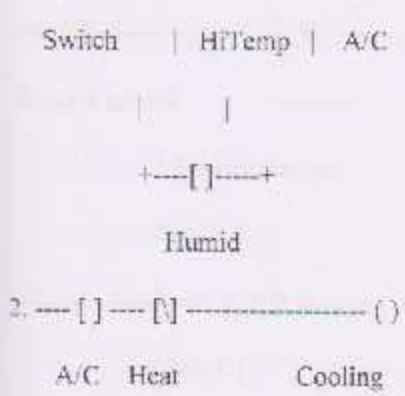
For safety reasons, an Emergency-Stop and/or Stop should be hardwired in series with the Start switch, and the relay logic should reflect this.



Complex logic

Here is an example of what two rungs in a ladder logic program might look like. In real world applications, there may be hundreds or thousands of rungs.

Typically, complex ladder logic is 'read' left to right and top to bottom. As each of the lines (or rungs) are evaluated, the output coil of a rung may feed into the next stage of the ladder as an input. In a complex system, there will be many "rungs" on a ladder, which are numbered in order of evaluation.



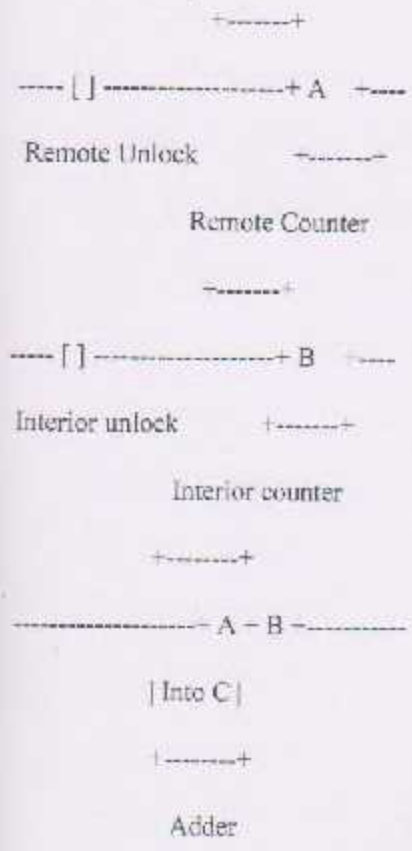
Line 1 realizes the function: A/C = Switch AND (HiTemp OR Humid)

Line 2 realizes the function: Cooling = A/C AND (NOT Heat)

This represents a slightly more complex system for rung 2. After the first line has been evaluated, the output coil "A/C" is fed into rung 2, which is then evaluated and the output coil "Cooling" could be fed into an output device "Compressor" or into rung 3 on the ladder. This system allows very complex logic designs to be broken down and evaluated.

Additional functionality

The PLC manufacturer as a special block can add additional functionality to a ladder logic implementation. When the special block is powered, it executes code on predetermined arguments. These arguments may be displayed within the special block.



In this example, the system will count the number of times that the interior and remote unlock buttons are pressed. This information will be stored in memory locations A and B. Memory location C will hold the total number of times that the door has been unlocked electronically.

PLCs have many types of special blocks. They include timers, arithmetic operators and comparisons, table lookups, text processing, PID control, and filtering functions. PLCs that are more powerful can operate on a group of internal memory locations and execute an operation on a range of addresses, for example, to simulate a physical sequential drum controller or a finite state machine. In some cases, users can define their own special blocks, which effectively are subroutines or macros. The large library of special blocks along with high-speed execution has allowed use of PLCs to implement very complex automation systems.

APPENDIX B

APPENDIX

B

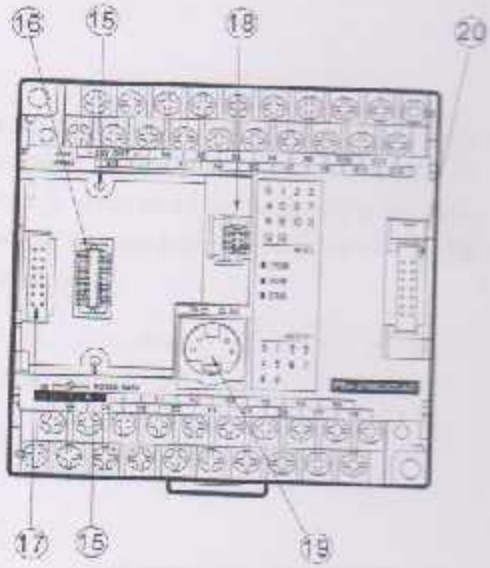
Chapter 1 Introduction of FATEK FBs Series PLC

The FATEK FBs Series PLC is a new generation of micro PLC equipped with excellent functions comparable to medium or large PLC, with up to five communication ports. The maximum I/O numbers are 256 points for Digital Input (DI) and Digital Output (DO), 64 words for Numeric Input (NI) and Numeric Output (NO). The Main Units of FBs are available in three types: MA (Economy Type), MC (High-Performance Type), and MN (High-Speed NC Type). With the combination of I/O point ranges from 10 to 60, a total of 17 models are available. Fifteen DI/DO and 19 NI/NO models are available for Expansion Units/Modules. With interface options in RS232, RS485, USB, Ethernet, CANopen, Zigbee and GSM, the communication peripherals are available with 15 boards and modules.

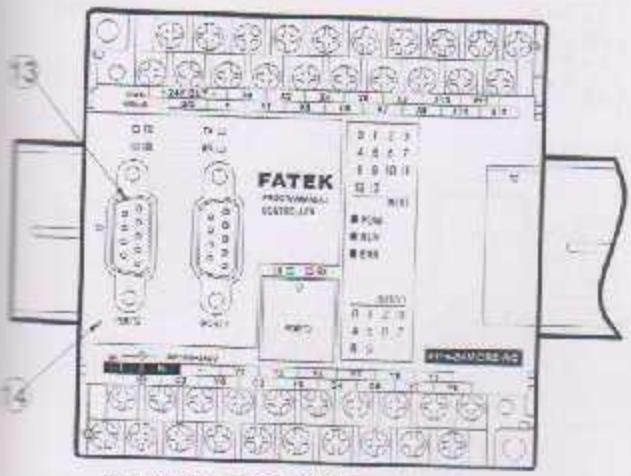
1.1 Appearance of Main Unit

All the Main Units of FBs-PLC have the same physical structure. The only difference is the case width. There are four different case sizes, which are 60mm, 90mm, 130mm, and 175mm. The figure below will use the Main Unit case of the FBs-24MC as an example for illustration:

(Front view without Communication Board)



(Front view with cover plate removed)



(Front view with CB-22 Board installed)

① 35mm-width DIN RAIL
② DIN RAIL tab
③ Hole for screw fixation (ϕ4.5×2)
④ Terminals of 24VDC power input and digital input (Pitch 7.62mm)
⑤ Terminals of main power input and digital output (Pitch 7.62mm)
⑥ Standard cover plate (without communication board)
⑦ Cover plate of built-in communication port (Port 0)

⑧ Indicators for transmit (TX) and receive (RX) status of built-in communication port (Port0)

⑨ Indicator for Digital Input (Xn)

⑩ Indicator for Digital Output (Yn)

⑪ Indicator for system status (POW, RUN, ERR).

⑫ I/O output expansion header cover [units of 20 points or beyond only], with esthetic purpose and capable of securing expansion cable.

⑬ FBs-CB22 Communication Board (CB).

⑭ FBs-CB22 CB cover plate (each CB has its own specific cover plate)

⑮ Screw holes of communication board.

⑯ Connector for communication board (for 7 types CB of CB2, CB22, CB5, CB55, CB25, CBE, CBCAN , 3 types AIO of B2DA, B2AD, B4AD, and 2 types DAP of BDAP and BPEP)

⑰ Left side (communication) expansion header (only available in MC/MN model, for CM22, CM25, CM55, CM25E, CM55E, and CMGSM connection).

⑱ Connector for Memory Pack.

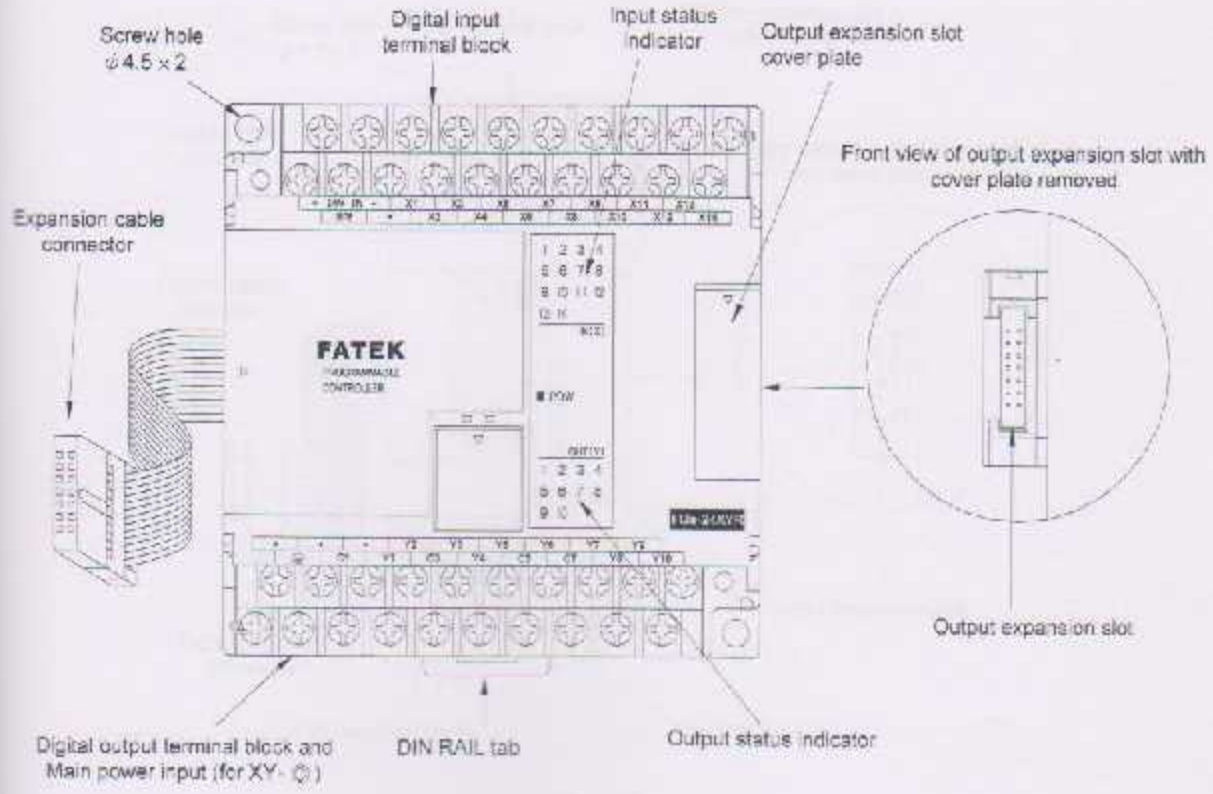
⑲ Connector for built-in communication port (Port 0) (With USB and RS232 optional, shown in the figure is for RS232)

⑳ Right side (I/O) output expansion header (only available in units with 20 points or beyond), for connecting with cables from expansion units/modules.

