CHAPTER 1

INTRODUCTION

This chapter describes the introduction and working principle or operation of automatic bottle filling and capping process. And then, the aim and objectives and outlines of thesis are also included in this chapter.

1.1 Introduction

Many industrial processes are now dependent on automatic machinery. The transition from manual systems to automatic systems was necessary to optimize the rate and capacity of production. To control an industrial process, a special microprocessor-based controller called the programmable logic controller (PLC) is used. There are many advantages of using PLC in process control. These controllers are built to withstand the harsh environment of industry floor, so these do not need special housing or protection. The PLCs are also built in a way so that the electronic circuitry of the controllers is not affected by moderate amount of noise. A more attractive feature which made PLC so popular is that, the same PLC can be reprogrammed using only software to perform another task or control another process. Before the introduction of PLC, electrical relays were used to automate processes, and the relays needed to be physically re-wired if these were intended to control another process. PLCs can be programmed many times to do different tasks. Besides in industries, PLCs are also used in building management systems (BMS), amusement parks, mills, water and waste treatment plants etc. The PLCs read the input states of switches, sensors etc. and can drive motors, relays, solenoids etc.One of the many uses of PLCs in industries is in beverages and juice industry, glass industry, cement manufacturing industry etc [1].

1.2 System Overview

This system presents bottle filling and capping technique based on both hardware and software. There are three main steps in this system. The first step is to fill the water from the reservoir to the tank. The second step is to fill the water into the bottle. The last step is to cap the bottle. Figure 1.1 shows the overall block diagram for automatic bottle filling and capping system.

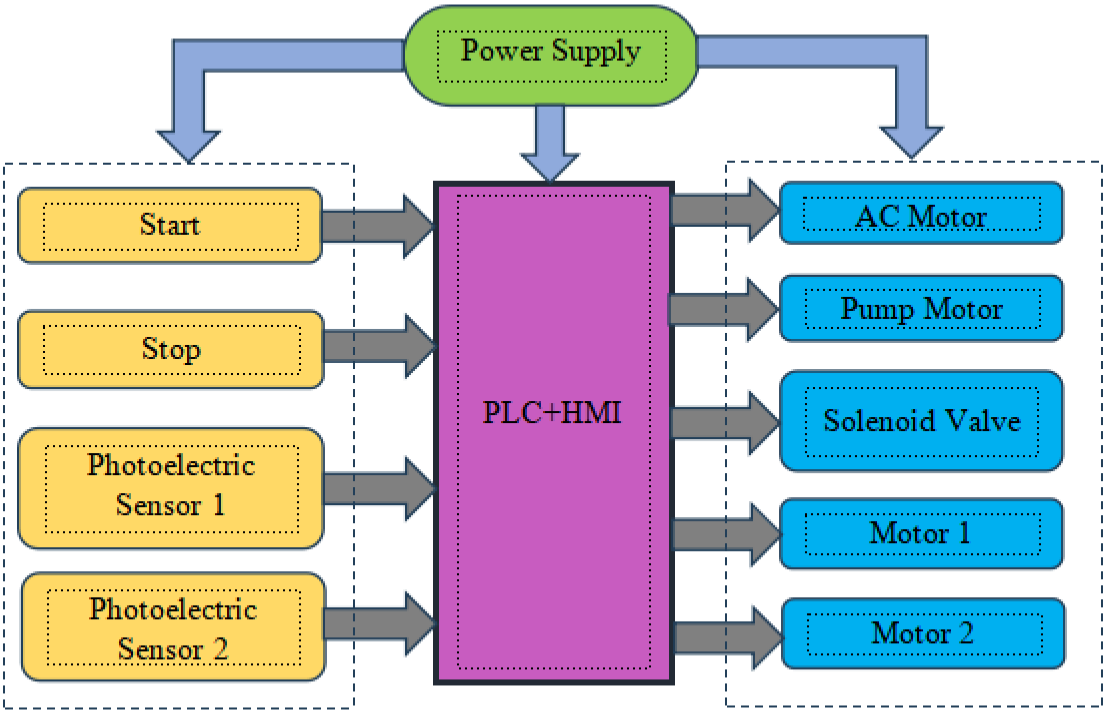

Power Supply
Start
Stop
Photoelectric Sensor 1
Photoelectric Sensor 2
PLC+HMI
AC Motor
Pump Motor
Solenoid Valve
Motor 1
Motor 2

Figure 1.1 Block Diagram of Automatic Bottle Filling and Capping

1.2.1 Hardware Description

In this thesis, Mitsubishi FX2N 20MR is used for controlling the inputs and outputs. Input supply to the PLC is given through a SMPS. The rating of the SMPS is 24V DC 3.1Amps. The PLC used in this system is a compact PLC which has fixed number of inputs and outputs. In this kind of PLC model, the CPU contains 12 digital inputs and 8 digital outputs. Photoelectric sensors have been used for the position of bottles. A geared AC motor has been used for running the conveyor system. The ratings of the DC motor are 12V and 50 RPM speed with a high starting torque of 70 Kg-cm (at no load). Toggle switches are used to serve the purpose of some inputs to the PLC.

1.2.2 Software Description

There are five important languages which are used for the programming of the PLC. The list of the methods are as follows:

- Functional block diagram (FBD)
- Structure text
- Instruction list
- Flow chart
- Ladder diagram

Out of these five languages, ladder diagram is the most widely used language and is simple as compared to other languages. Ladder diagram has been used for the programming of this PLC.

1.3 Aim and Objectives

The main aim of the system is to design and implement of an automatic bottle filling and capping system.

The objectives of this system are

- To comprehend the usefulness of PLC and HMI
- To study about the OP Series Edit Tool
- To study about the OP-320A Human Machine Interface (HMI)
- To know how to communicate the Human Machine Interface (HMI) and PLC

1.4 Implementation of the System

The systems to be implemented for achieving the desired automatic bottle filling and capping system are as follow:

- Studying the Programmable Logic Controller
- Searching and studying the operation of different types of automatic bottle filling and capping system
- Finding all necessary facts of Human Machine Interface
- Designing the of automatic bottle filling and capping system on HMI
- Testing the of automatic bottle filling and capping system on HMI

1.5 Outlines of Thesis

This thesis mainly composed of five chapters. Chapter one consists of the introduction, overview of the system and aim and objectives of the system. Chapter two includes the background theory and hardware components of the filling and capping system. Chapter three describes the OP320-A HMI OP20 Edit Tool software. In Chapter four, test and result of the research are discussed. Finally, conclusion, discussion and further extensions are expressed in chapter five.

CHAPTER 2

BACKGROUND THEORY

This chapter includes the background theory of filling and capping operation and the characteristic of these components. This chapter also described the important things of a PLC and HMI.

2.1 Programmable Logic Controller (PLC)

In the beginning of the industrial revolution, especially in the 1960 and 1970, automated machines were controlled by electromechanical relays. PLC is a programmable device developed to replace mechanical relays, timers and counters. A PLC is an industrial computer used to monitor inputs, and depending upon their state make decisions based on its program or logic, to control (turn on /off) its outputs to automate a machine or a process. In automated system, PLC controller is usually the central part of a process control system. Figure 2.1 shows the process of programmable logic controller. To run more complex processes, it is possible to connect more PLC controllers to a central computer. Industrial control system or ICS comprise of different types of control systems that are currently in operation in various industries. These control systems include PLC, SCADA and DCS and various others. PLCs control the components in the SCADA systems and HMI systems [2].

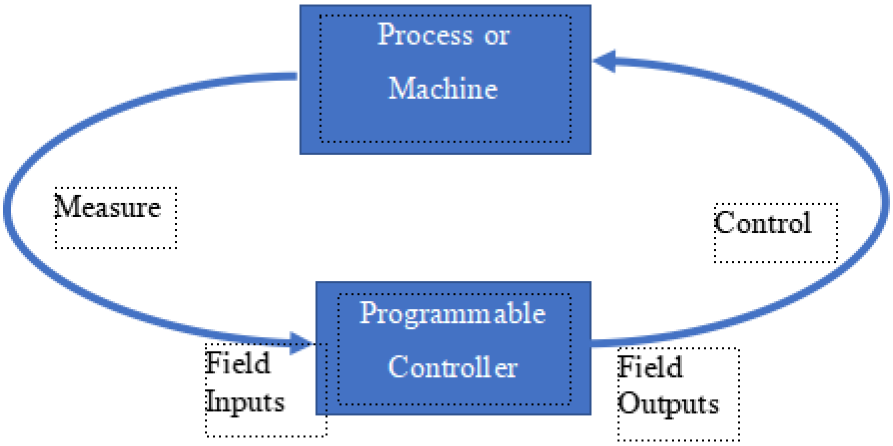


Figure 2.1 Process of Programmable Logic Controller [2]

PLC development began in 1968 in response to a request from an US car manufacturer (GE). The first PLCs were installed in industry in 1969.Communications abilities began to appear in approximately 1973. In the 70’s, varying voltages could also be sent and received by them to allow entry into the analog world. The 80’s saw an attempt to: standardize communications with manufacturing automation protocol (MAP), reduce the size of the PLC, and making them software programmable through symbolic programming on personal computers instead of dedicated programming terminals or handheld programmers. The latest standard “IEC 1131-3” has tried to merge PLC programming languages under one international standard. PLCs are now programmable in function block diagrams, instruction lists, ladder diagrams, C, and structured text all at the same time [2].

2.2 Hardware Components of a PLC System

PLC system consists of input/output (I/O) unit, central processing unit (CPU) and memory, power supply unit, programming device. As I/O unit acts as the interface between PLC and real time systems. All logic and control operations, data transfer and manipulation work is done by CPU. Figure 2.2 shows the hardware diagram of PLC [3].

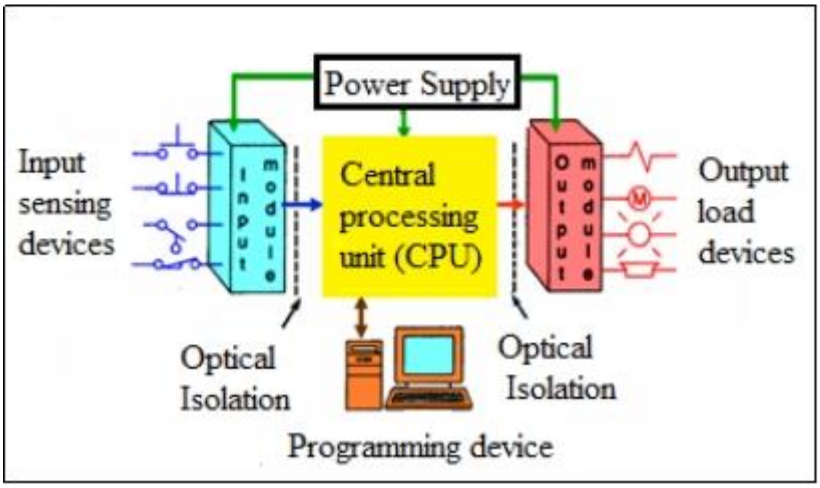


Figure 2.2 Hardware Diagram of PLC [3]

2.2.1 Inputs and Outputs Unit

Input unit of PLC receives signals from the external devices and sensors, which provide information about the status of the physical system being monitored or controlled. The input includes a push-button, limit switch, sensors or selector switches. The output of all the sensors is used as input to PLC. Push-button, switches, which form the basic man-machine interface. Figure 2.3 shows the input devices. For detection of workpiece, monitoring of moving mechanism, checking on pressure and or liquid level and many others, the PLC will have to tap the signal from the specific automatic sensing devices like proximity switch, limit switch, photoelectric sensor, level sensor and so on. Types of input signal to the PLC would be of ON/OFF logic or analogue. These input signals are interfaced to PLC through various types of PLC input module [3].

