CHAPTER ONE

1. INTRODUCTION

Industrial automation is the use of control systems to control machinery and process, reducing the need for human intervention, this made the production rate constant and almost error free.

If we compare a job being done by human and by automation , the physical part of the job is replaced by use of machine ,whereas the mental capabilities of the human are replaced by automation. The human sensory organs are replaced with electrical, mechanical or electronic sensors to enable the automation system to perform the job.

Control engineering has evolved over time. In the past, humans were the main method 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.
- With the invention of PLCs process controlling became easier, and production increase noticeably .

1.1 Literature review :

previous work similar to this project is submitted to Faculty of Electronics & Instrumentation Engineering Aarupadai Veedu Institute of Technology (**Vinayaka Mission University**) : Nowadays, the application of PLC is widely known and use in this digital world PLC's application is obviously applied at the industrial sector. Normally, the PLC's that have been used at the industrial field is usually to control a mechanical movement either of the machine or heavy machine in order to create an efficient production and accurate signal processing. In this project, a discussion about PLC application will be explained in more details and specified .Whereby, a machine that used to prepare automatic filling water into the bottle is fully controlled by the PLC CPM2A,which acts as the heart of the system. The system sequence of operation is designed by ladder diagram and the programming of this project by using CX-Programmer software. Sensor usually plays its vital part as an input signal transmitter for the PLC in this system. During this project sensor has been used to detect the bottle position that move along the conveyor belt at the low speed while the machine operates. The input signal that has been sent from the sensor to the PLC has being made as a reference. Signal in order to determine the output signal that exactly a same with the PLC programming language based on the user requirement. beside that, the electronics and electric devices that usually been controlled by the PLC are like a motor, pump, sensor, conveyor belt, buzzer and the others devices.

1.2 Problem Statement :

Control system implies direct interaction with the physical world . control system include sensor and actuators, the critical pieces needed to ensure that our automation systems can helps us manage our activities and environments in desired ways [1]. This project will reduce the usage of man power because all of the work will be done by machine. Human held filling process will cause inexact volume of liquid into the bottle. So using automated system will set the volume of the liquid exactly the same for each bottle. If all the process is done manually, it will cost lot of time to complete the task. This machine will also reduce the human error while doing this process manually.

1.3 Project Objective :

The main objective of this project is to apply PLC to design automatic filling system . the fascination and wide application of PLC has motivated to discovered more about plc. To drive the main objective there are several supporting goals need to be achieved as listed below :

- To perform a filling process into the bottle using PLC [ALLEN-BRADLEY MicroLogix1200]
- To design a closed-loop system which can control the filling process by PLC techniques.
- To make sure that the bottle does not overflow and conveyor must stop as long as sensor is working .
- To maintain an automatically and continuous filling flow into bottle .

١.4 Approach :

Hardware components such as **PLC MicroLogix 1200**, sensors, valve and motors will be used to build the Automatic bottle filling system. Software programs such as **RSLOGIX 500** will be used to write a program (ladder diagram) to direct and control the system .

1.5 Research Outlines :

- In this project , six chapters will be briefly discussed . in **chapter one**, the introduction of automatically filling system using PLC will mainly discussed about the project objectives and scope in order to achieve the desired goal.
- After that , **chapter two** : filling systems and explanation about the main type of PLC and the type of PLC that has been chosen for this project (ULLEN-BRADLEY) .
- **Chapter three** , methodology will describe about the overall project that has been testified and successfully operate. Come along with in this chapter is an explanation about material selection which is including controller, motor, sensor in order to design a good project.
- **Chapter four** , electrical design , will discuss about the electrical component used, and the installation of the electrical components on the system. This chapter also discuss the concept of how the input and output circuit of PLC should be understood , the wiring of dc input , ac input , relay output and the transistor outputs are also .
- After that programming development will be discuss in **chapter five** . systematic approach of control system design using programmable

logic controller. The machine sequences of operation will be discuss, Next the assignment of input and output are shown in table, finally the ladder diagram design.

- Finally **chapter six** there will be conclusion and recommendation .

CHAPTER TWO

FILLING SYSTEMS AND PROGRAMMABLE LOGIC CONTROLLER

2. Inline Filling Systems :

This analysis deals primarily with the lower capacity filling machine used by small to medium sized companies and excludes high speed rotary filling systems typically found only in the mass market beverage industry. In contrast, the filling systems discussed here are used throughout all industries including food, beverage, chemical, cosmetic and pharmaceutical but at lower speeds; usually less than 200 containers per minute. In fact, most of the market for filling systems in terms of units sold is for semiautomatic equipment that operates at speeds not exceeding 20 container per minute.[2]

No one type of filling machine can handle all liquids in all industries. For example, a machine that fills bottled water cannot fill cosmetic cold cream. Nor would a chemical duty filler be used to fill pharmaceutical grade or dairy products. Although there are many different types of filling technologies, there are relatively few that are versatile, practical and cost effective to own and operate. The choice of filling machine depends on the range of viscosities, temperature, chemical compatibility, particulate size, foam characteristics, and hazardous environment considerations. Each one of the machines below is discussed with its strengths and weaknesses and range of best suited applications.

2.١ Types of inline filling system

2.١.1 Overflow filling systems :

This type of filler is perhaps the most widely used filling machine in small bottle filling operations because it handles a wide range of thin, free flowing liquids as well as liquids with medium viscosity. This machine is also commonly referred to as a "fill to level" filling machine or cosmetic height filler. This means that machine fills to a target fill height in the container rather than volumetrically. But it can also be shown that as long as the container specification do not vary greatly, the volumetric accuracy of this machine is excellent.

How It Works:

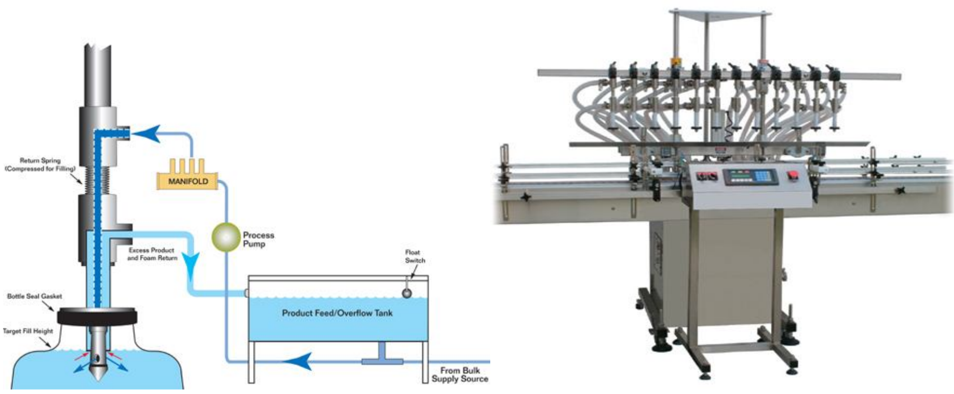

Figure 2.1 : Overflow filling systems

The supply side (dark blue) of a two part nozzle is used to pump product into the container. When the container fills up to the target fill height, the excess product and foam is forced out of the container (red arrows) via the return side to the original product source tank.

2.١.2 Servo Positive Displacement Filling Machine

This is a very versatile filling machine capable of filling nearly any type of product that can be pumped. Each nozzle has a dedicated servo controlled pump that can deliver thin liquids, medium and thick viscosity liquids, and liquids with large particulates. Because it is so versatile, it is often purchased by contract packagers who never know what their next filling challenge is going to be. Examples of the range of products that can be run on this machine include soaps, pharmaceutical products, oils and greases, cosmetics, salsa and sauces, etc.

How It Works:

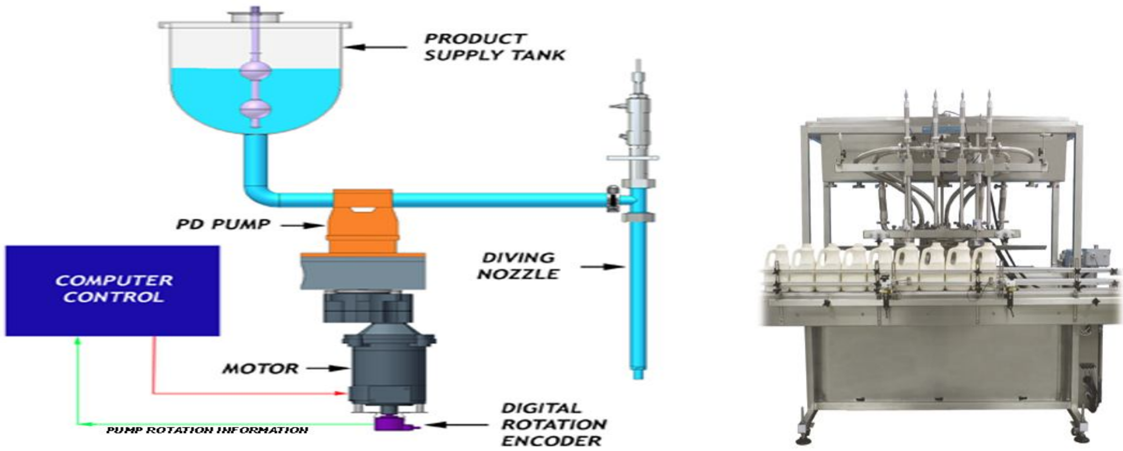

Figure 2.2 : Servo Positive Displacement Filling Machine

The filler's master computer independently tracks the rotation of each pump head so that it knows precisely how much product has been delivered. When the target fill volume is reached, each pump and nozzle is instantly shut off, resulting in high accuracy fills of your valuable products. The computer stores all fill parameters in memory for fast changeovers.

2.١.3 Piston filling systems:

The piston filler is one of the oldest and most reliable types of fillers used in the packaging industry. This filling machine is best suited for viscous products that are paste, semi paste, or chunky with large particulates. Piston fillers are primarily built to meet food grade standards and commonly fill heavy sauces, salsas, salad dressings, cosmetic creams, heavy shampoo, gels, and conditioners. Thy are also used for viscous chemical preparations like paste cleaners and waxes, adhesives and epoxy's, heavy lubricant oils and greases.

There are two types of piston fillers that are available namely check valve and rotary valve.

2.١.3.i Check Valve Piston Filling Machines :

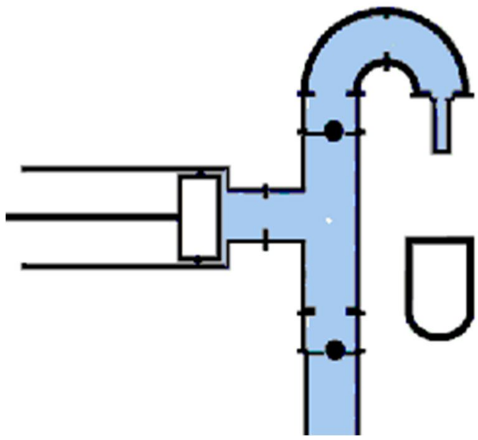

Figure 2.3 : Check Valve Piston Filling Machines

A check valve piston filler works on a check valve principle that opens the in feed valve on the draw stroke then forces the draw side check valve closed while opening the discharge valve on the dispense stroke .

