Faculty of Electrical and Electronic Engineering Technology

DEVELOPMENT OF IOT BASED CONTROL AND MONITORING MAP 201 USING PLC

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Bachelor of Electronics Engineering Technology (Industrial Electronics) with Honours

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A project report submitted
in partial fulfillment of the requirements for the degree of
Bachelor of Electronics Engineering Technology (Industrial Electronics) with Honours

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2021

DECLARATION

I declare that this project report entitled Development Of IoT Based Control And Monitoring MAP 201 Using PLC is the result of my own research except as cited in the references. The project report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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APPROVAL

I hereby declare that I have checked this project report and, in my opinion, this project report is adequate in terms of scope and quality for the award of the degree of Bachelor of Electronics Engineering Technology (Industrial Electronics) with Honours.

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DEDICATION

I dedicate this project to my beloved parents for providing all the support and assistance that have made possible the fruition of our efforts. They have never given up and will always be remembered in this heart.

Next, I dedicate this project to my supervisor lecturer for all support and cooperation during the Final Year Project. Your patience, knowledge, and words of encouragement gave me immense strength throughout the project.

Then, to all my friend's thanks for their cooperation, advice, motivation, and support while conducting the Final Year Project. To all lecturers, thank you for all their moral guidance and support during this semester in University Technical Malaysia Melaka.

ABSTRACT

This project aims to use IoT to control and monitor the virtual MAP 201 machine. The controller used by Siemens's software to design the ladder diagram is known as the Totally Integrated Automation Portal (TIA Portal). The virtual PLC used is the PLC-1200. Next, for IoT development, this project used Node-Red MQTT, which is the interface is at MQTT Dashboard applications using a mobile phone. Furthermore, Node-RED was used as a flow-based development tool for visual programming developed by IBM for connecting hardware devices. MAP 201 will use virtual factory software for the machine in this project designed at software named Factory io. A DC motor powers the automated handling machine. Sensors detect the movement of the cylinder. PLC Programming controls the cylinder for its control process, which includes monitoring how many parts have been rejected at a given time. Using IoT, the entire process is controlled and monitored remotely. Overall Equipment Effectiveness (OEE) analysis performs the report generation for the handling process to analyze the output ratio of the machine performance process performed during the specified cycle time. These data can be automatically saved in the Excel Data format.

ABSTRAK

Projek ini bertujuan untuk menggunakan IoT untuk mengawal dan memantau mesin MAP 201 maya. Pengawal yang digunakan oleh perisian Siemens untuk mereka bentuk rajah tangga dikenali sebagai Totally Integrated Automation Portal (Portal TIA). PLC maya yang digunakan ialah PLC-1200. Seterusnya, untuk pembangunan IoT, projek ini menggunakan Node-Red MQTT, iaitu antara muka adalah pada aplikasi Dashboard MQTT menggunakan telefon bimbit. Tambahan pula, Node-RED digunakan sebagai alat pembangunan berasaskan aliran untuk pengaturcaraan visual yang dibangunkan oleh IBM untuk menyambungkan peranti perkakasan. MAP 201 akan menggunakan perisian maya untuk mesin dalam projek ini direka pada perisian bernama Factory io. Motor DC menggerakkan mesin pengendalian automatik. Sensor mengesan pergerakan silinder. Pengaturcaraan PLC mengawal silinder untuk proses kawalannya, yang termasuk memantau bilangan bahagian yang telah ditolak pada masa tertentu. Menggunakan IoT, keseluruhan proses dikawal dan dipantau dari jauh. Analisis Keberkesanan Peralatan Keseluruhan (OEE) melaksanakan penjanaan laporan untuk proses pengendalian untuk menganalisis nisbah keluaran proses prestasi mesin yang dilakukan dalam masa kitaran yang ditetapkan. Data ini boleh disimpan secara automatik dalam format Data Excel.

ACKNOWLEDGEMENTS

The final year project was a long and challenging journey. Community support from family, colleagues and lecturers gave me endless strength to move further, and this project will be done successfully. First of all, I would like to thank my supporting supervisor, Ts. Ahmad Nizam Bin Mohd Jahari @ Mohd Johari and my co-supervisor Ts. Amiruddin Bin Zahamail and my co-supervisor industry for your constant encouragement, infinite advice, and advice on this initiative. First, I would always like to share my thoughts and acknowledge the support and assistance provided by my colleague and classmates. Last but not least, just most especially, thanks to my dad, who have been loving me all the way spiritually and the financial support for this endeavour is the strongest.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Automatic handling systems are widely used in manufacturing processes in all industries. The essential method is to sort the products in the industry. The selection of goods parts with the correct position is primarily operated by an automatic handling MAP 201 machine. This is mainly made up of a pneumatic cylinder, a proximity sensor and a single-cylinder, which help reduce material handling efforts. A handling system is a more practical and cost-effective automation process.

1.2 Project Background

The purpose of this project is to develop a model and simulate the functionality of an automated sorting system MAP 201 machine using virtual factory software to communicate with the PLC simulator, as shown in figure 1.1. The automated handling MAP 201 machine developed allows for a lot of flexibility, such as to rejects the faulty parts that do not meet the correct position specified in the system via evacuation ramp as defined in the Programmable Logic Controllers (PLC) regulation with a capacitive proximity sensor to detect the movement of the cylinder. This project will be designed and simulate by using virtual factory software that links or is connected to the virtual PLC simulator software. Further, the integration of the Internet of Things (IoT) will be implemented through this project. Therefore, the Overall Equipment Effectiveness (OEE) analysis will be performed to analyze the output ratio of the machine performance process performed during the specified cycle time.

