



PLC BASED CHEMICAL FLOW RATE RATIO CONTROL



A PROJECT REPORT

Submitted by

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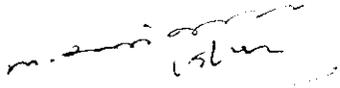
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BONAFIDE CERTIFICATE

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**“WE DEDICATE THIS PROJECT TO OUR
PARENTS, FACULTY MEMBERS, FRIENDS
AND ALL THE GREAT MINDS WHO HAVE
INSPIRED US...”**

ABSTRACT

Mixing of two or more chemicals in equal proportion or in any required ratio is a difficult task. It is possible only when there is control in the process. The controlling of flow rate is a tedious process, which requires proper feedback from the output, a controller and a final control element to control the process.

The flow rate can be controlled in two methods. The first method is done by controlling the control valve which automatically controls the flow rate. In this method, the components required are a motorized control valve, flow sensor, flow transmitter and a controller. The second method is done by controlling the speed of the motor. It can be done using a PLC as a controller, proximity sensor as a measuring device, AC drive as a final control element.

In this project, the second method is proposed for the control of flow rate using a PLC interfaced with proximity sensor. The output of the proximity sensor gives the signal to the PLC, the PLC controls according to the feedback from the proximity sensor and the PLC gives the signal to the AC drive, which automatically controls the speed of the motor.

In this project, the level of the reservoir tank is also being monitored. So when the level of the reservoir tank goes below an optimum level the flow sensor gives signal to the PLC, which automatically switch off the entire process.

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CHAPTER 1

1. INTRODUCTION

1.1 INSTRUMENTATION

Instrumentation is defined as "the art and science of measurement and control". Instrumentation can be used to refer to the field in which Instrument technicians and engineers work, or it can refer to the available methods of measurement and control and the instruments which facilitate this. An instrument is a device that measures or manipulates variables such as flow, temperature, level, or pressure. Instruments include many varied contrivances which can be as simple as valves and transmitters, and as complex as analyzers. Instruments often comprise control systems of varied processes. The control of processes is one of the main branches of applied instrumentation.

Control instrumentation includes devices such as solenoids, valves, circuit breakers, and relays. These devices are able to change a field parameter, and provide remote or automated control capabilities.

Transmitters are devices which produce an analog signal, usually in the form of a 4–20mA electrical current signal, although many other options using voltage, frequency, or pressure are possible. This signal can be used to control other instruments directly, or it can be sent to a PLC, DCS, SCADA system, or other type of computerized controller, where it can be interpreted into readable values and used to control other devices and processes in the system

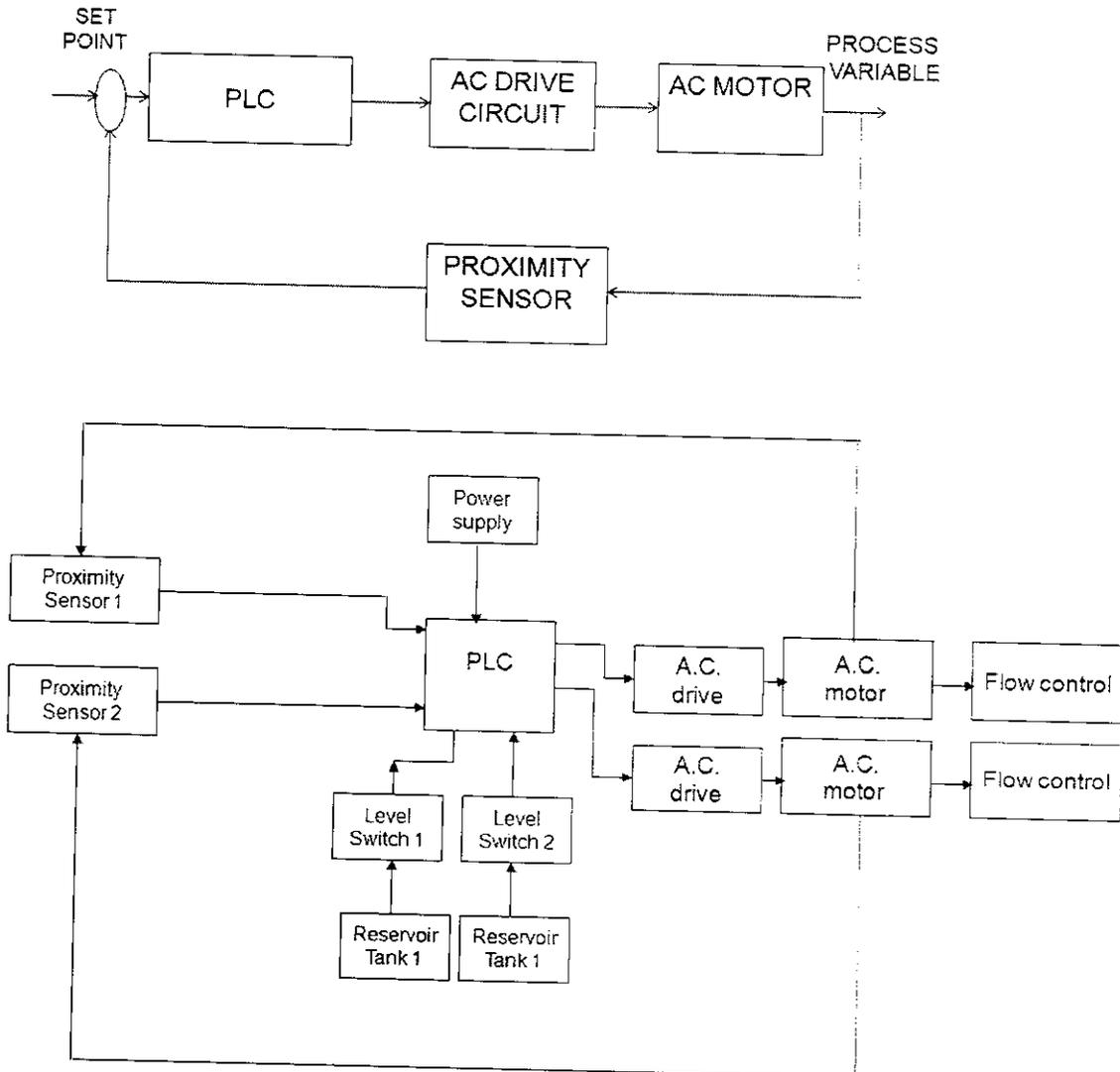
1.2 PROCESS

In industrial process engineering, mixing is a unit operation that involves manipulating a heterogeneous physical system, with the intent to make it more homogeneous. At an industrial scale, efficient mixing can be difficult to

achieve. A great deal of engineering effort goes into designing and improving mixing processes. Mixing at industrial scale is done in batches.

Our project is concerned with the mixing of two chemical in a fixed ratio for bonding the pulp, since the process needs a high time monitoring system we implemented this concept with PLC which can be upgraded to any latest controller. The basic block diagram below explains in detail about the process.

1.3 BASIC BLOCK DIAGRAM – FIG 1.2



The main objective of the project is to maintain the flow rate and through which the ratio of the mixture is obtained. The proximity sensor acts as feedback device, it counts down the RPM of motor, thus the process variable is fed to PLC. All the flow process includes two customary components Flow sensor or Flow Transmitter and a Control valve but we replaced this thing with an A.C. drive and Proximity sensor as both the components are comfortable with PLC. The digital counts are driven into PLC to calculate the RPM. The PLC through analog module controls the frequency to the drive which in turn controls the speed of motor. By varying the speed of two motors different mixing ratio and flow rate are obtained. Level switches are used to trigger low level liquid alarm.

PLC BLOCK DIAGRAM

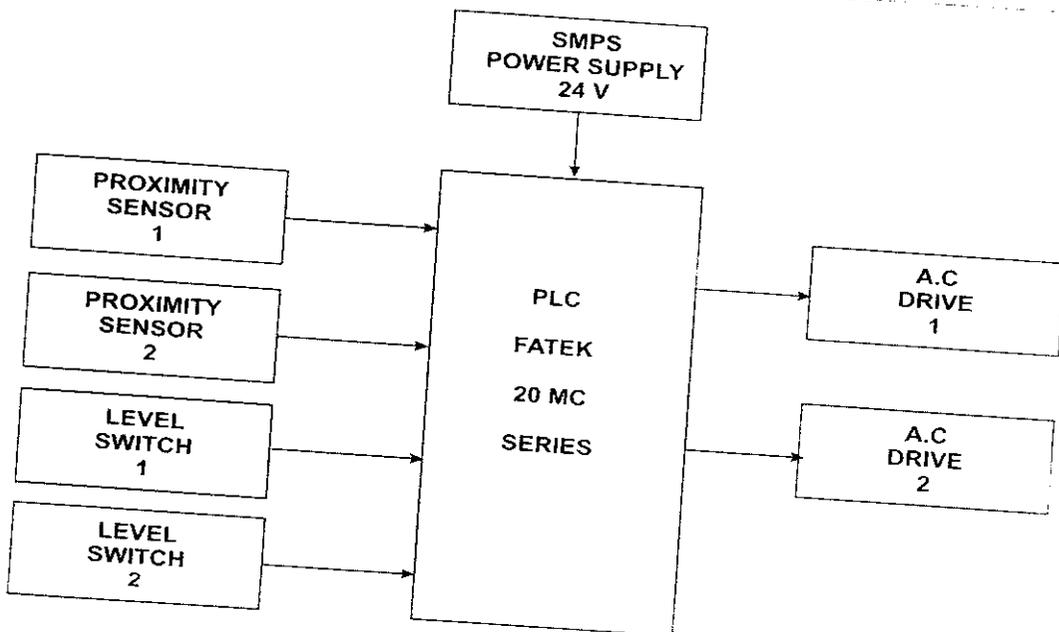


FIG 1.3

**PROGRAMMABLE LOGIC
CONTROLLER**

CHAPTER 2

2. PROGRAMMABLE LOGIC CONTROLLER

2.1 CONCEPTS OF PLC

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

The advent of the PLC began in the 1970s, and has become the most common choice for manufacturing controls. PLCs have been gaining popularity on the factory floor and will probably remain predominant for some time to come.

Most of this is because of the advantages they offer.

- Cost effective for controlling complex systems.
- Flexible and can be reapplied to control other systems quickly and easily.
- Computational abilities allow more sophisticated control.
- Trouble shooting aids make programming easier and reduce downtime.
- Reliable components make these likely to operate for years before failure.