The big advantage of a check valve filling system is it can self-prime and draw product directly from a drum or other container without need for pumping or otherwise transferring product to another vessel. Simply drop the hose into the drum, adjust the fill volume and start filling product with excellent accuracy of +/- one half percent.

Check valve piston fillers work well with most any free flowing liquid (meaning it pours easily), but does not work well on thicker products or products with particulates in them as they can foul the valves.

2.1.3.ii Rotary Valve Piston Filler :

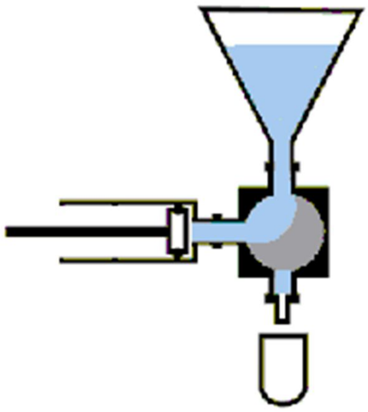

Figure 2.4 : Rotary Valve Piston Filler

Rotary valve piston filling machines can do all of the “hard” jobs like filling pastes and products with particulates such as cottage cheese, potato salads, peanut butter, salsas and many other chunky products.

The concept is actually rather simple in that the hopper flood feeds the rotary valve which connects between the hopper and cylinder on the draw stroke and then flips ninety degrees between the cylinder and discharge tube on the dispense stroke, as can be seen in the animation on the right. Because the rotary valve can be hollowed out, large particles of up to one half inch (sometimes larger) can pass through without damage.

Rotary valve piston filling systems are available as bench top, automatic inline, and rotary high speed systems and can be sized for your range of filling needs up to a 10:1 ratio and maintain its amazing +/- one half percent accuracy.

٢.2 Rotary Fillers :

Just about any type of filler that is available as an inline system is also found in a rotary filling machine. There are pressure fillers, gravity fillers, piston fillers, and carbonated beverage filling machines, canning and more, plus numerous arrays of configurations such as neck supporting for water bottles, bottom fill platforms or diving nozzles, to the brim fillers for many juices, plus hot fill options and much more.

2.3 Programmable Logic Controller (PLC) :

In the late 1960's PLCs were first introduced. The primary reason for designing such a device was eliminating the large cost involved in replacing the complicated relay based machine control systems. Bedford Associates (Bedford, MA) proposed something called a Modular Digital Controller (MODICON) to a major US car manufacturer. Other companies at the time proposed computer based schemes, one of which was based upon the PDP-8. The MODICON 084 brought the world's first PLC into commercial production.[3]

When production requirements changed so did the control system. This becomes very expensive when the change is frequent. Since relays are mechanical devices they also have a limited lifetime which required strict adhesion to maintenance schedules. Troubleshooting was also quite tedious when so many relays are involved. Now picture a machine control panel that included many, possibly hundreds or thousands, of individual relays. The size could be mind boggling. How about the complicated initial wiring of so many individual devices! These relays would be individually wired together in a manner that would yield the desired outcome. These “new controllers” also had to be easily programmed by maintenance and plant engineers. The lifetime had to be long and programming changes easily performed. They also had to survive the harsh industrial environment. That’s a lot to ask! The answers were to use a programming technique most people were already familiar with and replace mechanical parts with solid-state ones.

In the mid70’s the dominant PLC technologies were sequencer state-machines and the bitslice based CPU. The AMD 2901 and 2903 were quite popular in Modicon and A-B PLCs. Conventional microprocessors lacked the power to quickly solve PLC logic in all but the smallest PLCs. As conventional microprocessors evolved, larger and larger PLCs were being based upon them. However, even today some are still based upon the 2903.(ref A-B’s PLC-3) Modicon has yet to build a faster PLC than their 984A/B/X which was based upon the 2901.

Communications abilities began to appear in approximately 1973. The first such system was Modicon’s Modbus. The PLC could now talk to other PLCs and they could be far away from the actual machine they were controlling. They could also now be used to send and receive varying voltages to allow them to enter the analog world. Unfortunately, the lack of standardization coupled with continually changing technology has made PLC communications a nightmare of incompatible protocols and physical networks. Still, it was a great decade for the PLC!

The 80’s saw an attempt to standardize communications with General Motor’s manufacturing automation protocol(MAP). It was also a time for reducing the size of the PLC and making them software programmable through symbolic programming on personal computers instead of dedicated programming terminals or handheld programmers. Today the world's smallest PLC is about the size of a single control relay!

The 90's have seen a gradual reduction in the introduction of new protocols, and the modernization of the physical layers of some of the more popular protocols that survived the 1980's. The latest standard (IEC 1131-3) has tried to merge plc programming languages under one international standard. We now have PLCs that are programmable in function block diagrams, instruction lists, C and structured text all at the same time! PC's are also being used to replace PLCs in some applications. The original company who commissioned the MODICON 084 has actually switched to a PC based control system.

2.4 What is the PLC ?

A PLC (Programmable Logic Controller) is a hardware that was invented to replace the conventional relay logic circuits for machine and process control. This hardware can accept the real world inputs and can send the outputs command through its input/output modules. [4]

The PLC operates by sensing it's inputs and depending upon their conditions, the outputs are activated. The user writes a program as per the application, usually via a software, which when loaded and run in the PLC, produces the desired results.

PLC's are used in many "Real World" applications, in any industry, in this modern World of automation there is a need of a PLC. Particularly in the field of machining, packaging, material handling, automated assembly or countless other Industries the application that needs some type of electrical control has a need for a PLC.[4]

In any process, if there are number of operations to be taken place simultaneously, involving large number of relays, timers, counters, etc. the involvement of a PLC will Ensure a reliable and cost effective management in performing the desired system operation. So it is well understood that larger a control system is, it is evident that a PLC is used.

PLC's vary in size and sophistication. When PLC's were first introduced, they typically used a dedicated programming device for entering and monitoring the PLC program. The programming device could not only be used for programming a specific brand of PLC. These dedicated programmers, although user friendly, were very expensive and could not be used for anything designed that allowed a personal computer to program a PLC. Although dedicated programming devices still are available, the most common programming device used today is a personal computer running, i.e. windows based programming software.

Many engineers and/or technicians seem apprehensive about PLC's and their application in industry. One of the purposes of this manual is to explain PLC basis in a plain, easy-to understand approach so that engineers and technicians with no PLC experience will be more comfortable with their first exposure to Programmable Logic Controller .

2.5 The Internal Configuration of PLC

The main components of a PLC are the following**:**

- Main Rack
- Power Supply
- CPU
- Digital Input/output cards
- Analog Input/output cards

- Special Features Cards

2.5.1 Main Rack :

This is where the rest of the elements are connected or plugged in. It is normally screwed to the electric cabinet mounting plate. It can get a certain number of cards depending on the manufacturer and to be connected to other racks through a communication cable, being called in this auxiliary rack.

2.5.2. Power Supply :

Converts the input power of 110 or 220 V AC to 24 V DC and necessary current to supply the CPU and IN/OUT cards as well as auxiliary equipment if needed.

2.5.3. CPU :

This is the brain of the PLC. With one or more microprocessors (depending on the manufacturer) it is programmed with a special software. Most of them are using a standard programming language like instructions, contacts, functions, sequential etc. They work with logic 1-0, this is two different states for the same bit. Normally use 16 bits word as memory basis although some new ones work on a 32 bits words basis. Depending on the CPU models, are able to manage more memory and calculation functions as well as microprocessor speed.

Nowadays the calculation power of this devices is very high and usual to work with floating point numbers thus giving mathematical precision more than needed. It is normal to have 10 msec. scan cycle for typical digital application and about 40 msec, for an analogue one, much more fast than any process transmitter or valve actuator. The application program is made in a special language, it has beginning and an end. The time between them is called scan cycle and there is timer inside the PLC’s CPU unit that look for the program to be executed from the beginning to the end before that timer ends. This is the WATCHDOG timer. If this timer ends before the scan cycle, the PLC will go to the STOP status.

2.5.4. Digital Input/output Cards :

They are connected to the main or auxiliary rack and communicate with the CPU across related connection. In case of digital inputs these ones transmit the 0 or 1 status of the process signals (pressure switches, limit switches proximity sensors, switches etc.) to the CPU. In case of digital outputs, the CPU will set or reset them following the program instructions. 24 DC V for inputs and outputs are normally used, but 110 or 230 V AC inputs/outputs as well. The number of input/outputs per card can be from 8 ,16 or 32 points etc.

2.5.5. Analog Input/output Cards :

They are connected the same way than the previous ones but in some PLC's have to be as close to the CPU as possible. These cards receive an analogue value from filed and internally convert it to a digital value to be processed by the CPU. This conversion is made by Analogue to Digital converters located in the analogue card and distributed to one for the whole card or one per channel depending on the card model (this is the fastest one). They are made of 2.4.8 or 16 input /outputs called each one "channel" and referred from 0 to (Max-1), for example, the first channel of a 4 analogue outputs card is named 0 and the last one ids named 3.
Inputs and output ranges varies between 4-20 mA (milliamps), 0 to 10 VDC, etc.
The most important thing to be considered when designing a control using analogue input cards is that is desirable to be galvanically isolated, otherwise will have problems with the value readings.

2.5.6. Special Features Cards :

Connected in the same way than previous ones are normally used to control or monitories special process variables like rotation speed , position, frequency, etc. They normally have an independent processor that makes the work and discharge of it to the PLC's CPU. The following are some examples of Special cards:

- Fast counting cards
- Motors positioning cards
- Regulation cards…etc.

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.

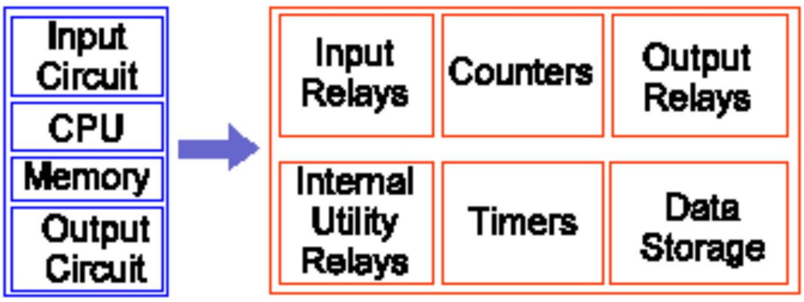

Figure 2.5 : PLC box

What does each part do?

- **Input Relays** (contacts) :

These are connected to the outside world. They physically exist and receive signals from switches, sensors, etc. Typically they are not relays but rather they are transistors.