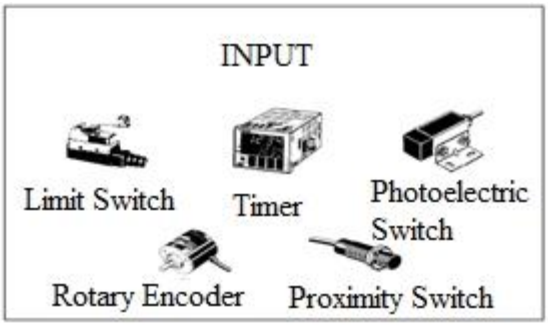


Figure 2.3 Input Devices [3]

An automatic system is incomplete and the PLC system is virtually paralyzed without means of interface to the field output devices. Some of the most commonly controlled devices are motors, solenoids, relays indicators, buzzers and etc. Through activation of motors and solenoids the PLC can control from a simple pick and place system to a much complex servo positioning system. Figure 2.4 shows type of output devices that are the mechanism of an automated system and so its direct effect on the system performance. However, other output devices such as the pilot lamp, buzzers and alarms are merely meant for notifying purpose. Like input signal interfacing, signal from output devices are interfaced to the PLC through the wide range of PLC output module [3].

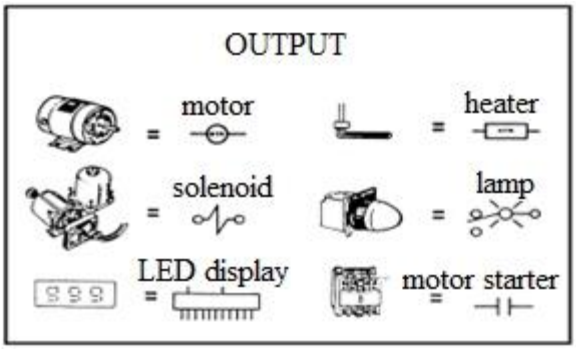


Figure 2.4 Output Devices [3]

2.2.2 Central Processing Unit (CPU)

The CPU, or Central Processing Unit, CPU acts as the microprocessor that orchestrates all operations within a PLC system. It is responsible for executing the programmed instructions that dictate the behavior of the PLC, including processing input signals from sensors, executing control algorithms, and generating output signals to control actuators and other external devices. The CPU also manages communication with external devices such as HMI (Human Machine Interface) panels, SCADA (Supervisory Control and Data Acquisition) systems, and other PLCs through various communication interfaces like Ethernet, serial ports, or fieldbus protocols.

2.2.3 Memory

There are various types of memory unit. It is the area that hold the operating system and user memory. The operating system is actually a system software that co-ordinates the PLC. Ladder program, Timer and Counter Values are stored in the user memory [4]. Depending on user's need, various types of memory are available for choice:

- Read-Only Memory (ROM)

  ROM is a non-volatile memory that can be programmed only once. It is therefore unsuitable. It is least popular as compared with others memory type [4].
- Random Access Memory (RAM)

  RAM is commonly used memory type for storing the user program and data. The data in the volatile RAM would normally be lost if the power source is removed. However, this problem is solved by backing up the RAM with a battery [4].

2.2.4 Power Supply

Most PLC controllers operate using either a 24V DC or 220V AC electrical supply. In larger PLC systems, the power supply is often a separate module that converts incoming AC power (typically 110V or 230V AC) to the required DC voltage (24V DC) used by the PLC components. This separate power supply module ensures stable and regulated power delivery to the PLC's CPU, I/O modules, and other peripherals. On the other hand, smaller and medium-sized PLC series often integrate the power supply directly within the PLC housing. This integrated design simplifies installation and reduces space requirements in control panels, making these PLCs more compact and easier to deploy in various industrial applications.

2.2.5 Programming Device

The programming device is used to enter the required program into the memory of the processor. The program is developed in the programming device and then transferred to the memory unit of the PLC.

2.3 PLC Operation

Input relays, internal utility relays, counters, timers, output relays, and data storage are operation of PLC.

Input relays are connected to the outside world, physically existing and receiving signals from input devices. Typically, these are not relays but transistors. Internal utility relays do not receive signals from the outside world nor do they physically exist. These are simulated relays, enabling a PLC to eliminate external relays. Counters do not physically exist; these are simulated counters programmed to count pulses. Typically, these counters can count up, down, or both up and down. Some manufacturers also include high-speed counters that are hardware-based.

Timers also do not physically exist and come in many varieties and increments. The most common type is an on-delay type, with others including off-delay and both retentive and non-retentive types. Increments vary from 1ms through 1s. Output relays are connected to the outside world, physically existing and sending ON/OFF signals to output devices. These can be transistors, relays, or triacs depending upon the model chosen. In data storage, registers are typically assigned to simply store data, usually used as temporary storage for math or data manipulation. These can also typically be used to store data when power is removed from the PLC.

2.4 Types of PLC

The three types of PLCs include unitary PLCs, which are compact; modular PLCs, which allow flexibility; and rack-mounting PLCs, designed for larger systems with multiple interchangeable modules for various applications.

2.4.1 Unitary

A unitary PLC is the simpler type of controller, and contains all of the basic system components within a single housing, or box. These components typically include the processor, which runs the software program, in addition to ports for input and output connections. Unitary PLCs are typically attached directly to the device or application that is being controlled. Figure 2.5 shows the Unitary PLC [4].

Figure 2.5 Unitary PLC [4]

2.4.2 Modular

A modular PLC contains several different modules that can be coupled together to build a customized controller. A base module contains core functions such as electrical power regulation, the computer processor, and inputs connections. Additional modules, including analog to digital signal converters or additional outputs, can be added to this core unit as needed. This modular design allows a PLC to be customized and changed easily. Figure 2.6 shows the Modular PLC [4].

Figure 2.6 Modular PLC [4]

2.4.3 Rack Mounting

The rack mounting type of PLC is similar to the modular concept, but is implemented differently. Whereas each module in a modular PLC connects to the base unit directly, a rack mounting PLC keeps each module separate. All extra modules are connected through a network, and modules are held in organized racks. This approach allows for larger systems to be built without becoming overly cluttered and complicated. Modules are well organized on the rack and can be removed and reinserted as needed. Figure 2.7 shows the Rack Mounting PLC [4].

Figure 2.7 Rack Mounting PLC [4]

2.5 PLC Output Units

PLC output units can be: relay, transistor, or triac.

- Relay Outputs

One of the most common types of outputs available is the relay output. Existence of relays as outputs makes it easier to connect with external devices. A relay is non-polarized and typically it can switch either AC or DC [5].

- Transistor Outputs

  Transistor type outputs can only switch a dc current. The PLC applies a small current to the transistor base and the transistor output “closes”. When it’s closed, the device connected to the PLC output will be turned on. A transistor cannot switch as large a load as a relay. If the load current to switch exceeds the specification of the output, connect the PLC output to an external relay, then connect the relay to the large load.

  Typically, a PLC will have either NPN or PNP transistor outputs. Some of the common types available are BJT and MOSFET. A BJT type often has less switching capacity than a MOSFET type. The BJT also has a slightly faster switching time. A transistor is fast, switches a small current, has a long lifetime and works with dc only. A relay is slow, can switch a large current, has a shorter lifetime and works with AC or DC [5].

- Triac Output

  Triac output can be used to control AC loads only. Triac output is faster in operation and has longer life than relay output. Inductive loads have a tendency to deliver a “back current” when they turn on. This back current is like a voltage spike coming through the system. This could be dangerous to output relays. Typically, a diode, or other “snubber” circuit should be used to protect the PLC output from any damage [5].

2.6 Advantages and Disadvantages of PLC

Advantages of PLC are as follows:

- The wiring of the system usually reduces by 80% compared to conventional relay control system.
- The power consumption is greatly reduced as PLC consume much less power.
- The PLC self-diagnostic functions enable easy and fast troubleshooting of the system.
- Modification of control sequence or application can easily be done by programming through the console or computer software without changing of input/output wiring, if no additional input or output devices are required.
- In PLC system spare parts for relays and hardware times are greatly reduced as compared to conventional control panel.
- The machine cycle time is improved tremendously due to the speed of PLC operation is a matter of milliseconds. Thus, productivity increases.
- It costs much less compared to conventional system in situation when the number of input/outputs is very large and control functions are complex.
- The reliability of the PLC is higher than the mechanical relays and timers.
- An immediate printout of the PLC program can be done in minutes. Therefore, hardcopy of documentation can be easily maintained.

Disadvantages of PLC are as follows:

- Too much work required in connecting wires.
- Difficulty with changes or replacements.
- When a problem occurs, hold-up time is indefinite, usually long.
- Huge initial investment
- Unemployment increases due to machine replacing human [5].

2.7 Applications of PLC

Proper application of a PLC begins with an economic justification analysis. The batch process in chemical, cement, food and paper industries are sequential in nature, requiring time or event-based decisions. PLCs are being used more and more as total solutions to batch problem in these industries rather than just a tool. In batch process saving are developed principally from reduced cycle time and scheduling. In large process plants PLCs are being increasing used for automatic start up and shutdown of critical equipment. A PLC ensures that an equipment cannot be started unless all the permissive conditions for safe start have been established. It also monitors the conditions necessary for safe running of the equipment and trip the equipment whenever any abnormality in the system is detected.

The PLC can be programmed to function as an energy management system for boiler control for maximum efficiency and safety. In the burner management system, it can be used to control the process of purging, pilot light off, fame safety checks, main burner light off and valve switching for changeover of fuels [5].

2.8 Human-Machine Interface (HMI)

The Human-Machine Interface (HMI) is a pivotal component in industrial automation, designed to facilitate seamless interaction between human operators and complex machinery or processes. Originating from basic mechanical interfaces with limited functionality, HMIs have evolved significantly with the advent of digital technology and graphical user interfaces (GUIs). Modern HMIs, developed using sophisticated software tools like Mitsubishi's GT Designer3, provide intuitive graphical interfaces that enable real-time monitoring, control, and optimization of industrial processes. These interfaces integrate with Programmable Logic Controllers (PLCs) to offer enhanced functionality, including real-time data visualization, process control, and data logging for performance analysis. The design of HMIs prioritizes user-friendliness and ergonomics, ensuring that operators can manage systems effectively and safely, ultimately contributing to improved operational efficiency and productivity in automated environments [6].

2.8.1 Integration with Programmable Logic Controllers (PLCs)

The integration of HMIs with Programmable Logic Controllers (PLCs) is a fundamental aspect of modern industrial automation. PLCs act as the brains of automation systems, executing control logic and managing the operation of machinery and processes. HMIs serve as the interface through which operators interact with these PLCs, providing a visual representation of the system's status and enabling control through user-friendly screens. This integration allows operators to start and stop processes, adjust settings, and monitor performance in real-time. By translating complex PLC data into accessible visual formats, HMIs enhance the usability and functionality of automated systems, making it easier for operators to manage and optimize operations [6].