Figure 1.1 Overview interaction of Virtual Factory and PLC

1.3 Problem Statement

Nowadays, some industrial machines cannot incorporate flexibility into their design concept. For example, the evacuation ramp rejects the faulty parts that do not meet the correct position specified in the system. This handling machine allows for a lot of flexibility designed by PLC simulator software. Next, the running machine might fail, and the failure cannot be monitored. In this project, with the implementation of IoT, the machine will be controlled and monitored using the Node-Red MQTT and Node-Red Dashboard. Besides, there is a lack of productivity in terms of machine monitoring.

1.4 Project Objective

The aim of this project is based on the problem statement above:

a) To design and develop a Programmable Logic Controller (PLC) to control the MAP 201 machine based on virtual implementation.

b) To develop an Internet of Things (IoT) based monitoring system for the virtual MAP 201 machine.

c) To analyze the output ratio of the machine performance process performed in a predetermined cycle time.

1.5 Scope of Project

The scope of this project are as follows:

a) A program controlled by using software Siemens Totally Integrated Automation Portal (TIA Portal).

b) Construct an automated sorting machine implementing the Internet of Things (IoT) implementation integration.

c) Control and monitoring MAP 201 virtual machine that performed by Overall Equipment Effectiveness (OEE) analysis to analyze the output ratio of the machine performance process performed during the specified cycle time.

1.6 Expected Result

The expected outcome of this project is that when the cylinder pushes the object, it will check its incorrect position. Then if the object is in the wrong position, the cylinder will reject via evacuation ramp. The sensor will then determine whether the object is in an incorrect position or not. The implementation of IoT will then control the machine processes and monitor the number of objects that have been rejected via the evacuation ramp.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The application of information and communication technology, production networks, the internet, and cellular networks corresponds to the development and evolution of industrial production. Because of the current framework concepts of manufacturing, manufacturers are often more resilient than most to the dynamic global economic market dynamics that involve infrastructure and connectivity among all actors throughout the manufacturing cycle. Handling model design and its controller with control software through the virtual factory are more beneficial throughout the digital world of the industry 4.0 revolution. The intelligent production environment built by this automated factory structuring is the intelligent environment of production that will make a smart factory. An intelligent factory that interacts with IoT is a convenient product development option that should meet the expectations of today's marketplace and achieve convergence among manufacturing and non-manufacturing partners, who mostly form virtual organizations. Furthermore, IoT incorporates hardware elements of the manufacturing system and interactive, intangible, and virtual features into a single network dubbed cyber-physical production technologies system.

2.2 Conveyor monitoring and control using PLC and SCADA

PLCs vary from small-scale modular devices with dozens of inputs and outputs (I/O) in housings built into the processor to significant modular rack-mounted devices that often link to other PLC and SCADA systems with thousands of I/O [1]. The I/O configurations may be configured with different digital and analogue settings, wide temperature ranges, electrical noise immunity, and vibration and impact resistance. Non-volatile memory or battery-backed data generally is used to store machine operating programs.

This project aims to monitor and control the belt conveyor components using PLC and SCADA. The conveyor is powered by a direct current (DC). To monitor the components of the conveyor, sensors are employed. Tracking the number of completed components travelled through the transport at a particular time, and power reduction for its control mechanism The conveyor is handled using energy-efficient PLC programming using PLC. SCADA is a remote monitoring and control system utilized for the whole operation. SCADA is designed to provide reports for transport activities like Conveyer Cycle Time and Conveyer Idle Time that can be automatically stored in the Excel data format.

2.2.1 Project Description and Working Principle

A Delta PLC, Wonderware Intouch SCADA, three conveyor belts, three DC motors, three proximity sensors, a switch-mode power supply, a relay, a miniature circuit breaker, and a switch were all used in the project's design. To control the numerous components, the project makes use of a PLC. This machine contains three conveyors, each with its proximity sensor and powered by a dc motor. As a consequence, the thing going through the conveyor may be seen. The conveyor is only active when the proximity sensor identifies an item, and it is switched off after a certain amount of time. Each conveyor follows the same routine, and the third conveyor begins after gathering five articles. The DELTA PLC collects and controls all components of the process. The Wonderware Intouch SCADA system is used for monitoring. The Intouch is utilized for remote work monitoring, and the data recording sheet is utilized to establish the conveyor's optimum and operating hours.

```
SCADA PROGRAM
ON SHOW
  SW = 0;
  C1 = 0;
  V1 = 0;
  V2 = 0;
  H1 = 0;
  H2 = 0;

WHILE SHOWING
 If SW = = 1 AND H1 < = 180 AND V1 = = 0 Then H1 = H1
+ 5; END If;
If SW = = 1 AND H1 > = 180 AND V1 < = 100 Then V1 =
V1 + 5; END If;
 If SW = = 1 AND H1 < = 360 AND V1 > = 100 Then H1 =
H1 + 5; END If;
```

```
If SW = = 1 AND H1 > = 360 AND V1 < = 200 Then V1 =
V1 + 5; END If; If SW = = 1 AND V1 > = 200 Then H2 < =
170 Then H2 = H2 + 5; C1 = C1 + 5; END If;
If SW = = 1 AND H2 > = 170 AND V2 < = 40 Then V2 =
V2 + 5; END If;
 If SW = = 1 AND V2 > = 40 Then H2 = 0; C1 = 0; V2 = 0;
END If;
```


Figure 2.1 SCADA Program

2.3 PLC-HMI-system for use in Vietnam with a drip coffee maker for Drip Coffee Brewing

The current major innovation in digital technology is rapidly rising in impact, according to [2]. Automation is a social effort to make many activities easier. Automation emphasizes being efficient. Several drinks take a long time to mix, such as sugar, tea, and coffee. Meanwhile, other, more critical operations have been put on hold. It is possible that speeding up these processes may be desired. The great majority of the population also eats coffee. Everyone is occupied; therefore, everything must be speedy and efficient. According to this trend, we must design an automated, fast, and precise system control that can be done using a PLC and an HMI to deliver efficient, simple, and effective management (HMI). Meanwhile, Omron PLC and HMI are developing an automated Vietnamese Drip Coffee drink maker device that will cater to the demand for coffee while also being more efficient. The PLC and HMI-based Vietnamese Drip Coffee, an automated coffee maker device, is created to make Vietnamese Drip Coffee simpler in hot weather. No other method to utilize this gizmo is known. The machine's original design function was to manage and monitor the automated process of creating Vietnamese Drip Coffee, which included selecting coffee types and ending with the mixing stage.