- **Internal Utility Relays** (contacts) :

These do not receive signals from the outside world nor do they physically exist. They are simulated relays and are what enables a PLC to eliminate external relays. There are also some special relays that are dedicated to performing only one task. Some are always on while some are always off. 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.

- **Outputs 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 will still have the same contents as before power was removed.

2.6 Basics of 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. [5]

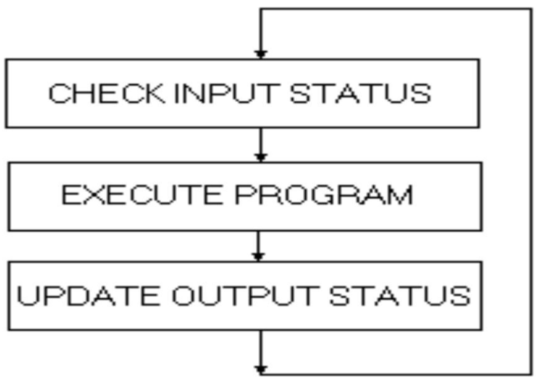

Figure 2.6 : Scan cycle of PLC

Step1: 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. Based on the example in step 2 it would now turn on the first output because the first input was on and your program said to turn on the first output when this condition is true. After the third step the PLC goes back to step one and repeats the steps continuously. One scan time is defined as the time it takes to execute the 3 steps listed above.

2.7 Time response of PLC :

The PLC can only see an input turn on/off when it's looking. In other words, it only looks at its inputs during the check input status part of the scan.

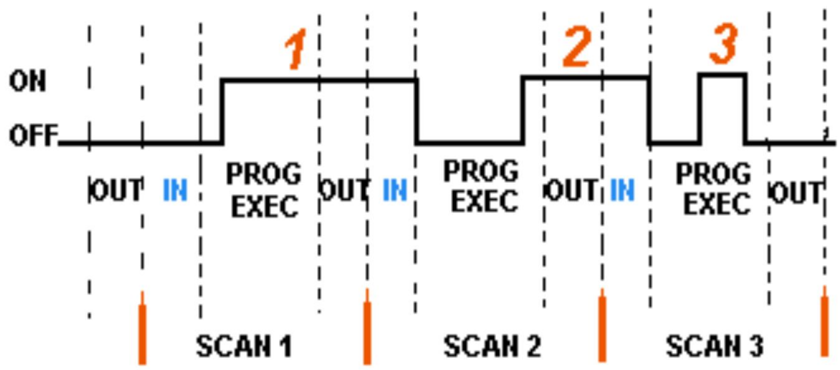

Figure 2.7 : Time response of PLC

In the diagram, **input 1** is not seen until scan 2. This is because when input 1 turned on, scan 1 had already finished looking at the inputs.

Input 2 is not seen until scan 3. This is also because when the input turned on scan 2 had already finished looking at the inputs.

Input 3 is never seen. This is because when scan 3 was looking at the inputs, signal 3 was not on yet. It turns off before scan 4 looks at the inputs. Therefore signal 3 is never seen by the plc.

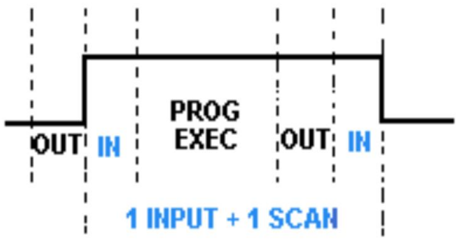

Figure 2.8 : Perfect input

To avoid this we say that the input should be on for at least 1
input delay time + one scan time.

But what if it was not possible for the input to be on this long? Then the plc doesn't see the input turn on. Therefore it becomes a paper weight! Not true... of course there must be a way to get around this. Actually there are two ways :

i. Pulse stretch function:

This function extends the length of the input signal until the plc looks at the inputs during the next scan.(i.e. it stretches the duration of the pulse.)

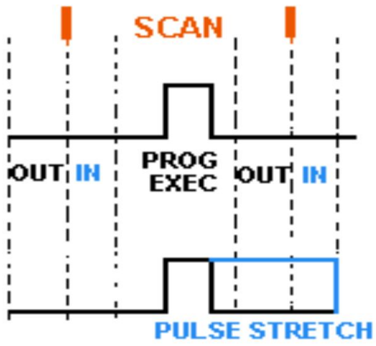

Figure 2.9 : Pulse stretch function

ii. Interrupt function:

This function interrupts the scan to process a special routine that you have written. i.e. As soon as the input turns on, regardless of where the scan currently is, the plc immediately stops what it's doing and executes an interrupt routine. (A routine can be thought of as a mini program outside of the main program.) After its done executing the interrupt routine, it goes back to the point it left off at and continues on with the normal scan process.

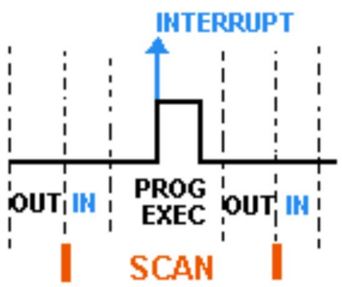

Figure 2.10 : Interrupt function

Now let's consider the longest time for an output to actually turn on. Let's assume that when a switch turns on we need to turn on a load connected to the plc output. The diagram below shows the longest delay (worst case because the input is not seen until scan 2) for the output to turn on after the input has turned on.

The maximum delay is thus **2 scan cycles - 1 input delay time.**

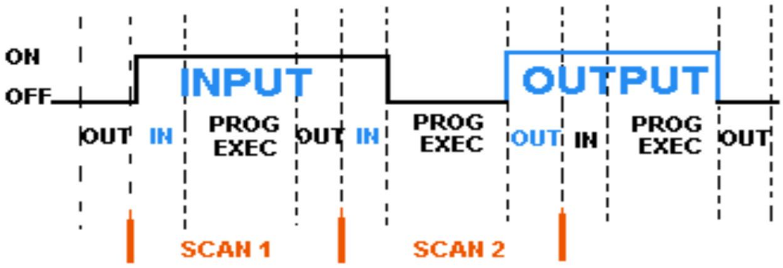

Figure 2.11 : Maximum Delay Time

2.8 MicroLogix 1200 Control System :

Bulletin 1762 MicroLogix 1200 Controllers are small enough to fit in tight spaces and powerful enough to accommodate a broad range of applications. Our controller is available in 24-point and 40-point versions. You can expand the I/O count using rack less I/O modules. You can build larger control systems, achieve greater application flexibility, and expand your system at a lower cost and with reduced parts inventory. A field-upgradeable flash operating system keeps you be up-to-date with the latest features.

Figure 2.12 : PLC Allen-Bradley MicroLogix 1200

Features :

- Contains isolated RS-232/RS-485 combo port for serial and networked communication
- Provides four latching or pulse-catch inputs and four interrupt inputs
- Includes built-in independent 20 kHz high-speed counter
- Offers Programmable Limit Switch function
- Includes two built-in ¾-turn trim potentiometers with a digital output range of 0...250
- Provides program data security
- Supports floating point data files
- Expands up to 136 I/O points
- Compatible with 1762 MicroLogix Expansion I/O modules (up to six modules per controller)
- Provides additional programming/HMI port for connectivity to a DF1 full-duplex compatible device (only on MicroLogix 1200R controllers)

Software

- RSLogix 500 programming software
- RSLogix Micro programming software

CHAPTER THREE

METHODOLOGY OF THE AUTOMATIC FILLING SYSTEM

3. INTRODUCTION

This chapter will mainly discuss about the methodology of the project and also the aspect or factors that must be taken into consideration during the development process. All this factors were very important to make sure the project will achieve its objective. Moreover, this chapter will also discuss about the designation stage on this project including electronic design, hardware component .

In this section, it will discuss an overall overview of Automatically Filling Water System Using PLC project. The introduction to system task will also briefly explain in this chapter. Finally, the entire decision making will be addressed in this section. Basically, software and hardware design will be used in order to implement this project. In addition, there some methods must be executed to keep this project implemented successfully.

3.1 How Does the System Work?

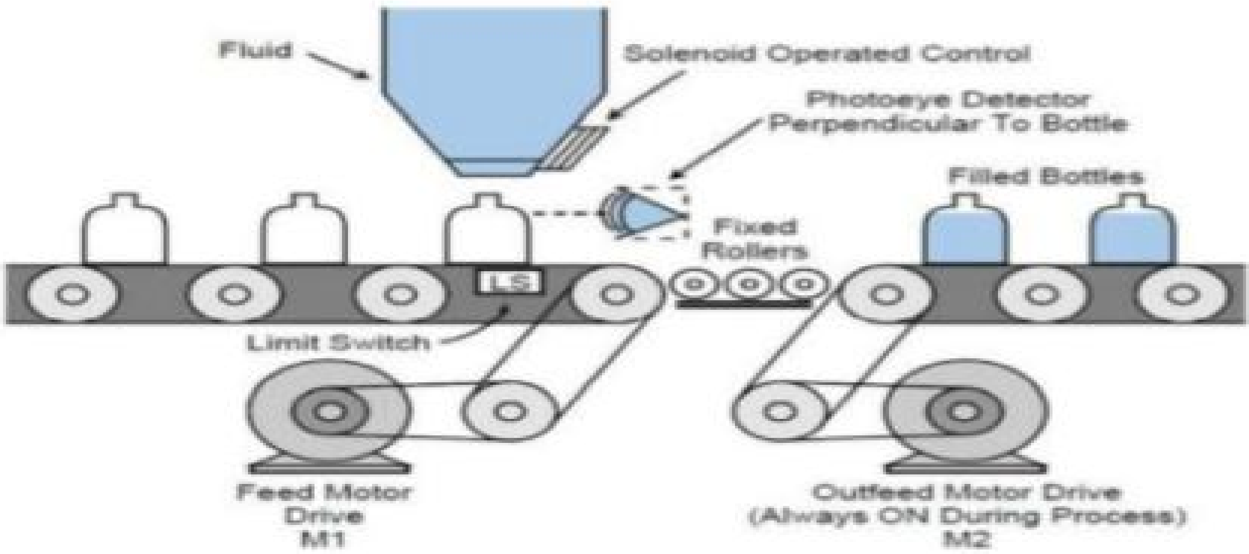

Figure 3.1 : Automatic filling system

Through this project, the bottle will move on the conveyor belt. The conveyor will be stopped automatically after photo sensor detected the presence of the bottle then wait 0.5 sec , and then The controller (PLC) will switch on the solenoid valve to fill the bottle until the level detector detect the fill condition of the bottle. After the bottle is filled the indicator lamp will light and the control program will again wait for 0.5 sec before moving to the next bottle . until the photoelectric sensor signal the in feed motor M1 runs, while there are fixed rollers which carry the filled bottles, out feed motor M2 keeps running after process has been started .