FATEK PLC

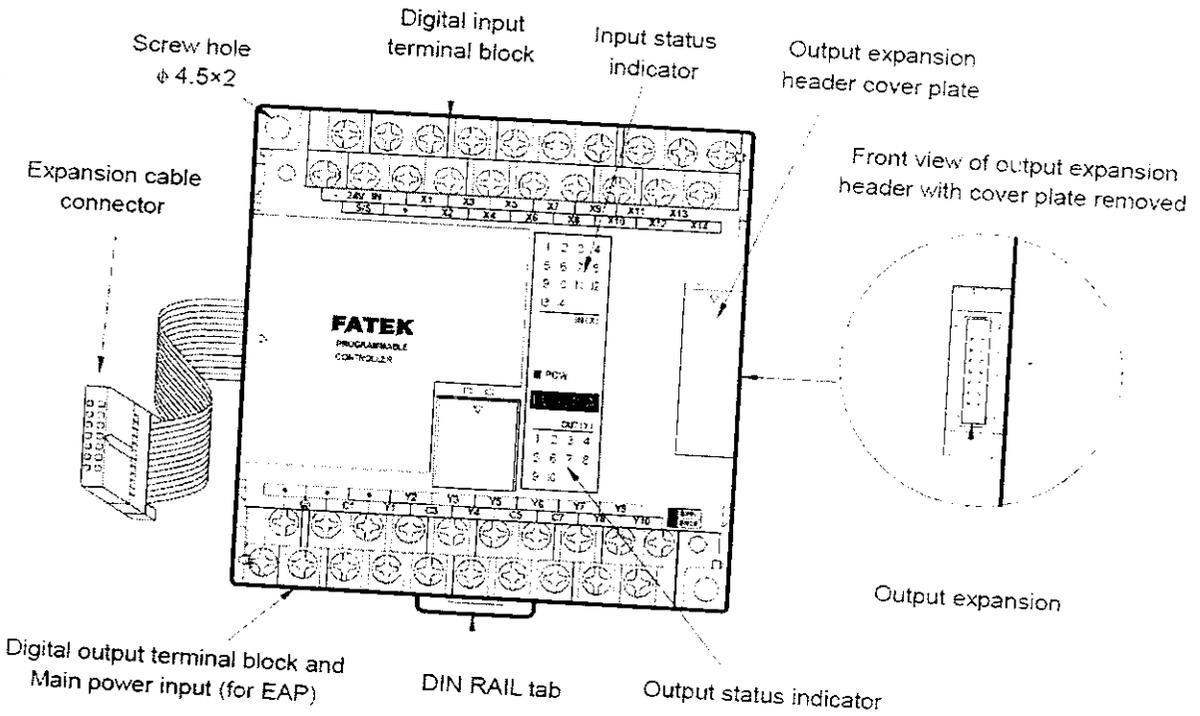


FIG 2.1

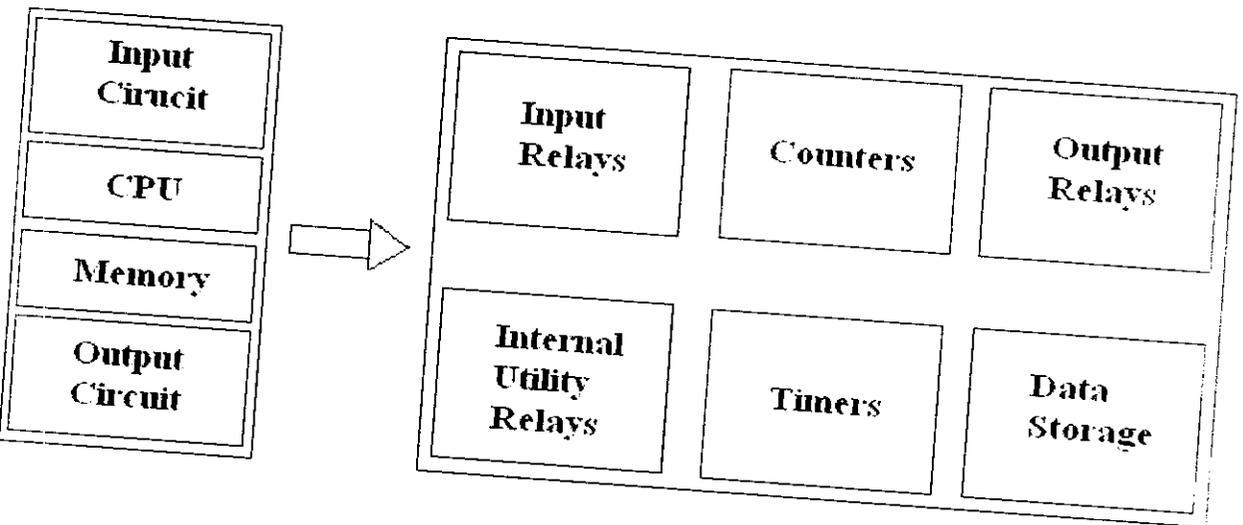
2.2 INTRODUCTION

A PLC (i.e. Programmable Logic Controller) is a device that was invented to replace the necessary sequential relay circuits for machine control. The PLC works by looking at its inputs and depending upon their state, turning on/off its outputs. The user enters a program, usually via software, that gives the desired results. PLCs are used in many “real world” applications. If there is industry present, chances are good that there is a plc present. If you are involved in machining, packaging, material handling, automated assembly or countless other industries you are probably already using them. If you are not, you are wasting money and time. Almost any application that needs some type of electrical control has a need for a PLC.

2.3 GUTS INSIDE A PLC

The **PLC** mainly consists of a **CPU**, memory areas, and appropriate circuits to receive input/output data. We can actually consider the PLC to be a box full of hundreds or thousands of separate relays, counters, timers and data storage locations. Do these counters, timers, etc. Really exist? NO, they don't "physically" exist but rather they are simulated and can be considered software counters, timers, etc. These internal relays are simulated through bit locations in registers.

INPUT RELAYS-(contacts) these are connected to the outside world. They physically exist and receive signals from switches, sensor, etc. Typically they are not relays but rather they are transistors.



GUTS INSIDE A PLC

FIG 2.2

INTERNAL UTILITY RELAYS-(contacts) these do not receive signals from outside world not do they physically exist. They are simulated relays and what enables a PLC to eliminate external relays. There are also some special relays that are dedicated to performing only one task. Some are on only

once during power-on and are typically used for initializing data that was stored.

COUNTERS-These again do not physically exist. They are simulated counters and they can be programmed to count pulses. Typically these counters can count up, down or both up and down. Since they are simulated they are limited in their counting speed. Some manufacturers also include high-speed counters that are hardware based. We can think of these as physically existing. Most times these counters can count up, down or up and down.

TIMERS-These also do not physically exist. They come in many varieties and increments. The most common type is an on-delay type. Others include off-delay and both retentive and non-retentive types. Increments vary from 1ms through 1s.

OUTPUT RELAYS-(coils) these are connected to the outside world. They physically exist and send on/off signals to solenoids, lights, etc. They can be transistors, relays, or triacs depending upon the model chosen.

DATA STORAGE-Typically there are registers assigned to simply store data. They are usually used as temporary storage for math or data manipulation. They can also typically be used to store data when power is removed from the PLC. Upon power-up they still have the same contents as before power was removed.

4 INPUTS AND OUTPUTS FOR A PLC

Inputs to, and outputs from, a PLC is necessary to monitor and control a process. Both inputs and outputs can be categorized into two basic types: digital or continuous.

Consider the example of a light bulb. If it can only be turned on or off, it is logical control.

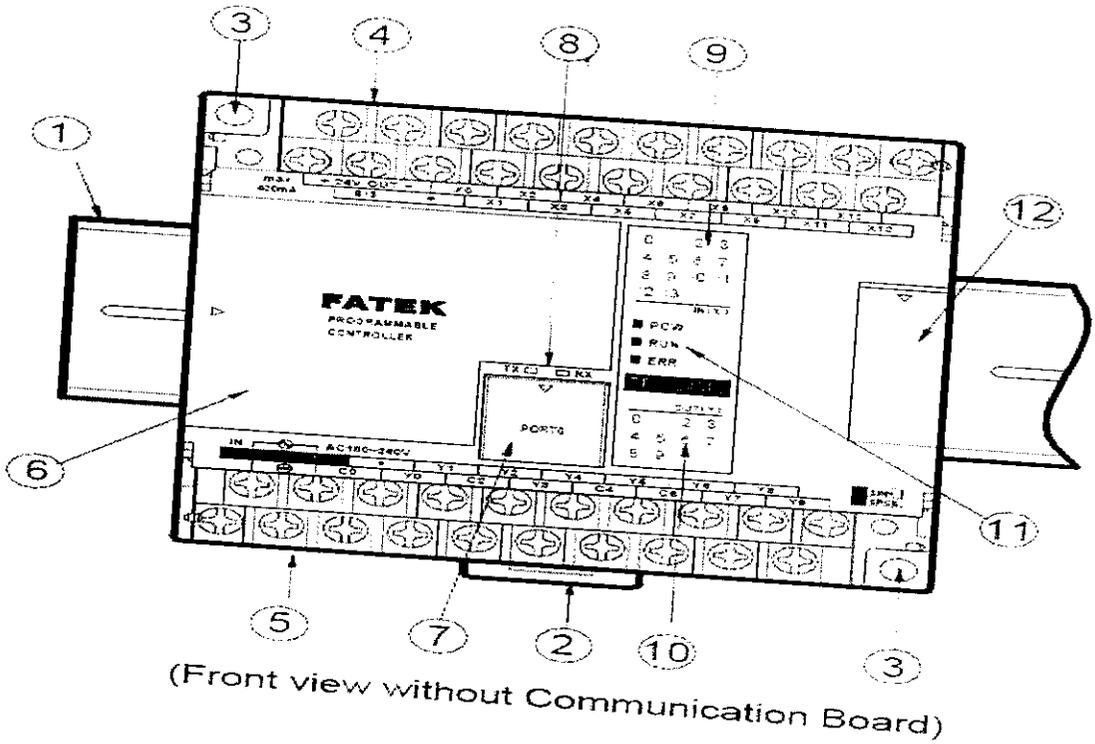


FIG 2.3

If the light can be dimmed to different levels, it is continuous. Continuous values seem more intuitive, but logical values are preferred because they allow more certainty, and simplify control.

As a result most controls applications (and PLCs) use logical inputs and outputs for most applications. Hence, we will discuss logical I/O and leave continuous I/O for later.

LIGHTS – logical outputs that can often be powered directly from PLC output boards.

MOTOR STARTERS – motors often draw a large amount of current when started, so they require motor starters, which are basically large relays.

PROXIMITY SWITCHES – use inductance, capacitance or light to detect an object logically.

SWITCHES – mechanical mechanisms will open or close electrical contacts for a logical signal.

2.5 PLC PROGRAMMING

Ladder logic is the main programming method used for PLCs. As mentioned before, ladder logic has been developed to mimic relay logic. The decision to use the relay logic diagrams was a strategic one. By selecting ladder logic as the main programming method, the amount of retraining needed for engineers and trades people was greatly reduced.

LADDER LOGIC FUNCTIONS

Ladder logic input contacts and output coils allow simple logical decisions. Functions extend basic ladder logic to allow other types of control. For example, the addition of timers and counters allowed event based control.

Based PLC Function Categories

Combinatorial Logic

relay contacts and coils

vents

mer instructions

ounter instructions

ta Handling

oves

thematics

versions

Numerical Logic

-boolean operations

-comparisions

Lists

-shift registers/stacks

-sequencers

Program Control

-branching/looping

Immediate inputs/outputs

-fault/interrupt detection

Input and Output

-PID

-communications

-high speed counters

-ASCII string functions

2.6 PLC OPERATION

A PLC works by continually scanning a program. We can think of this scan cycle as consisting of 3 important steps. There are typically more than 3 but we can focus on the important parts and not worry about the others. Typically the others are checking the system and updating the current internal counter and timer values.

OPERATION CYCLE

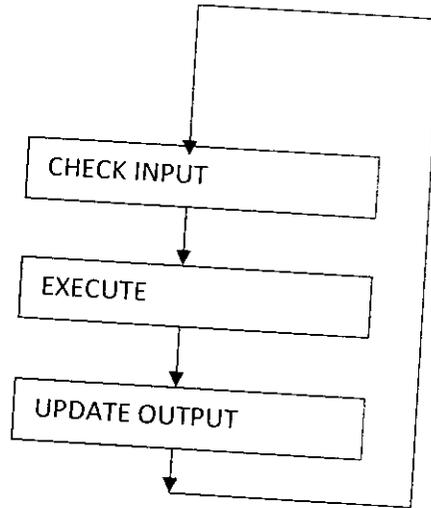


FIG 2.4

Step 1-CHECK INPUT STATUS-First the PLC takes a look at each input to determine if it is on or off. In other words, is the sensor connected to the first input on? How about the second input? How about the third... It records this data into its memory to be used during the next step.

Step 2-EXECUTE PROGRAM-Next the PLC executes your program one instruction at a time. Maybe your program said that if the first input was on then it should turn on the first output. Since it already knows which inputs are on/off from the previous step it will be able to decide whether the first output should be turned on based on the state of the first input. It will store the execution results for use later during the next step.

Step 3-UPDATE OUTPUT STATUS-Finally the PLC updates the status of the outputs. It updates the outputs based on which inputs were on during the first step and the results of executing your program during the second step.