Industrial, automotive, and manufacturing industries often use PLCs to replace relay functions. Personal Computers equipped with diverse control systems, such as PLCs, can conduct intricate and sophisticated control processes. This helps with monitoring and control features. Meanwhile, HMI is in the Supervisory, Govern, and Data Acquisition (SCADA) system, providing remote supervision capabilities while working on master control and data collector's Remote Terminal Unit (RTU). SCADA may implement both automatic and human control utilizing an HMI-based controlling mechanism.

2.3.1 Research Method

The design and manufacture of the system were completed at this stage, and a block diagram of the system was used to construct a detailed representation of the system and then create software design algorithms. Figure 2.2 shows the results. This figure shows a simple system used by an HMI OMRON NB7W-TW00B. You will also see a power supply with a

24 VDC output, a PC connected to an HMI, and an HMI connection to a PLC through an RS232 9-pin cable in Figure 2.3.

Chocolate coffee, prepared automatically when making chocolate coffee, is located on the HMI's main menu. Milk coffee, which is ready automatically when serving milk coffee, is located in the HMI's secondary menu. Finally, Original coffee, available to customers, is located in the HMI's final menu.

As a part of the procedure, some of the circumstances that appear are shown on the menu screen. System checking features are also included. These are only a few examples of tasks to design your project. In Figure 2.4, you can see a layout design generated using the NB-Designer programmer.

Adopting programming entails working with prepared addresses that include PLC inputs and outputs. This PLC has 36 inputs and 24 outputs. These three addresses are being used: 0000, 0011, and 0111. They're also using addresses ranging from 0200 to 0211. Meanwhile, the outputs are allocated the numbers 1000, 1001, 1002, 1003, 1004, 1005, 1006, 1007, and 1200, 1201, 1202, 1203, 1204, 1205, 1206, and 1207.

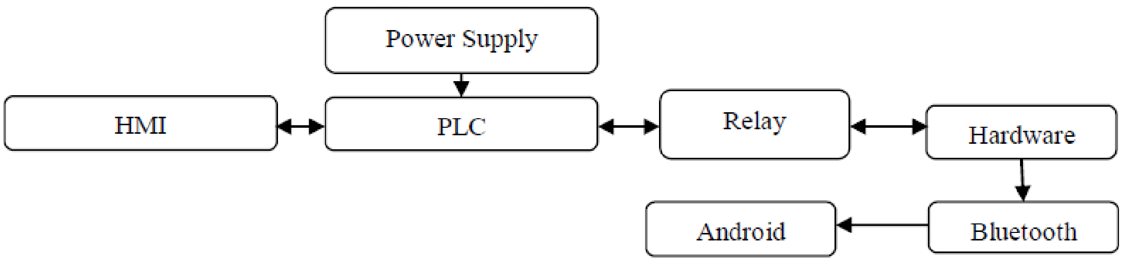


Figure 2.2 Block Diagram of Control and Monitor System

Figure 2.3 Hardware Connection of HMI Omron NB7W-TW00B

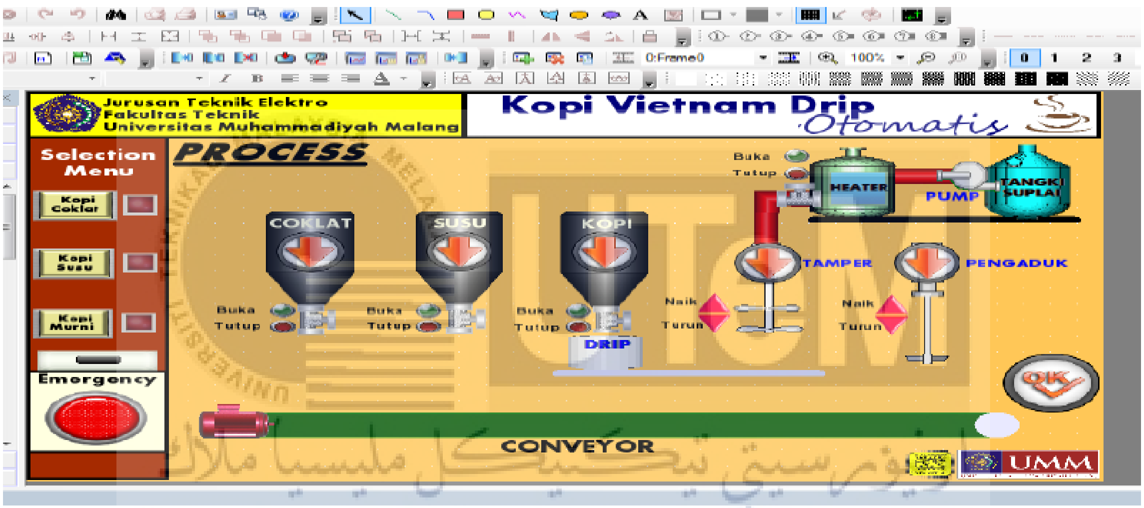


Figure 2.4 HMI Process

2.4 Design and implementation of a remote control and monitoring system for the automatic packaging industry using PLCs

Based on [3], this project presents the development of a human-machine interface (HMI) for an automated packaging process based on a programmable logic controller (PLC) that can be handled and monitored remotely using a mobile application. A Siemens LOGO! 230 RCE PLC drives a conveyor belt that transfers products to a predetermined position for packing. The relays are controlled by the microcontroller (Arduino UNO) depending on the performance of the infrared sensors that detect the items. The PLC receives the relay states. An HMI is constructed using an Android application and a microcontroller to offer a communication connection between the operators and the PLC-based factory (as the processor). The interface allows for remote control and tracking. The suggested approach lowered total expenses by replacing the frequently used supervisory control and data acquisition (SCADA) system with conventional sensors and mobile application-based control. The prototype's output is tested using multiple real-time procedures, and the results are promising.