3.2 Hardware Components :

In the hardware design part, overall components such as conveyor system, motor, infrared sensor, solenoid valve and indicator light circuit will be integrated to form the complete prototype. The hardware components are the backbone of the system. More detailed information of each section will be discussed in the following sections.

3.2.1 Conveyor System :

There are two conveyor in feed conveyor and out feed conveyor separated by fixed roller. It presents a continually moving surface that is designed to move objects from one location to another. Conveyor belt is a long loop of rubber or plastic (usually combined with steel for strength, just like tire threads), that is wrapped around a set of motorized rollers. A simple conveyor belt will be stretched between two rollers, one driven roll which powers it and one idle roll which is free to spin as the belt moves.

3.2.2 Electric Motor :

An electric motor is an electric machine that converts electrical energy into mechanical energy. in this project three phase induction motor will be used because it can spin 360° continuously. Moreover, it is strong enough to move the Trek. A three phase motor has 2 parts a stator and rotor the supply is fed to the stator windings. As a result of that a magnetic field is developed on the stator windings which runs at synchronous speed. This magnetic field is induced on the rotor's windings which produces a torque on it and it starts rotating . This is how a three phase motor rotates. A three phase motor has 2 parts a stator and rotor

3.2.3 Solenoid Valve :

A solenoid valve is an electro mechanical devices which allows electrical devices to control the flow of a gas or liquid. The electrical devices cause a current to flow through a coil that located on the solenoid valve. This current flow in turn produces a magnetic field which cause the displacement of a metal actuator. The actuator is linked to a mechanical valve inside the solenoid valve. The valves then will change their state either opening or closing just to allow a gas or liquid to either flow through or blocked by solenoid valve. A spring is used to return the actuator and the valve back to their original state when the current flow is removed.

Figure 3.2 : Solenoid Valve

3.2.4 photoelectric sensor:

A photoelectric sensor is a type of position sensing device. Photoelectric sensors use a modulated light beam that is either broken or reflected by the target.

scan technique :

which is a method used by photoelectric sensors to detect an object (target). In part, the best technique to use depends on the target. Some targets are opaque and others are highly reflective. In some cases it is necessary to detect a change in color. Scanning distance is also a factor in selecting a scan technique. Some techniques work well at greater distances while others work better when the target is closer to the sensor. There are many scan technique [6] :

i. Thru-Beam :

Separate emitter and receiver units are required for a thru-beam sensor. The units are aligned in a way that the greatest possible amount of pulsed light from the transmitter reaches the receiver.

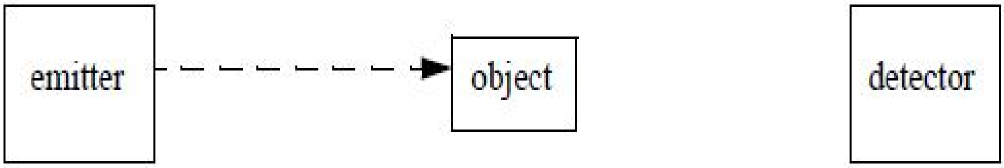

Figure 3.3 : Thru-Beam

An object (target) placed in the path of the light beam blocks the light to the receiver, causing the receiver's output to change state. When the target no longer blocks the light path the receiver's output returns to its normal state. Thru-beam is suitable for detection of opaque or reflective objects. It cannot be used to detect transparent objects. In addition, vibration can cause alignment problems. The high excess gain of thru-beam sensors make them suitable for environments with airborne contaminants. The maximum sensing range is 300 feet.

ii. reflective scan :

Reflective and retro reflective scan are two names for the same technique. The emitter and receiver are in one unit.

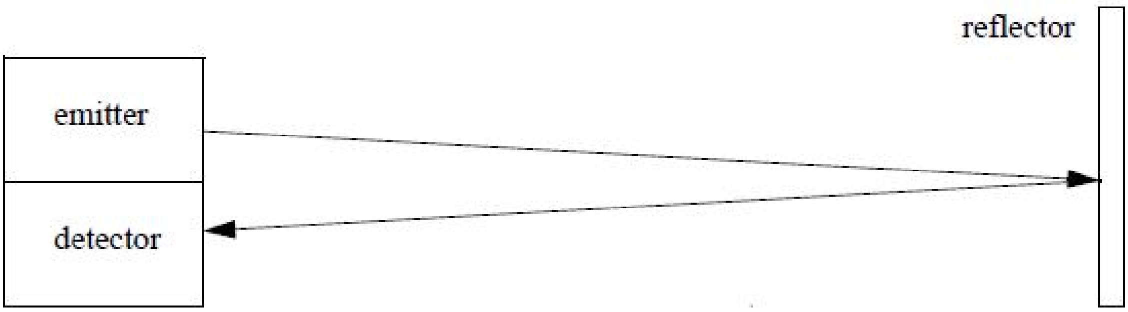

Figure 3.4 : Reflective scan

Light from the emitter is transmitted in a straight line to a reflector and returns to the receiver. A normal or a corner-cube reflector can be used. When a target blocks the light path the output of the sensor changes state. When the target no longer blocks the light path the sensor returns to its normal state. The maximum sensing range is 35 feet.

iii Diffuse Scan :

The emitter and receiver are in one unit. Light from the emitter strikes the target and the reflected light is diffused from the surface at all angles.

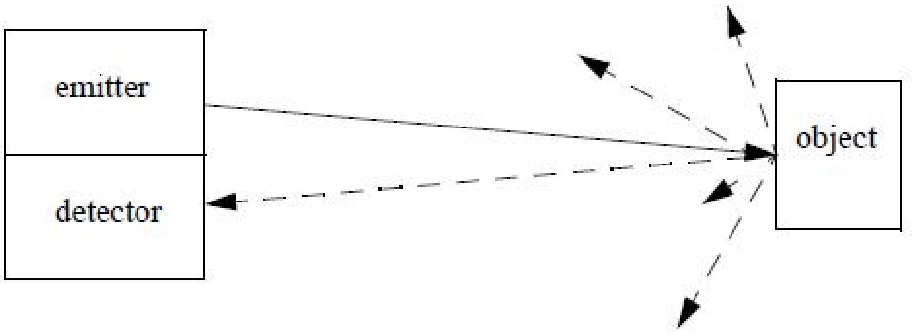

Figure 3.4 : Diffuse scan

If the receiver receives enough reflected light the output will switch states. When no light is reflected back to the receiver the output returns to its original state. In diffuse scanning the emitter is placed perpendicular to the target. The receiver will be at some angle in order to receive some of the scattered (diffuse) reflection. Only a small amount of light will reach the receiver, therefore, this technique has an effective range of about 40”.

CHAPTER FOUR

ELECTRICAL DESIGN OF PROGRAMMABLE LOGIC CONTROLLER

4. INTRODUCTION

Electrical design of the Automatic Filling Water System involves the electrical components used, and the installation of the electrical components on the system. Before all connection was established all the input and output devices to PLC, the concept on how the input and outputs circuits of PLC must be understood. The wiring of the DC input, AC input, relay output, and the transistor output is discussed.

4.1 DC Input :

Typically, dc input modules are available that will work with 5, 12, 24, and 48V. the connections of the DC input modules is either PNP(sourcing) or NPN(sinking) transistor types devices. For a regular switch (i.e. toggle or pushbutton, etc), typically no need to worry about whether wire it as NPN or PNP. Most PLCs not allow mix NPN and PNP devices on the same modules.

The difference between the two types is whether the load switched to ground or positive voltages. An NPN type's sensor has the load switches to ground whereas a PNP device has the load switches to positive voltage.

4.2 Sinking/Sourcing concept :

Sinking sensors allow current to flow into the sensor to the voltage common, while sourcing sensors allow current to flow out of the sensor from a positive source. When discussing sourcing and sinking we are referring to the *output* of the sensor that is acting like a switch. In fact the output of the sensor is normally a transistor, that will act like a switch (with some voltage loss). A PNP transistor is used for the sourcing output, and an NPN transistor is used for the sinking input. When discussing these sensors the term sourcing is often interchanged with PNP, and sinking with NPN. A simplified example of a sinking output sensor is shown in Figure (4.1). The sensor will have some part that deals with detection, this is on the left. The sensor needs a voltage supply to operate, so a voltage supply is needed for the sensor. If the sensor has detected some phenomenon then it will trigger the active line. The active line is directly connected to an NPN transistor.

(Note: for an NPN transistor the arrow always points away from the center.) If the voltage to the transistor on the *active line* is 0V, then the transistor will not allow current to flow into the sensor. If the voltage on the active line becomes larger (say 12V) then the transistor will switch on and allow current to flow into the sensor to the common.

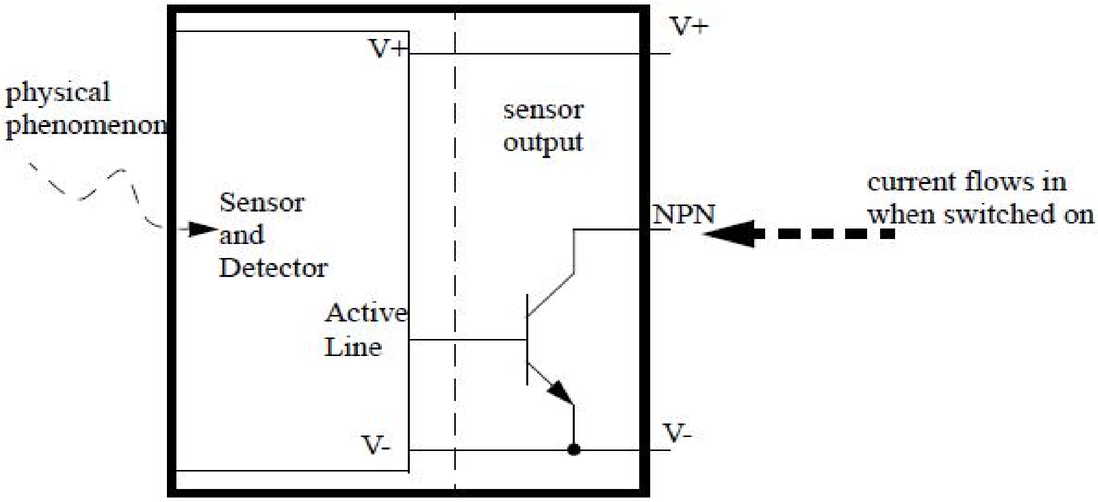

Figure 4.1: A Simplified NPN/Sinking Sensor

Sourcing sensors are the complement to sinking sensors. The sourcing sensors use a PNP transistor, as shown in Figure 4.2. (Note: PNP transistors are always drawn with the arrow pointing to the center.) When the sensor is inactive the active line stays at the V+ value, and the transistor stays switched off. When the sensor becomes active the active line will be made 0V, and the transistor will allow current to flow out of the sensor.