PROXIMITY SENSOR

CHAPTER 3

3. PROXIMITY SENSOR

3.1 INTRODUCTION

The inductive proximity sensor detects all metals with its high-frequency electro-magnetic field. In automated processes, sensors are used to provide signals on positions and limits, serve as pulse pick-ups for counting tasks or for monitoring rotational speed. Inductive proximity sensors are indispensable for these types of applications.

As compared to mechanical devices, they offer ideal features: non-contact detection of all metals, high switching frequencies, accuracy, and durability in the most aggressive environments.

They are insensitive to vibration, dust, and moisture. Proximity sensors can have a high reliability and long functional life because of the absence of mechanical parts and lack of physical contact between sensor and the sensed object.

3.2 Types of Proximity sensors:

- Capacitive sensor
- Magnetic
- Inductive
- Photocell
- Laser rangefinders
- Sonar
- Radar

3.3 INDUCTIVE PROXIMITY SENSORS:

Inductive sensors are widely used in various applications to detect metal devices. They can be used in various environment and need high reliability.

Inductive proximity sensors generate electromagnetic field and detect the eddy current losses induced when the metal target enter the field.

PROXIMITY SENSOR



FIG 3.1

The field is generated by the coil, wrapped around a ferrite core, which is used by transistorized circuit to produce oscillation. The target, while entering the electromagnetic field produced by the coil, will decrease the oscillation due to eddy current developed in the target. If the target approaches the sensor within the so called "sensing range", the oscillation cannot be produced anymore: the detector circuit generates then an output controlling a relay or switch.

3.4 OPERATING PRINCIPLE:

An inductive proximity sensor contains four essential components: a coil of wire wrapped in a ferrite core, an oscillator circuit, an evaluation circuit, and an output circuit.

When voltage is applied to the sensor, an oscillating current flows through the coil and radiates an electromagnetic field from the active face of the sensors. This field is directed and shaped by the ferrite core.

Inductive proximity sensors take advantage of changes in a resonant circuit caused by eddy current losses in conductive materials. The target, while entering the electromagnetic field produced by the coil, will decrease the oscillations due to eddy "sensing range", the oscillations cannot be produced anymore: eddy currents are drawn from the oscillator and induced into the target, the distance and position of the target, and the size and shape of the target.

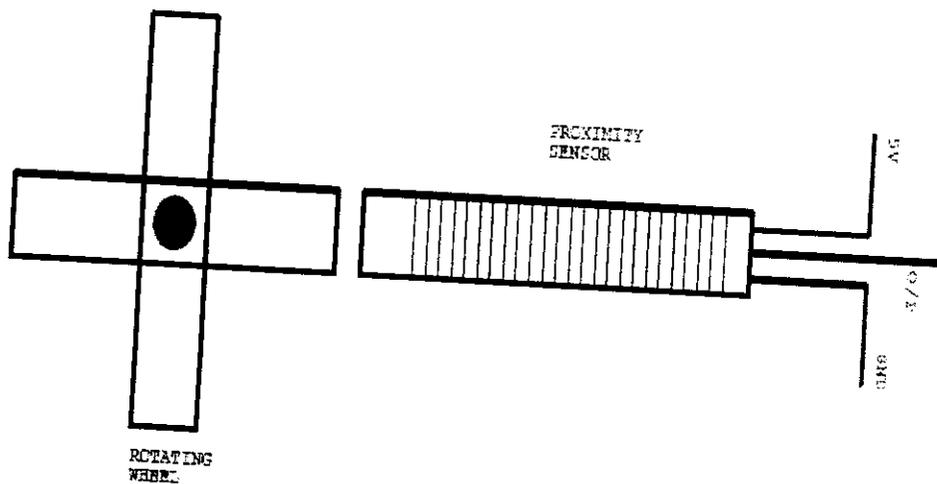
When the metal target is positioned at a precise distance from the active face of the sensor, the energy loss caused by the eddy currents becomes so large that the amplifier cannot output sufficient energy to maintain oscillation and the magnetic field collapses. The breakdown in oscillation is detected by the evaluation circuit, which then changes the state of the output circuit thus giving pulse to the PLC. By using this pulse count, we can find revolution per minute. A program is coded in PLC to count the pulses. The program is based on the number of pulses produced by proximity for a 360 degree rotation and when it is manipulated for the given frequency

RPM Vs VOLTAGE

OUTPUT STATUS(RPM)	VOLTAGE(Volts)
300	5.4
600	6.3
900	8.3
1200	9.8
1500	11.7

TABLE 3.1

FIG 3.2 SPEED MEASUREMENT USING PROXIMITY



AC MOTOR

CHAPTER 4

4. AC MOTOR

4.1 INTRODUCTION

An electric motor converts electrical power to mechanical power in its rotor. There are several ways to supply power to the rotor. In a DC motor this power is supplied to the armature directly from a DC source, while in an induction motor this power is induced in the rotating device. An induction motor is sometimes called a rotating transformer because the stator is essentially the primary side of the transformer and the rotor is the secondary side. Unlike the normal transformer which changes the current by using time varying flux, the induction motor uses rotating magnetic field to transform the voltage. The primary side's currents evoke a magnetic field which interacts with the secondary side's Emf to produce a resultant torque, henceforth serving the purpose of producing mechanical energy. Induction motors are widely used, especially polyphase induction motors, which are frequently used in industrial drives.

Induction motors are now the preferred choice for industrial motors due to their rugged construction, absence of brushes and thanks to modern power electronics the ability to control the speed of the motor.

4.2 CONSTRUCTION

The stator consists of wound 'poles' that carry the supply current to produce a magnetic field that penetrates the rotor. In a very simple motor, there could be a single projecting piece of the stator for each pole, with windings wound it; in fact, to optimize the distribution of the magnetic field, the windings are distributed in many slots located around the stator, but the magnetic field

still has the same number of north-south alternations. The number of 'poles' can vary between motor types but the poles are always in pairs (i.e. 2, 4, 6, etc.).

Induction motors are most commonly built to run on single-phase or three-phase power, but two-phase motors also exist. In theory, two-phase and more than three phase induction motors are possible; many single-phase motors having two windings and requiring a capacitor can actually be viewed as two-phase motors, since the capacitor generates a second power phase 90 degrees from the single-phase supply and feeds it to a separate motor winding. Single-phase power is more widely available in residential buildings, but cannot produce a rotating field in the motor (the field merely oscillates back and forth), so single-phase induction motors must incorporate some kind of starting mechanism to produce a rotating field. They would, using the simplified analogy of salient poles, have one salient pole per pole number; a four-pole motor would have four salient poles. Three-phase motors have three salient poles per pole number, so a four-pole motor would have twelve salient poles. This allows the motor to produce a rotating field, allowing the motor to start with no extra equipment and run more efficiently than a similar single-phase motor.

There are three types of rotor:

Squirrel-cage rotor

The most common rotor is a squirrel-cage rotor. It is made up of bars of either solid copper (most common) or aluminum that span the length of the rotor, and these solid copper or aluminium strips can be shorted or connected by a ring or some times not, i.e. the rotor can be closed or semiclosed type. The rotor bars in squirrel-cage induction motors are not straight, but have some skew to reduce noise and harmonics.

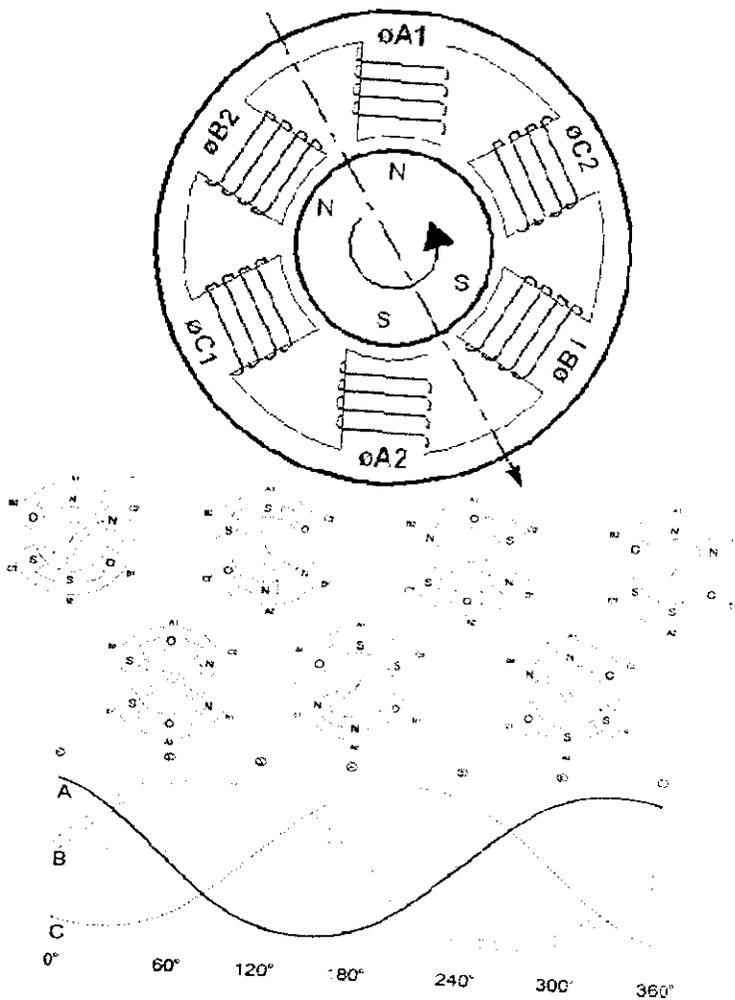
- Slip ring rotor

A slip ring rotor replaces the bars of the squirrel-cage rotor with windings that are connected to slip rings. When these slip rings are shorted, the rotor behaves similarly to a squirrel-cage rotor; they can also be connected to resistors to produce a high-resistance rotor circuit, which can be beneficial in starting

- Solid core rotor

A rotor can be made from solid mild steel. The induced current causes the rotation.

FIG 4.1



A.C. MOTOR AND ITS ROTATION

4.3 SPEED CONTROL

The synchronous rotational speed of the rotor is controlled by the number of pole pairs and by the frequency of the supply voltage. Before the development of cheap power electronics, it was difficult to vary the frequency to the motor and therefore the uses for the induction motor were limited. As an induction motor has no brushes and is easy to control, many older DC motors are being replaced with induction motors and accompanying inverters in industrial applications. The induction motor runs on induced current. Speed of induction motor varies according to the load supplied to the induction motor. As the load on the induction motor is increased the speed of the motor gets decreased and vice versa

4.4 STRATING OF INDUCTION MOTOR

DIRECT-ON-LINE STARTING

The simplest way to start a three-phase induction motor is to connect its terminals to the line. This method is often called "direct on line" and abbreviated DOL.

In an induction motor, the magnitude of the induced emf in the rotor circuit is proportional to the stator field and the slip speed of the motor, and the rotor current depends on this emf. When the motor is started, the rotor speed is zero. The synchronous speed is constant, based on the frequency of the supplied AC voltage. So the slip speed is equal to the synchronous speed, the slip ratio is 1, and the induced Emf in the rotor is large. As a result, a very high current flows through the rotor. This is similar to a transformer with the secondary coil short circuited, which causes the primary coil to draw a high current from the mains.

When an induction motor starts DOL, a very high current is drawn by the stator, in the order of 5 to 9 times the full load current. This high current can, in some motors, damage the windings; in addition, because it causes heavy line voltage drop, other appliances connected to the same line may be affected by the voltage fluctuation. To avoid such effects, several other strategies are employed for starting motors.