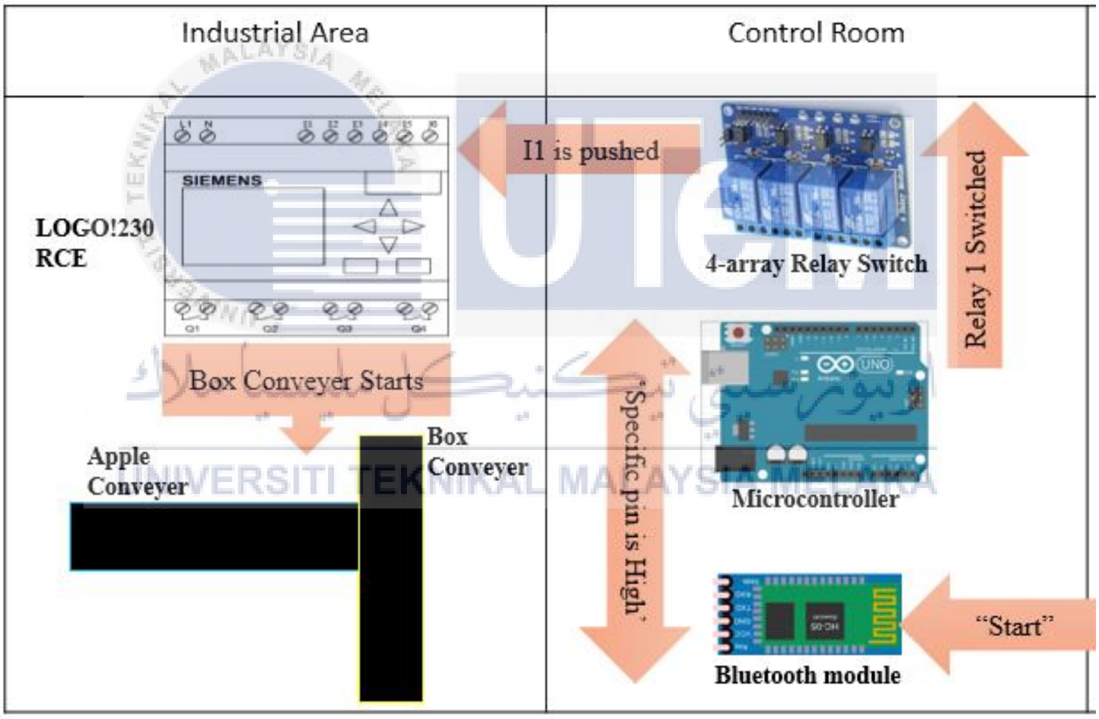


Figure 2.5 Proposed procedure of start packaging system

The proposed design of an automated packaging machine using PLC LOGO! 230 RCE can be split into four steps, as shown below:

a) Start Packaging System

b) Box Sensing and Counting

c) Sample Sensing and Counting

d) Stop Packaging System

Implementing software includes creating a PLC ladder diagram, creating an android framework, and configuring the required programs (remote control and monitoring system) for the Arduino.

A. PLC Ladder Diagram

Input				Output	
I1	I2	I3	I4	Q1	Q2
PLC starts	PLC stops	Apple or sample sensed	Box sensed	Apple or sample conveyor belt	Box conveyor belt
Relays				Counter	
M1		M2		C001	
Relay contacts		Relay contacts		Apple Counter	