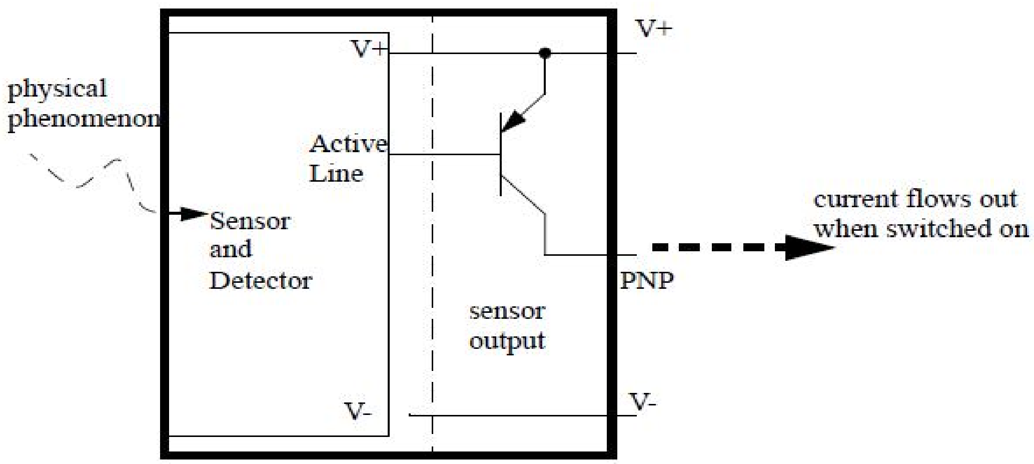

Figure 4.2 : A Simplified Sourcing/PNP Sensor

4.3 PLC Input Card for Sinking Sensors :

When a PLC input card does not have a common but it has a V+ instead, it can be used for NPN sensors. In this case the current will flow out of the card (sourcing) and we must switch it to ground.

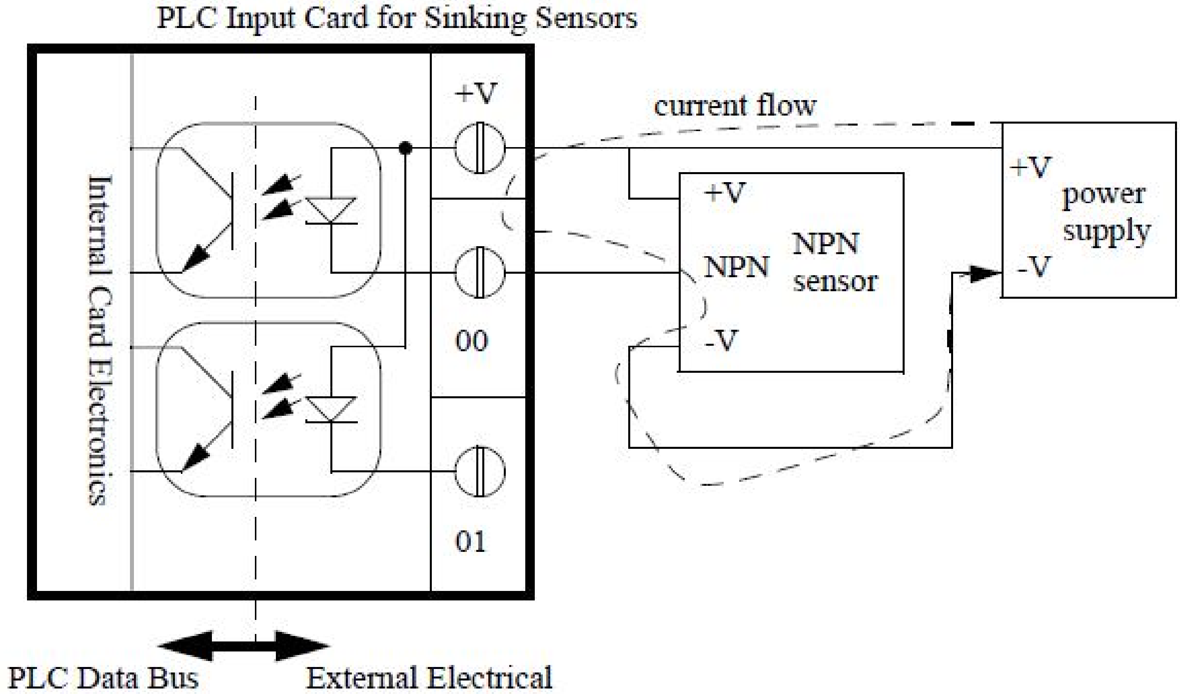

Figure 4.3 : A PLC Input Card for Sinking Sensors

This card is shown with 2 optocouplers (one for each output). Inside these devices the is an LED and a phototransistor, but no electrical connection. These devices are used to isolate two different electrical systems. In this case they protect the 5V digital levels of the PLC computer from the various external voltages and currents.

The dashed line in the figure represents the circuit, or current flow path when the sensor is active. This path enters the PLC input card first at a V+ terminal (Note: there is no common on this card) and flows through an optocoupler. This current will use light to turn on a phototransistor to tell the computer in the PLC the input current is flowing. The current then leaves the card at input *00* and passes through the sensor to V-. When the sensor is inactive the current will not flow, and the light in the optocoupler will be off. The optocoupler is used to help protect the PLC from electrical problems outside the PLC.

4.4 PLC Input Card for Sourcing Sensors :

When we have a PLC input card that has a common then we can use PNP sensors. In this case the current will flow into the card and then out the common to the power supply.

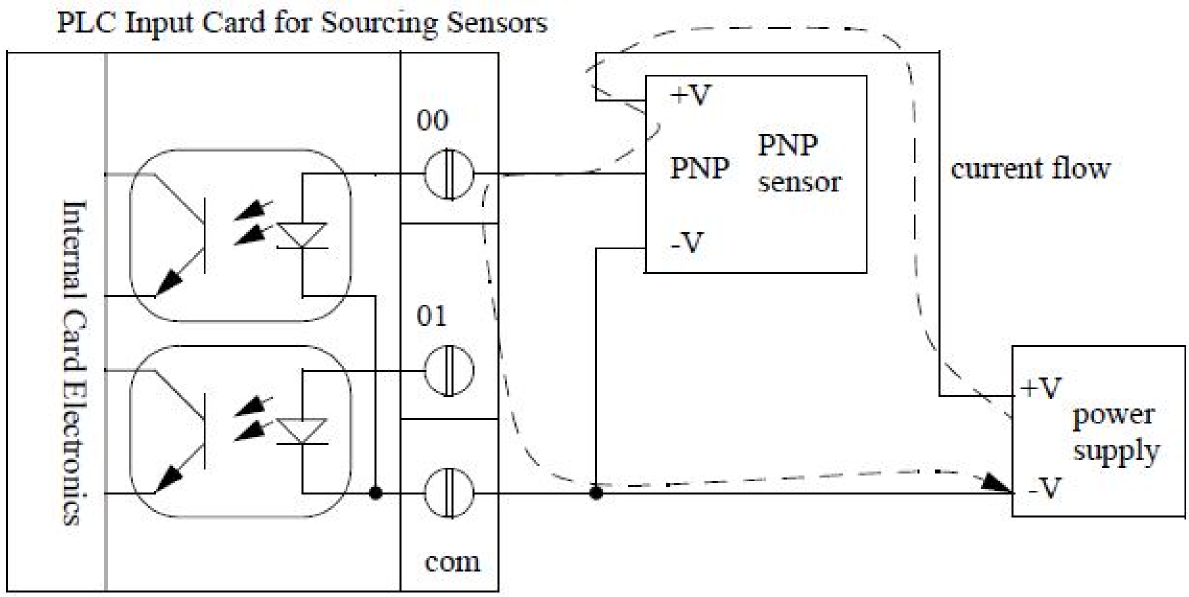

Figure 4.4 : PLC Input Card for Sourcing Sensors

The current flow loop for an active sensor is shown with a dashed line. Following the path of the current we see that it begins at the *V+*, passes through the sensor, in the input *00*, through the optocoupler, out the common and to the *V-*.

Wiring is a major concern with PLC applications, so to reduce the total number of wires, two wire sensors have become popular. But, by integrating three wires worth of function into two, we now couple the power supply and sensing functions into one. Two wire sensors are shown in Figure 4.5.

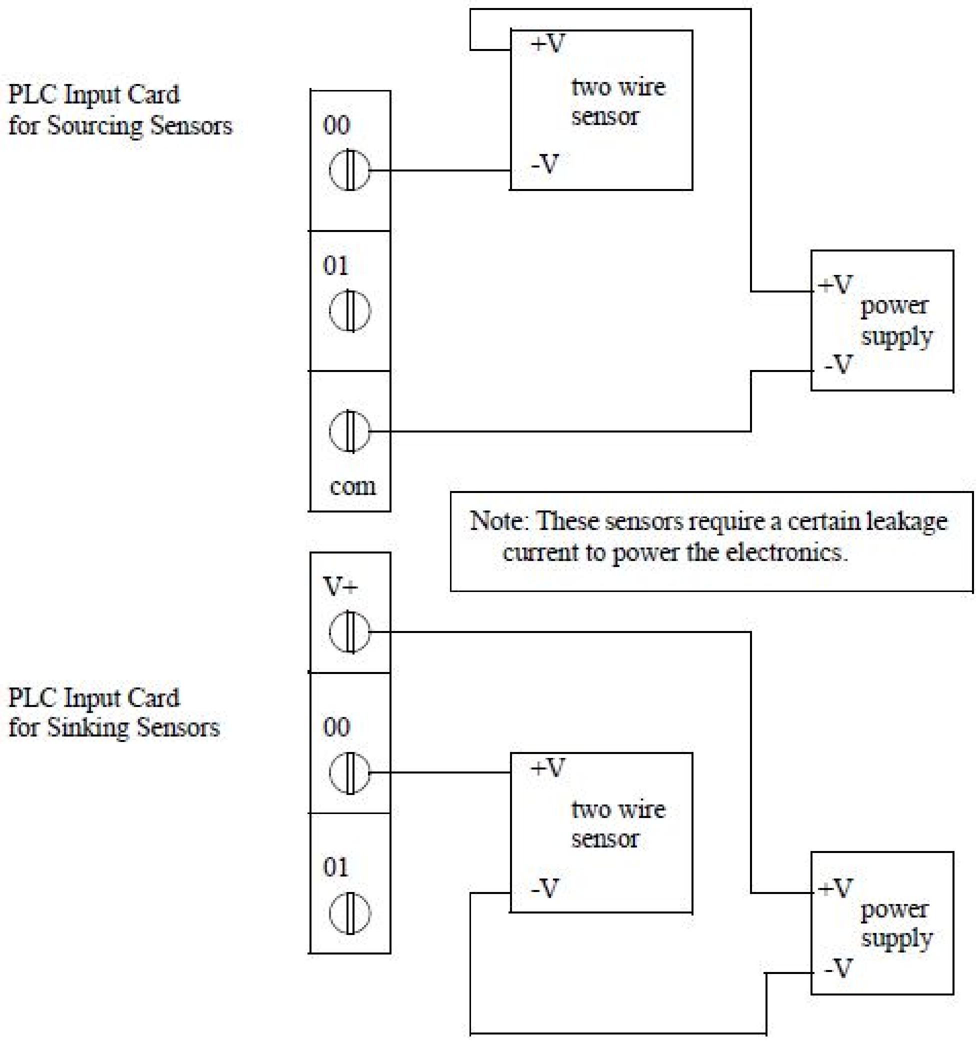

Figure 4.5 : Two Wire Sensors

A two wire sensor can be used as either a sourcing or sinking input. In both of these arrangements the sensor will require a small amount of current to power the sensor, but when active it will allow more current to flow. This requires input cards that will allow a small amount of current to flow (called the leakage current), but also be able to detect when the current has exceeded a given value.