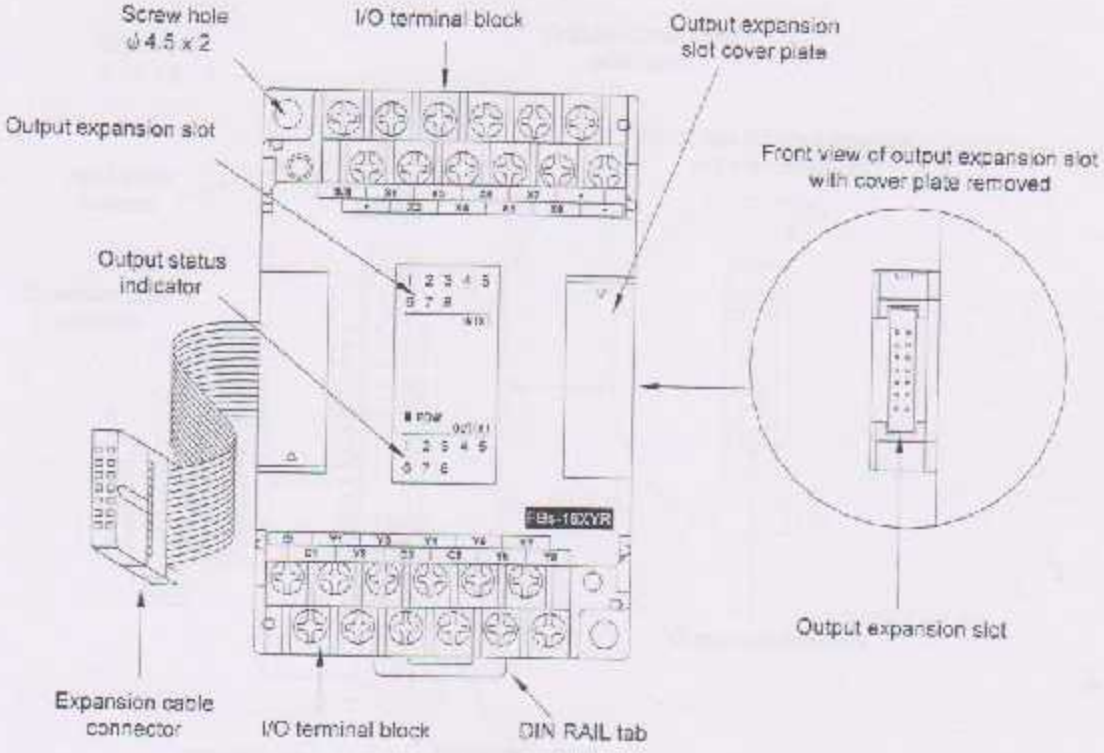
1.2 Appearance of Expansion Unit/Module

There are three types of cases for expansion units/modules. One type uses the same case as main unit that of the 90mm, 130mm, and 175mm, while the other two have thinner 40mm and 60mm cases, which are for expansion modules. All expansion cables (left) of expansion units/modules are flat ribbon cables (6cm long), which were soldered directly on the PCB and the expansion header (right) is a 14Pin Header, with this to connect the right adjacent expansion units/modules. In the following, each of the three types of expansion units/modules is described as an example.

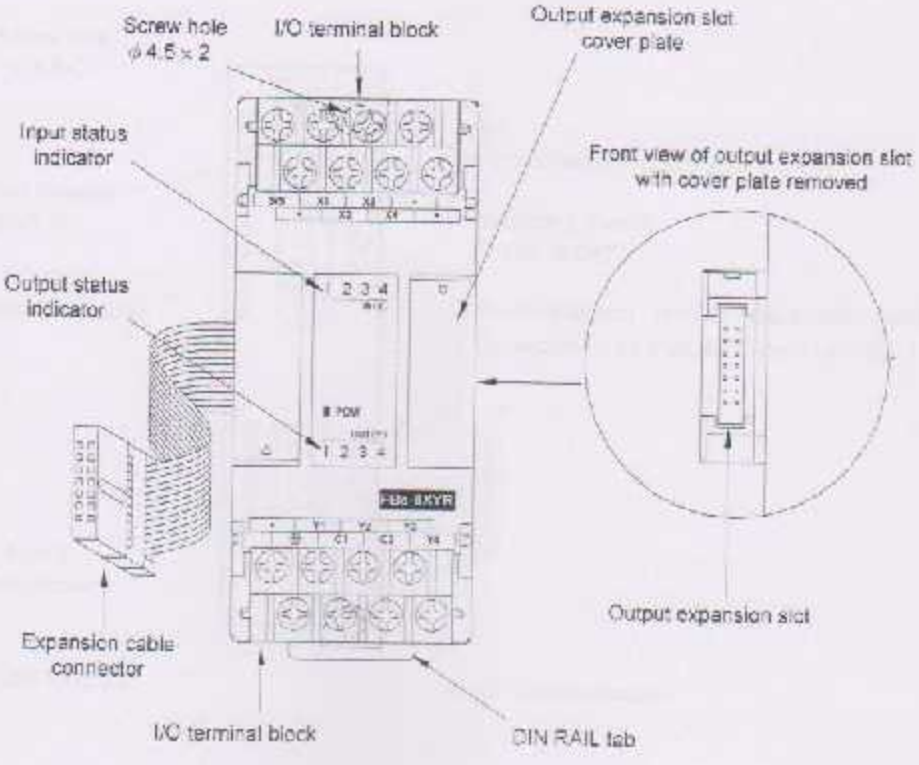
- Expansion unit/module with 90mm, 130mm, or 175mm width case: [-24XY◇ - ㉑, -40XY◇ - ㉒, -60XY◇ - ㉓, -16TC, -16RTD]



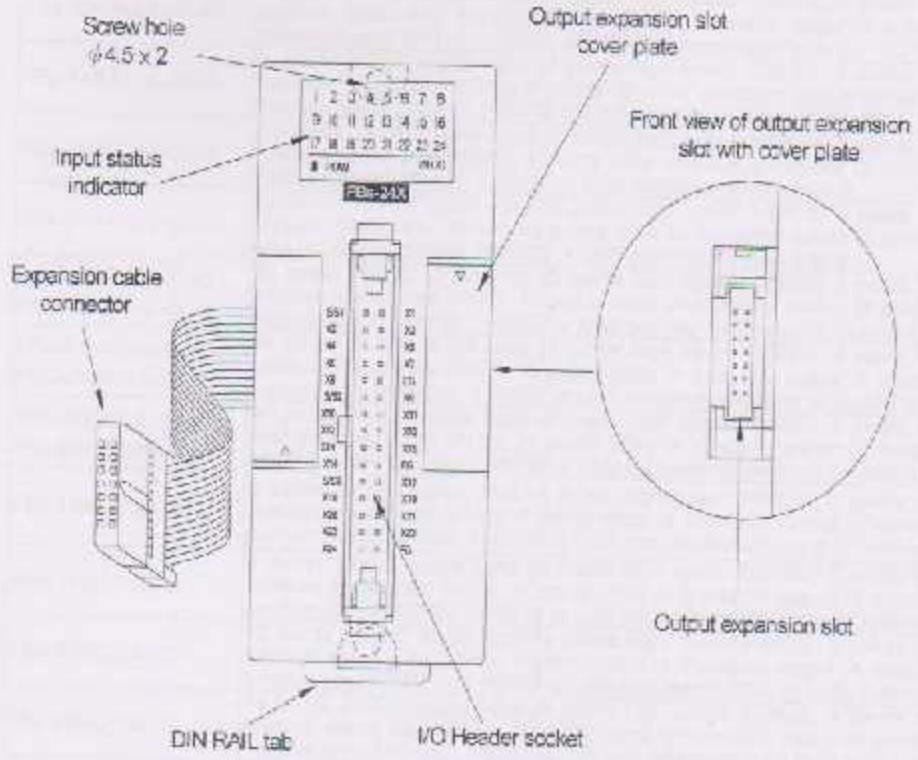
- Expansion unit/module with 60mm width case [-16XY○, -16Y○, -20X]



- Expansion module with 40mm width case [-8XY○, -8Y○, -8X, -8AD, -2DA, -4DA, -4A2D, -2A4TC, -2A4RTD, -7SG1, -7SG2, -2TC, -8TC, -8RTD, -CM5H, -8NTC, -4PT, -1LC, -1HLC, -VOM]

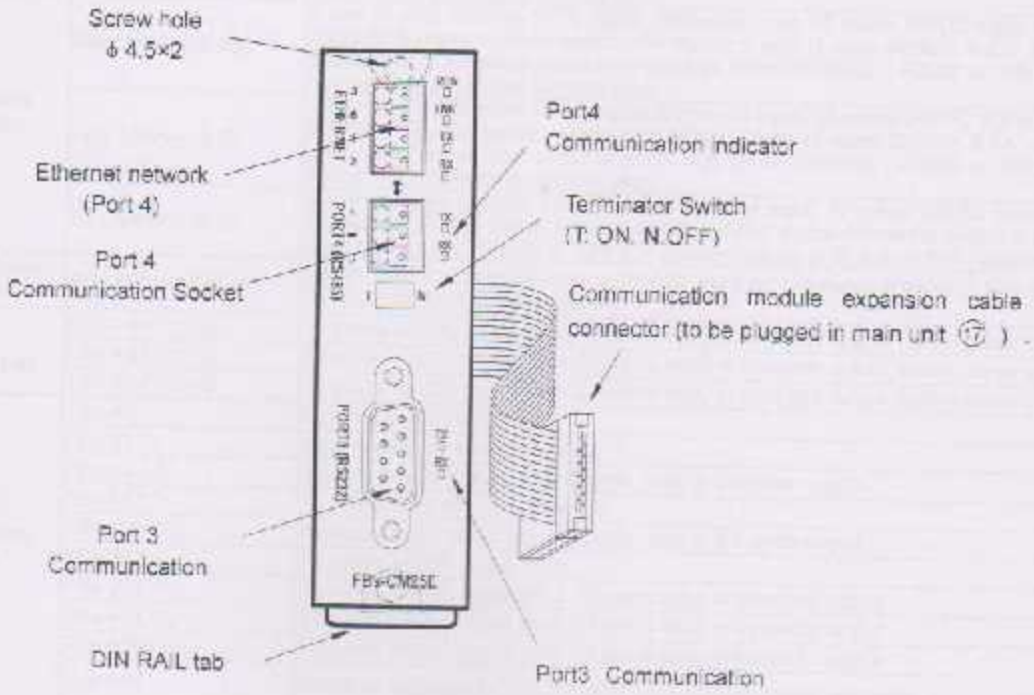


- Expansion module with 40mm width case [-24X, -24YT, -24YJ, -32DGI]



1.3 Appearance of Communication Expansion Module

The Communication Module (CM) of FBs-PLC has a 26mm width case, which can be used in the following seven modules: -CM22, -CM25, -CM55, -CM25E, -CM55E, -CM25C, -CM5R.