STAR-DELTA STARTERS

An induction motor's windings can be connected to a 3-phase AC line in two different ways:

A delta connection of the machine winding results in a higher voltage at each winding compared to a wye connection (the factor is $\sqrt{3}$). A star-delta starter initially connects the motor in wye, which produces a lower starting current than delta, then switches to delta when the motor has reached a set speed. Disadvantages of this method over DOL starting are:

- Lower starting torque, which may be a serious issue with pumps or any devices with significant breakaway torque
- Increased complexity, as more contactors and some sort of speed switch or timers are needed
- Two shocks to the motor

VARIABLE-FREQUENCY DRIVES

Variable-frequency drives can be of considerable use in starting as well as running motors. A VFD can easily start a motor at a lower frequency than the AC line, as well as a lower voltage, so that the motor starts with full rated torque and with no inrush of current. The rotor circuit's impedance increases

with slip frequency, which is equal to supply frequency for a stationary rotor, so running at a lower frequency actually increases torque.

RESISTANCE STARTERS

This method is used with slip ring motors where the rotor poles can be accessed by way of the slip rings. Using brushes, variable power resistors are connected in series with the poles. During start-up the resistance is large and then reduced to zero at full speed.

At start-up the resistance directly reduces the rotor current and so rotor heating is reduced. Another important advantage is the start-up torque can be controlled. As well, the resistors generate a phase shift in the field resulting in the magnetic force acting on the rotor having a favorable angle

SERIES REACTOR STARTERS

In series reactor starter technology, an impedance in the form of a reactor is introduced in series with the motor terminals, which as a result reduces the motor terminal voltage resulting in a reduction of the starting current; the impedance of the reactor, a function of the current passing through it, gradually reduces as the motor accelerates, and at 95 % speed the reactors are bypassed by a suitable bypass method which enables the motor to run at full voltage and full speed. Air core series reactor starters or a series reactor soft starter is the most common and recommended method for fixed speed motor starting.

CHAPTER 5

5.AC DRIVE

5.1 VARIABLE FREQUENCY DRIVE

The A.C. drive which is used is a Variable-Frequency Drive (VFD). VFD is a system for controlling the rotational speed of an alternating current electric motor by controlling the frequency of the electrical power supplied to the motor.

BLOCK DIAGRAM OF VFD

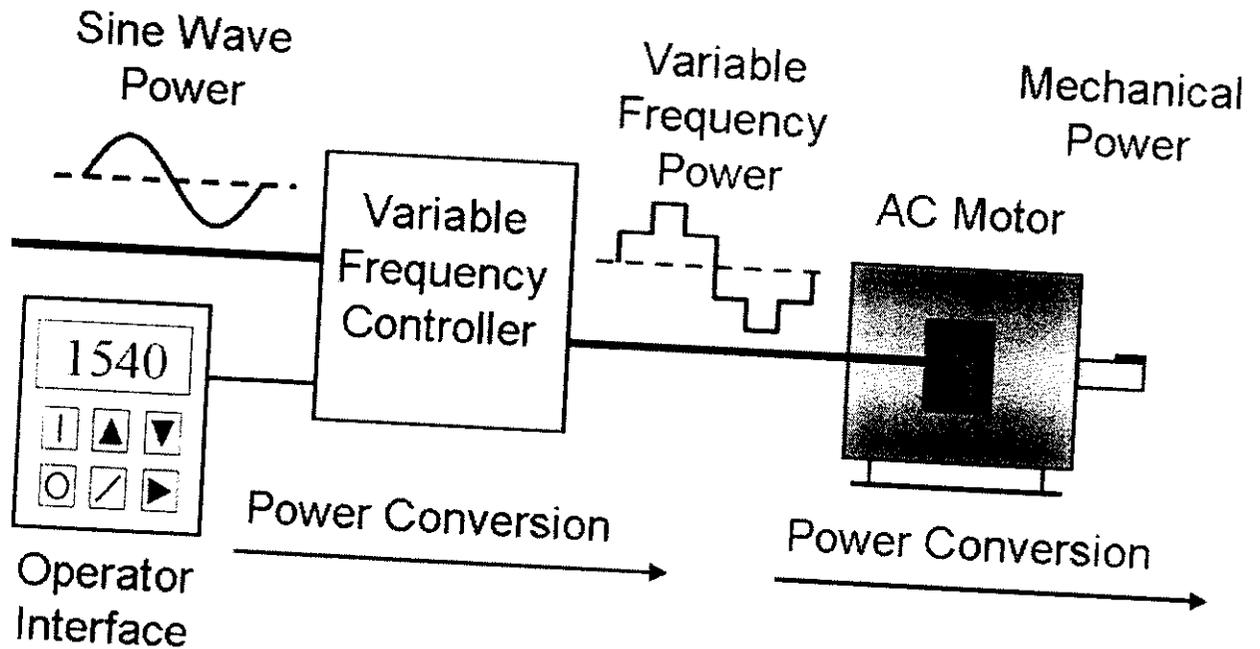


FIG 5.1

The input of the VFD is single phase A.C supply. Here the operator interface is PLC. The PLC controls the frequency of the power which is supplied to the motor. This control is done according to the program in the PLC. PLC controls the speed of both the pumps. Thus the RPM of the motor is deduced.

5.2 INTRODUCTION

A variable-frequency drive (VFD) is a system for controlling the rotational speed of an alternating current (AC) electric motor by controlling the frequency of the electrical power supplied to the motor. A variable frequency drive is a specific type of adjustable-speed drive. Variable-frequency drives are also known as adjustable-frequency drives (AFD), variable-speed drives (VSD), AC drives, microdrives or inverter drives. Since the voltage is varied along with frequency, these are sometimes also called VVVF (variable voltage variable frequency) drives.

Variable-frequency drives are widely used. In ventilation systems for large buildings, variable-frequency motors on fans save energy by allowing the volume of air moved to match the system demand. They are also used on pumps, conveyor and machine tool drives

5.3 TYPES OF VFD

All VFDs use their output devices only as switches, turning them only on or off. Using a linear device such as a transistor in its linear mode is impractical, since the power dissipated in these devices would be about as much as the power delivered to the load.

Drives can be classified as:

Constant voltage

- Constant current
- Cycloconverter

In a constant voltage converter, the intermediate DC link voltage remains approximately constant during each output cycle. In constant current drives, a large inductor is placed between the input rectifier and the output bridge, so the current delivered is nearly constant. A cycloconverter has no input rectifier or DC link and instead connects each output terminal to the appropriate input phase.

The most common type of packaged VF drive is the constant-voltage type, using pulse width modulation to control both the frequency and effective voltage applied to the motor load.

BASIC CIRCUIT DIAGRAM:

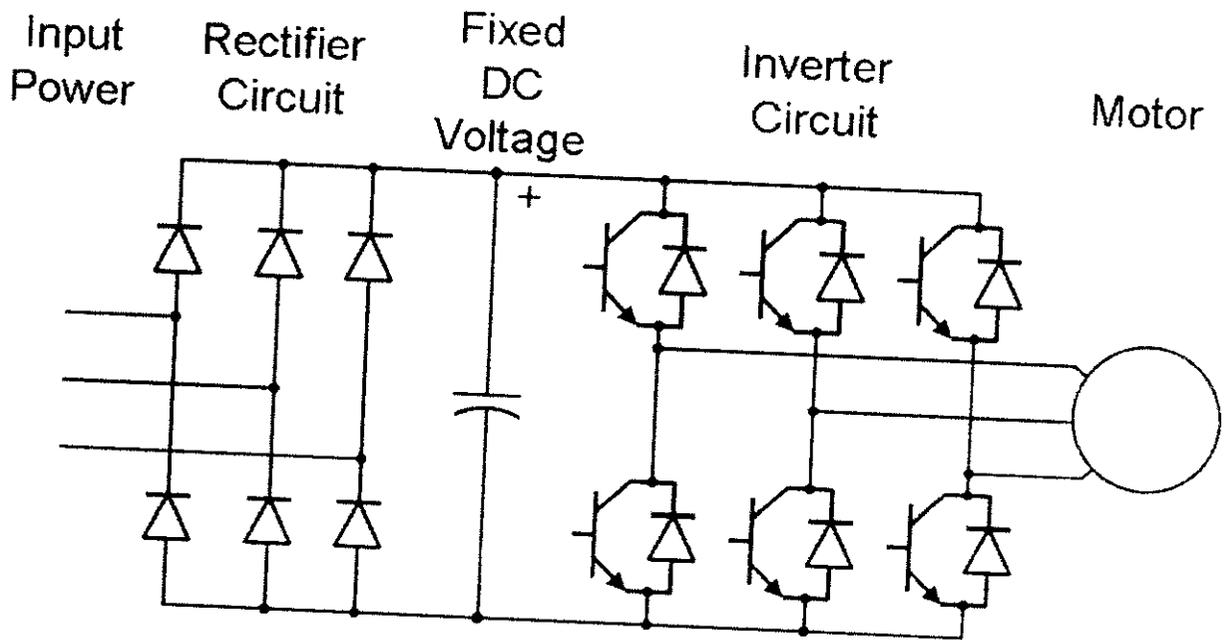


FIG 5.2

5.4 THREE PHASE INVERTER

Three-phase inverters are used for variable-frequency drive applications and for high power applications such as HVDC power transmission. A basic three-phase inverter consists of three single-phase inverter switches each connected to one of the three load terminals. For the most basic control scheme, the operation of the three switches is coordinated so that one switch operates at each 60 degree point of the fundamental output waveform. This creates a line-to-line output waveform that has six steps. The six-step waveform has a zero-voltage step between the positive and negative sections of the square-wave such that the harmonics that are multiples of three are eliminated as described above. When carrier-based PWM techniques are applied to six-step waveforms, the basic overall shape, or envelope, of the waveform is retained so that the 3rd harmonic and its multiples are cancelled.

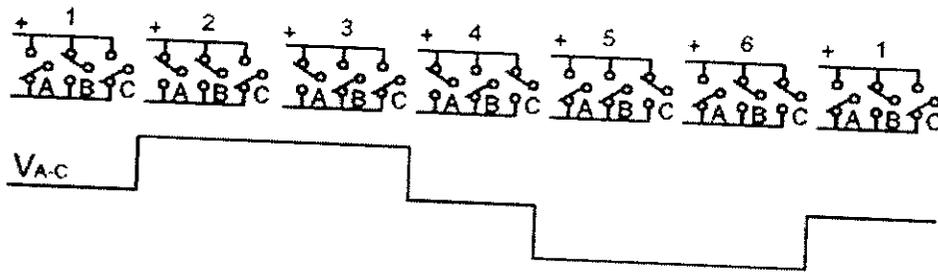


FIG 5.3

To construct inverters with higher power ratings, two six-step three-phase inverters can be connected in parallel for a higher current rating or in series for a higher voltage rating. In either case, the output waveforms are phase shifted to obtain a 12-step waveform. If additional inverters are combined, an 18-step inverter is obtained with three inverters etc. Although inverters are usually

combined for the purpose of achieving increased voltage or current ratings, the quality of the waveform is improved as well.

5.5 VFD CONTROLLERS

Variable frequency drive controllers are solid state electronic power conversion devices. The usual design first converts AC input power to DC intermediate power using a rectifier or converter bridge. The rectifier is usually a three-phase, full-wave-diode bridge. The DC intermediate power is then converted to quasi-sinusoidal AC power using an inverter switching circuit. The inverter circuit is probably the most important section of the VFD, changing DC energy into three channels of AC energy that can be used by an AC motor. These units provide improved power factor, less harmonic distortion, and low sensitivity to the incoming phase sequencing than older phase controlled converter VFD's. Since incoming power is converted to DC, many units will accept single-phase as well as three-phase input power (acting as a phase converter as well as a speed controller); however the unit must be derated when using single phase input as only part of the rectifier bridge is carrying the connected load.

As new types of semiconductor switches have been introduced, these have promptly been applied to inverter circuits at all voltage and current ratings for which suitable devices are available. Introduced in the 1980s, the insulated-gate bipolar transistor (IGBT) became the device used in most VFD inverter circuits in the first decade of the 21st century.

AC motor characteristics require the applied voltage to be proportionally adjusted whenever the frequency is changed in order to deliver the rated torque. For example, if a motor is designed to operate at 460 volts at 60 Hz, the applied voltage must be reduced to 230 volts when the frequency is reduced to 30 Hz.