4.5 AC Input :

An ac voltage is non-polarized, means that there is no positive and negative polarity. Typically, ac input modules are available that will work with 24, 48, 110, and 220V an ac device is connected to input PLC as shown in Figure 4.3

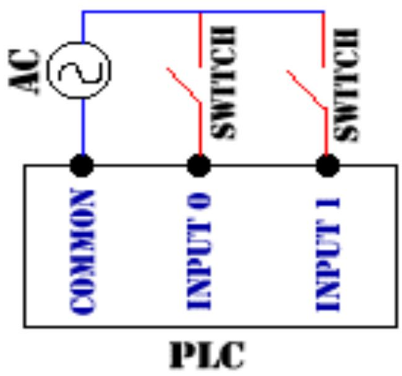

Figure 4.6 : Wiring of AC input

Commonly the ac "hot" wire is connected to the switch while the "neutral" goes to the PLC common. The ac ground (3rd wire) should be connected to the frame ground terminal of the PLC. AC connection is typically color code. In US is commonly white (neutral), black (hot), and green (3rd wire ground when applicable). Outside the US its commonly coded as brown (hot), blue (neutral), and green with yellow stripe (3rd wire ground when applicable). A common switch (i.e. limit switch, pushbutton, toggle, etc) would be connected to the input terminals directly as shown in Figure 4.4. One side of the switch would be connected directly to PLC input. The other end goes to the ac hot wire. This assumes the common terminal is connected to neutral.

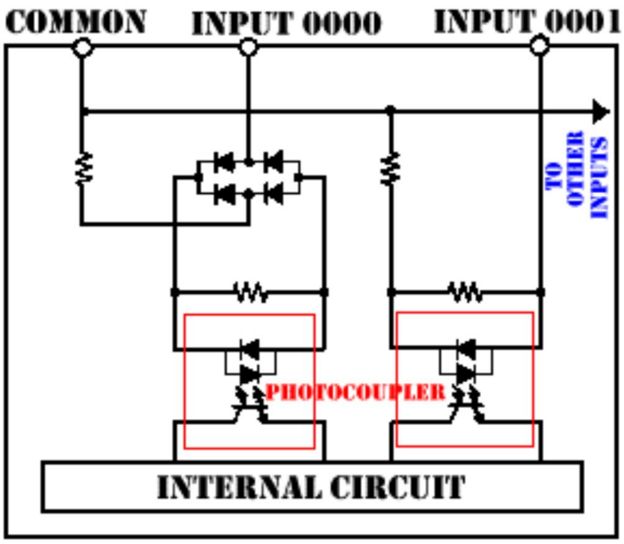

Figure 4.7 : Internal input circuit diagram

4.6 Relay Output :

One of the most common types of outputs available is the relay outputs. A relay can be used with both AC and DC loads. Some forms of a load are a solenoid, buzzer, motor, etc. Always check the specifications of the load before connecting it to the PLC output and make sure that the maximum current it will consume is within the specifications of the PLC outputs. Some types of loads are very deceiving. These deceiving loads are called inductive loads. These have a tendency to deliver a “back current” when they turn on. This back current is like a voltage spike coming through the system. Typically a diode, resistor, or other snubbed circuit should be used to prevent any damage to the relay.

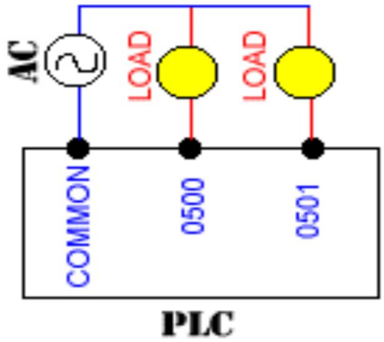

Figure 4.8 : Wiring of Relay Output

Figure 4.8 is a typical method of connecting the outputs to the PLC relays. AC supply or DC supply can be used as well connected to the output. A relay is no polarized and typically it can switch either AC or DC. Here the common is connected to one end of the AC power supply or DC power supply and the other end of the supply is connected to the load. The other half of the load gets connected to the actual PLC outputs.

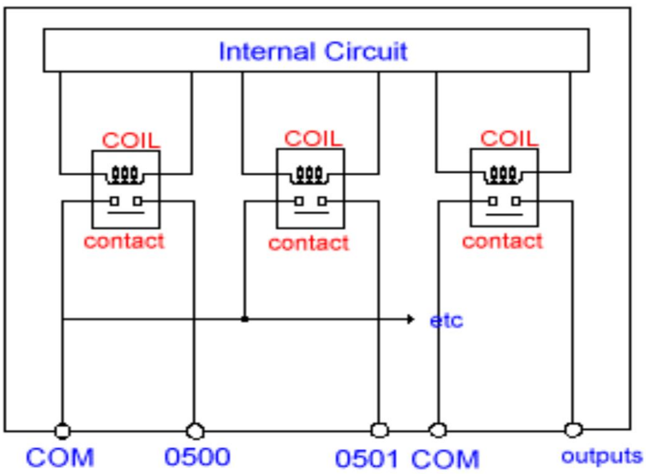

Figure 4.9 : Internal relay of PLC

The relay is internal to the PLC. Its circuit diagram is shown in Figure 4.9. When ladder diagram tells the outputs to turn on, the PLC will internally apply a voltage to the relay coil. This voltage will allow the proper contact to close. When the contact close, and external current is allowed to flow through our external circuit. When the ladder diagram tell the PLC to turn off the output, it will simply remove the voltage from the internal circuit thereby enabling the output contact to release the load will than have an open circuit and will therefore be off.

4.7 Transistor Output :

The next type of outputs is transistor type outputs. Typically a PLC will have either NPN or PNP type outputs. It is important to note that a transistor can only switch a dc current. For this reason it cannot be used with an ac voltage. A transistor is a solid-state switch or an electrical switch. A small current applied to the transistor base (i.e. input) and switch a much larger current through its outputs. The PLC applies a small current to the transistor base and the transistor output "close". When it's closed, the devices connected to the PLC output will be turn on.

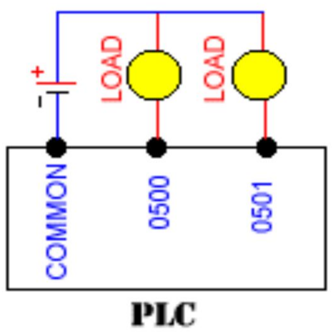

Figure 4.10 : Wiring of Transistor for NPN Type

Figure 4.10 shows how to connect the output devices to the transistor output for NPN type transistor. If it were a PNP type, the common terminal is connected to V+ and V- would connect to one end of the load.

4.8 The Electrical Wiring System :

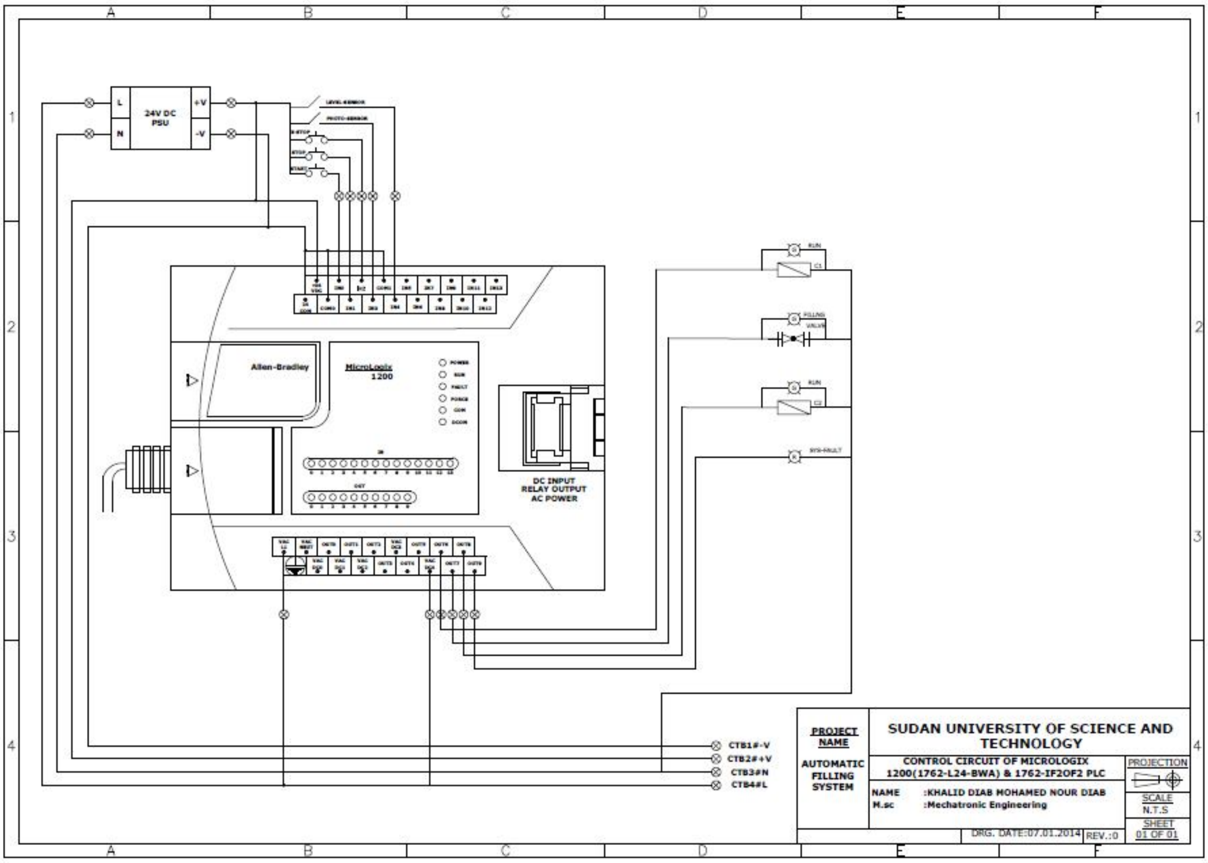

Figure 4.11 : Electrical wiring of PLC I/O devices

CHAPTER FIVE

PROGRAMMING AND SIMULATION

A systematic approach of control system design using programming logic controller is presented in this chapter. As a rule, the layout of the entire of Automatic Filling Water System using PLC is designed before implementing programming development process. The machine sequences of operation will be discussed. Next, the assignment of input and outputs are shown in tables. Finally, the ladder diagram design using RSLOGIX 500 are shown.