Table 2.1 Input, Output, and Relay Configurations of PLC

a) Carrying Empty Boxes to Desired Location

b) Packaging Samples into Boxes

B. Developing an Android Application

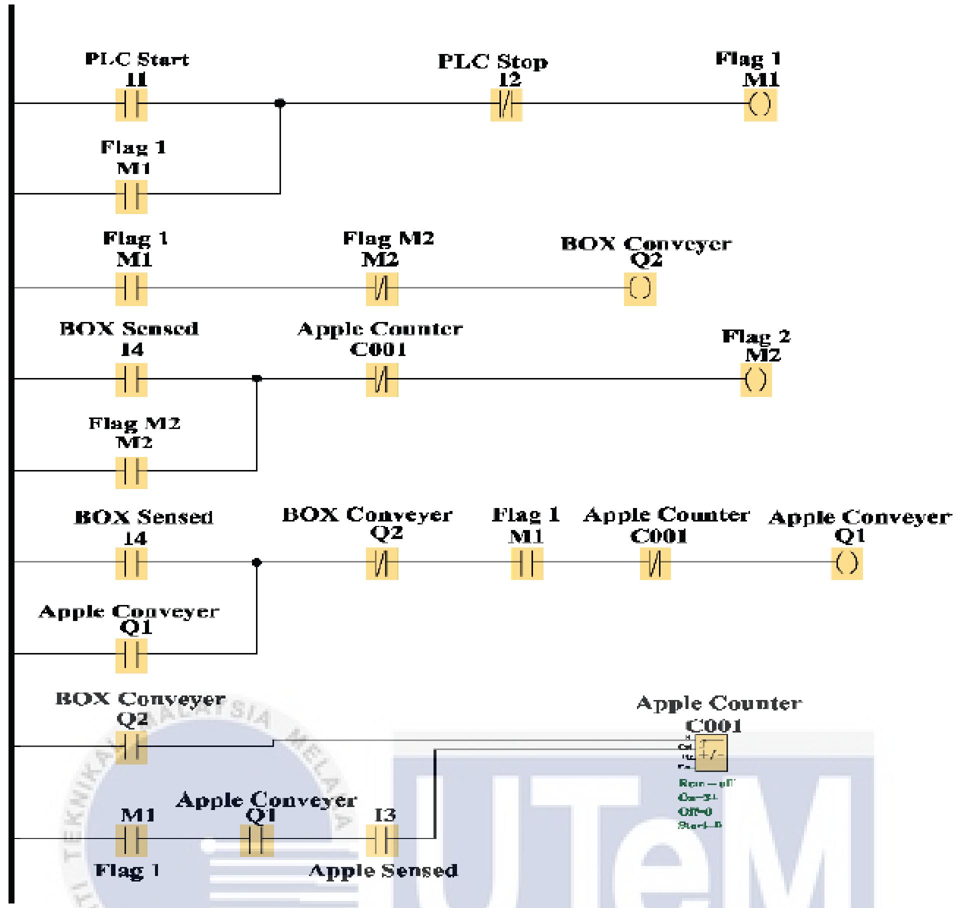


Figure 2.6 Ladder diagram of the automatic packaging system.

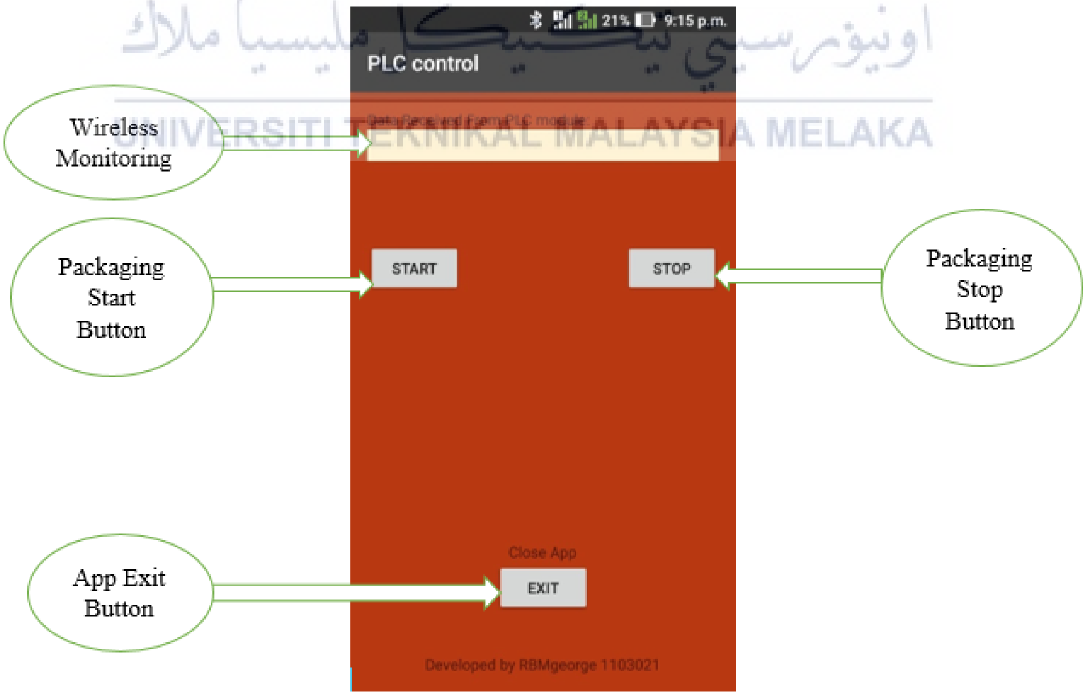


Figure 2.7 An android application of automatic packaging & monitoring system

2.5 Paper Machine Automation using PLC, VFD's and HMI

The difference is that Ruchira Papers Ltd focused on the automated operation of a paper mill while [4] covered the industry in general. One motor powered the whole line in the past, causing mechanical wear and tear, synchronization concerns, and the motor's constant speed to be troublesome. A new controller with sophisticated drives and a better display unit was implemented, addressing the shortcomings of the prior system. This machine uses both hardware and software to minimize mechanical stress, boost dependability, conserve energy, and improve output standards, all while also increasing the speed of the machine.