2.9 Introduction to OP320-A HMI

OP series is a mini human machine interface of programmaable controller, which monitor and modifies the value and status of register or relay inside PLC, in this way the operator can control the machine easily. OP series operate panel can control the PLC through buttons, texts, lamps. On the face of OP320-A, there is not only LCD display window, but also 8 film buttons, 12 number buttons. These buttons can be defined to special function such as sen on/off bit, screen jump. If no need special functions, the buttons will execute basic functions: set the value of register, reset original screen, page up/down.

The buttons on the OP320-A panel can be defined as many functions.These can instead of the buttons on the control machine which has long using life and better touch feeling. There is a potentiometer at the reverse side of OP320-A cover. It can adjust the LCD bright. OP Series Edit Tool software is required to design the OP320-A. The front view and back view of OP320-A as shown in Figure 2.8 (a) and (b). Table 2.1 shows its overall specifications [7].

(a)

(b)

Figure 2.8 (a) Front View of OP320-A (b) Back View of OP 320-A

Table 2.1 OP320-A Specifications

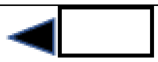
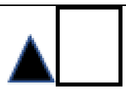
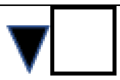
Input voltage	DC24V
Input voltage range	DC20V-DC28V

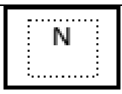
Power	<4W (TYPE2.0W)
Power-off permission	<20ms
Voltage endurance	AC1000V-10MA 1 minutes(signal and ground)
Insulated resistance	DC500V-about 10M (signal and ground)
Operate temperature	0~50’C, no condensation
Storage temperature	~20~60’C
Humidity	20~85%(no condensation)
Vibration endurance	10~25Hz(X,Y,Zdirection 30 minutes 2G)
Noise immunity	Voltage noise: 1000V p-p, pulse width is 1
Air	No corrosive gas
Protection	IP65 for front cover
Cooling method	Natural cooling
Display type	Blue LCD
Use life	Above 20000 hours, temperture 25’C, 24-hours running
Display area	192*64
Brightness	Adjust potentiometer
Text	English (24 words x 4 rows)
Font	Lattice, vector
Buttons	20
Memory	64KB FlashROM
Communication Port	RS232/ RS422

2.10 Button Functions

Table 2.2 shows the basic functions of HMI .

Table 2.2 Basic Functions of HMI

Key	Basic function
ESC	Pressing this key returns the display to the user-defined initial screen, typically the main menu, unless it’s set as a function key.
	It is used as a function key.
	It is used as a function key.
	It is used as a function key.
	It is used as a function key.
SET	Press this key to modify the register’s value, indicated by a contrasting color and flickering bits. If no register is set, no action occurs. Use [SET] before [END] to cancel modifications. This key can also serve as a function key.
ENT	Wirte the modified data to the register and then continue to modify the next data register (When the key is not set as a function key). When the current screen’s last register been modified, exit the state of modifying register, It can also used as function key.
ALM	Alarm list key (When the key is not set as a function key), after setting alarm list function, press this key to fast switch to the alarm list screen. It can also used as a function key.
CLR	When modifying the register’s data, clear the choosing area (When the key is not as a function key). It can also used as a function key.
+/-	When modifying the register’s data, set the data positive or negative (When the key is not as a function key). It can also used as a function key.

	Number key (0-9), in the status of number been set, the modified number bit change to the correspond key value (When the key is not as a function key). It can also used as a function key.

2.10.1 Inerface Definition and Connection Graph

The serial communication port pin's definition and ID number of OP320-A are shown in Table 2.3 [7]. The OP-SYS-CAB connection graph as shown in Figure 2.9.

Table 2.3 Pin ID and Definition

Pin ID	Definition
1	TD+
2	RXD
3	TXD
4	
5	GND
6	TD-
7	
8	RD-
9	RD+

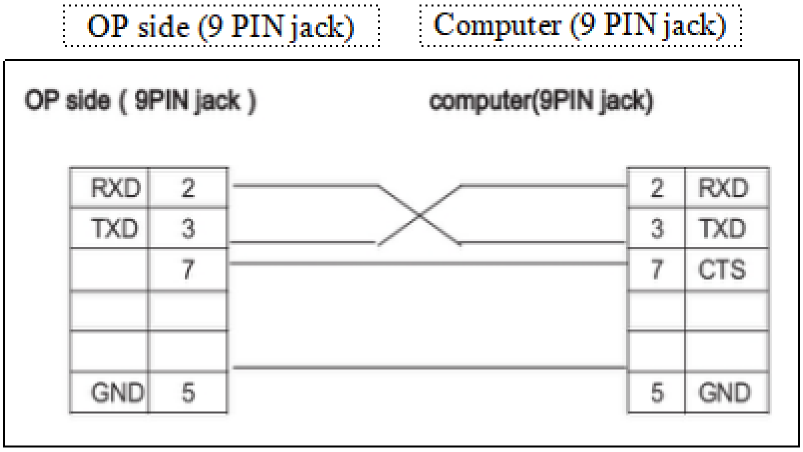


Figure 2.9 OP-SYS-CAB Connection Graph [7]

2.11 Software Requirement

All programmers need a software application to write the program. As OP320-A is used in this system, OP20 Series Edit Tool software must be chosen. OP20 Series Edit Tool is fit for OP operate panel, MP touch panel and XP HMI&PLC controller. The software is easy to learn and use. All parts including lamp, text, buttons, trend map, data setting, etc, can be put into the OP screen. Figure 2.11 shows Logo of OP 20 Series Edit Tool Software.

Figure 2.10 Logo of OP 20 Series Edit Tool Software

2.12 S250-24 Power Supply

A power supply is a component that convert relatively high input source power into lower regulated power for the internal circuity in PLC and its components. It is also known as power supply unit, power brick or power adapter. The power supply has a fixed output. There has a small adjustment that can made and it may be necessary to check that it can be adjusted the voltage to the required value. S-250-24 power supply is a switching mode power supply. S-250-24 power suppply can be widely used in industrial automation because they offer in term of size, weight, cost, efficiency and overall performance. Figure 2.12 shows the S-250-24 power supply. And also specificaions of power supply are described in Table 2.4 [8].

Figure 2.11 PS-2402 Power Supply [8]

Table 2.4 PS-2402 Power Supply Specifications

Model	S-250-24
DC Output	24V/10A
Wave and Noise	150mVp-p
Inlet Stability	+0.5%
Load Stability	+0.5%
Effciency	86%
Adjustable range for DC Voltage	10%
AC Input Voltage	90~132V/180~264VAC Slected Switch
AC Input Current	6A/115VAC 3.5A/230VAC
Working Temperature	-10~50’C
Safety Standards	GB4943, UL60950, EN60950
EMC Standards	GB9254, 55022, Class B
Weight	1.1kg

2.13 Mitsubishi PLC

Mitsuishi PLCs is one kind of industrial computer, is the key parts of industrial automation equipment. Mitsubishi PLCs is one of the widest in the industry due to their compact diemensions and low cost. The Mitsubishi PLC family of higher-performance Mircro controllers is available with 14,16,20,32,48,64,80 and 120 I/O points. Many appllications can now benefit from the many advantages of these controllers for which automation was once not even a option.

In addition to fast logic operation, human machine interface, temperature controller,VFD, Servo and various communication protocol can made possible using their simple programming suites [9].

2.13.1 Mitsubishi FX2N-20MR

There are many types of PLC available and Mitsubishi PLC is used in this thesis. It is possible to choose between relay and transistor output type. Among so many models of Mitsubishi, FX2N-20 MR is used for this system. This module has samll size, stable performance, smooth operation and use. FX2N-20MR can support text screen connection and touch screen connection. LEDs has for indicating the input and outputs status. FX2N-20 MR has 12 inputs and 8 outputs and 24V DC power supply units is required. GX Work2 is required to program FX2N-20MR PLC. Figure 2.13

shows FX2N-20 MR. Table 2.5 shows overall specifications of FX2N-20 MR. Overall, the FX2N-20MR is versatile and efficient choice for various automation tasks [9].

Figure 2.12 FX2N-20MR [9]

Table 2.5 Overall Specifications of FX2N-20 MR

Output Type	Relay output
Input Points	12
Output Points	8
Supply Voltage	24V DC
Output Currrent	5A
Memory Capacity	8,000 steps
Communication Port	9600 baud rates, USB to RS232 Serial Program download and HMI Display Communication support
Programming Software	GX Developer Or GX Work 2

2.13.2 General Wiring Diagram of FX2N-20MR Model

At the input terminals, power supply of the model is 24V and connect 0V and 24V from the power supply. At the output section, different number of four source can be used as it has 5 COM terminals at the output section. Figure 2.14 shows wiring diagram of FX2N-20MR [9].

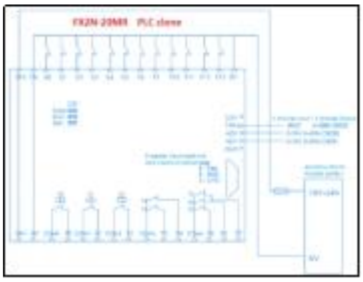


Figure 2.13 Wiring Diagram of FX2N-20MR [9]

2.14 LY2NJ Omron Relays

The output of sensors cannot be given directly to the PLC, as the input voltage to the PLC should be 24V. Hence, outputs are routed through signal conditioning circuits that prepare the input signals for the PLC. For safety purposes, inputs are not connected directly to the PLC but are routed through relay circuits.

A relay is an electrically operated switch. Many relays use an electromagnet to mechanically operate a switch, but other operating principles, such as solid-state relays, are also used. Relays control circuits with a separate low-power signal or allow several circuits to be controlled by one signal. The first relays were used in long-distance telegraph circuits as amplifiers, repeating signals from one circuit and re-transmitting them on another circuit. Relays found extensive use in telephone exchanges and early computers for logical operations. In Figure 2.15, LY2NJ Omron relays are used in this thesis which has the following specifications:

- Description: General purpose power relay.
- Rated coil voltage: 24VDC / 110VAC.
- Rated switching current: 16A at 250VAC / 16A at 30VDC.

Figure 2.14 LY2NJ Omron relays [10]

2.15 AC Gear Motor (60KTYZ)

An AC gear motor is an electric motor driven by an alternating current (AC). The AC gear motor commonly consists of two basic parts, an outside stator having coils supplied with alternating current to produce a rotating magnetic field, and an inside rotor attached to the output shaft producing a second rotating magnetic field. The rotor magnetic field may be produced by permanent magnets, reluctance saliency, or DC or AC electrical windings.

In this thesis, AC220V 2.5Rpm 14W 50 Hz Synchronous Gear Motor-60KTYZ is shown in Figure 2.16. This is a 220V 50 Hz synchronous AC gear motor with 2.5 Rpm speed and 14W power. The gear reduction of these motors lets them deliver high torques. The rated torque of these motors is 50 kg.cm. Since the motor is AC, a 24V relay circuit is needed to connect the PLC output module. And AC pump motor which is the output of electrode water level sensor is used to fill water to the tank [11].