Thus the ratio of volts per hertz must be regulated to a constant value ($460/60 = 7.67$ V/Hz in this case). For optimum performance, some further voltage adjustment may be necessary especially at low speeds, but constant volts per hertz is the general rule. This ratio can be changed in order to change the torque delivered by the motor.

In addition to this simple volts per hertz control more advanced control methods such as vector control and direct torque control (DTC) exist. These methods adjust the motor voltage in such a way that the magnetic flux and mechanical torque of the motor can be precisely controlled.

The usual method used to achieve variable motor voltage is pulse-width modulation (PWM). With PWM voltage control, the inverter switches are used to construct a quasi-sinusoidal output waveform by a series of narrow voltage pulses with pseudosinusoidal varying pulse durations.

Operation of the motors above rated name plate speed (base speed) is possible, but is limited to conditions that do not require more power than nameplate rating of the motor. This is sometimes called "field weakening" and, for AC motors, means operating at less than rated volts/hertz and above rated name plate speed. Permanent magnet synchronous motors have quite limited field weakening speed range due to the constant magnet flux linkage. Wound rotor synchronous motors and induction motors have much wider speed range. For example, a 100 hp, 460 V, 60 Hz, 1775 RPM (4 pole) induction motor supplied with 460 V, 75 Hz (6.134 V/Hz), would be limited to $60/75 = 80\%$ torque at 125% speed (2218.75 RPM) = 100% power. At higher speeds the induction motor torque has to be limited further due to the lowering of the breakaway torque of the motor. Thus rated power can be typically produced only up to 130...150 % of the rated name plate speed. Wound rotor synchronous

motors can be run even higher speeds. In rolling mill drives often 200...300 % of the base speed is used. Naturally the mechanical strength of the rotor and lifetime of the bearings is also limiting the maximum speed of the motor. It is recommended to consult the motor manufacturer if more than 150 % speed is required by the application

FREQUENCY CONTROLLER OUTPUT

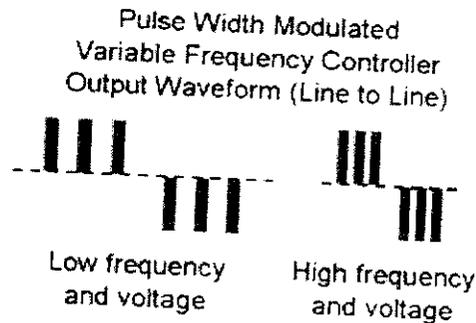


FIG 5.4

5.6 VFD OPERATION

When an induction motor is connected to a full voltage supply, it draws several times (up to about 6 times) its rated current. As the load accelerates, the available torque usually drops a little and then rises to a peak while the current remains very high until the motor approaches full speed.

By contrast, when a VFD starts a motor, it initially applies a low frequency and voltage to the motor. The starting frequency is typically 2 Hz or less. Thus starting at such a low frequency avoids the high inrush current that occurs when a motor is started by simply applying the utility (mains) voltage by turning on a switch. After the start of the VFD, the applied frequency and voltage are increased at a controlled rate or ramped up to accelerate the load

without drawing excessive current. This starting method typically allows a motor to develop 150% of its rated torque while the VFD is drawing less than 50% of its rated current from the mains in the low speed range. A VFD can be adjusted to produce a steady 150% starting torque from standstill right up to full speed. Note, however, that cooling of the motor is usually not good in the low speed range. Thus running at low speeds even with rated torque for long periods is not possible due to overheating of the motor. If continuous operation with high torque is required in low speeds an external fan is needed. Please consult the manufacturer of the motor and/or the VFD.

In principle, the current on the motor side is in direct proportion of the torque that is generated and the voltage on the motor is in direct proportion of the actual speed, while on the network side, the voltage is constant, thus the current on line side is in direct proportion of the power drawn by the motor, that is $U \cdot I$ or $C \cdot N$ where C is torque and N the speed of the motor

With a VFD, the stopping sequence is just the opposite as the starting sequence. The frequency and voltage applied to the motor are ramped down at a controlled rate. When the frequency approaches zero, the motor is shut off. A small amount of braking torque is available to help decelerate the load a little faster than it would stop if the motor were simply switched off and allowed to coast. Additional braking torque can be obtained by adding a braking circuit

DRIVE SPEED RATIO

RATIO	PUMP 1 RPM	PUMP 2 RPM
1:2	250	500
2:1	500	250
1:5	100	500

1:1.5	1000	1500
1:5	300	1500

TABLE 5.1

CHAPTER 6

6. FLOAT SWITCH

6.1 INTRODUCTION

A float switch is a device used to detect the level of liquid within a tank. The switch may be used in a pump, an indicator, an alarm, or other devices.

Float switches range from small to large and may be as simple as a mercury switch inside a hinged float or as complex as a series of optical or conductance sensors producing discrete outputs as the liquid reaches many different levels within the tank. Perhaps the most common type of float switch is simply a float raising a rod that actuates a microswitch.

6.2 TYPES OF FLOAT SWITCHES

- Magnetic float
- Electronic float
- Mechanical type

- Mounting type

6.3 OPERATION

A very common application is in sump pumps and condensate pumps where the switch detects the rising level of liquid in the sump or tank and energizes an electrical pump which then pumps liquid out until the level of the liquid has been substantially reduced, at which point the pump is switched off again. Float switches are often adjustable and can include substantial hysteresis. That is, the switch's "turn on" point may be much higher than the "shut off" point. This minimizes the on-off cycling of the associated pump.

Some float switches contain a two-stage switch. As liquid rises to the trigger point of the first stage, the associated pump is activated. If the liquid continues to rise, the second stage will be triggered. This stage may switch off the source of the liquid being pumped trigger an alarm, or both.

MOUNTING TYPE FLOAT SWITCH

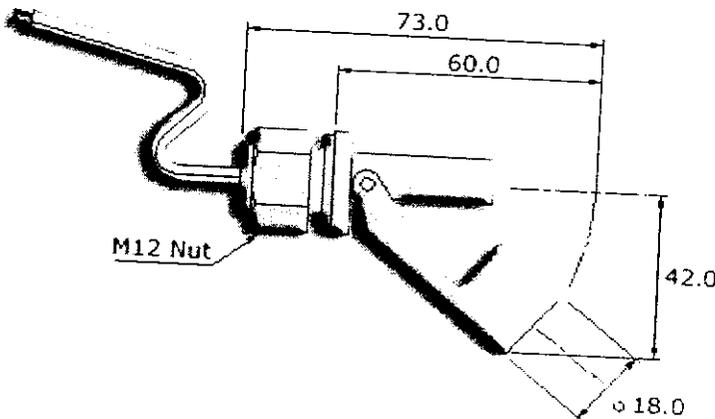


FIG 6.1

6.4 USES

- Used in non-corrosive liquids
- Normally open (NO) contact
- Different on and off angles available
- RoHS Compliant and Lead-free
- Does not require power for operation
- Various types of leads and connectors available

6.5 SPECIFICATIONS

CONTACT FORM		
Contact Rating (max)		A
Switching Current (max)	W / VA	30.0
Carry Current (max)	A	0.5
Switching Voltage (max)	A	2.5
Breakdown Voltage (min)	V DC/AC	230
Initial Contact Resistance (max)	V DC	350
Operating Temperature	mΩ	150
Shock Resistance (½Sin wave for 11ms)	°C	-40 to +70
Vibration Resistance (10-2000Hz)	g	50
	g	20

TABLE 6.1

REQUIREMENTS

CHAPTER 7

7. REQUIREMENTS

7.1 SWITCH MODE POWER SUPPLY

7.1.1 BLOCK DIAGRAM

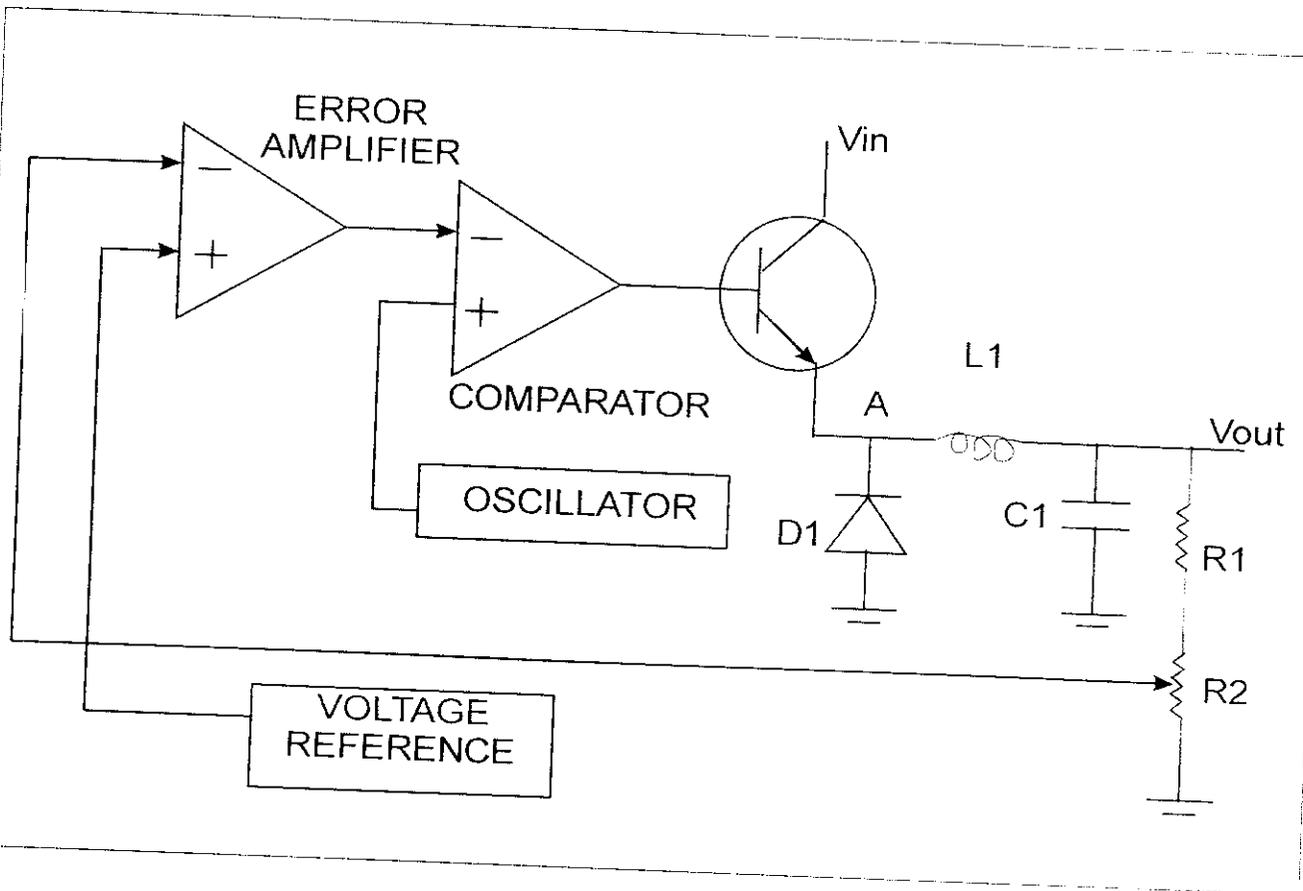


FIG 7.1.1

7.1.2 WORKING PRINCIPLE

The figure shows the functional block diagram of basic switching voltage regulator, which uses transistor Q1 as a switch. The part $R2/R1+R2$ of the output is feedback to the inverting input of error amplifier. It is compared with the reference voltage. The difference is amplified and given to the comparator terminal.

The oscillator generates a triangular waveform at a fixed frequency. It is applied to the non-inverting terminal of the comparator. The output of the comparator is high when the triangular voltage waveform is above the level of the error amplifier output. Due to this the transistor Q1 remains in cut-off state. Thus the output of the comparator is nothing but a required pulse waveform.