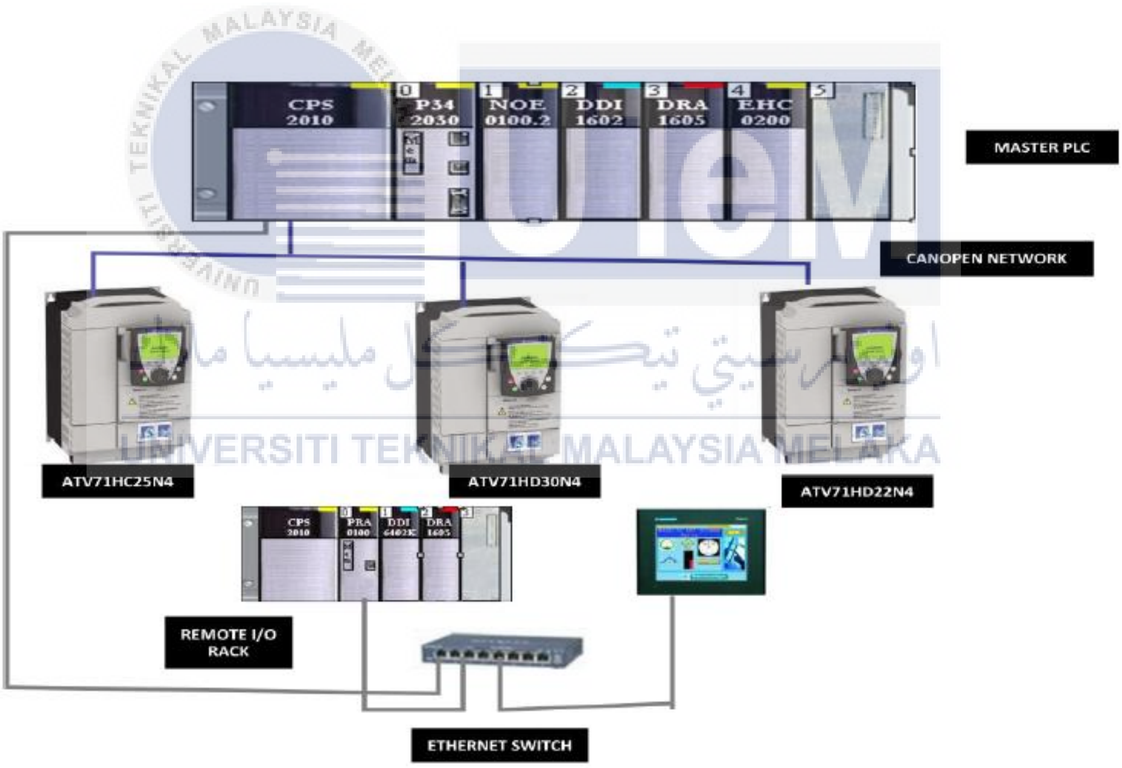


Figure 2.8 Automation of Paper Machine

2.5.1 Scanning Process of A PLC

A PLC (Programmable Logic Controller) is a real computer that can receive data via its inputs and send commands via its outputs. As soon as we start the program, the controller will cycle through three phases:

Phase 1: A snapshot of the status of its inputs

Phase 2: Program execution

Phase 3: Output activation or deactivation

At the end of Phase 3, the controller returns to Phase 1, and so on.

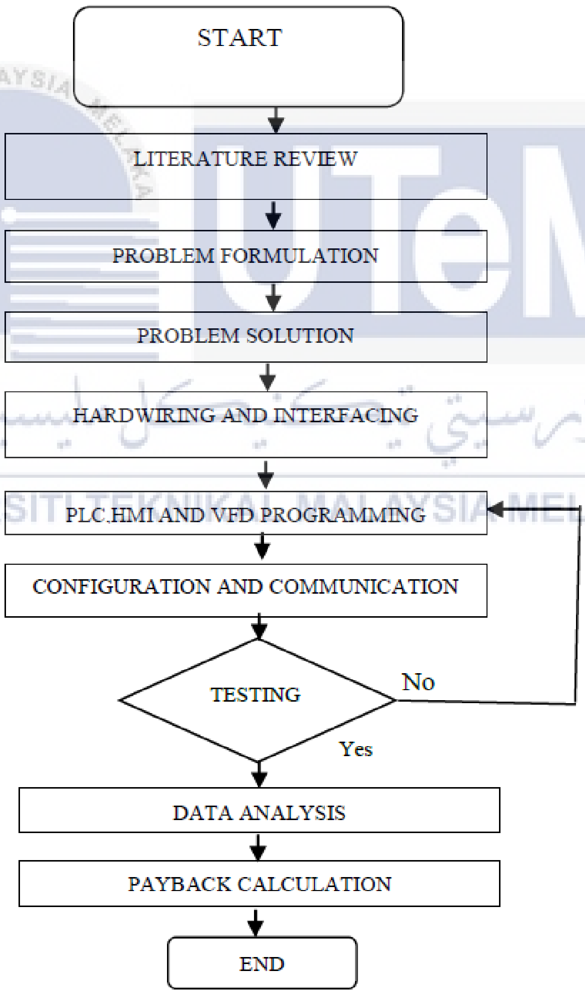


Figure 2.9 Methodology adopted

2.6 Transformer Cooling Control System with PLC-based Intelligence

[5] Every day, the distribution network has low and high load levels. Distribution networks account for around 70% of total power system losses. Replacement transformer service is a significant issue. Transformers need transformers. This research is focused on a novel and novel cooling system that combats transformer heat loss and insulation waste.

The need for transformers is more significant due to the growth of the smart grid and smart cities. PLCs are suitable for gathering and monitoring internet data. This research presents an intelligent cooling system that employs a PLC to eliminate manual transformer cooling techniques. There are three cooling banks, each with a fan and a pump.

The three cooling banks will be operational. Once one bank fails, another one will replace it. Until the malfunctioning bank is corrected, the third bank will operate. The PLC prevents incorrect bank switching. Also, constant monitoring and data logging occurs concurrently. We achieved it via the periodic switching technique. Using just when needed minimizes electricity waste and other unproductive actions. HMI is utilized in the control room to show the whole operation.