1.4 List of FBs-PLC Models

Module Name		Specifications
Basic Main Units	FBs-10MA◇Δ-Ⓑ-C	6 points 24VDC digital input (2 points high speed 100KHz, 2 points medium speed 20KHz, 2 points medium speed total 5KHz); 4 points relay or transistor output (2 points high speed 100KHz, 2 points medium speed 20KHz); 1 RS232 or USB port(expandable up to 3); I/O is not expandable
	FBs-14MA◇Δ-Ⓒ-C	8 points 24VDC digital input (2 points high speed 100KHz, 2 points medium speed 20KHz, 4 points medium speed total 5KHz); 6 points relay or transistor output (2 point high speed 100KHz, 4 points medium speed 20KHz); 1 RS232 or USB port(expandable up to 3); I/O is not expandable
	FBs-20MA◇Δ-Ⓓ-C	12 points 24VDC digital input (2 points high speed 100KHz, 4 points medium speed 20KHz, 6 points medium speed total 5KHz); 8 points relay or transistor output (2 points high speed 100KHz, 6 points medium speed 20KHz); 1 RS232 or USB port(expandable up to 3)
	FBs-24MA◇Δ-Ⓔ-C	14 points 24VDC digital input (2 points high speed 100KHz, 6 points medium speed 20KHz, 6 points medium speed total 5KHz); 10 points relay or transistor output (2 points high speed 100KHz, 6 points medium speed 20KHz); 1 RS232 or USB port(expandable up to 3)
	FBs-32MA◇Δ-Ⓕ-C FBs-32MB◇Δ-Ⓕ-C	20 points 24VDC digital input (2 points high speed 100KHz, 6 points medium speed 20KHz, 8 points medium speed total 5KHz); 12 points relay or transistor output (2 points high speed 100KHz, 6 points medium speed 20KHz); 1 RS232 or USB port(expandable up to 3); (MB is detachable terminal block)
	FBs-40MA◇Δ-Ⓖ-C FBs-40MB◇Δ-Ⓖ-C	24 points 24VDC digital input (2 points high speed 100KHz, 6 points medium speed 20KHz, 8 points medium speed total 5KHz); 16 points relay or transistor output (2 points high speed 100KHz, 6 points medium speed 20KHz); 1 RS232 or USB port(expandable up to 3); (MB is detachable terminal block)
	FBs-60MA◇Δ-Ⓗ-C FBs-60MB◇Δ-Ⓗ-C	36 points 24VDC digital input (2 points high speed 100KHz, 8 points medium speed 20KHz, 8 points medium speed total 5KHz); 24 points relay or transistor output (2 points high speed 100KHz, 6 points medium speed 20KHz); 1 RS232 or USB port(expandable up to 3); (MB is detachable terminal block)
Advanced Main Units	FBs-10MC◇Δ-Ⓑ	6 points 24VDC digital input (2 points high speed 200KHz, 2 points medium speed 20KHz, 2 points medium speed total 5KHz); 4 points relay or transistor output (2 points high speed 200KHz, 2 points medium speed 20KHz); 1 RS232 or USB port (expandable up to 5); built-in RTC; I/O is not expandable
	FBs-14MC◇Δ-Ⓒ	8 points 24VDC digital input (2 points high speed 200KHz, 2 points medium speed 20KHz, 4 points medium speed total 5KHz); 6 points relay or transistor output (2 points high speed 200KHz, 4 points medium speed 20KHz); 1 RS232 or USB port (expandable up to 5); built-in RTC; I/O is not expandable
	FBs-20MC◇Δ-Ⓓ	12 points 24VDC digital input (4 points high speed 200KHz, 2 points medium speed 20KHz, 6 points medium speed total 5KHz); 8 points relay or transistor output (4 points high speed 200KHz, 4 points medium speed 20KHz); 1 RS232 or USB port (expandable up to 5); built-in RTC; detachable terminal block
	FBs-24MC◇Δ-Ⓔ	14 points 24VDC digital input (4 points high speed 200KHz, 4 points medium speed 20KHz, 6 points medium speed total 5KHz); 10 points relay or transistor output (4 points high speed 200KHz, 4 points medium spec 20KHz); 1 RS232 or USB port (expandable up to 5); built-in RTC; detachable terminal block
	FBs-32MC◇Δ-Ⓕ	20 points 24VDC digital input (6 points high speed 200KHz, 2 points medium speed 20KHz, 8 points medium speed total 5KHz); 12 points relay or transistor output (6 points high speed 200KHz, 2 points medium speed 20KHz); 1 RS232 or USB port (expandable up to 5); built-in RTC; detachable terminal block
	FBs-40MC◇Δ-Ⓖ	24 points 24VDC digital input (6 points high speed 200KHz, 2 points medium speed 20KHz, 8 points medium speed total 5KHz); 16 points relay or transistor output (6 points high speed 200KHz, 2 points medium speed 20KHz); 1 RS232 or USB port (expandable up to 5); built-in RTC; detachable terminal block
	FBs-60MC◇Δ-Ⓗ	36 points 24VDC digital input (8 points high speed 200KHz, 8 points medium speed total 5KHz); 24 points relay or transistor output (8 points high speed 200KHz); 1 RS232 or USB port (expandable up to 5); built-in RTC; detachable terminal block
PC Positioning Main Units	FBs-20MN◇Δ-Ⓓ	2 sets (1 axis) 920KHz 5VDC digital differential input, 10 points 24VDC digital input (4 points high speed 200KHz, 6 points medium speed total 5KHz), 2 sets (1 axis) 920KHz 5VDC digital differential output, 6 points relay or transistor output (average high speed 200KHz); 1 RS232 or USB port (expandable up to 5); built-in RTC; detachable terminal block
	FBs-32MN◇Δ-Ⓕ	4 sets (2 axes) 920KHz 5VDC digital differential input, 16 points 24VDC digital input (4 points high speed 200KHz, 8 points medium speed total 5KHz); 4 sets (2 axes) 920KHz 5VDC digital differential output, 8 points relay or transistor output (4 points high speed 200KHz); 1 RS232 or USB port (expandable up to 5); built-in RTC; detachable terminal block
	FBs-44MN◇Δ-Ⓔ	8 sets (4 axes) 920KHz 5VDC digital differential input, 20 points 24VDC digital input (8 points medium speed total 5KHz); 8 sets (4 axes) 920KHz 5VDC digital differential output, 8 points relay or low speed transistor output; 1 RS232 or USB port (expandable up to 5); built-in RTC; detachable terminal block
Expansion Power Supply	FBs-EPW-AC/D24	Power supply of 100~240VAC or 24VDC input for expansion module; 3 sets output power with 5VDC, 24VDC, and 24VDC, 14W capacity
DIO Expansion Units	FBs-24XY◇-Ⓒ	14 points 24VDC digital input, 10 points relay or transistor output, built-in power supply
	FBs-40XY◇-Ⓖ	24 points 24VDC digital input, 16 points relay or transistor output, built-in power supply
	FBs-60XY◇-Ⓗ	36 points 24VDC digital input, 24 points relay or transistor output, built-in power supply
PC Expansion Modules	FBs-8X	8 points 24 VDC digital input
	FBs-8Y◇	8 points relay or transistor output
	FBs-6XY◇	4 points 24VDC digital input, 4 points relay or transistor output
	FBs-16Y◇	16 points relay or transistor output
	FBs-16XY◇	8 points 24VDC digital input, 8 points relay or transistor output
	FBs-20X	20 points 24VDC digital input
	FBs-24XY◇	14 points 24VDC digital input, 10 points relay or transistor output
	FBs-40XY◇	24 points 24VDC digital input, 16 points relay or transistor output
	FBs-60XY◇	36 points 24VDD digital input, 24 points relay or transistor output
	FBs-24X	24 points high-density 24VDC digital input, 30 pins header with latch
	FBs-24YT/J	24 points high-density transistor SINK(T) or SOURCE(J) output (0.1A max.) , 30 pins header with latch

Module Name		Specifications
Thumbwheel switch module	FBs-32DGI	8 sets 4 digits (total 32 digits) thumbwheel switch (or 128 points independent switch) multiplex input module, 30 pins header connector
8/7 Segment LED display modules	FBs-7SG1	1 set 8 digits 7-segment/4 digits 16-segment LED display (or 64 points independent LED) output display module, 16 pins header connector
	FBs-7SG2	2 sets 8 digits 7-segment/4 digits 16-segment LED display (or 128 points independent LED) output display module, 16 pins header connector
A/D modules	FBs-2DA	2 channels, 14-bit analog output module (-10~10V, 0~10V or -20~20mA, 0~20mA)
	FBs-4DA	4 channels, 14-bit analog output module (-10~10V, 0~10V or -20~20mA, 0~20mA)
	FBs-4A2D	4 channels, 14-bit analog input (same specification as 6AD)+2 channels, 14-bit analog output (same specification as 2DA) combo module
	FBs-6AD	6 channels, 14-bit analog input module (-10~10V, 0~10V or -20~20mA, 0~20mA)
Temperature measurement modules	FBs-2TC	2 channels, thermocouple temperature input module with 0.1°C resolution
	FBs-6TC	6 channels, thermocouple temperature input module with 0.1°C resolution
	FBs-16TC	16 channels, thermocouple temperature input module with 0.1°C resolution
	FBs-6RTD	6 channels, RTD temperature input module with 0.1°C resolution
	FBs-16RTD	16 channels, RTD temperature input module with 0.1°C resolution
	FBs-6NTC	6 channels, NTC temperature input module with 0.1°C resolution
A/D Temperature measurement combo modules	FBs-2A4TC	2 channels, 14-bit analog input (same specifications as 6AD)+ 4 channels thermocouple temperature input (same specifications as 6TC) combo module
	FBs-2A4RTD	2 channels, 14-bit analog input (same specifications as 6AD) + 4 channels RTD temperature input (same specifications as 6RTD) combo module
Voice modules	FBs-VOM	Built-in 1MB memory (play continuously up to 2 minutes), extendable 4GB SD card(play continuously up to 8,000 minutes) voice module, 245 messages, output 2W
Load Cell Module	FBs-1LC	1 channel, load cell measurement module with 16-bit resolution (including sign bit)
Potential Meter Module	FBs-4PT	4 channels, 14-bit potential meter input module (Impedance range: 1~10KΩ)
Communication modules	FBs-CM22	2 ports RS232 (Port3 +Port 4) communication module
	FBs-CM55	2 ports RS485 (Port3 +Port 4) communication module
	FBs-CM25	1 port RS232 (Port3) + 1 port RS485 (port 4) communication module
	FBs-CM25E	1 port RS232 (Port3) + 1 port RS485 (port 4) + Ethernet network interface communication module
	FBs-CM55E	1 port RS485 (Port3) + 1 port RS485 (port 4) + Ethernet network interface communication module
	FBs-CMZB	ZigBee communication module
	FBs-CMZBR	ZigBee communication repeater
	FBs-CMGSM	GSM wireless communication module
	FBs-CM25C	General purpose RS232 to RS485/RS422 communication interface converter with photocouple isolation
	FBs-CM5R	General purpose RS485 repeater with photocouple isolation
	FBs-CM5H	General purpose 4 ports RS485 HUB with photocouple isolation, RS485 can be connected as star connection
Communication boards	FBs-CB2	1 port RS232 (Port 2) communication board
	FBs-CB22	2 ports RS232 (Port 1+ Port 2) communication board
	FBs-CB5	1 port RS485 (Port 2) communication board
	FBs-CB55	2 ports RS485 (Port 1+ Port 2) communication board
	FBs-CB25	1 port RS232 (Port 1) + 1 port RS485 (Port 2) communication board
	FBs-CBE	1 port 10 Base T Ethernet communication board
	FBs-CBEH	1 port 100 Base T Ethernet communication board
	FBs-CBCAN	1 port CANopen communication board
A/D boards	FBs-B2DA	2 channels, 12-bit analog output board (0~10V or 0~20mA)
	FBs-B2A1D	2 channels, 12-bit analog input + 1 channel, 12-bit analog output combo analog board (0~10V or 0~20mA)
	FBs-B4AD	4 channels, 12-bit analog input board (0~10V or 0~20mA)
Precision Load Cell Module	FBs-1HLC	1 channel, high precision weighing control module with 24-bit resolution
Basic Motion Control Module	FBs-30GM	3-Axis with linear and circular interpolation advanced motional control module, 3 sets of 200KHz high speed pulse input, 3 sets of 500KHz high speed pulse output, 14 points main unit, 16M Bytes program capacity, 20K Words retentive file register, built-in RS485 and Ethernet, 7.62mm detachable terminal block
Simple HMI	FBs-BDAP	Board type Data Access Panel
	FBs-BPEP	Board type Parameter Entry Panel
	FBs-PEP/PEPR	Multi characters with graphics-based Parameter Entry Panel, built-in RFID Read/Write module with PEPR
	FBs-DAP-B/BR	16 X 2 LCD character display, 20 keys keyboard, 24VDC power supply, RS485 communication interface, built-in RFID Read/Write module with BR
	FBs-DAP-C/CR	16 X 2 LCD character display, 20 keys keyboard, 5VDC power supply, RS232 communication interface, built-in RFID Read/Write module with CR

Module Name		Specifications
RFID Card	CARD-H	Read / Write wireless card (for FBs-DAP-BR/CR and FBs-PEPR)
Programming Devices	FP-08	FBs- Series PLC handheld programmer
	Winproladder	FATEK-PLC Winproladder Programming software
Memory Pack	FBs-PACK	FBs-PLC program memory pack with 20K Words program, 20K Words register, write protection switch
PWMDA module	PWMDA	10-bit single channel pulse width modulation(PWM) 0~10V analog output (AO) module
USB- RS232 Converter Cable	FBs-U2C-MD-180	Communication converter cable with standard USB AM connector to RS232 MD4M connector (used in standard PC USB to FBs main unit Port 0 RS232), length 180cm
Communication cables	FBs-232P0-9F-150	MD4M to DB9F communication cable (FBs main unit Port 0 RS232 connect to standard DB9M), length 150cm
	FBs-232P0-9M-400	MD4M to DB9M communication cable (FBs main unit Port 0 RS232 connect to DB9F), length 400cm
	FBs-232P0-MD-200	MD4M to MD4M communication cable (FBs main unit Port 0 RS232 connect to FBs-PEP/PEPR), length 200cm
	FBs-232P0-MDR-200	MD4M to 90° MD4M communication cable (FBs main unit Port 0 RS232 connect to FBs-PEP/PEPR), length 200cm
High density DIO cable	HD30-22AWG-200	High density modules(FBs-24X, FBs-24YT/J, FBs-32DGI) connector + 30pin Socket, 22AWG I/O cable, length200cm
8"-Segment LED display	DBAN.8-nR	0.8" 4-digit 16-segment LED display, n means R(Red) 16-segment LED chereclers display installed, can be 1~4
	DBAN.2.3-nR	2.3" 4-digit 16-segment LED display, n means R(Red) 16-segment LED characters display installed, can be 1~4
	DB.56-nR	0.56" 8-digit 7-segment display, n means R(Red) 7-segment LED characters display installed, can be 1~8
	DB.8-nR	0.8" 8-digit 7-segment display, n means R(Red) 7-segment LED characters display installed, can be 1~8
	DB2.3-nR	2.3" 8-digit 7-segment display, n means R(Red) 7-segment LED characters display installed, can be 1~8
	DB4.0-nR	4.0" 4-digit 7-segment display, n means R(Red) 7-segment LED characters display installed, can be 1~4
Training Box	FBs-TBOX	46cm x 32 cm x 16cm suitcase, containing FBs-24MCT main unit, FBs-CM25F communication module (RS232 + RS485 + Ethernet network), 14 simulated input switches, 10 external relay output, Doctor terminal outlet I/O, peripherals such as stepping motor, encoder, 7-segment display, 10 of 10mm LED indicator, thumbwheel switch, and 16 key keyboard.