Figure 2.15 AC Gear Motor [11]

2.16 DC Motor

A DC motor is any of a class of rotary electrical machines that converts direct current electrical energy into mechanical energy. The most common types rely on the forces produced by magnetic fields. Nearly all types of DC motors have some internal mechanism, either electromechanical or electronic, to periodically change the direction of current flow in part of the motor.

In this thesis, the author used 24V DC Gear Motor and MG996R Gear Motor.

2.16.1 24V DC Gear Motor

In this thesis, the author used 24V 10Rpm 37mm Geared DC Motor as shown in Figure 2.17. This motor is a great choice for projects that require high torque. It can be easily used in sumo robot and field robot projects. This motor technical specifications are as follow:

- Operating Voltage : 24V
- Speed : 10rpm
- Free running current : 25mA
- Stall Torque : 0.5A
- Power : 12W

Figure 2.16 24V DC Motor [12]

2.16.2 MG996R Gear Motor

In Figure 2.18, a servomotor is a rotary actuator or linear actuator that allows for precise control of angular or linear position, velocity and acceleration. It consists of a suitable motor coupled to a sensor for position feedback. It also requires a relatively sophisticated controller, often a dedicated module designed specifically for use with servomotors. This motor specifications are as follow:

- Modulation : Digital
- Torque : 4.8V: 130.5 oz-in (9.40 kg-cm) | 6.0V: 152.8 oz-
    - in (11.00 kg-cm)
- Speed : 4.8V: 0.19 sec/60° | 6.0V: 0.15 sec/60°
- Weight : 1.94 oz (55.0 g)
- Dimensions: Length :1.60 in (40.7 mm)
- Width :0.78 in (19.7 mm)
- Height :1.69 in (42.9 mm)

Figure 2.17 MG996R Gear Motor [13]

2.17 Photoelectric Sensors (E3JK-R4M1)

Photoelectric sensors are commonly found in daily life. These devices help safely control the opening and closing of garage doors, activate sink faucets with a hand wave, control elevators, open grocery store doors, detect winning cars at racing events, and more.

A photoelectric sensor, or photo eye, is equipment used to detect the distance, absence, or presence of an object using a light transmitter, often infrared, and a photoelectric receiver. These sensors are widely used in industrial manufacturing.

Photoelectric sensor is made up of a light source (LED), a receiver (phototransistor), a signal converter, and an amplifier. The phototransistor analyzes incoming light, verifies that it is from the LED, and appropriately triggers an output.

A photoelectric sensor is a device that detects a change in light intensity. Typically, this means either non-detection or detection of the sensor’s emitted light source. The type of light and method by which the target is detected varies depending on the sensor.

There are many different types of photoelectric sensor, but really only three basic technologies;

- Reflective mode (Diffuse Beam)
- Thru-beam mode
- Retro-reflective mode

Figure 2.18 Photoelectric Sensor (E3JK-R4M1) [14]

Figure 2.19 shows the photoelectric sensor (E3JK-R4M1) used in this thesis to detect the arrival of a bottle at the filling station and capping station. A photoelectric sensor is a device used to detect the absence or presence of an object using infrared transmitter and photoelectric receiver. They are largely used in industrial manufacturing. Our sensor is of type retro-reflective. E3JK-RAM1 is a retro-reflective sensor [14].

2.18 Solenoid Valve

A solenoid valve is an electromechanical device in which the solenoid uses an electric current to generate a magnetic field and thereby operate a mechanism which regulates the opening of fluid flow in a valve.

The valve features a solenoid, which is an electronic coil with a movable ferromagnetic core in its centre. This core is called the plunger. In rest position, the plunger closes off a small orifice. An electronic current through the coil creates a magnetic field. The magnetic field exerts a force on the plunger. As a result, the plunger is pulled toward the centre of the coil so that the orifice opens. This is the basic principle that is used to open and close solenoid valves.

Solenoid valves are amongst the most used components in gas and liquid circuits. The use of solenoid valves includes heating systems, compressed air technology, industrial automation, swimming pools, sprinkler systems, washing machines, car wash systems and irrigation systems. In this system, the solenoid valves are used for filling the bottle. The below Figure 2.20 shows the solenoid valve [15].

Figure 2.19 Solenoid Valve [15]

This thesis utilizes a solenoid valve that operates by electric signal. When an electrical signal is received, the valve opens; otherwise, the valve remains closed. The solenoid valve in this project operates at 220 V AC. Since the PLC configuration has a 24 V DC output, a 24V relay is used for switching to provide 220 V AC. A pipe connects the solenoid valve to a tank.

Direct operated (direct acting) solenoid valves have the simplest working principle. The medium flows through a small orifice which can be closed off by a plunger with a rubber gasket on the bottom. A small spring holds the plunger down to close the valve. The plunger is made of a ferromagnetic material. An electric coil is positioned around the plunger. As soon as the coil is electrical energized, a magnetic field is created which pull the plunger up towards the centre of the coil. This opens the orifice so that the medium can flow through. This is called a Normally Closed (NC) valve. A Normally Open (NO) valve works the opposite way; it has a different construction so that the orifice is open when the solenoid is actuated, the orifice will be closed.

The maximum operating pressure and flow rate are directly related to the orifice diameter and magnetic force of the solenoid valve. Direct-operated solenoid valves require no minimum operating pressure or pressure difference, allowing use from 0 bar up to the maximum allowable pressure. The displayed solenoid valve is a direct-operated, normally closed 2/2-way valve. Table 2.6 shows the specifications of the 2W025-08 solenoid valve. [15].

Table 2.6 Specifications of Solenoid Valve

Model	2W025-08
Working Medium	air, water, oil
Motion pattern	Direct drive type
Type	Normally close type
Aperture of flow rate	2.5mm
Voltages	AC 220V
Working Temperature	-5℃ ~ 80℃
Working pressure (bar)	0 ~ 7

2.19 Pump Motor

A pump is a device that moves fluids (liquids or gases), or sometimes slurries, by mechanical action. Pumps can be classified into three major groups according to the method they use to move the fluid: direct lift, displacement, and gravity pumps.Pumps operate by some mechanism (typically reciprocating or rotary), and consume energy to perform mechanical work for moving the fluid. Pumps operate via many energy sources, including manual operation, electricity, engines, or wind power, come in many sizes, from microscopic for use in medical applications to large industrial pumps. In this thesis, At-707 submersible water pump is used as shown in Figure 2.21 [16].

Figure 2.20 AT-707 Submersible Water Pump [16]

2.20 Electrode Water Level Sensor

Electrode water level sensor is also known as a “Conductivity Level Sensors”. Electrode sensor basically requires a physical contact with the water to detect the water level. The water acts a resistance. Small electronic current will be passing through the water which helps the sensor to sense the water. For this reason, not all liquid can use this sensor for detection. One example is the oil, which has an insulating property in nature.

In this thesis, electrode holder is used to detect the amount of water in tank. Three electrodes are used to sense the water level, such as lower, upper, and common level electrodes. These electrodes are put in the tank. When the water in the tank is in contact with the common electrode and any other (upper/lower level) electrodes, an electrical circuit is completed. This condition is controlled by controller which is connected to AC pump motor. Then, AC pump motor starts working to fill the tank which is low in water. Figure 2.22 shows the electrode holder and C61F-GP floatless level switch. Table 2.7 shows the specification of C61F-GP floatless level switch [17].

Figure 2.21 Electrode Water Level Sensor [17]

Table 2.7 Specification of C61F-GP Floatless Level Switch.

Sensing Mode	General
Rated Voltage	AC(V): 110, 220, 240, 50/60Hz
Indicator Operating	Two LED’s use for two statuses
Operating Voltage	85-110% of rated voltage
Contact Rating	5A, 250VAC (resistive load)
Reset Time	1500VAC, 50/60Hz, for 1 minute
Ambient Temperature	-10℃ ~ 55℃

2.21 Summary

In this chapter, Programmable Logic Controller and its specification are explained. Introduction of OP320-A HMI and its specifications are presented. Mitsubishi PLC and its specifications are also presented. And, the hardware requirements of the automatic bottle filling and capping system are briefly described and expressed in respective Figures. The overall operation of the system and implementation of human machine interface (HMI) will be described in the next chapter.

CHAPTER 3

IMPLEMENTATION OF HUMAN MACHINE INTERFACE (HMI)

This chapter describes the implementation of human machine interface. A step-by-step procedure for using OP Series Edit Tool is included with the illustration diagrams. The four layers are created to implement and control the whole system.

3.1 Using OP Series Edit Tool

The procedures for using OP Series Edit Tool are shown in Figure 3.1. After creating the HMI screen with the following procedures, the offline screen can be downloaded in the hardware HMI.

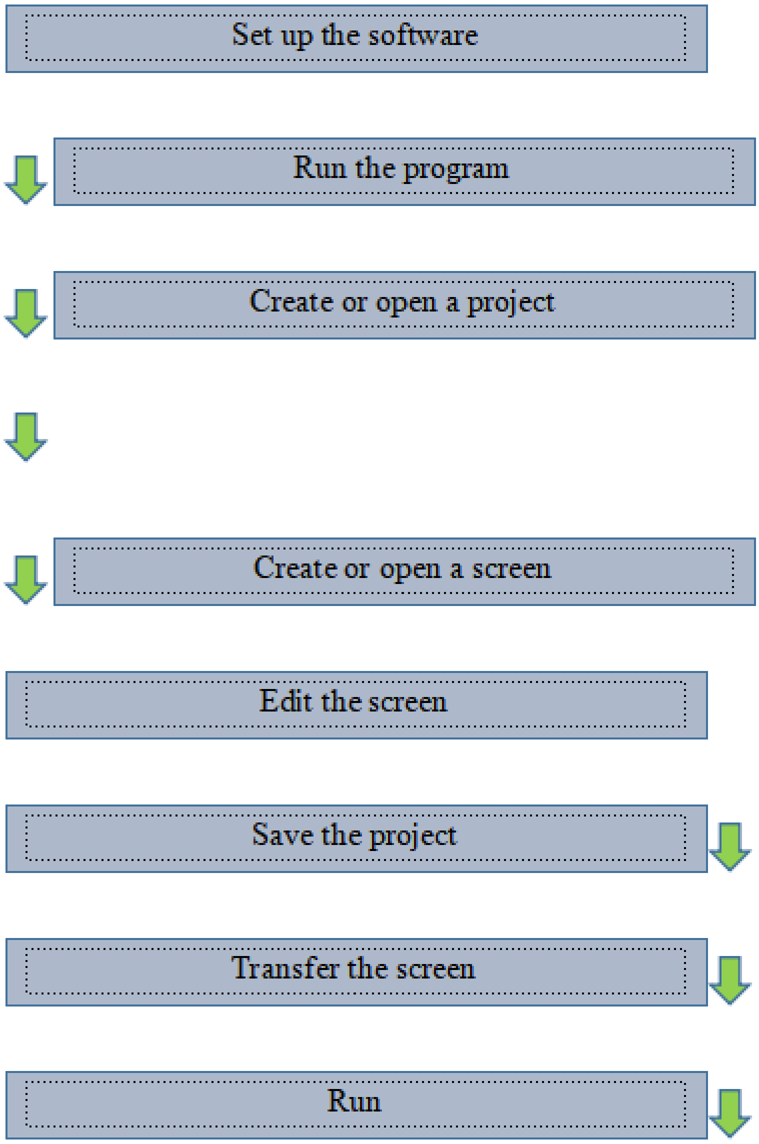


Figure 3.1 Block Diagram of the Procedure for OP Series Edit Tool

3.1.1 USB Programming Port

HMI-PLC uses Micro USB (USB2.0) port as programming port. The connector port is same as HMI programming port. Users can use cables with same connector port for PLC programming.