Figure 2.10 SCHEMATIC S7-200 PLC

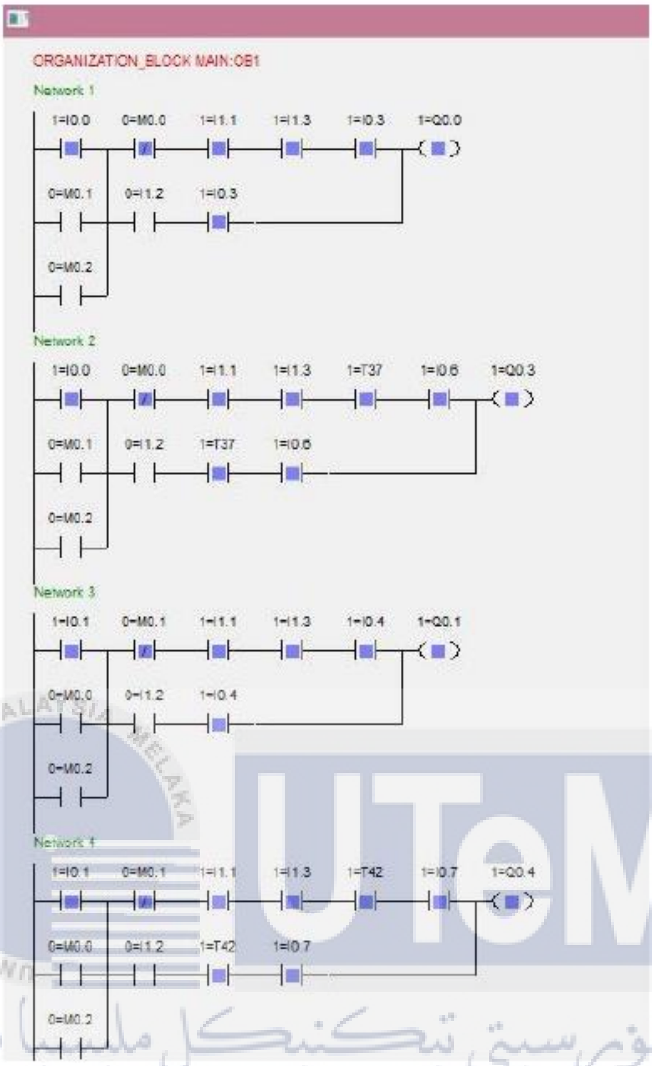


Figure 2.11 Software Screen and Simulation Process

2.6.1 System Configuration

The PLC's output pins are connected to output devices like cooling fans and pumps. Each of the 12 output pins is connected to pumps and fans. The input pins are wired to the power supply, which is a 24V DC SMPS, and the toggle switches. Take a look at the diagram in Figure 2.12.

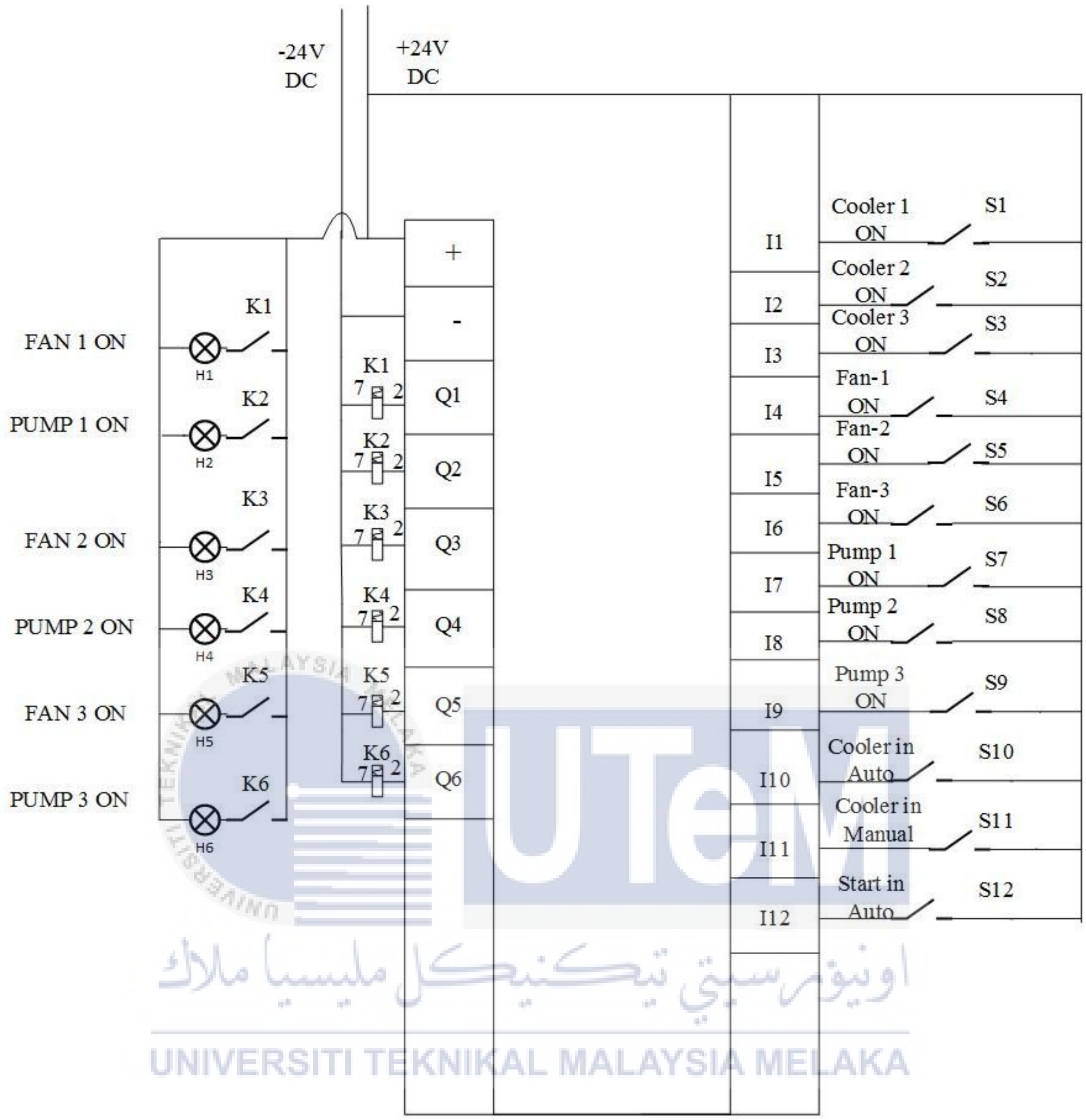


Figure 2.12 Circuit configuration and connections

2.7 The Use of Programmable Logic Controllers to Control Induction Motors Is Becoming More Popular (PLC)

[6] found that automation is a way to manage numerous process parameters, such as flow, temperature, etc., without a person accountable interference. PLCs are utilized to tackle complicated difficulties to maintain in conventional controls. To provide better control, more

flexibility, and reliability through an intelligent diagnostic of machine failures, soft controller development has moved toward industrial applications, with the result that industrial sectors gradually from conventional relay control to programmable logic controllers (PLC) have moved and 3-phase squirrel cage induction motors are widely used.