R – Relay output ; T – Transistor SINK(NPN) output J – Transistor SOURCE (PNP) output

C – built-in RS232 port ; U – built-in USB port (non-standard)

AC – 100~240VAC power supply ; D12 – 12VDC power supply ; D24 – 24VDC power supply

Blank – Standard ; -C – add in RTC

Remarked frequencies of Digital Input (DI) or Digital Output (DO) are low speed.

1.5 Specifications of Main Unit

Item				Specification	Note
Execution Speed				0.33uS / per Sequence Command	
Space of Control Program				20K Words	
Program Memory				FLASH ROM or SRAM + Lithium battery for Back-up	
Sequence Command				36	
Application Command				326 (129 types)	Include Derived Commands
Flow Chart (SFC) Command				4	
Single Point (BIT Status)	X	Output Contact(DI)		X0~X255 (256)	Corresponding to External Digital Input Point
	Y	Output Relay(DO)		Y0~Y255 (256)	Corresponding to External Digital Output Point
	TR	Temporary Relay		TR0~TR39 (40)	
	M	Internal Relay	Non-retentive	M0~M799 (800)*	Can be configured as retentive type
				M1400~M1911 (512)	
			Retentive	M800~M1399 (600)*	Can be configured as non-retentive type
		Special Relay		M1912~M2001 (90)	
	S	Step Relay	Non-retentive	S0~S499 (500)*	S20~S499 can be configured as retentive type
			Retentive	S500~S999 (500)*	Can be configured as non-retentive type
	T	Timer "Time Up" Status Contact		T0~T255 (256)	
	C	Counter "Count Up" Status Contact		C0~C255 (256)	
Register (WORD Data)	TMR	Current Time Value Register	0.01S Time base	T0~T49 (50)*	T0 ~ T255 Numbers for each time base can be flexibly adjusted.
			0.1S Time base	T50~T199 (150)*	
			1STime base	T200~T255 (56)*	
	CTR	Current Counter Value Register	16-Bit Retentive	C0~C139 (140)*	Can be configured as non-retentive type
			16-Bit Non-retentive	C140~C199 (60)*	Can be configured as retentive type
			32-Bit Retentive	C200~C239 (40)*	Can be configured as non-retentive type
			32-Bit Non-retentive	C240~C255 (16)*	Can be configured as retentive type
	HR DR	Data Register	Retentive	R0~R2999 (3000)*	Can be configured as non-retentive type
				D0~D3999 (4000)	
			Non-retentive	R3000~R3839 (840)*	Can be configured as retentive type
	HR ROR		Retentive	R5000~R8071 (3072)*	When not configured as ROR, it can serve as normal register (for read/Write)
			Read-only Register	R5000~R8071 can be configured as ROR, default setting is (0)*	ROR is stored in special ROR area and not consume program space
			File Register	F0~F8191 (8192)*	Must save/retrieved via special commands
	IR	Input register		R3840~R3903 (64)	Corresponding to external numeric input
	OR	Output Register		R3904~R3967 (64)	Corresponding to external numeric output
	SR	Special System Register		R3968~R4167 (197) R4000~R4095 (96)	
	(Special Register)	0.1mSHigh Speed Timer register		R4152~R4154 (3)	
		High Speed Counter Register	Hardware(4 sets)	DR4096~DR4110 (4×4)	
			Software (4 sets)	DR4112~DR4126 (4×4)	
		Real Time Calendar Register (Not available in MA model)		R4128 (sec) / R4128 (min) / R4130 (hour) / R4131 (day) / R4132 (month) / R4133 (year) / R4134 (week)	Optional for MA module
	XR	Index Register		V、Z (2), P0~P9 (10)	
Interrupt Control	External Interrupt Control			32 (16 point input positive/negative edges)	
	Internal Interrupt Control			8 (1, 2 3, 4, 5, 10, 50, 100mS)	
0.1mS High Speed Timer (HST)				1 (16bits), 4 (32bits, derived from HHSC)	

High Speed Counter	Hardware High Speed Counter (HHSC) /32 bits	Channels	Up to 4	• Total number of HHSC and SHSC is 8. • HHSC can change into High Speed Timer with 32 bits/0.1mS Time base.
		Counting mode	8 (U/D, U/D×2, K/R, K/R×2, A/B, A/B×2, A/B×3, A/B×4)	
		Counting frequency	Up to 200KHz (single-end input) or 920KHz (differential input)	
	Software High Speed Counter (SHSC) /32 bits	Channels	Up to 4	
		Counting mode	3 (U/D、K/R、A/B)	
		Counting frequency	Maximum sum up to 5KHz	
Communication Interface	Port0 (RS232 or USB)		Communication Speed 4.8Kbps~921.6Kbps (9.6Kbps)*	
	Port1~Port4 (RS232, RS485 or Ethernet)		Communication Speed 4.8Kbps~921.6Kbps (9.6Kbps)*	Port1~4 talk FATEK or Modbus RTU Master/Slave Communication Protocol
	Maximum Connections		254	
NC Positioning Output (PSO)	Number of Axes		Up to 4	
	Output Frequency		200KHz single output (single) 100KHZ (A/B way) 920KHz(single way) and 460KHz(A/B way) differential output.	
	Output Pulse Mode		3 (U/D、K/R、A/B)	
	Positioning Language		Special Positioning Programming Language	
HSPWM Output	Number of Points		Up to 4	
	Output Frequency		72Hz~18.432KHz (with 0.1% resolution) 720Hz~184.32KHz (with 1% resolution)	
Captured input	Points		Max.36 points (all of main units have the feature)	
			> 10μS(super high speed/high speed input)	
	Captured pulse width		> 47μS(medium speed input)	
			> 470μS(mid/low speed input)	
Setting of Digital Filter	X0~X15		Frequency 14KHz ~ 1.8MHz	Chosen by frequency at high frequencies
			Time constant 0 ~ 1.5mS/0 ~ 15mS adjustable by step of 0.1mS/1mS	Chosen by time constant at low frequencies
	X16~X35		Time constant 1mS~15mS adjustable by step of 1mS	
Maximum expandable module			32	

1.6 Environmental Specifications

Item			Specification	Note
Operating Ambient Temperature	Enclosure equipment	Minimum	5°C	Permanent Installation
		Maximum	40°C	
	Open equipment	Minimum	5°C	
		Maximum	55°C	
Storage Temperature			-25°C~+70°C	
Relative Humidity (non-condensing, RH-2)			5%~95%	
Pollution Level			Degree II	
Corrosion Resistance			By IEC-68 Standard	
Altitude			≦2000m	
Vibration	Fixed by DIN RAIL		0.5G for 2 hours each along the 3 axes	
	Secured by screws		2G for 2 hours each along the 3 axes	
Shock			10G 3 times each along the 3 axes	
Noise Suppression			1500Vp-p, width 1us	
Withstand Voltage			1500VAC, 1 minute	L, N to any terminal

⚠ Warning

The listed environmental specifications are for FBs-PLC under normal operation. Any operation in environment not conform to above conditions should be consulted with FATEK.

1.7 Connection Diagrams of Various Models

1.7.1 NC Control Main Unit [7.62mm Detachable Terminal Block]

- 20 point digital I/O main unit (12 points IN, 8 points OUT)

AC Power

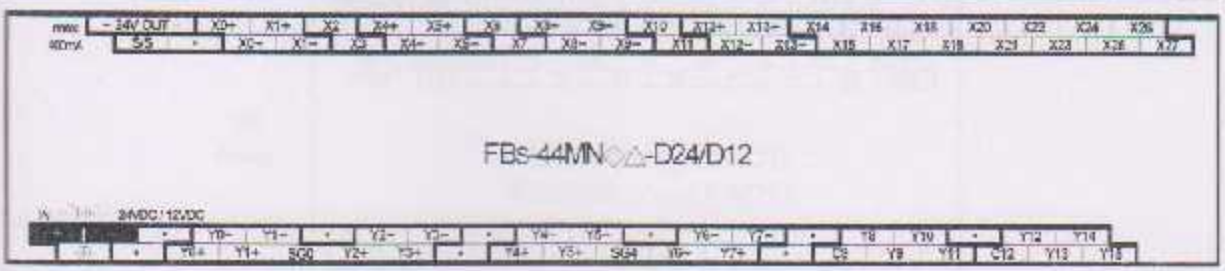
DC Power

- 32 point digital I/O main unit (20 points IN, 12 points OUT)

AC Power

DC Power

- 44 point digital I/O main unit (28 points IN, 16 points OUT)

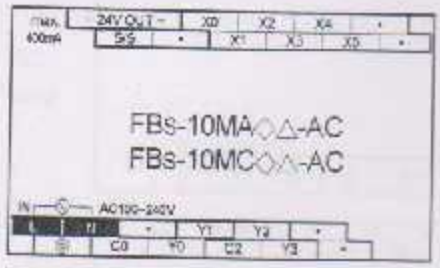


1.7.2 Basic/Advanced Main Unit

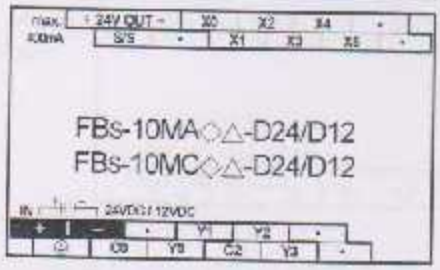
[7.62mm Terminal Block: fixed in model MA, detachable in models MB/MC]

- 10 point digital I/O main unit (6 points IN, 4 points OUT)

AC Power

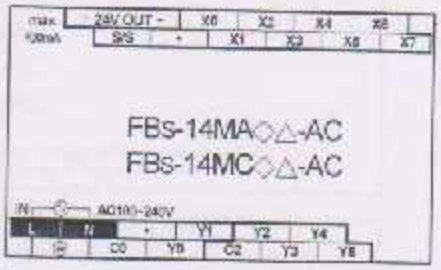


DC Power

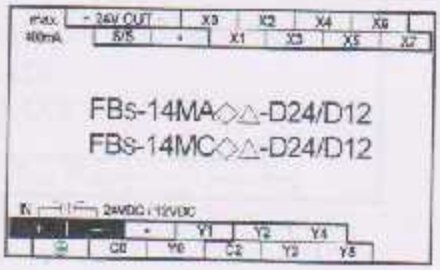


- 14 point digital I/O main unit (8 points IN, 6 points OUT)

AC Power

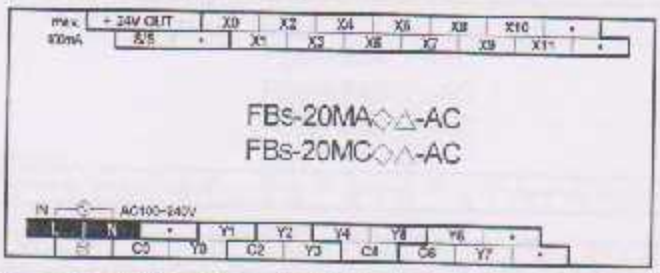


DC Power

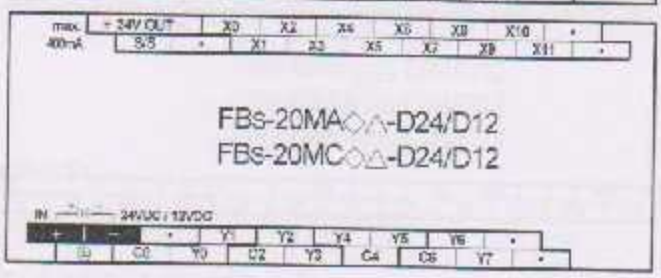


- 20 point digital I/O main unit (12 points IN, 8 points OUT)