The period of this pulse waveform is same as that of oscillator output say T. The duty cycle is denoted as $t_{on} f$ as mentioned earlier. This duty cycle is controlled by the difference between the feedback voltage and the reference voltage.

When Q1 is on in saturation state, $V_{ce} (sat)$ for Q1 is zero. Hence entire input voltage V_{in} appears at point A. Thus the current flows through inductor L1.

When Q1 is off, L1 still continue to supply current through itself to the load. The diode D1 provides the return path for the current.

The capacitor C1 acts to smooth out the voltage and the voltage at the output is almost d.c. in nature. The output voltage V_o of the switching regulator

is a function of duty cycle and the input voltage V_{in} . Mathematically it is expressed as,

$$V_o = (t_{on}/T)V_{in}$$

Thus when T is constant, output is proportional to t_{on} . This method is called pulse width modulation (PWM). When t_{on} is constant, the output is inversely proportional to period T i.e. proportional to frequency of the pulse waveform. This method is called frequency modulation.

7.2 RELAY

7.2.1 INTRODUCTION

A relay is an electrically operated switch. Current flowing through the coil of the relay creates a magnetic field which attracts a lever and changes the switch contacts. The coil current can be on or off so relays have two switch positions and they are double throw (changeover) switches. Relays allow one circuit to switch a second circuit which can be completely separate from the first. For example a low voltage battery circuit can use a relay to switch a 230V AC mains circuit. There is no electrical connection inside the relay between the two circuits; the link is magnetic and mechanical.

The coil of a relay passes a relatively large current, typically 30mA for a 12V relay, but it can be as much as 100mA for relays designed to operate from lower voltages. Most ICs (chips) cannot provide this current and a transistor is usually used to amplify the small IC current to the larger value required for the relay coil. The maximum output current for the popular 555 timer IC is 200mA so these devices can supply relay coils directly without amplification.

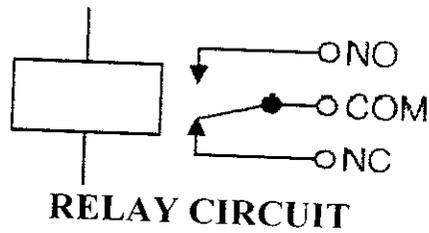


FIG 7.2.1

The relay's switch connections are usually labeled COM, NC and NO:

- COM = Common, always connect to this, it is the moving part of the switch.
- NC = Normally Closed, COM is connected to this when the relay coil is off.
- NO = Normally Open, COM is connected to this when the relay coil is on.

7.2.2 CIRCUIT DESCRIPTION:

RELAY CIRCUIT - SPST

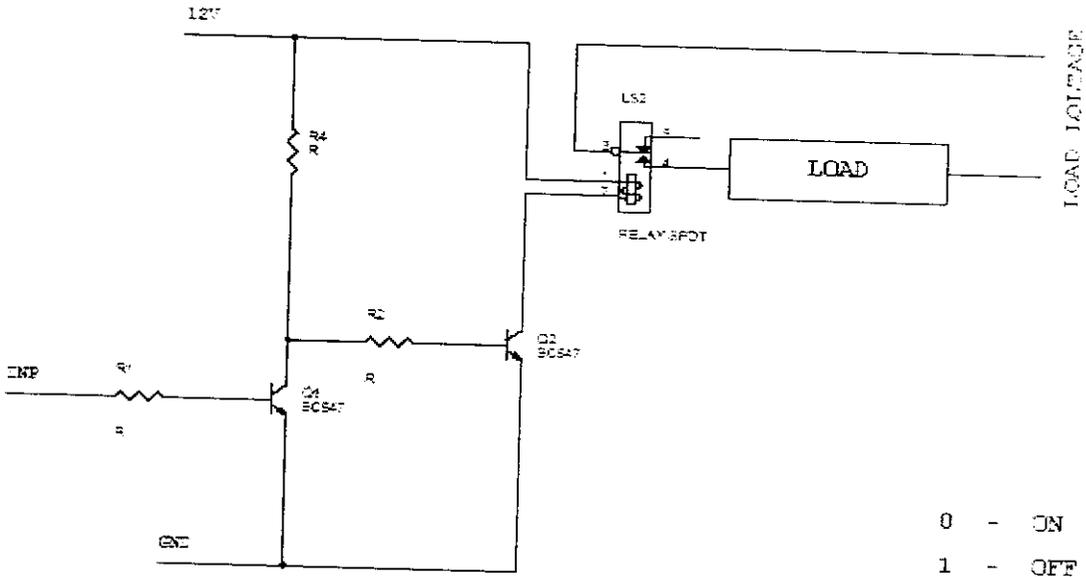


FIG 7.2.2

7.2.3 OPERATION

This circuit is designed to control the load. The load may be motor or any other load. The load is turned ON and OFF through relay. The relay ON and OFF is controlled by the pair of switching transistors (BC 547). The relay is connected in the Q2 transistor collector terminal. A Relay is nothing but electromagnetic switching device which consists of three pins. They are Common, Normally close (NC) and Normally open (NO).

The relay common pin is connected to supply voltage. The normally open (NO) pin connected to load. When high pulse signal is given to base of the Q1 transistors, the transistor is conducting and shorts the collector and emitter

terminal and zero signals is given to base of the Q2 transistor. So the relay is turned OFF state.

When low pulse is given to base of transistor Q1 transistor, the transistor is turned OFF. Now 12v is given to base of Q2 transistor so the transistor is conducting and relay is turned ON. Hence the common terminal and NO terminal of relay are shorted. Now load gets the supply voltage through relay.

RELAY ON OFF STATE

Voltage Signal from Microcontroller or PC	Transistor Q1	Transistor Q2	Relay
1	On	off	off
0	Off	on	on

TABLE 7.1

CHAPTER 8

8. SOFTWARE DETAILS

8.1 WIN PROLADDER:

This software is used to embed the Ladder Program into the PLC. Initially the program is loaded into the software and transferred to the PLC, by using a specialized data cable.

8.2 FUNCTIONS OF THE SOFTWARE:

- To read the program from the PLC.
- To erase the program in the PLC if necessary.
- To program any type of PLC.
- It is simulation software where we can check the output of the process.
- To check whether the program is done properly (shows any error if present).