In personal computer, the programming port of the HMI-PLC will be a virtual COM port, the driver must be installed for it when using in personal computer (PC) first time. After finishing installing software OP Series Edit Tool, there will be different drivers in the path "OP Series Edit Tool \Drivers\" for different versions of Windows system.

When connecting programming cable to HMI-PLC and personal computer (PC) first time, Windows system will detect new hardware and mention installing driver, users can install the driver according to the version of Window [10].

3.1.2 Starting OP Series Edit Tool

To start the OP Series Edit Tool, locate the application icon on the desktop or in the applications menu and double-click it to launch the tool. If this is the first time using the application, a welcome window will appear, guiding the user through the initial setup process. However, if the tool has been used previously, it will automatically open the last operated project. When the project is opened, users can begin editing as needed. Figure 3.2 shows the starting screen of OP Series Edit Tool. If start menu is clicked, user clicks OP Series Edit Tool in “All program”.

Figure 3.2 Starting OP Series Edit Tool

3.1.3 Quit OP Series Edit Tool

After starting OP Series Edit Tool software, there are two ways to quit the software. If the close button on the upper right side of the window is clicked, OP Series Edit Tool from “File” menu is clicked. Then, “Exit” in the menu is clicked. Figure 3.3 shows exiting OP Series Edit Tool.

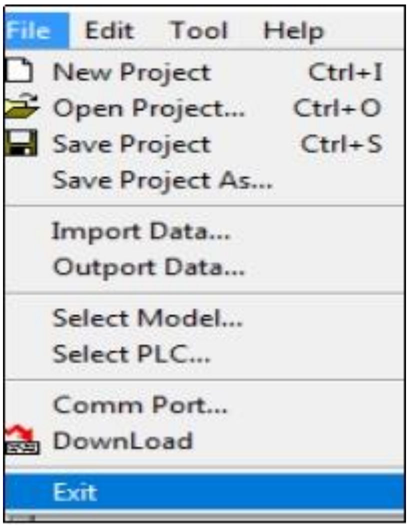


Figure 3.3 Exiting OP Series Edit Tool

3.1.4 Installing USB Driver

When it is first time to use OP Series Edit Tool, it needs to install the USB driver for downloading HMI project. User can install USB driver by manual as following procedure:

USB cable can be used to connect the USB SLAVE port of HMI to USB HOST port of personal computer, and the power supply of HMI can be connected correctly and powered on, then it will pop up dialog box of (Update Driver Software), then click “Browse my computer for driver software”.

3.2 Starting OP Series Edit Tool

To start the OP Series Edit Tool, first, locate and double-click the application icon on the desktop or in the program menu. Upon opening the tool for the first time, click the "New" icon in the toolbar to create a new project. A dialog box will appear, prompting you to select the appropriate Human Machine Interface (HMI) model. After selecting the desired model, click "OK" to proceed. Additional configuration options may then be available for customization of project settings. Following these steps will facilitate the effective development of the HMI interface tailored to specific application needs.

3.2.1 Selecting HMI Model

The button or click  (create a new project) command will be clicked, in the center of the screen there will pop up a dialog box to choose HMI's type. Drag "OP320-A" in "HMI" from "Graph element window" to construct window. When the mouse can be released after dragging HMI icon, it will popup "Display Mode" dialog box as following Figure 3.4. There are "Horizontal" and "Vertical" option in it and then click "OK". Figure 3.4 shows the selection of HMI.

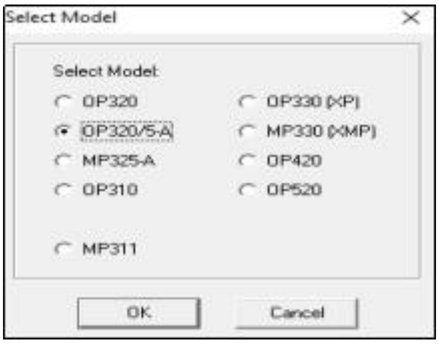


Figure 3.4 Selecting HMI Model

3.2.2 Selecting PLC model

After choosing the HMI model, a dialog box appears to select the type of PLC.PLC’s type can be chosen according to the display’s communicate object. When OP20 download the screen, the apppoint PLC’s communication protocol along with the screen data to the display will be transfered. When the display is working, it will communicate with PLC according to this protocol. Figure 3.5 shows selecting PLC model.

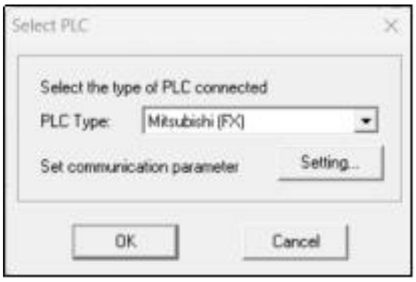


Figure 3.5 Selecting PLC Model

3.2.3 Device Connection

The PLC and OP are powered on, the cable connection is secure, and the correct PLC device is selected in the OP20 software.The communication parameters of PLC and OP are the same. The register ID of each part in the OP program should be same to PLC. When the OP and PLC are connected using the PLC cable and both devices are powered on, the OP will start to work. Figure 3.6 shows the device connection between PLC and HMI.

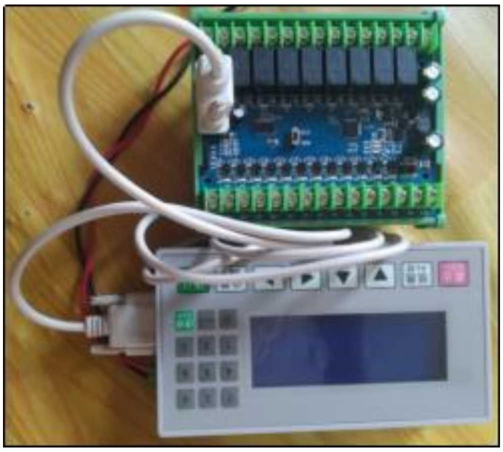


Figure 3.6 Device Connection Between PLC and HMI

3.2.4 Parameters Setting (HMI setting)

Firstly, when the set OP series from the buttons in the tool bar is clicked, there will come out a dialog box of setting OP20's system parameter. Figure 3.7 shows Parameter setting (HMI setting).

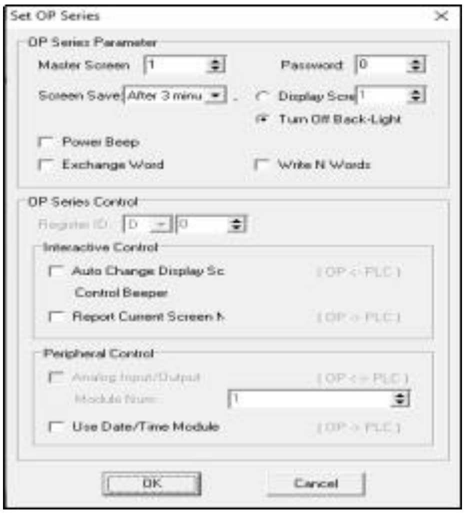


Figure 3.7 Parameters Setting (HMI setting)

3.2.5 Editing Frame

To edit a frame in the OP Series Edit Tool, first, open the project containing the desired frame. In the project tree on the left, locate and select the frame you wish to edit. Once the frame is displayed in the main editing area, various tools and properties will be accessible in the toolbar and property panel. Adjust the frame's dimensions, background color, and any interactive elements such as buttons or indicators as needed. To add new components, use the toolbar to select and place elements onto the frame.

Finally, save the changes to ensure the modifications are applied to the project.3.2.6 Open HMI Window.

3.2.6 Opening HMI Window

The function keys at the bottom of the OP320-A can be defined for various purposes, including screen jumps and switch control. To set a function for a key, right-click the desired function button, which will open a window displaying the hand graph and options for configuring the function key. For more details, refer to Figure 3.8.

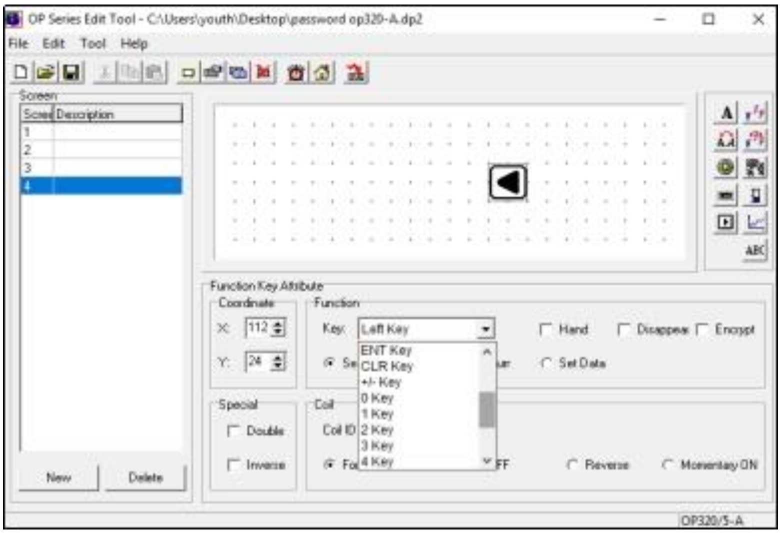
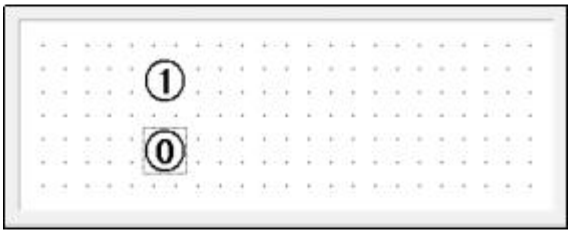


Figure 3.8 Opening HMI Edit Window

3.3 Implementation of HMI

The first step is to select function key to display start and stop. The address type and address are set according to the address of Mitsubishi PLC program. The selection switch and setting address as shown in Figure 3.9 (a) and (b). The lamps will be selected to display conveyor motor and photoelectric sensor. The address type and address are set according to the address of Mitsubishi PLC program.



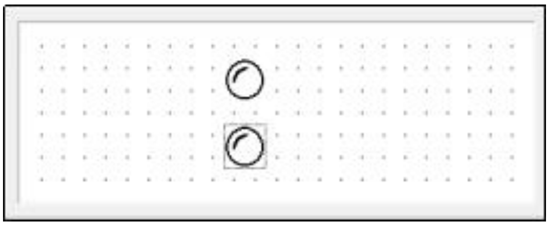
(a)

(b)

Figure 3.9 (a) Selection Switch (b) Setting Address

The set coil item of function key can be chosen, the coil address (coil ID) and the coil action (force ON/ force OFF/ reverse/ momentary ON) are set. The coil's define

No. is set to be X0, and the action mode is set to be ON. Figure 3.10 (a) and (b) shows selection conveyor, Solenoid Valve and setting address.