AC Power



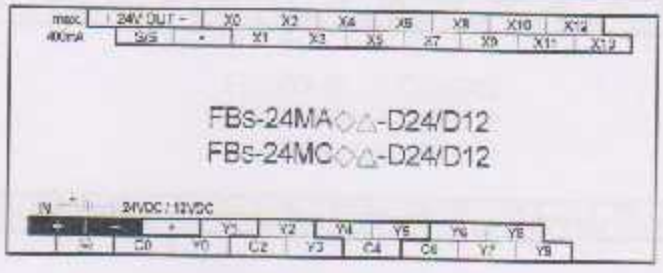
DC Power



- 24 point digital I/O main unit (14 points IN, 10 points OUT)

AC Power

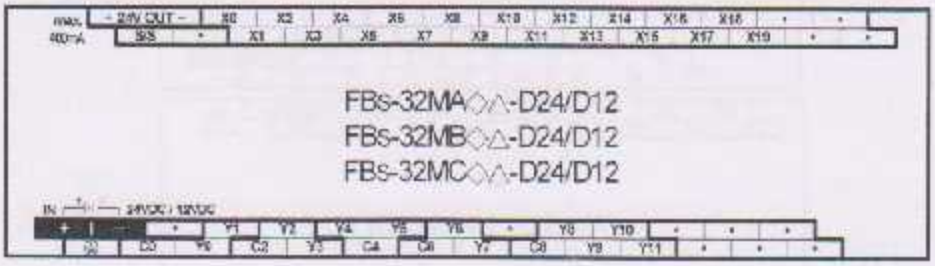
DC Power



- 32 point digital I/O main unit (20 points IN, 12 points OUT)

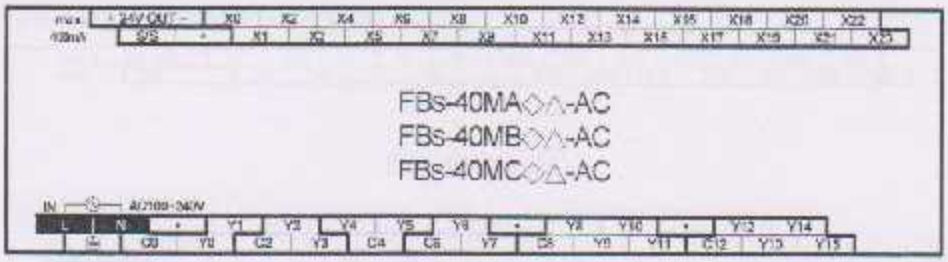
AC Power

DC Power



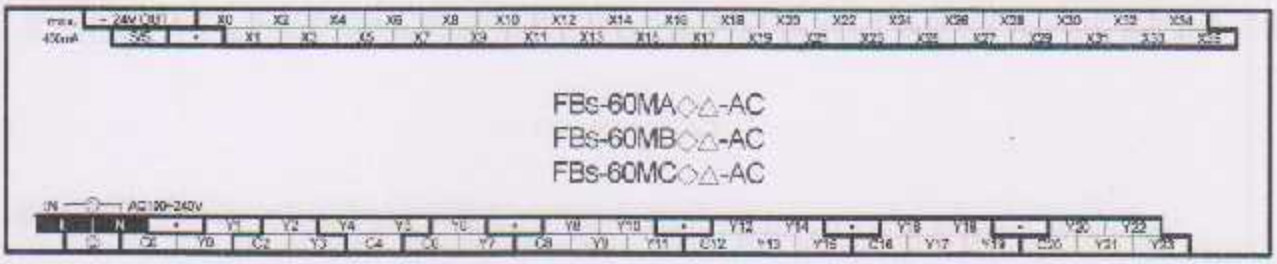
- 40 point digital I/O main unit (24 points IN, 16 points OUT)

AC Power



DC Power

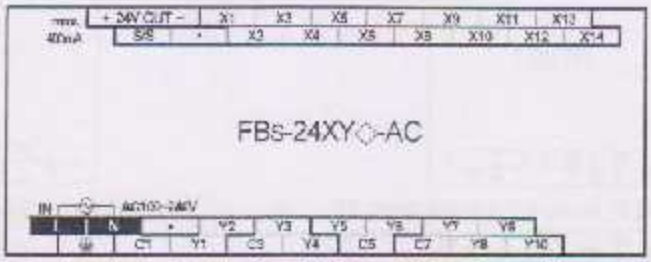
- 60 point digital I/O main unit (36 points IN, 24 points OUT)



1.7.3 Digital I/O Expansion Unit [7.62mm fixed terminal block]

- 24 point I/O expansion unit (14 points IN, 10 points OUT)

AC Power



DC Power

- 40 point I/O expansion unit (24 points IN, 16 points OUT)

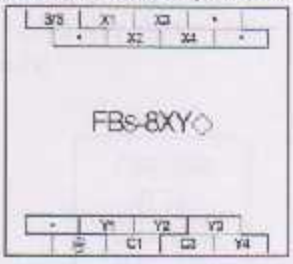
AC Power

DC Power

- 60 point I/O expansion unit (36 points IN, 24 points OUT)

1.7.4 Digital I/O Expansion Module [7.62mm fixed terminal block]

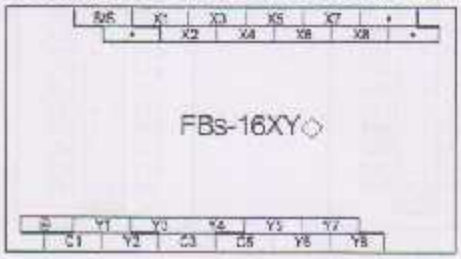
- 8 point digital I/O module (4 points IN, 4 points OUT)



- 8 point digital input module (8 points IN)

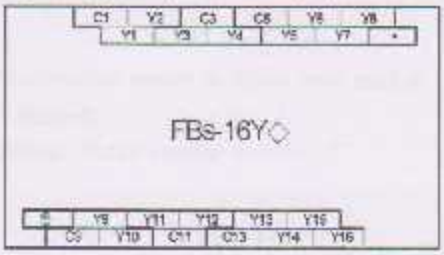
- 8 point digital output module (8 points OUT)

- 16 point digital I/O module (8 points IN, 8 points OUT)



- 20 point digital input module (20 points IN)

- 16 point digital output module (16 points OUT)



- 24 point digital I/O module (14 points IN, 10 points OUT)

- 40 point digital I/O module (24 points IN, 16 points OUT)

- 60 point digital I/O module (36 points IN, 24 points OUT)

1.7.5 High-Density Digital I/O Expansion Module [30Pin/2.54mm Header connector]

- 24 point high-density input module
  (24 points IN)

- 24 point high-density transistor output module
  (24 points OUT)

1.7.6 Numeric I/O Expansion Module [2.54mm Header connector]

- 7 segment LED display module
  (8 digits/-7SG1, 16 digits/-7SG2)
  [16 pin/2.54mm Header connector]

- Thumbwheel switch multiplex input module
  (4 digits×8)
  [30Pin/2.54mm Header connector]

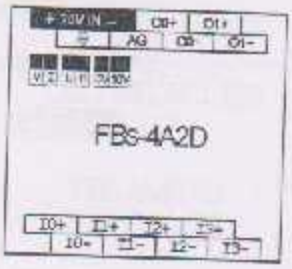
1.7.7 Analog I/O Expansion Module [7.62mm fixed terminal block]

- 6 channel A/D analog input module

- 2 channel D/A output module

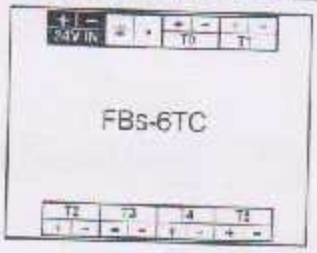
- 4 channel D/A output module

- 4 channel A/D input, 2 channel D/A output module

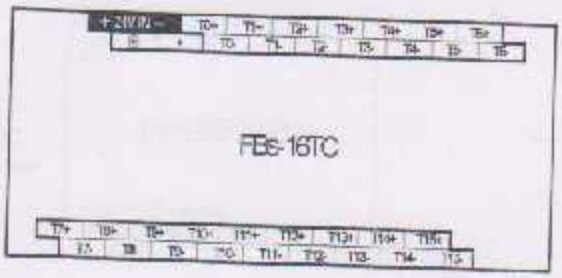


1.7.8 Temperature Input Module [7.62mm fixed terminal block]

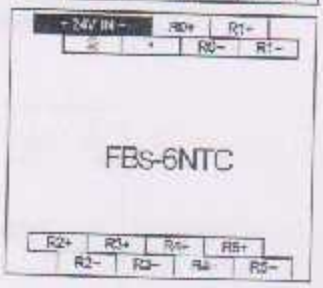
- 2/6 channel thermocouple input module



- 16 channel thermocouple input module



- 6 channel RTD input module



- 16 channel RTD input module

1.7.9 Analog/Temperature Combo Module

[7.62mm fixed terminal block]

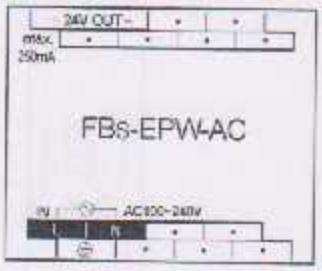
- 2 channel A/D analog input & 4 channel thermocouple input module

- 2 channel A/D analog input & 4 channel RTD input module

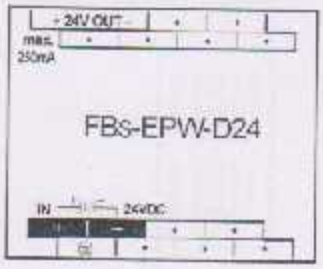
1.7.10 Expansion Power Module

[7.62mm fixed terminal block]

AC Power

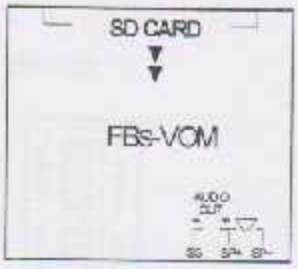


DC Power



1.7.11 Voice Output Module

[7.62mm fixed terminal block]



1.7.12 Potential Meter Module

[7.62mm fixed terminal block]

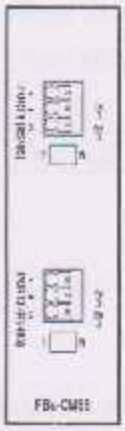
1.7.13 Load Cell Module

[7.62mm fixed terminal block]

1.7.14 Communication Module (CM) [DB-9F connector/3Pin or 4Pin spring terminal block]

- 2 RS232 ports

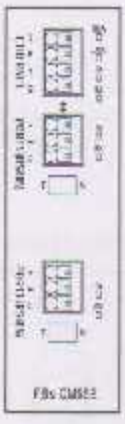
- 2 RS485 ports



- 1 RS232 – 1 RS485 ports

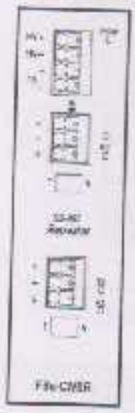
- 1 RS232 – 1 RS485 + Ethernet

- 2 RS485 ports + Ethernet



- RS232 ↔ RS485 /RS222 Converter

- RS485 Repeater
- GSM/GPRS



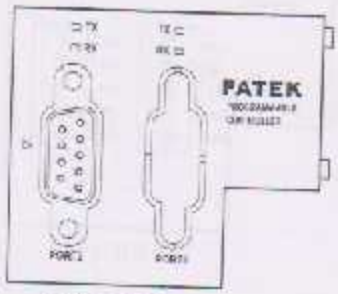
- RS485 HUB

[7.62mm fixed terminal block]

1.7.15 Communication Board (CB)

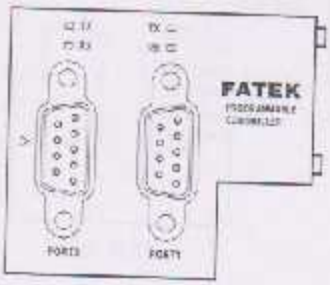
[DB9F/3Pin spring terminal block](Below are outlooks of CB and the corresponding cover plates)