5. Systematic Approach of Control System Design :

In general, a control system is a collection of electronic devices and equipment which are in place to ensure the stability, accuracy and smooth transition of a process or a manufacturing activity. Every single component in a control system plays an important role regardless of size.

Before programming, the concept of controlling a control system is introduce, which is the systematic approach of control system design using a PLC. The operation procedure of the system approach is shown in Figure (5.1).

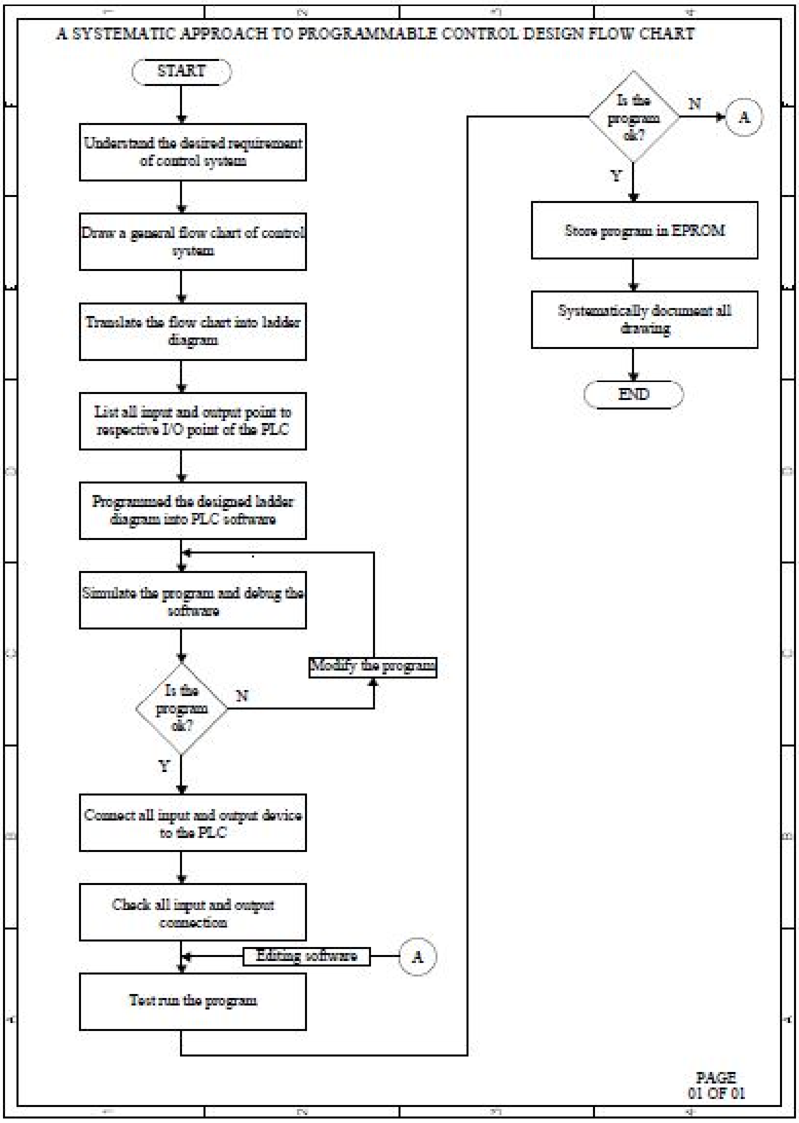

Figure 5.1: A Systematic Approach to Programmable Control Design Flow Chart

5.2 Process flow chart :

The general flow chart of the sequences of operation is shown in Figure 5.2

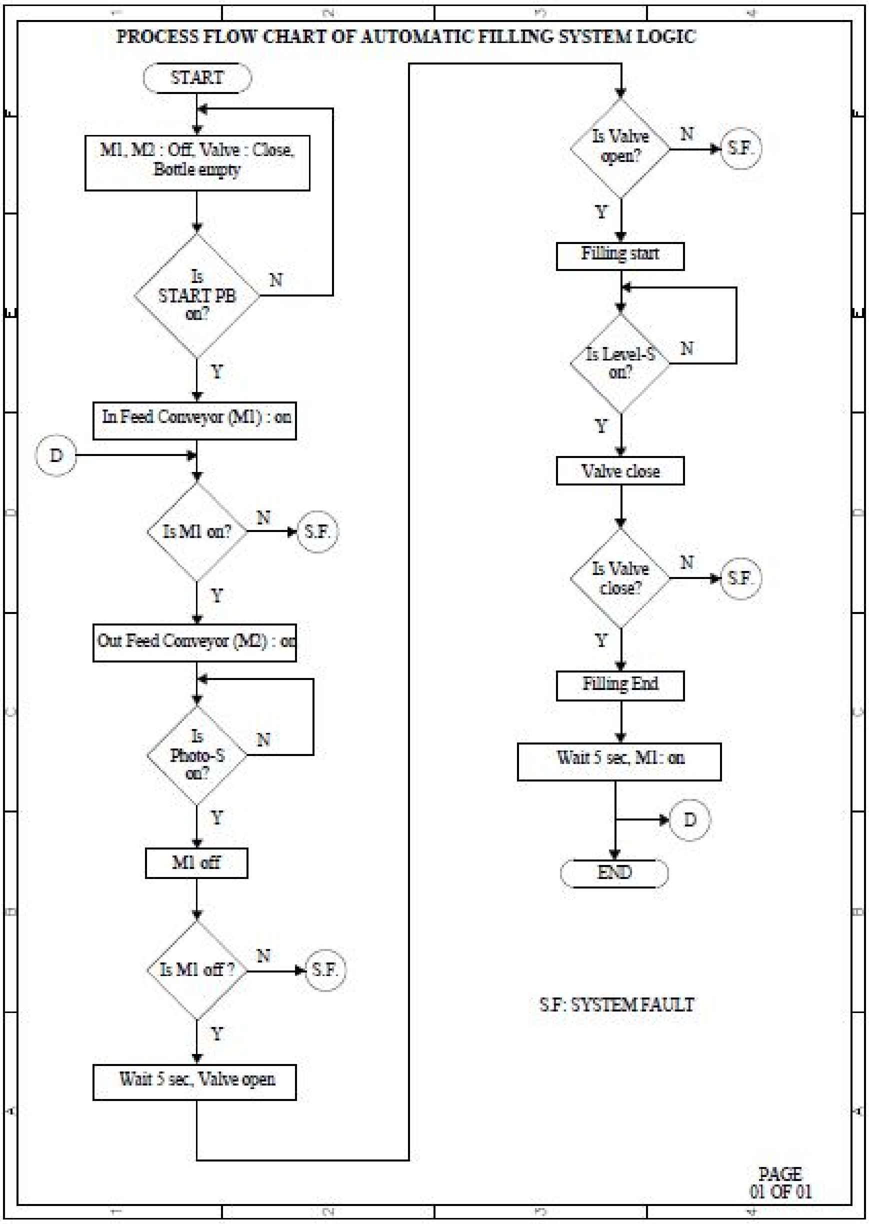

Figure 5.2: Flow chart of the Operation

5.3 Assignment of Inputs and Outputs :

After the system sequence of operation is determine, all external input and output devices connected to the PLC must be determined and assigned the number corresponding to the input and output number. Table 5.1 and 5.2 shows the assignment of inputs and outputs.

Table 5.1: Assignment of Inputs

Name	Address	Comment
Start - PB	I0:0/0	Start process
Stop -PB	I0:0/1	Stop process
E - Stop	I0:0/2	Immediately stops the entire system
Photo-S	I0:0/3	Indicates presence of bottle
Level-S	I0:0/4	Indicates to fluid level in bottle

Table 5.2: Assignment of Outputs

Name	Address	Comment
M1	O0:0/0	Driven in feed motor
M2	O0:0/1	Driven out feed motor
Valve	O0:0/2	Supplies fluid to the bottles
System fault	O0:0/3	Indicating the system has generated a fault and is stopped

5.4 Program of the system :

A ladder diagram is produced according to the flow chart of the system and based on the system operation and condition. Figure 5.3 shows the ladder diagram of the system. The system in the ladder diagram form will be programmed into RSLOGIX 500 PLC software. Once the programs have been downloaded into PLC emulator, it can be monitored in the Diagram Workspace during execution. Furthermore, the RSLOGIX 500 software provides on-line editing functions during execution. Note that the on-line editing is not possible in Run mode. All activities occurs can be observed using the RSLOGIX 500 emulator.