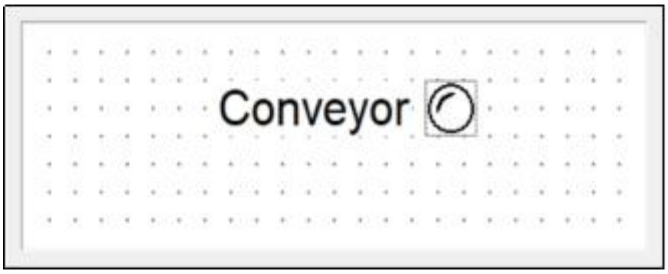


(a)

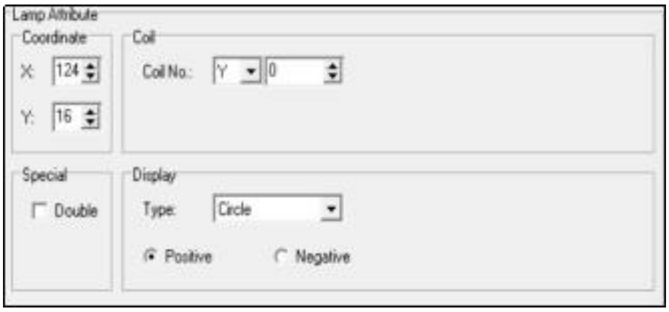
(b)

Figure 3.10 (a) Selection Conveyor, Solenoid Valve (b) Setting Address

The second step is to select the lamp to display conveyor motor. The address type and address are set according to the address of Mitsubishi PLC program. The selection conveyor motor and setting address as shown in Figure 3.11 (a) and (b).



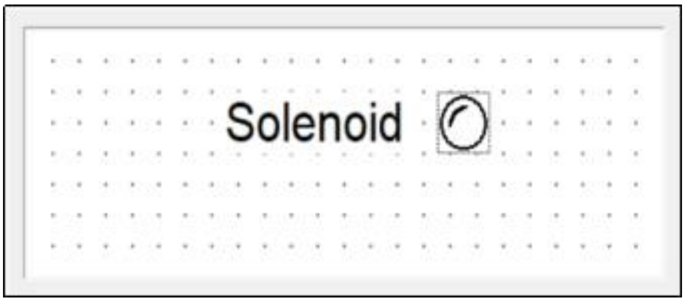
(a)



(b)

Figure 3.11 (a) Selection Conveyor Motor (b) Setting Address

Another lamp is selected to display the working of solenoid valve. The address type and address will set according to the address of Mitsubishi PLC program. The selection solenoid valve and setting address as shown in Figure 3.12 (a) and (b).

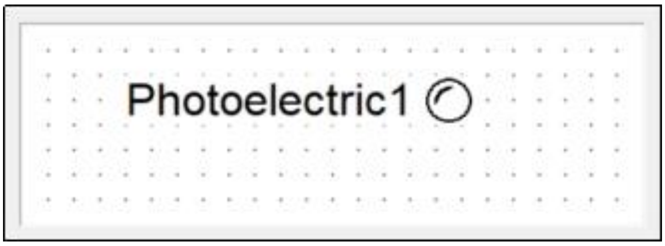


(a)

(b)

Figure 3.12 (a)Selection Solenoid Valve (b) Setting Address

Additional lamp is selected to display photoelectric sensor 1. The address type and address will set according to the address of Mitsubishi PLC program. The selection photoelectric sensor 1 and setting address as shown in Figure 3.13 (a) and (b).

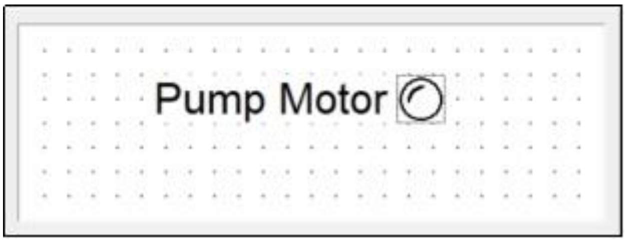


(a)

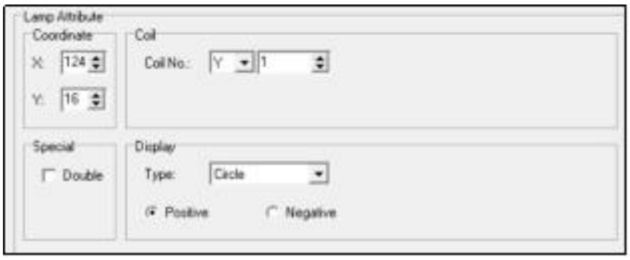
(b)

Figure 3.13 (a) Selection Photoelectric Sensor 1 (b) Setting Address

Next lamp is selected to display working of pump motor. The address type and address will set according to the address of Mitsubishi PLC program. The selection pump motor and setting address as shown in Figure 3.14 (a) and (b).



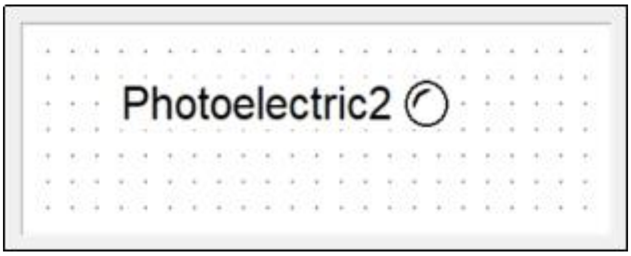
(a)



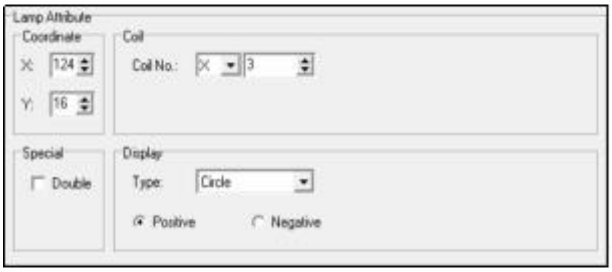
(b)

Figure 3.14 (a) Selection Pump Motor (b) Setting Address

Another different lamp is selected to display photoelectric sensor 2. The address type and address will set according to the address of Mitsubishi PLC program. The selection photoelectric sensor 2 and setting address as shown in Figure 3.15 (a) and (b).



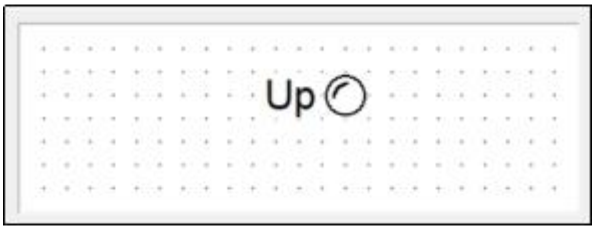
(a)



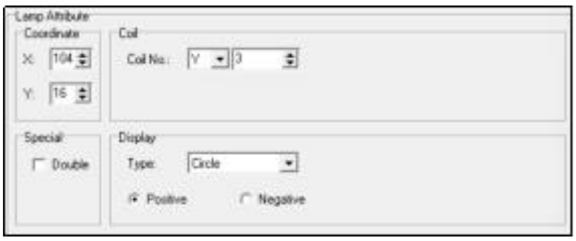
(b)

Figure 3.15 (a) Selection Photoelectric sensor 2 (b) Setting Address

Additional lamp is selected to display up motor. The address type and address will set according to the address of Mitsubishi PLC program. Figure 3.16 (a) and (b) shows selection up motor and setting address.



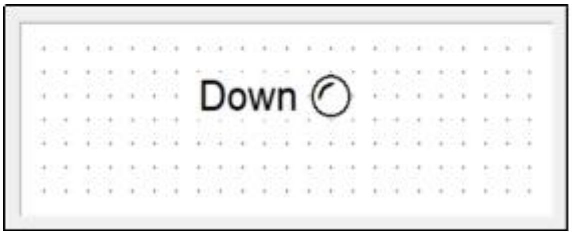
(a)



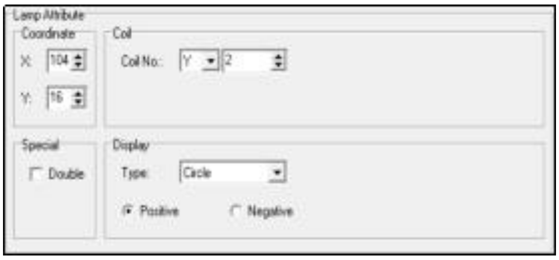
(b)

Figure 3.16 (a) Selection Up motor (b) Setting Address

Additionally, lamps are selected to display down motor. The address type and address will set according to the address of Mitsubishi PLC program. The selection down motor and setting address as shown in Figure 3.17 (a) and (b).



(a)

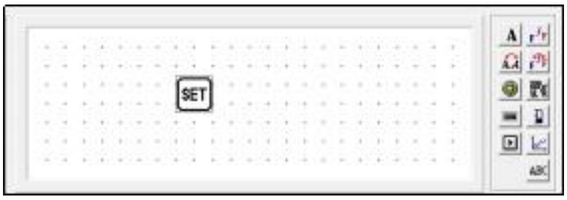


(b)

Figure 3.17 (a) Selection Down Motor (b) Setting Address

3.3.1 Selecting Date and Time

The step is to select date and time from Function Parts. The screen jump and date/time item are chosen. Press  key (for example) to jump screen. Then user can set the date and time on that screen. Figure 3.18 (a) and (b) shows date and time.



(a)

(b)

Figure 3.18 (a) Selection Date and Time (b) Setting Address

3.3.2 Window Password Setting

For some parameters or screen, user doesn’t want other person to operate. User can set password for these screens. Firstly, when “Set OP Series” command is clicked, there will be a dialog box: Figure 3.19 shows the password window setting.

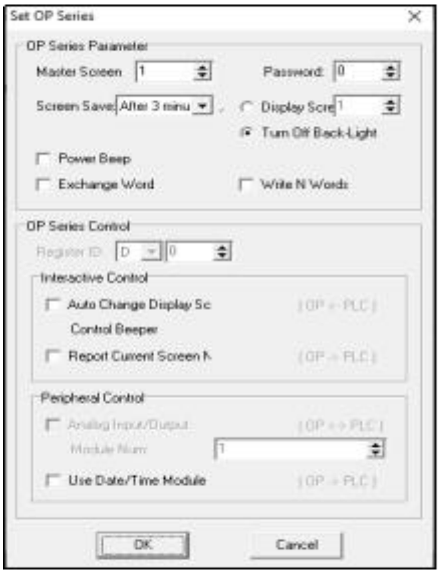


Figure 3.19 Password Window Setting

The password or modify the original password can be input, e.g. input password “5678”, then press “OK” button, the password is confirmed. Before modifying the data, the system’s password is opened. The one function key from HMI is selected for the password jump key. And then the password jump key is pressed. After pressing the password jump key, the screen will display as the following Figure 3.20.