8.3 PROGRAMMING WINDOW

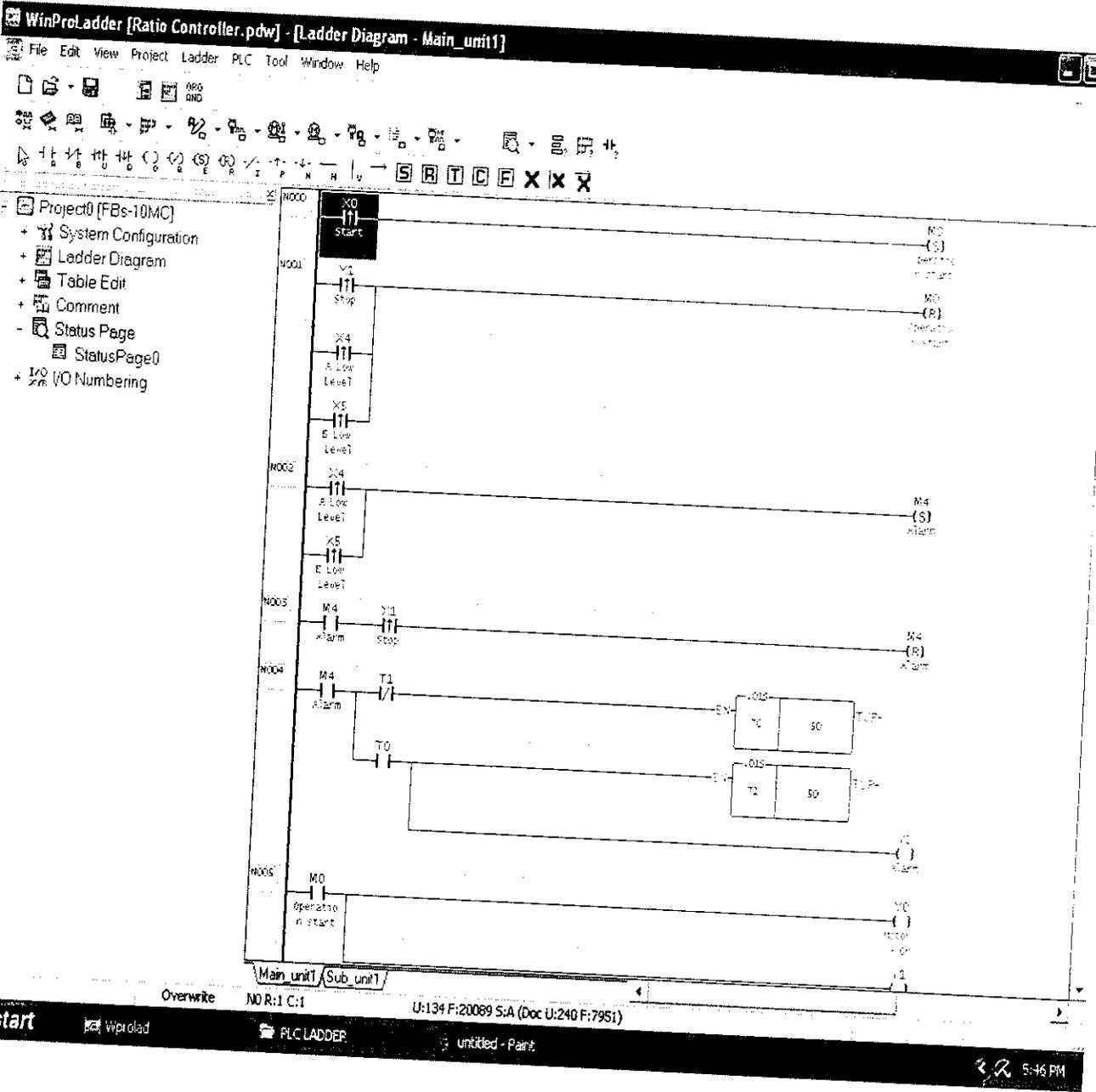


FIG 7.1

PROGRAMMING WINDOW

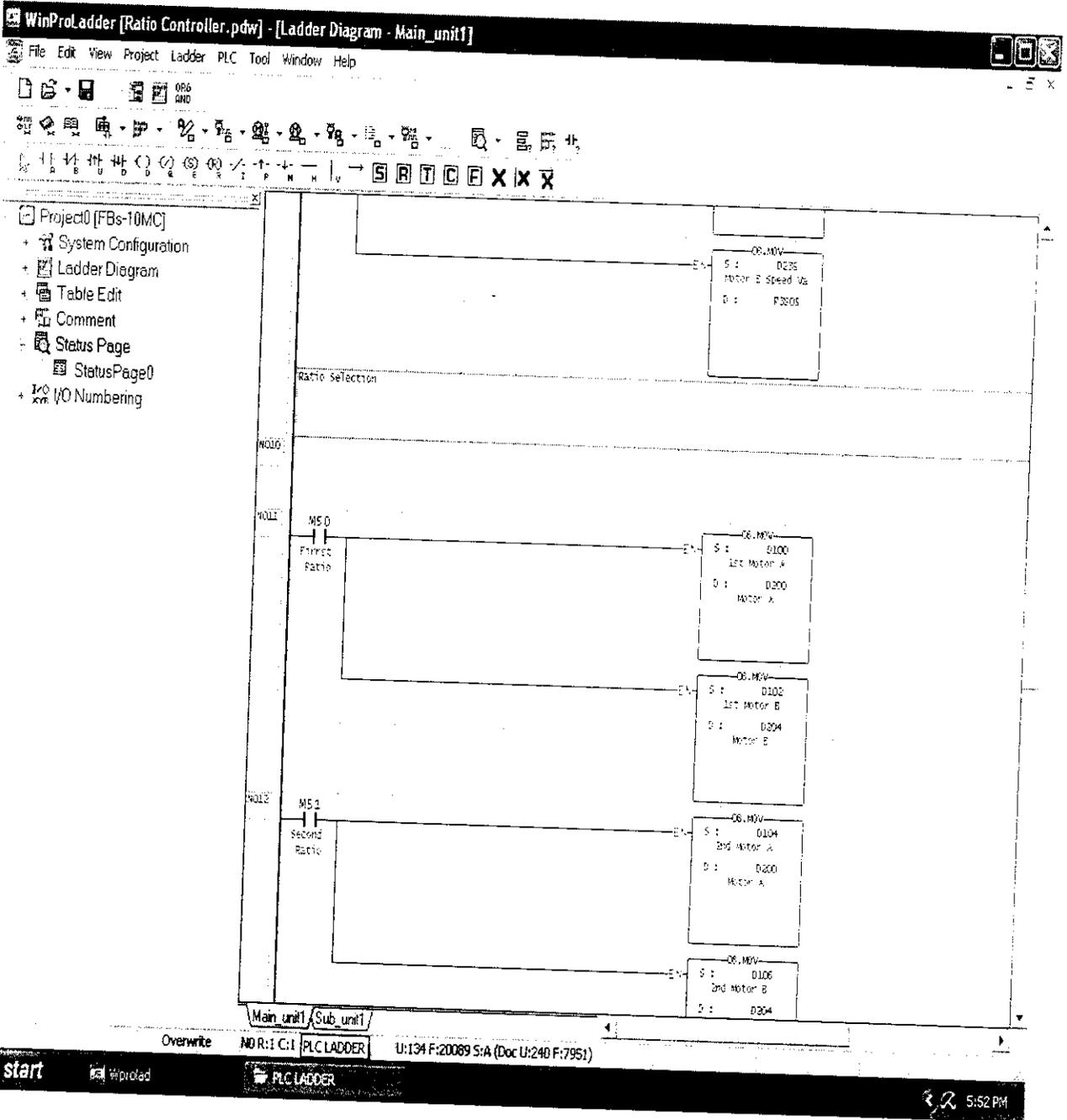


FIG 7.2

CONCLUSION

CONCLUSION

RESULTS AND CONCLUSION

Thus, this project gives an optimized solution by adopting efficient and user friendly techniques, to promote effective flow and ratio control. As PLC is used as controller, it also ensures flexibility and better performance of the process.

Since the PLC design is generic, the same system can be applied to any process, by just analyzing the process parameter. The project leaves a significant scope for further research in same and allied fields. The system, if implemented will produce high time process monitoring and Automation at Industries.

REFERENCE

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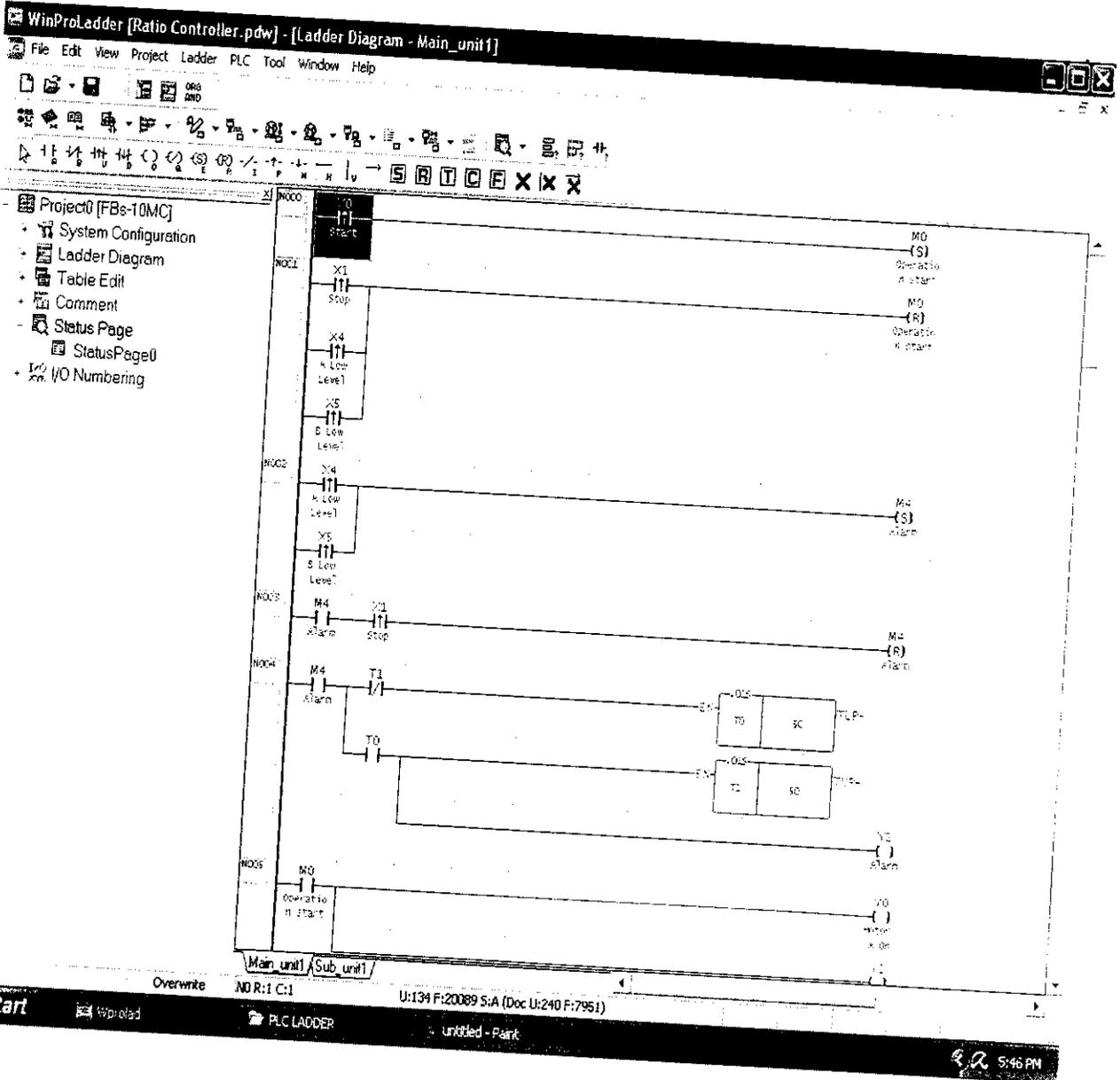
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- www.sensirion.com

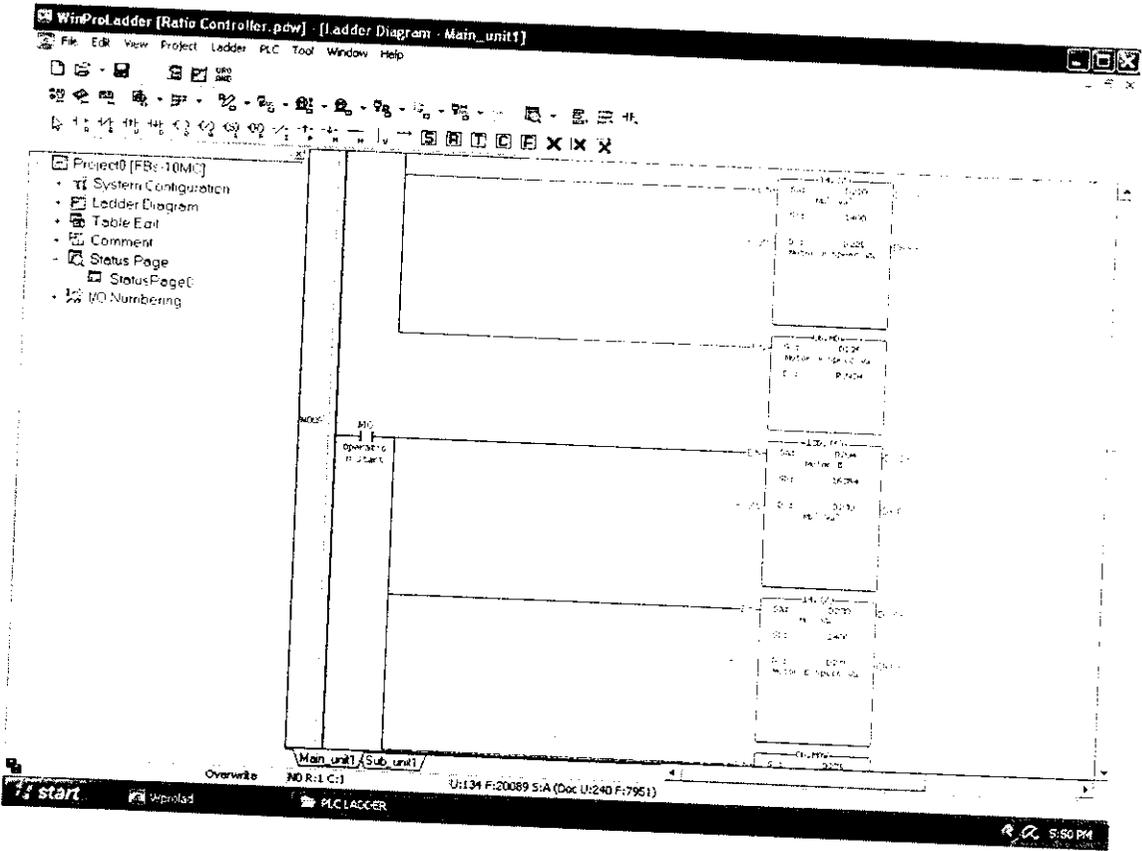
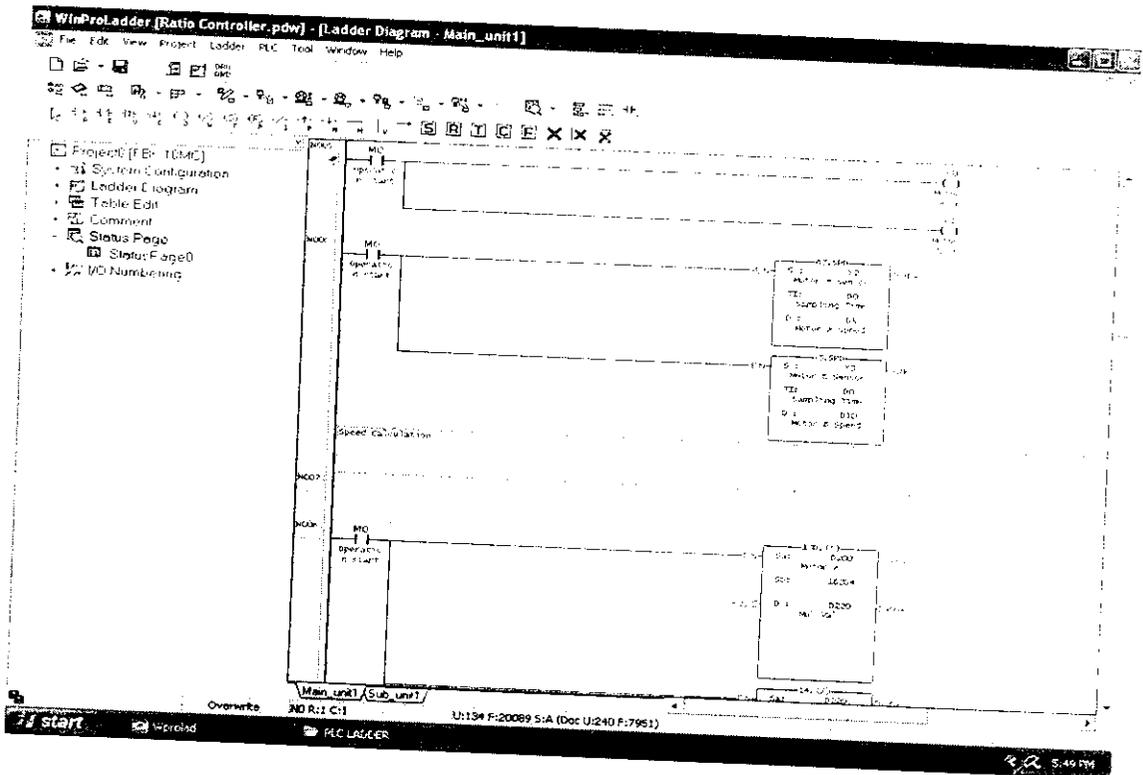
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APPENDIX - I