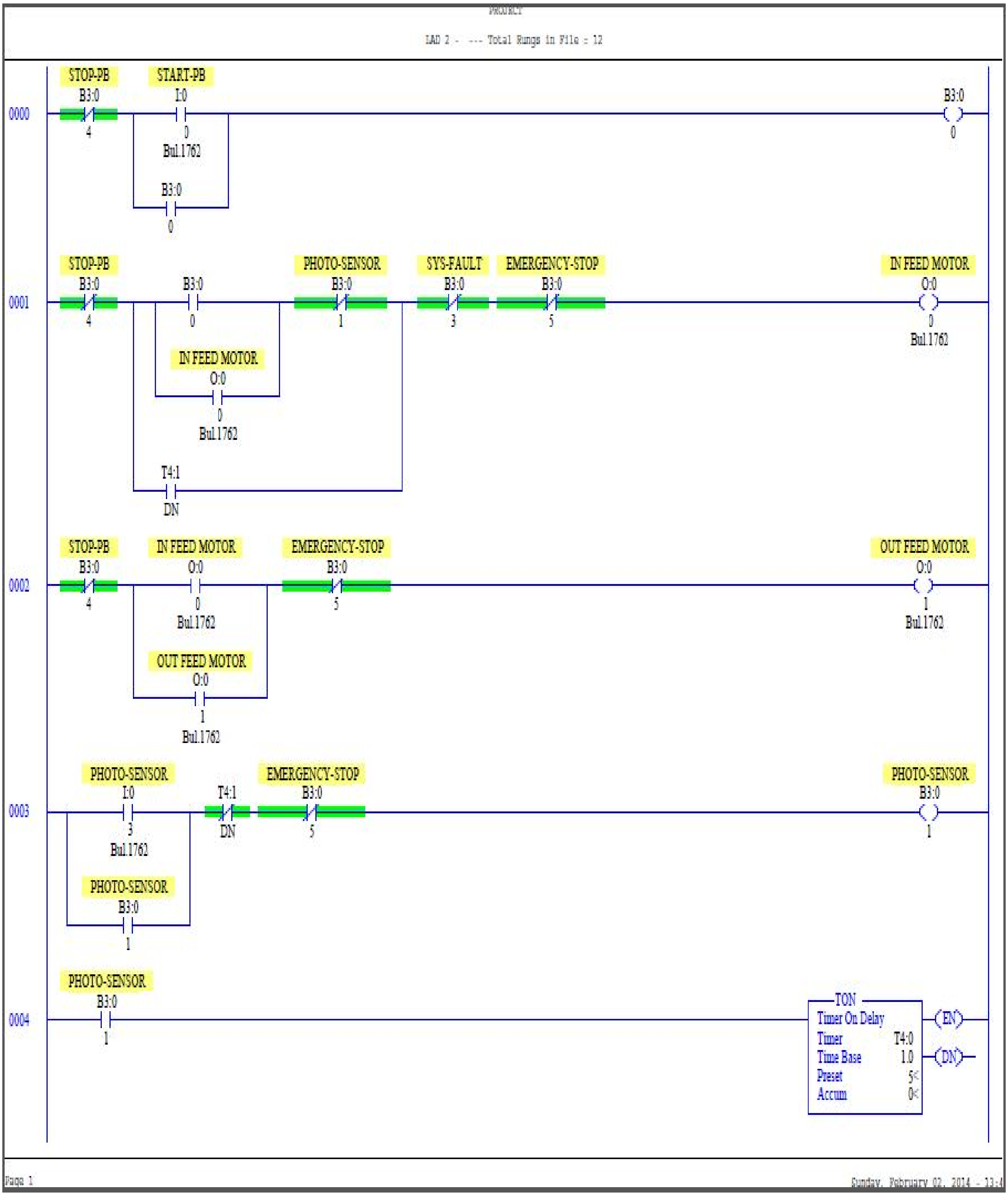

Figure 5.3 (a) : Ladder diagram

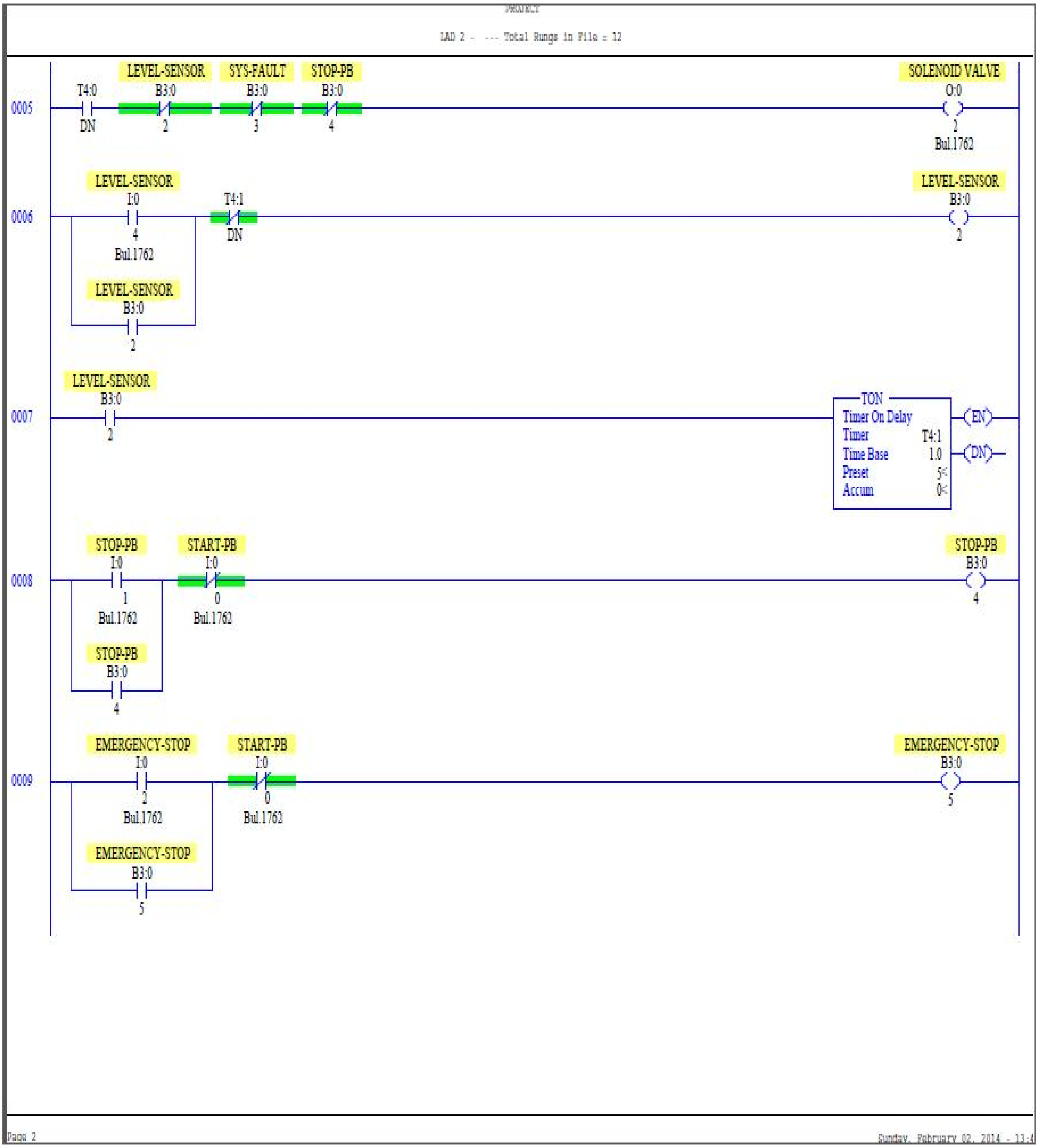

Figure 5.3 (b) : Ladder diagram

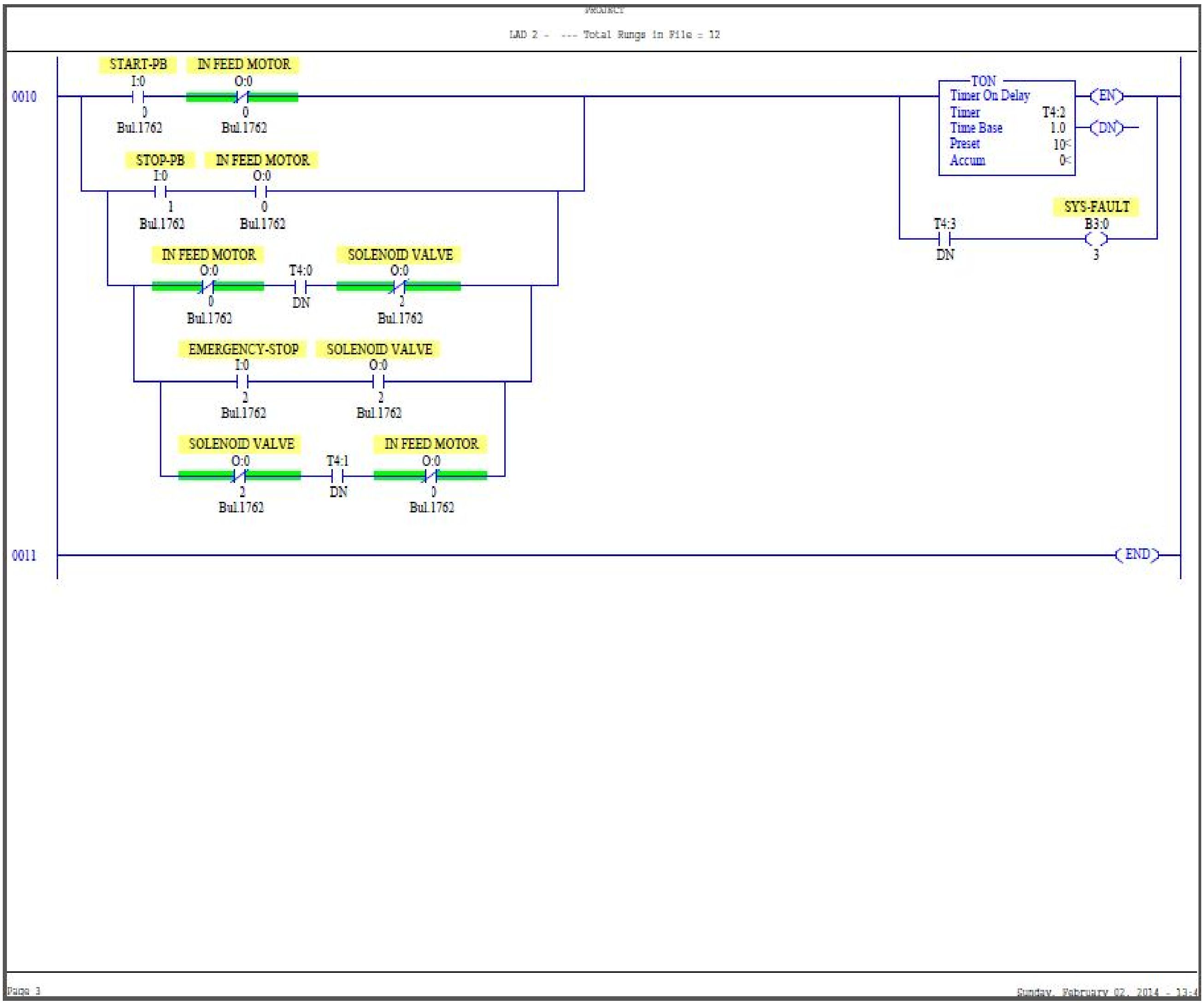

Figure 5.3 : Bottle filling system control program

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

An Automatic Filling System using PLC has been successfully designed and simulated by applying all the concept of control system at this project. The system that is produced can be modified to be better if some of the electrical devices and system are upgraded and improved.

6.1 Conclusions :

The theory and concept of the automatic filling system is based on the control system. In electrical design, the features and functions of the electrical components are required to determine the system requirement. Furthermore, the theoretical of the wiring system is required for connecting the inputs and outputs devices to PLC. In programming design, understandings of the desired control system and how to use the Ladder Diagram to translate the machine sequence of operation are the most important parts, because it have direct effect on the system performance. The main aim in this process is to apply PLC to design automatic filling water system and all objectives in this project were successfully done as planned. Finally, the basis control system and logic design apply in this project can be used as a references to design other applications of automation system, and also can be used as a teaching material for the Industrial Control subject.

6.2 Recommendations :

Actually, a lot of weakness from the project can be taken as future works so that the improved system will be better in terms of performance. So that, there are several recommendations or suggestions that we can take to increase performance in this project. The performance of Automatic Filling System can be improved based on two recommendations which are :

- We can use a multiple filling head to increase the production rate of filling bottles , and also we can control the speed of process by using (VFD) which can control the speed of motor.

- Besides using PLC as controller, the other controller can be used in this future work is like Microcontroller. However, many factors must be considered like cost, practically and others.

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