Figure 3.20 Setting Password

3.4 Downloading the Screen

The computer's 9 pins RS232 port and the 9 pins port of OP320-A are connected with the communication download cable. It needs to give power supply. The button is clicked to begin downloading data, there will be a reminder to clue the download schedule. Figure 3.21 shows downloading process of HMI screen.

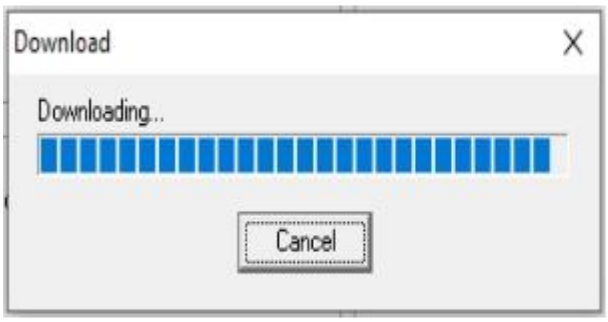


Figure 3.21 Downloading Process of HMI Screen

After finishing transferring the screen, there will be a dialog box, it tells that all the screens have been transferred. Figure 3.22 shows completing the downloading process.

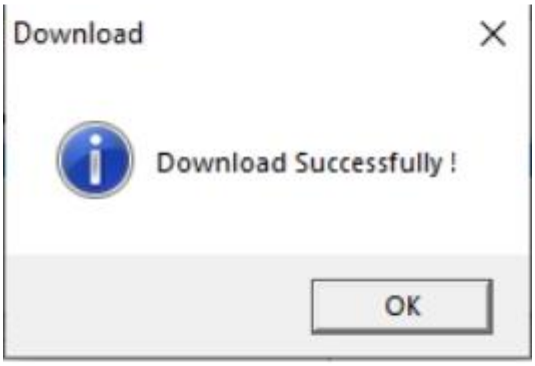


Figure 3.22 Completing Download Process

3.5 System Operation of Automatic Bottle Filling and Capping

In this system, Programmable Logic Controller serves as the controller and is connected to two photoelectric sensor, pump motor, solenoid valve, AC motor for conveyor DC motor for capping and HMI to display the whole process. When user press the start button, the conveyor starts running and up motor start up for 9s to secure the capping process.

When a bottle reaches the filling system, Photoelectric Sensor 1 detects its presence, stopping the conveyor. This triggers the filling pump and opens the solenoid valve for 45 seconds. Once the filling process is completed after 45 seconds, the conveyor resumes operation, transporting the filled bottle to the capping system. This automated sequence ensures efficient filling and capping. Figure 3.23 illustrates the flowchart of the filling system, highlighting each step in the process from detection to filling and finally to capping, demonstrating how sensors and valves work together to optimize production efficiency.

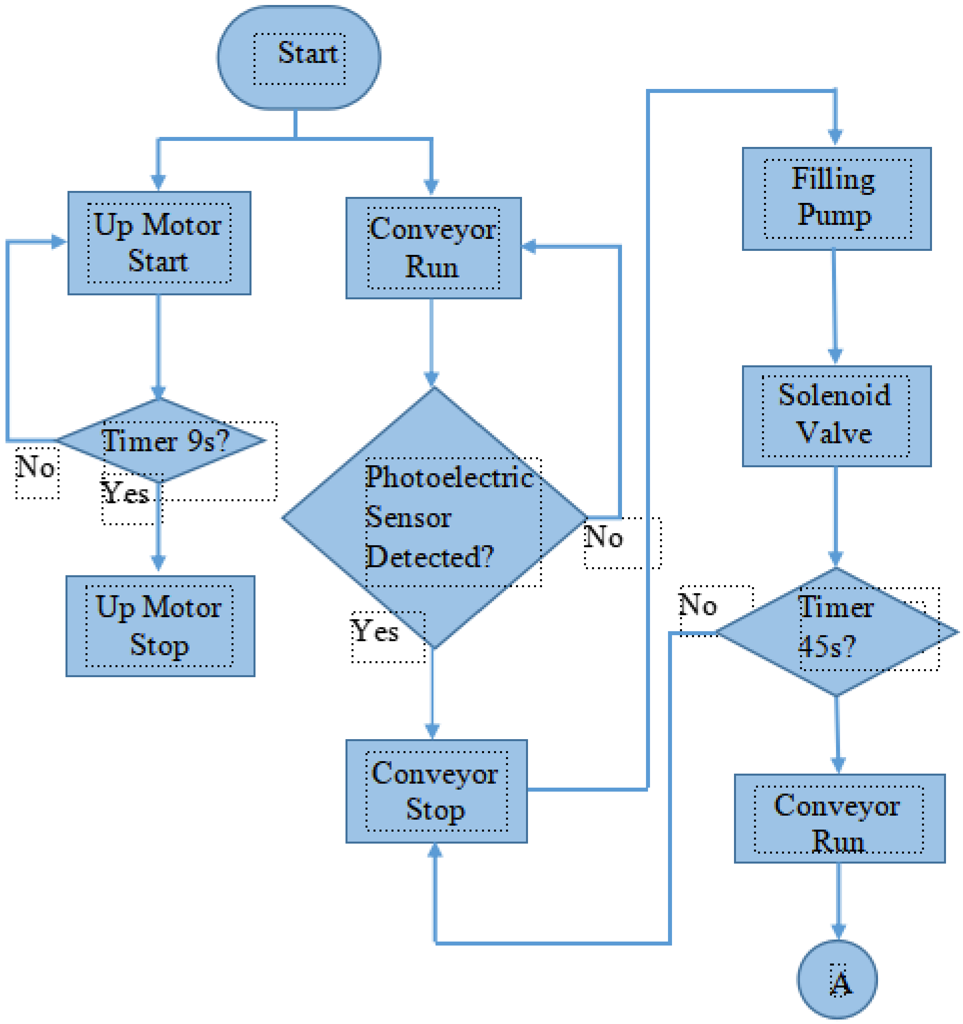
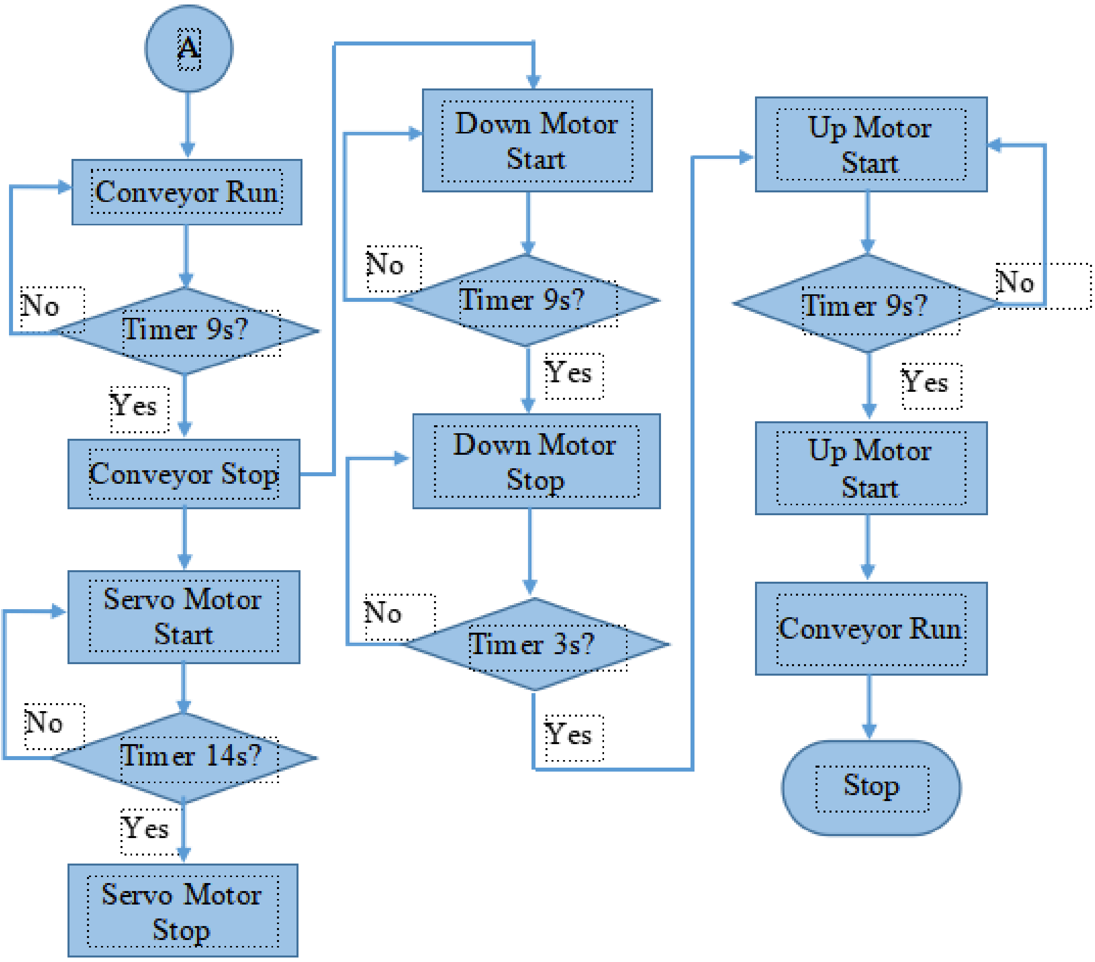


Figure 3.23 Flow Chart of Filling System

As the bottle reaches the capping station, photoelectric sensor 2 detects its presence and stops the conveyor. At this moment, both the servo motor and down motor activate, operating simultaneously for 14 seconds and 9 seconds, respectively. Once the down motor completes its cycle, the up motor engages for an additional 9 seconds. After this sequence is completed, the conveyor resumes its operation, finalizing the capping process. This coordinated timing ensures precise and efficient capping, allowing for smooth transitions between the filling and capping stages while maintaining optimal productivity in the automated system.



CHAPTER 4

TEST AND RESULTS

This chapter includes the simulation results of the whole system of the automatic bottle filling and capping system using HMI.

4.1 Testing Results of Automatic Bottle Filling and Capping System with HMI

The automatic bottle filling and capping system can be efficiently controlled through a human machine interface (HMI), which streamlines the entire process. This system is organized into five distinct layers to enhance functionality and user interaction.

The welcome layer introduces university name and department name. The information layer provides essential details about the system's operation and capabilities. The process layer contains the control switches specifically designed for managing the bottle filling and capping functions, allowing for seamless automation.

The welcome layer operates offline, providing an accessible entry point for users before engaging with the system, as illustrated in Figure 4.1.

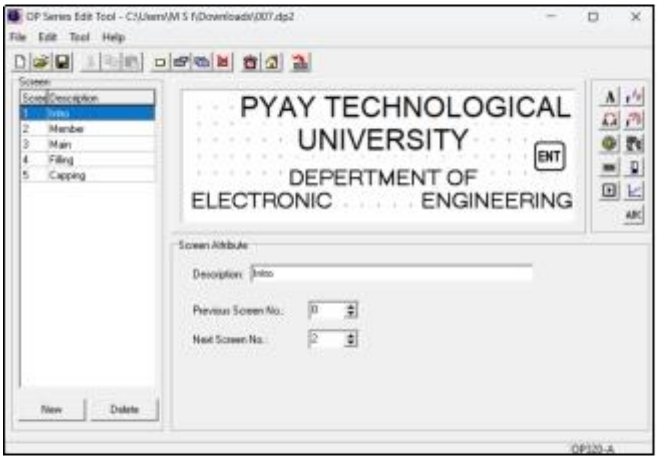


Figure 4.1 Welcome Layer of Automatic Bottle Filling and Capping with Offline

When the user starts the system, HMI will display the title Window as shown in Figure 4.2. This layer includes university name and department name.