- 1 RS232 port



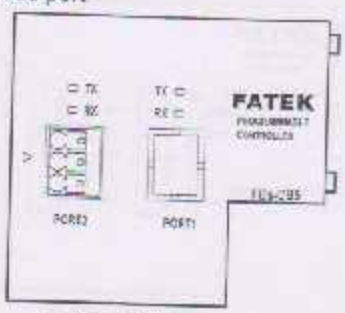
FBs-CB2

- 2 RS232 ports



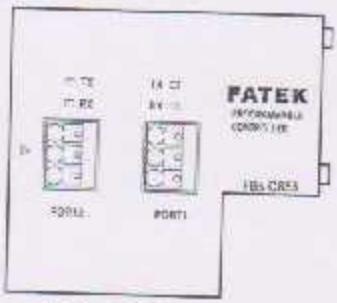
FBs-CB22

- 1 RS485 port



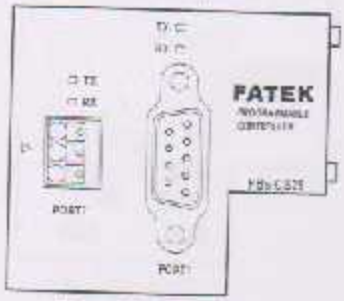
FBs-CB5

- 2 RS485 ports



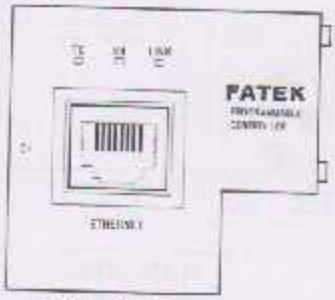
FBs-CB55

- 1 RS232 + 1 RS485 ports



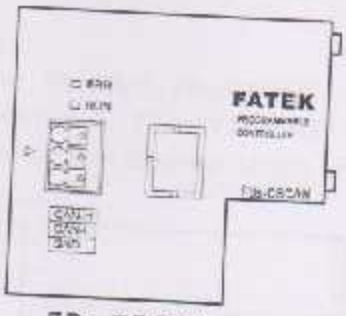
FBs-CB25

- 1 Ethernet port



FBs-CBE

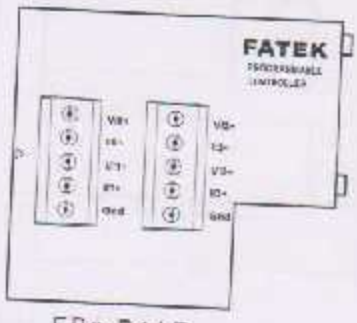
- CANopen



FBs-CBCAN

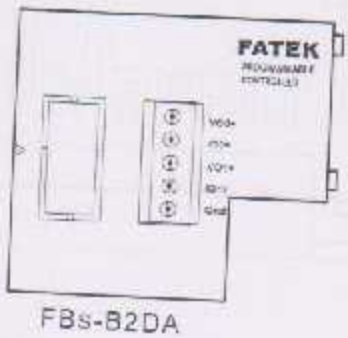
1.7.16 Analog Expansion Board [5Pin European terminal block]

- 4 channel A/D analog input board



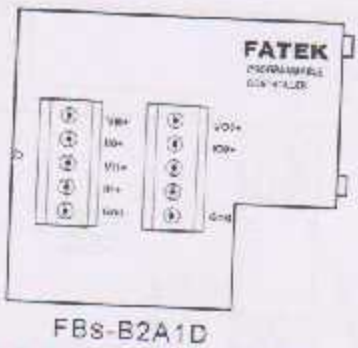
FBs-B4AD

- 2 channel D/A analog output board



FBs-B2DA

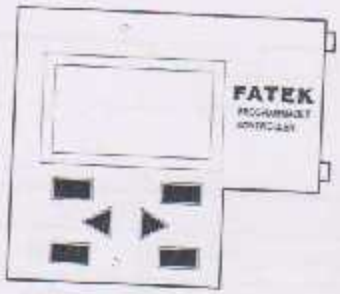
- 2 channel A/D analog input & 1 channel D/A analog output board



FBs-B2A1D

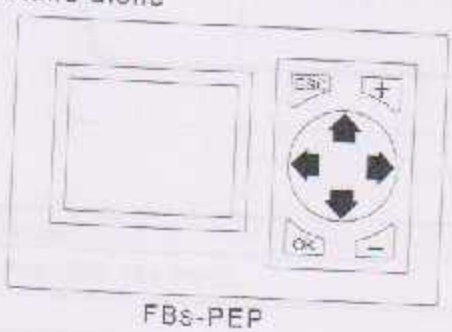
1.7.17 Simple HMI

- Board-type



FBs-BDAP
FBs-BPEP

- Stand-alone



FBs-PEP

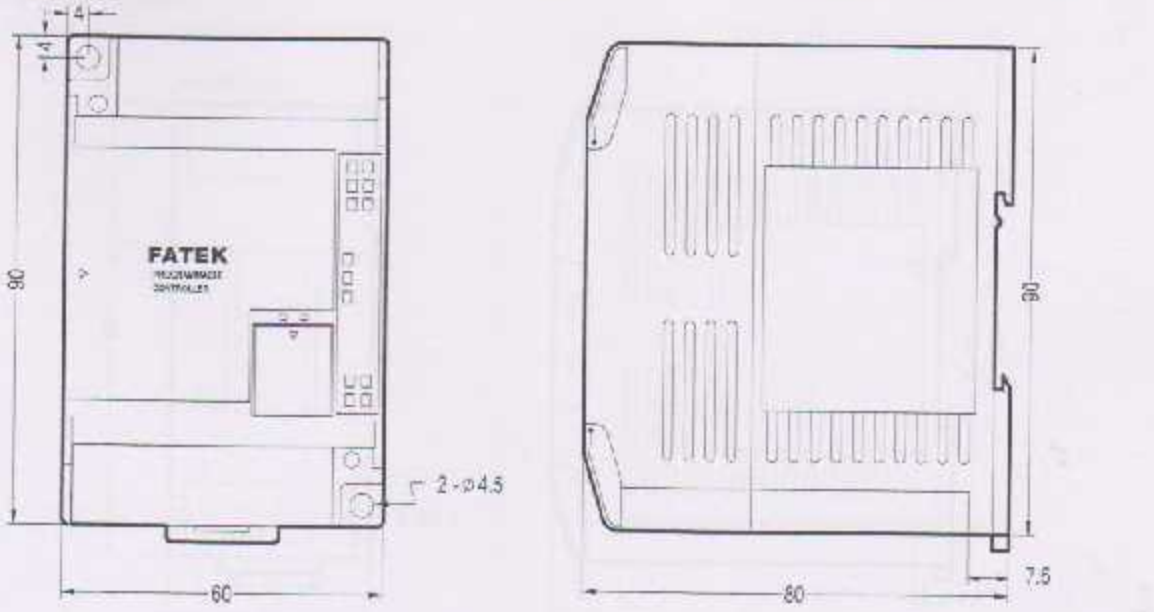
1.8 Drawings with External Dimensions

(1) Outlook I :

Main Unit : FBs-10M△, FBs-14M△

Expansion Module : FBs-16Y,FBs-16XY, FBs-20X

＊ (Main Unit and Expansion Module have the same type of base with different top cover, as shown in the figure)

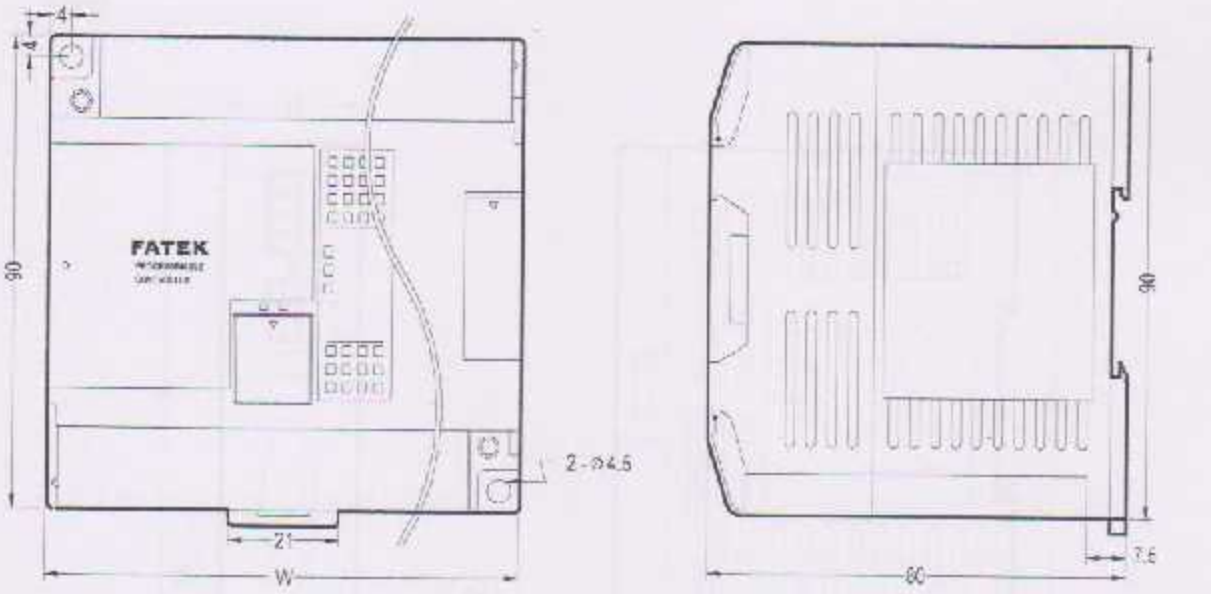


units : mm

(2) Outlook II :

Main Unit : FBs-20M△, FBs-24M△, FBs-32M△, FBs-40M△, FBs-60M△

Expansion Module : FBs-24XY(②), FBs-40XY(③), FBs-60XY(④), FBs-16TC, FBs-16RTD



units : mm

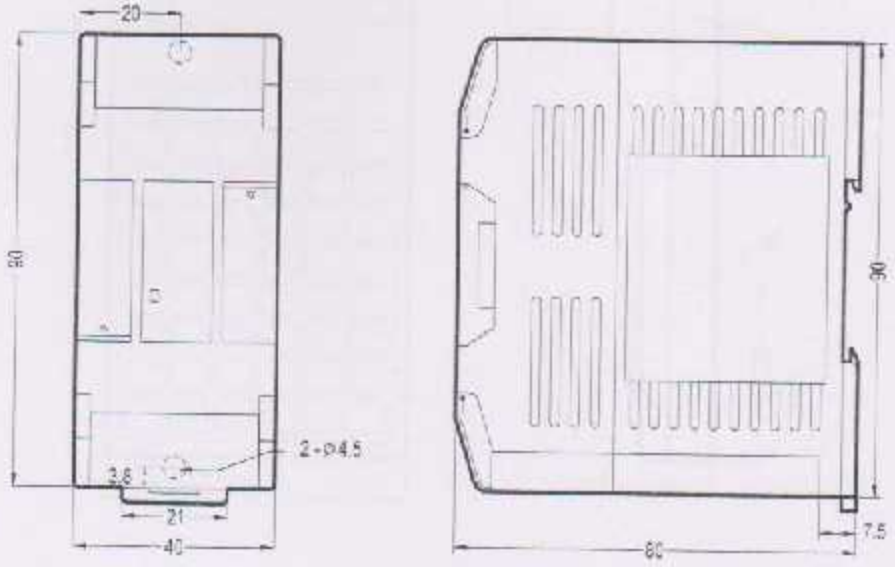
W	Model
90mm	FBs-20M△, FBs-24M△, FBs-24XY(②), FBs-16TC, FBs-16RTD
130mm	FBs-32M△, FBs-40M△, FBs-40XY(③)
175mm	FBs-60M△, FBs-60XY(④)

(3) Outlook III :

Expansion Module : ① FBs-8X, FBs-8Y, FBs-8XY, FBs-7SG1, FBs-7SG2, FBs-8AD, FBs-2DA, FBs-4DA, FBs-4A2D, FBs-2TC, FBs-6TC FBs-6RTD, FBs-CM5H, FBs-2A4TC, FBs-2A4RTD, FBs-4PT, FBs-1LC, FBs-1HLC, FBs-6NTC, FBs-VOM