SOFTWARE CODING





WinProLadder [Ratio Controller.pdw] - [Ladder Diagram - Main_unit1]

File Edit View Project Ladder PLC Tool Window Help

Project0 [FBs-10AC]

- System Configuration
- Ladder Diagram
- Table Edit
- Comment
- Status Page
- StatusPage0
- I/O Numbering

MS0 OFF

MS1 OFF

MS2 OFF

Network 1: S0.0 S0.0

Network 2: S0.1 S0.1

Network 3: S0.2 S0.2

Man_unit1 / Sub_unit1

NO R1 C1 PLC LADDER U:134 F:20089 S:A (Doc U:240 F:7951)

start WinProLad 5:52 PM

WinProLadder [Ratio Controller.pdw] - [Ladder Diagram - Main_unit1]

File Edit View Project Ladder PLC Tool Window Help

Project0 [FBs-10MC]

- System Configuration
- Ladder Diagram
- Table Edit
- Comment
- Status Page
- StatusPage0
- I/O Numbering

MS0 OFF

MS1 OFF

MS2 OFF

Network 1: S0.0 S0.0

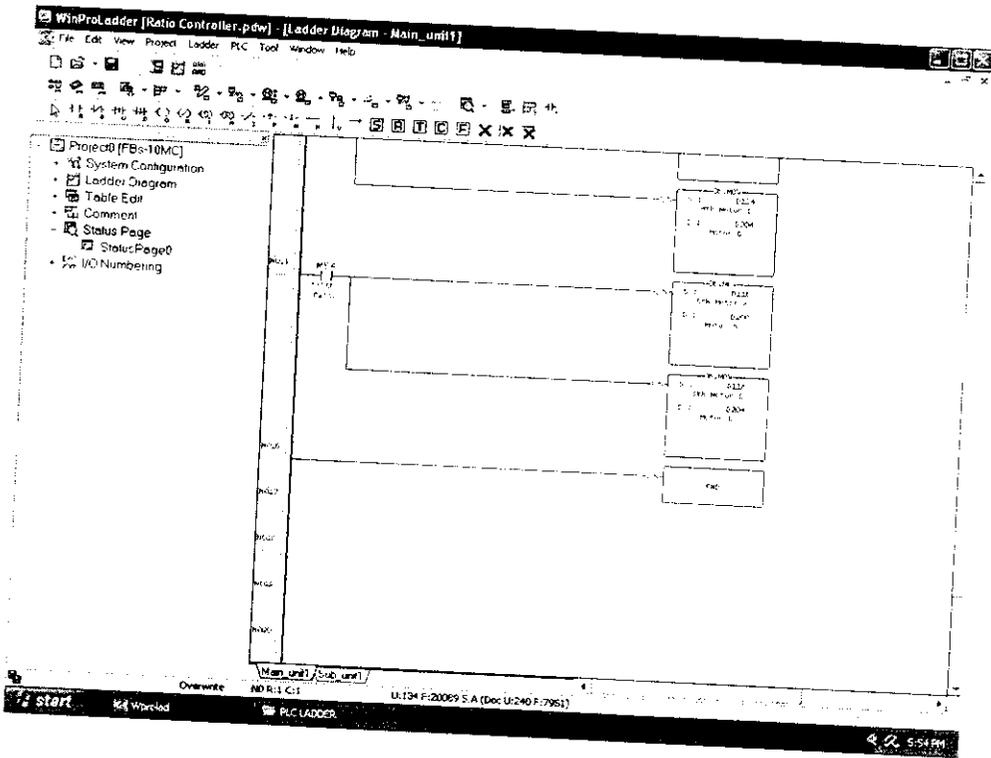
Network 2: S0.1 S0.1

Network 3: S0.2 S0.2

Man_unit1 / Sub_unit1

NO R1 C1 U:134 F:20089 S:A (Doc U:240 F:7951)

start WinProLad 5:53 PM



APPENDIX – II

DATA SHEETS

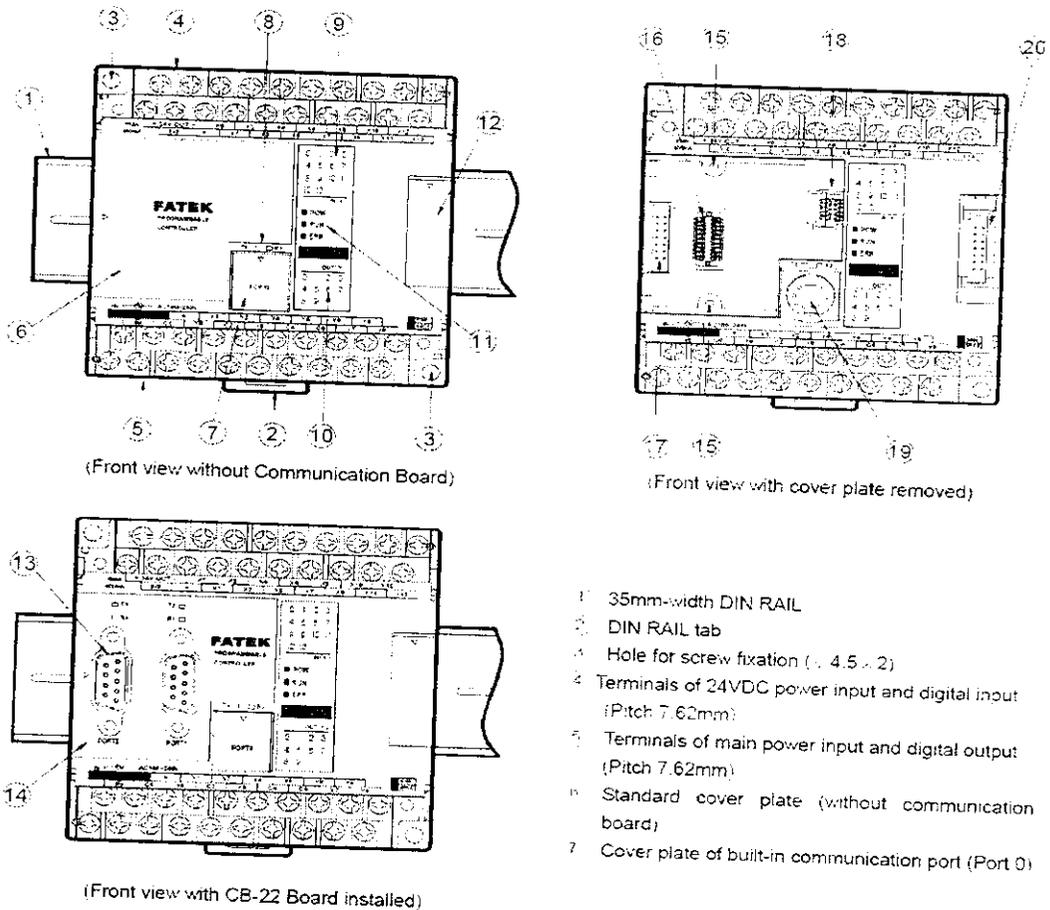
【Hardware】

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. Fourteen DI/DO and 12 NI/NO models are available for Expansion Units/Modules. With interface options in RS232, RS485, USB and Ethernet, the communication peripherals are available with 14 boards and modules. The various models are described in the following:

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:

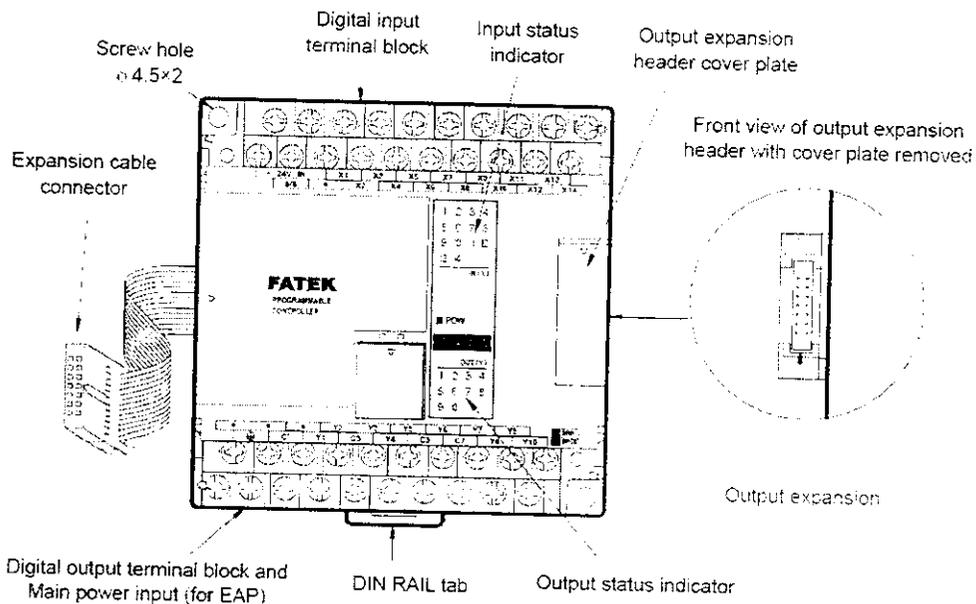


- 8 Indicators for transmit (TX) and receive (RX) status of built-in communication port (Port0).
- 9 Indicator for Digital Input (Xn).
- 10 Indicator for Digital Output (Yn).
- 11 Indicator for system status (POW, RUN, ERR).
- 12 I/O output expansion header cover [units of 20 points or beyond only], 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 CB2, CB22, CB5, CB55, and CB25)
- 17 Connector for Communication Module (CM) (only available in MC/MN model, for CM22, CM25, CM55, CM25E, and CM55E 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 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: [-24EA(P), -40EA(P), -60EA(P), -TC16, -RTD16]



1.5 Specifications of Main Unit

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Item		Specification		Note		
Execution Speed		0.33μS / 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		300 (113 types)				
Flow Chart (SFC) Command		4		Include Derived Commands		
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)* M1400 ~ M1911 (512)	Can be configured as retentive type	
			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)*		
			1S Time base	T200 ~ T255 (56)*		
	CTR	Current Counter Value Register	16-Bit	Retentive	C0 ~ C139 (140)*	Can be configured as non-retentive type
				Non-retentive	C140 ~ C199 (60)*	Can be configured as retentive type
		32-Bit	Retentive	C200 ~ C239 (40)*	Can be configured as non-retentive type	
			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)	Can be configured as retentive type	
	HR ROR		Non-retentive	R3000 ~ R3879 (880)*	Can be configured as retentive type	
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/retrieve 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 (199); R4090 ~ R4095 (6)	Except R4152 ~ 4154			
Special Register	0.1mS High 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		R4129 (sec) R4126 (min) R4130 (hour) R4131 (day)			
		R4132 (month) R4133 (year) R4134 (week)	Not available in MA mode			
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) 32Points	Channels	Up to 4	<ul style="list-style-type: none"> Total number of HHSC and SHSC is 8. HHSC can change into High Speed Timer with 32 bits of 1ms Time base.
		Counting mode	3 (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 100KHz (single-end input) or 500KHz (differential input)		
	Software High Speed Counter (SHSC) 32Points	Channels	Up to 4	
		Counting mode	3 (U/D, K/R, A/B)	
		Counting frequency	Maximum sum up to 10KHz	
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		920KHz single output (single or 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) > 10 μs: Super high speed/high speed input	
	Captured pulse width		> 47 μs: Medium speed input; > 470 μs: Slow 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 ~ 5mS adjustable by step of 1mS

1.6 Environmental Specifications

Item		Specification	Note
Operating Ambient Temperature	Enclosure equipment	Minimum	5°C
		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 1μs
Withstand Voltage			1500VAC, 1 minute
			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.