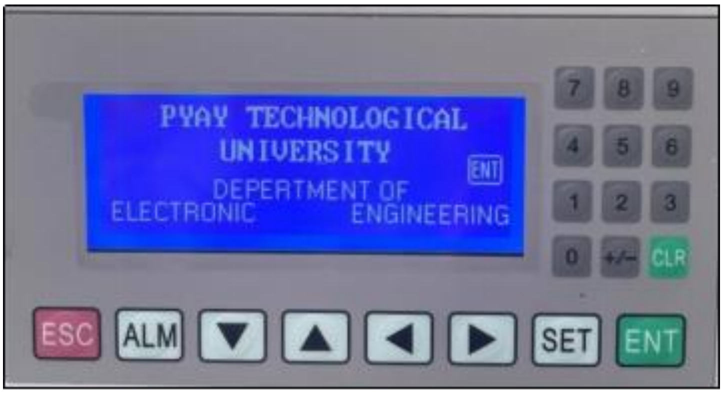


Figure 4.2 Welcome Layer of Automatic Bottle Filling and Capping with Online

The information layer of bottle filling and capping system with offline is illustrated in Figure 4.3. This layer includes supervisor name and member list.

Figure 4.3 Information Layer of Automatic Bottle Filling and Capping with Offline

When the user presses the enter key, HMI will display the List Window as shown in Figure 4.4.

Figure 4.4 Information Layer of Automatic Bottle Filling and Capping with Online

The operation layer of bottle filling and capping system with offline is illustrated in Figure 4.5. This layer includes start and stop switches, the lamp of conveyor.

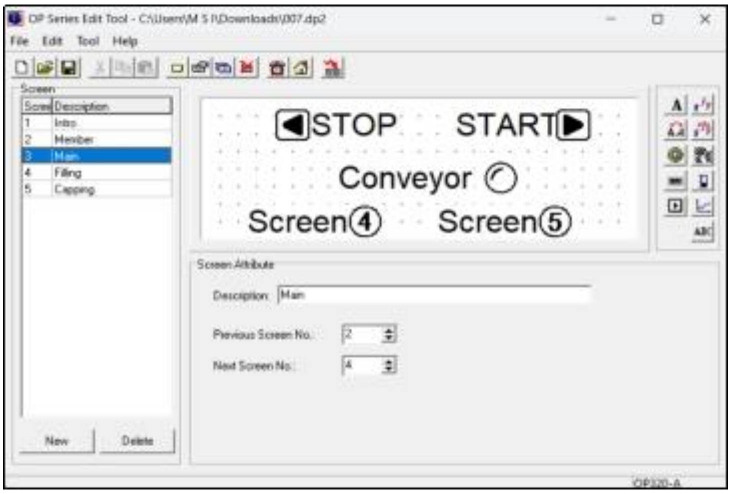


Figure 4.5 Operation Layer of Automatic Bottle Filling and Capping with Offline

When the user presses the set switch, HMI will display the operation window with stop condition as shown in Figure 4.6.

Figure 4.6 Operation Window with Stop Condition with Online

Switches are utilized to start and stop the conveyor motor, which carries the bottles under the control of a programmable logic controller (PLC). When a user presses the start switch, the conveyor lamp lights up, indicating that the system is active. Additionally, the HMI will display the illuminated lamp and a blinking motor, as shown in Figure 4.7. This visual feedback helps users monitor the operational status of the conveyor system effectively.

Figure 4.7 Operation Window with Start and Conveyor Motor with Online

The process layer 2 of bottle filling and capping system with offline is illustrated in Figure 4.8. This layer includes photoelectric sensor 1, pump motor, solenoid valve and conveyor motor.

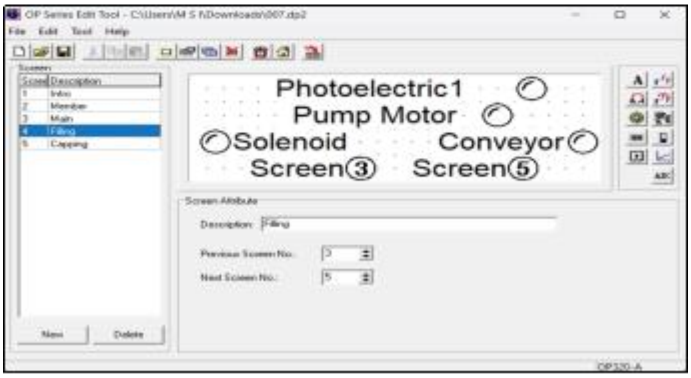


Figure 4.8 Filling Layer of Bottle Filling and Capping with Offline

When the user presses the 4 key, HMI will display the Filling layer as shown in Figure 4.9. If the objective is not detected by photoelectric sensor 1, the lamp of conveyor is lighting and it is running.

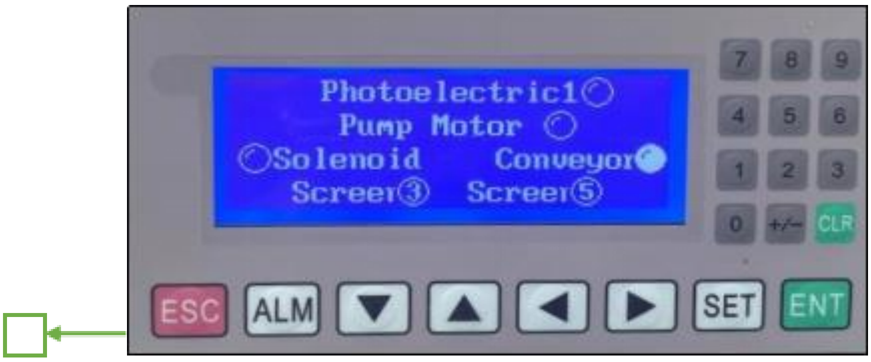


Figure 4.9 Filling Layer with No Detection Condition

If the object is detected by photoelectric sensor 1, the conveyor stops running. Then, the solenoid valve opens, and the bottle is automatically filled. HMI will display the lamp of photoelectric sensor, pump motor, solenoid valve are lighting and the lamp of conveyor is off as shown in Figure 4.10.

Figure 4.10 Filling Layer with Detection Condition

The process layer 3 of bottle filling and capping system with offline is illustrated in Figure 4.11. This layer includes photoelectric sensor 2, up, down and conveyor.

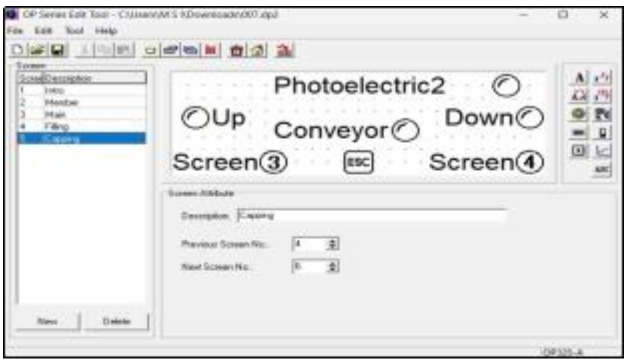


Figure 4.11 Capping Layer of Bottle Filling and Capping with Offline

When the user presses the 4 key, HMI will display the Process layer 2 as shown in Figure 4.12. This indicates a non-running situation condition.

Figure 4.12 Capping Layer with No Detection Condition

If the object is detected by photoelectric sensor 2, the conveyor stops running. And the actuator will down to do capping process. HMI will display the lamp of the photoelectric 2 and down is lighting as shown in Figure 4.13.

Figure 4.13 Capping Layer with Actuator Down

After 9 seconds, the actuator moves upward for another 9 seconds and complete the capping process. HMI will display the lamp of the up and photoelectric 2 is lighting as shown in Figure 4.14.

Figure 4.14 Capping Layer with Actuator Up

4.2 Summary

This chapter presents the test and results of the Automatic Bottle Filling and Capping system, along with clear Figures. The next chapter includes the discussion, conclusion, and further extension of the overall system.

CHAPTER 5

DISCUSSION, CONCLUSION AND FURTHER EXTENSION

This chapter describes the discussion and conclusion of automatic bottle filling and capping system. This chapter also states the further extension for designing automatic bottle filling and capping system.

5.1 Discussion

Automatic bottle filling and capping system is designed by using Programmable Logic Controller (PLC) has been successfully designed and implemented by applying all the concept of control system in this research. This research provides an overview of the hardware and software tools used to support PLC programming for an automatic bottle filling and capping system. It highlights the essential components and technologies that facilitate the efficient operation of the system, ensuring seamless automation in the filling and capping processes. Furthermore, the theoretical of the wiring system is required for connecting the inputs and outputs devices to PLC. In programming design, understanding 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 has direct effect on the system performance. The main aim in this process is to apply Programmable Logic Controller and to design automatic bottle filling and capping process. All objectives in this thesis were successfully done as planned. The purpose of implementing the automatic bottle filling and capping is to sue modern technology and bring a sustainable human settlement improving the quality of life.

5.2 Conclusion

Programmable Logic Controller based Automatic Bottle Filling and Capping system can able to consistently perform the same repetitive motion to the same standard and reduce the risk of injuries and accidents. Human machine interface (HMI) is the user interface that connects a person to a machine, system, or device. By using HMI, it reduces many costly problems caused by lack of information or human error. All of these processes are monitored and controlled on HMI screen.

An automatic bottle filling and capping system has been developed using Mitsubishi PLC. This system meets the need for high-speed production. In this study revealed valuable insights into the usefulness of PLC and HMI systems, as well as the OP Series Edit Tool and the OP-320A Human Machine Interface (HMI). Key learnings included effective methods for interfacing the PLC with the HMI and understanding the communication process between the two systems. These findings contribute to a comprehensive understanding of the integration and functionality of these technologies, emphasizing their significance in automation processes.

5.3 Further Extension

HMIs continuously grow and evolve to become the optimal choice for various industrial automation applications. These interfaces are particularly beneficial in a wide range of industries when paired with PLCs, especially in the filling and capping process. The system can be enhanced through several improvements in programming and components. Integrating vision systems or color sensors can help check filled bottles. This ensures that bottles meet quality standards, such as the right fill levels and no contaminants. Additionally, developing a recipe management system on the HMI allows for the selection of different bottle sizes or product types, enabling the PLC to adjust filling and capping parameters accordingly. Utilizing ultrasonic or capacitive sensors provides precise detection of liquid levels in bottles during filling, ensuring accurate filling without overflow. These enhancements contribute to greater efficiency and quality in the automatic filling and capping process.

Figure 3.24 Flow Chart of Capping System

3.6 Summary

This chapter provides a brief description of the steps involved in operating the system. It also includes a detailed explanation of the procedure for the op series edit tool, selection and address for each screen layer. The next chapter will discuss the test and results of the automatic bottle filling and capping machine using HMI.