② FBs-24X, FBs-24YT, FBs-24YJ, FBs-32DGI

* (Modules ① and ② have the same type of base, with different top cover. Top cover of Module ① is shown in the following figure)

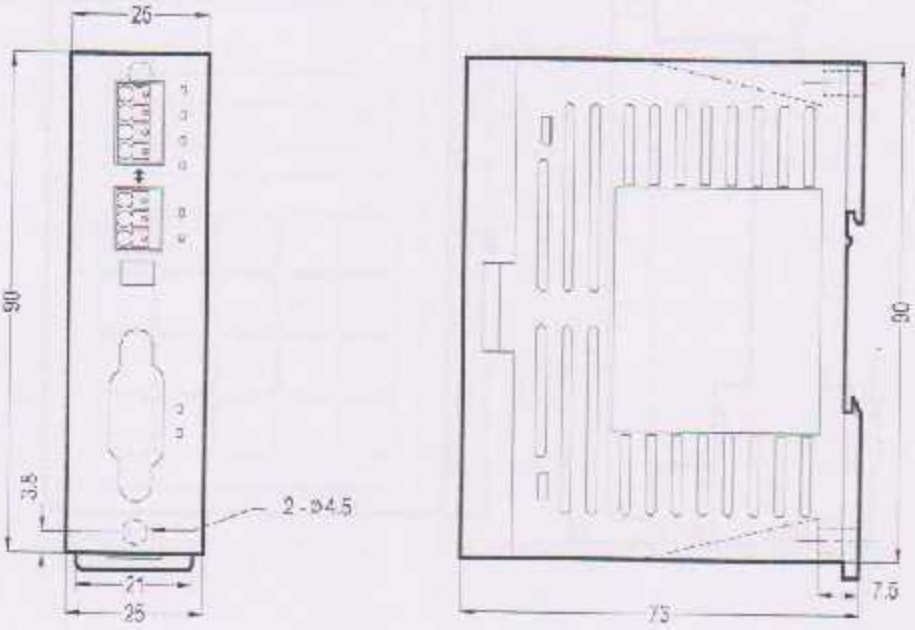


units : mm

(4) Outlook IV:

Communication Module : FBs-CM22, FBs-CM55, FBs-CM25, FBs-CM25E, FBs-CM55E, FBs-CM25C, FBs-CM5R

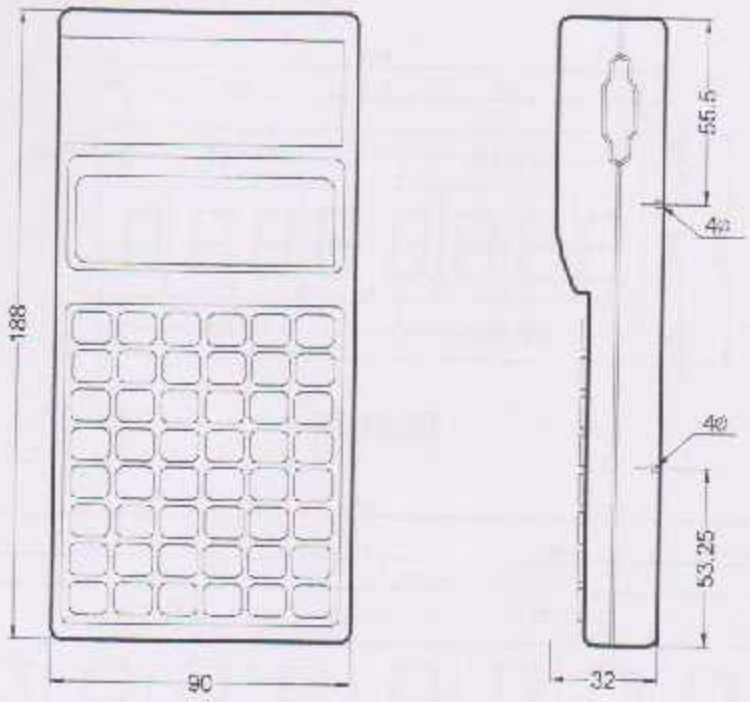
* (All modules have the same type of base, with different top cover. Top cover of Module -CM25E is shown in the figure)



units : mm

(5) Outlook V :

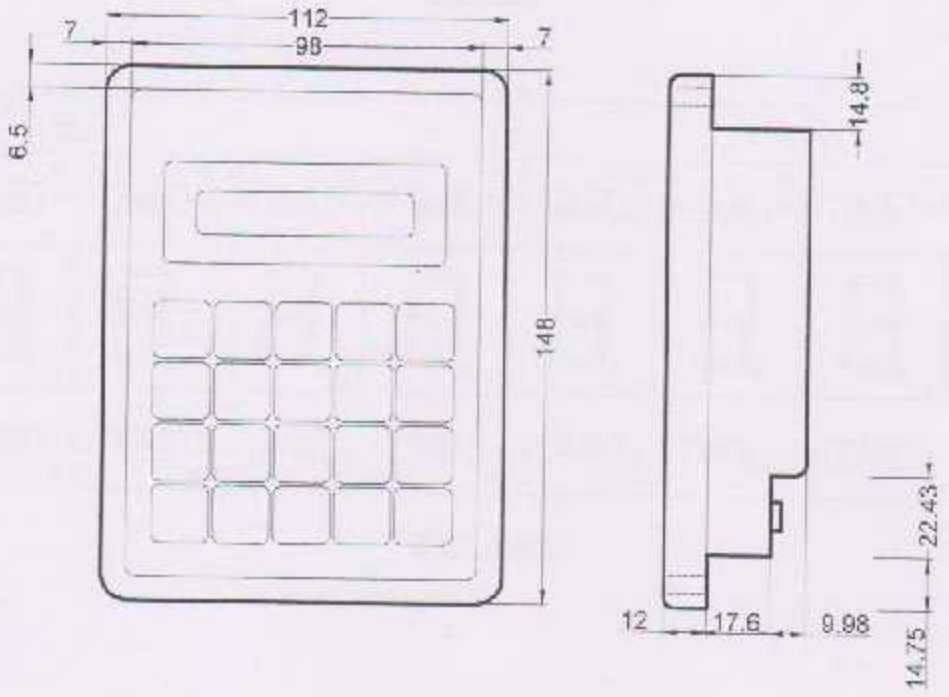
Programming Panel : FP-08



(6) Outlook VI :

Data Access Panel : FB-DAP

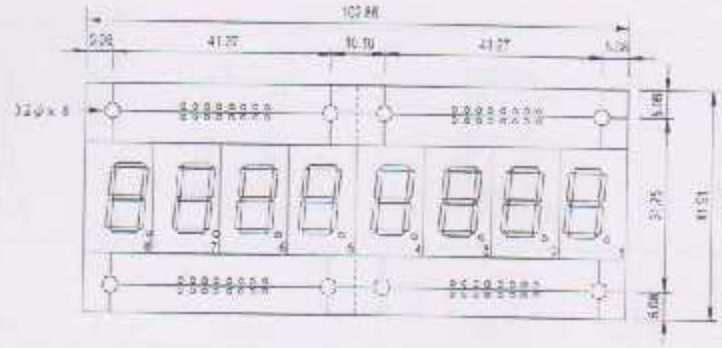
units : mm



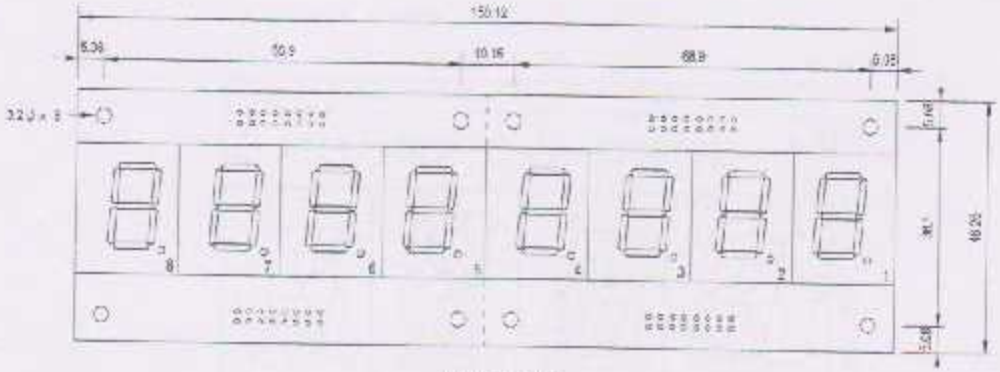
(7) Outlook VII :

7-segment / 16-segment LED display board :

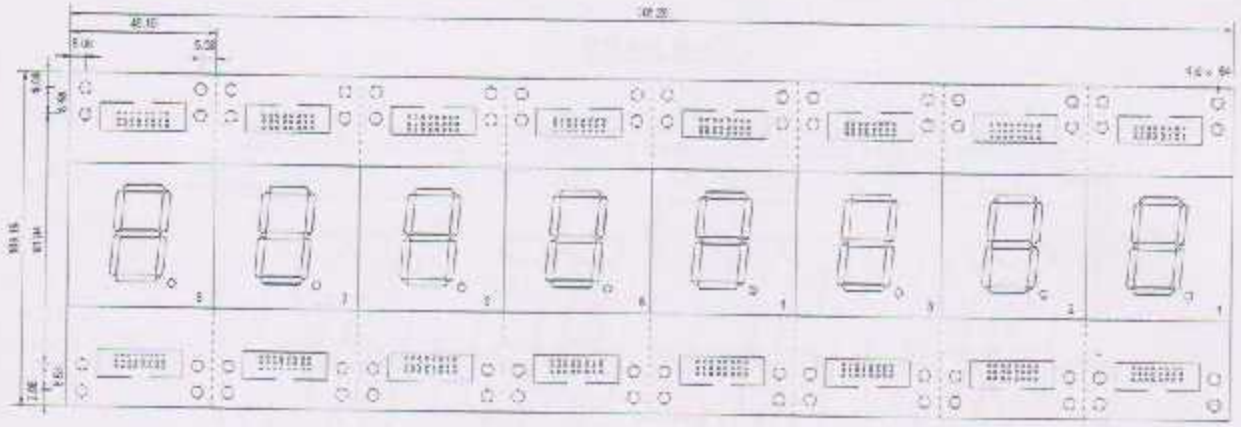
DB.56-8R/DB.8-8R/DB2.3-8R/DB4.0-4R/DBAN.8-4R/DBAN2.3-4R



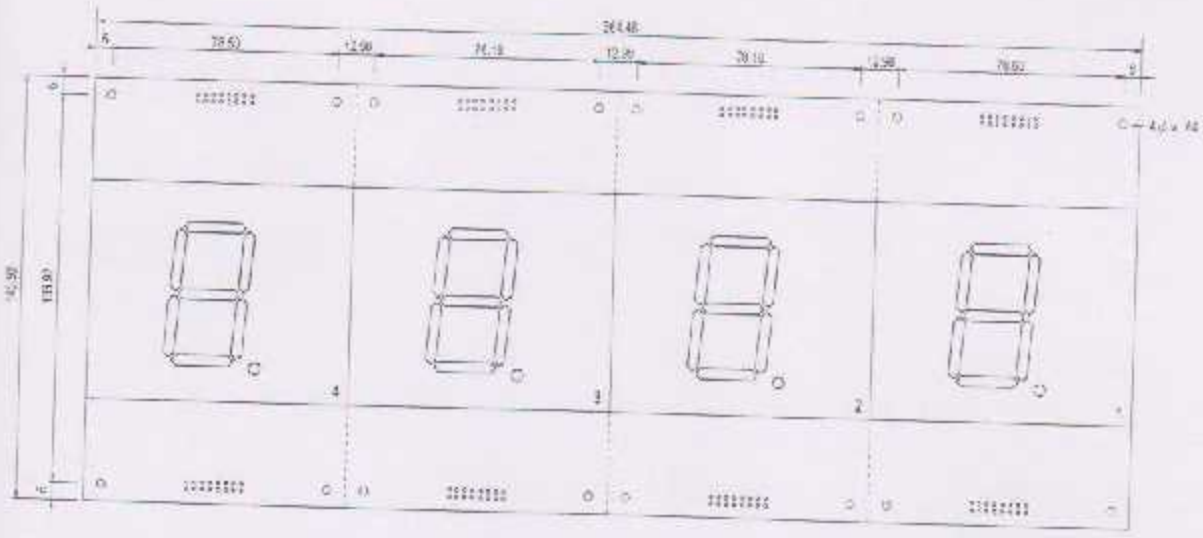
DB.56-8R



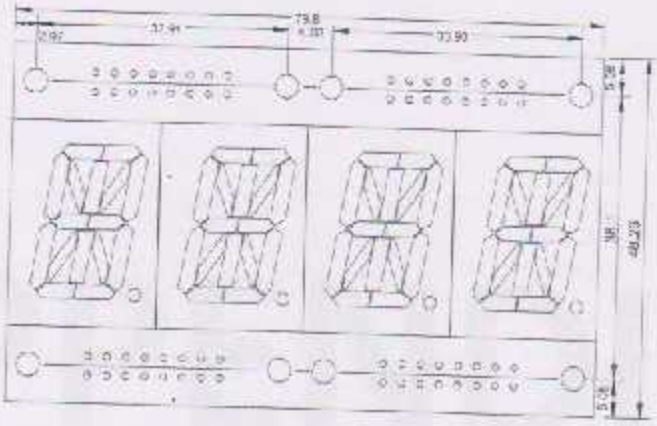
DB.8-8R



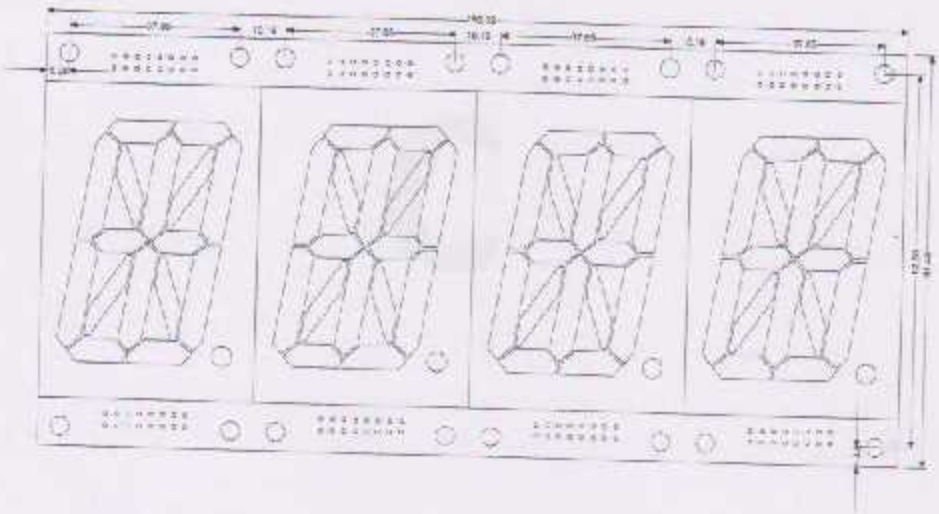
DB2.3-8R



DB4 0-4R



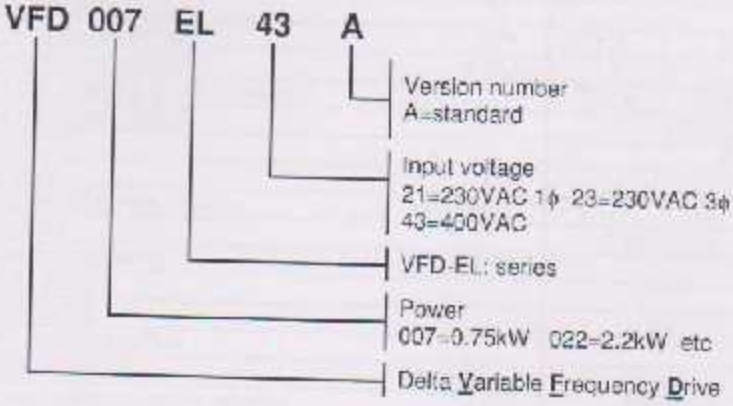
DBAN.8-4R



DBAN2.3 4R

APPENDIX C

Type number key



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.

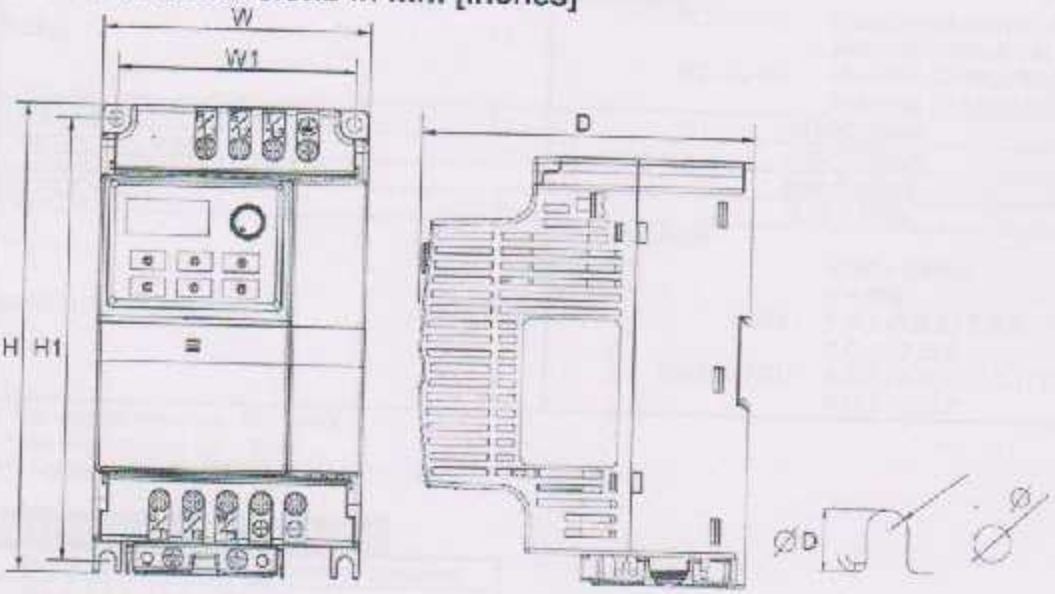
400V 0.4 ~ 3.7kW

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 BUE40032 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]

Common data VFD-EL

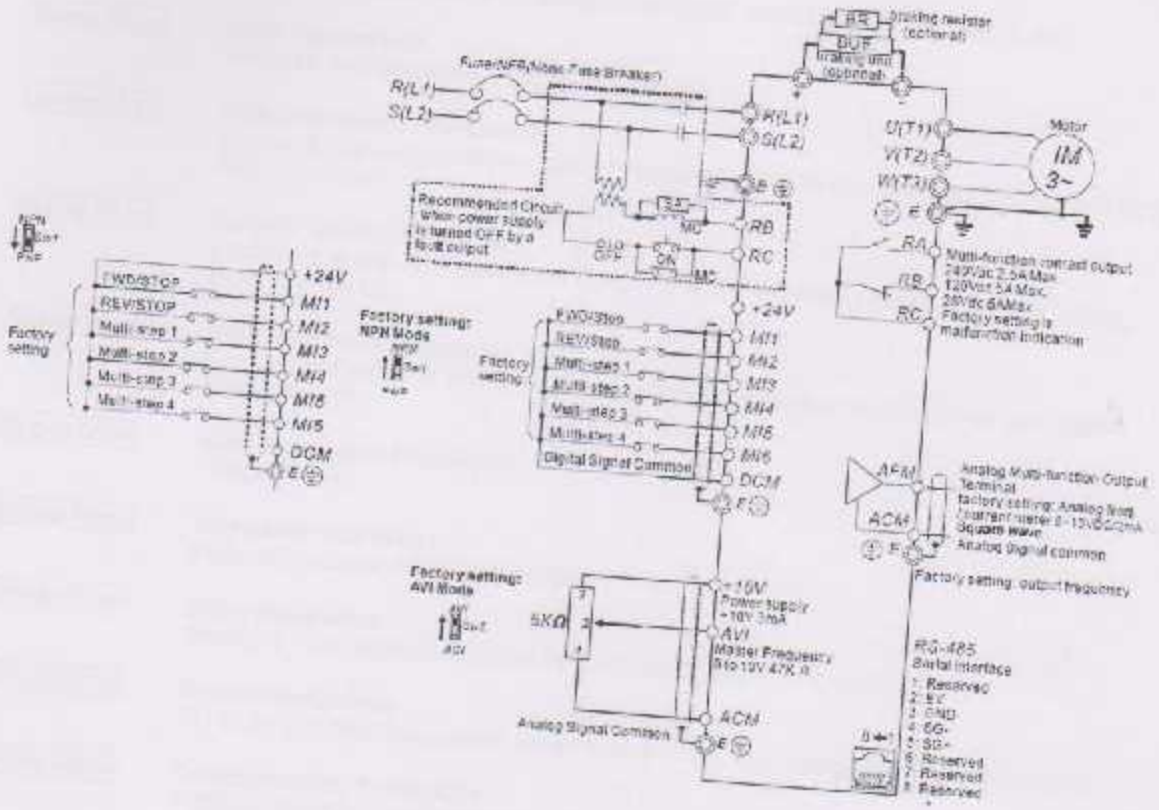
Mains voltage range	V	200V: 180 ~ 264 400V: 342 ~ 528
Mains frequency	Hz	47 ~ 63
Output frequency range	Hz	0 ~ 600
Output voltage range	V	0 ~ Mains
Operating temperature	°C	-10 ~ +50 *
Storage temperature	°C	-20 ~ +60
Atmospheric pressure	kPa	86 ~ 106
Relative humidity	%	≤90 (non condensing)
Vibration		<20Hz: 1G / 20~50Hz: 0.6G
Degree of protection		IP20
Pollution degree		2
Altitude	m	≤1000
Keypad		Standard
Max. Signal cable section	mm^2	0.2 ~ 1.3 **
Digital inputs	6x MIx	SINK or SOURCE: Via jumper Range: 24VDC Debounce time: 2~40ms Pull up (internal): 3.6kΩ (ca. 6mA)
Analogue inputs	1x AVI	Accuracy: 10 bits Range: 0~10VDC or 4~20mA Impedance: 47kΩ 250Ω
Digital outputs	1x MOx	Optocoupler OC: 48VDC/50mA
Analogue outputs	1x AFM	Accuracy: 8 bits Range: 0~10VDC/2mA (square wave) Impedance: 47Ω
Relays	1x	Change-over NO: R_A~R_C: Resistive 5A/240VAC-24VDC; Inductive 1.5A/240VAC-24VDC NC: R_B~R_C: Resistive 3A/240VAC-24VDC; Inductive 0.5A/240VAC 24VDC
Signal supply	1x	+24VDC/50mA
Potentiometer supply	1x	+10VDC/3mA
Trip memory		Last 5 errors
Acc/Dec Times	s	0.01 ~ 600s
Serial communication	1x RJ45	Modbus RS485 Baudrate: 4800 ~ 38400 Address: 1 ~ 254 Mode: ASCII: 7,N,1 /7,N,2 / 7,E,1 / 7,E,2 / 7,O,1 / 7,O,2 Modbus RTU: 8,N,2 / 8,N,2 / 8,E,1/ 8,E,2 / 8,O,1 / 8,O,2

* Side-by-side mounting –10 ~ +40°C
** For standard relay 0.2 ~ $3mm^2$
*** Select via switch ACI/AVI

Power terminals (general)

Terminal symbol	Terminal function
R/L1, S/L2, T/L3	Mains input
U/T1, V/T2, W/T3	Motor output
+ -	DC-bus connection for brake unit
⏚	Ground

Basic wiring diagram



Options

Filters
Built-in option:
230V 1-phase: 1st Environment Class C1, motor cable ≤1m, carrier frequency ≤8kHz
400V: 1st Environment Class C2, motor cable ≤5m, carrier frequency ≤8kHz
2nd Environment Class C3, motor cable ≤15m, carrier frequency ≤8kHz

Braking
Brake resistors and Brake units.

Keypad&Cables
PU06 Copy Keypad.

Mounting
DIN-rail and Earthing plate.

Communication
USB converter, Communication converters, Splitters, Cables.

Fieldbus
Option modules: Devicenet, Profibus, LonWorks, CANopen.

Software
To read, save, copy, change parameters, download VFDSoft.
It can be downloaded from www.delta.com.tw [Products] [Industrial Automation] [Drive].
Select any drive series and go to Download.

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.

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