This idea also comprises the design and execution of a three-phase inductive monitoring and control system based on PLC technology and correlates its associated programmable logical controller (PPC). Therefore, the Programmable Logic Controller (PLC) is a powerful instrument for industrial electrical drive control.

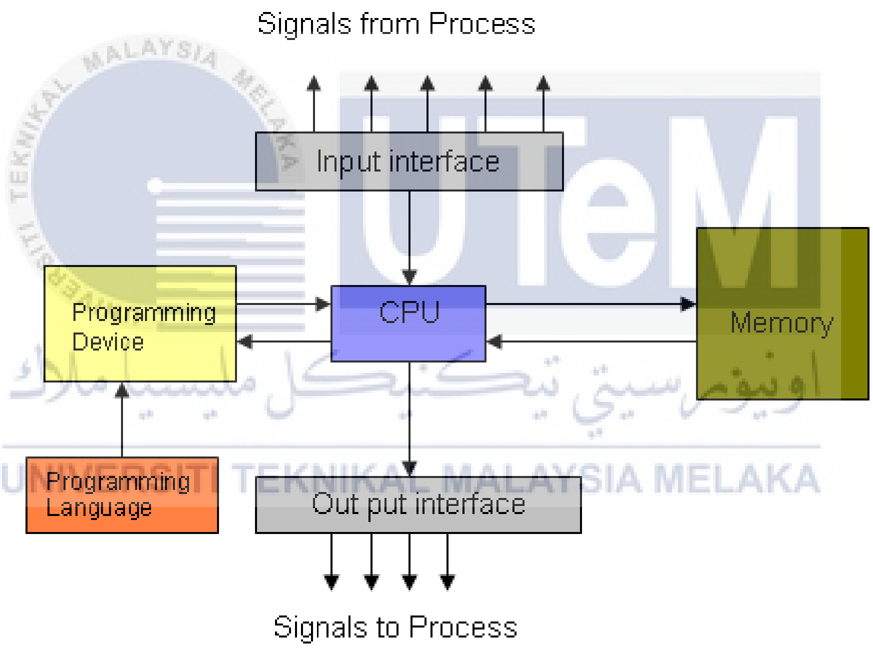


Figure 2.13 Parts of PLC

2.7.1 Material and Methods

The project's overall purpose is to employ a programmable logic controller (PLC) to construct a reliable protection system for a three-phase induction motor. It should safeguard the motor against voltage unbalancing, single phasing, under-voltage, overvoltage, and thermal protection. Engineering used to be focused on hardware-intensive engineering systems. Adding more gear and wiring has made designing a system with distance control impractical. PLCs (programmable logic controllers) have helped design and material utilization since PLCs integrate exclusive designs in software programming paradigms.

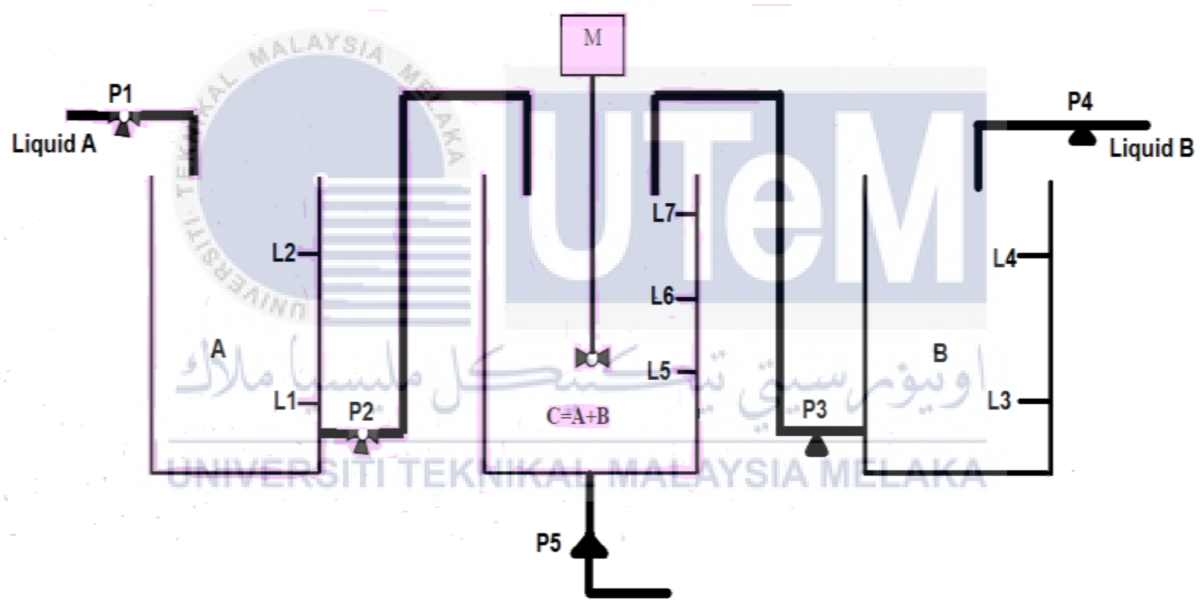


Figure 2.14 Elementary diagram of tank process

To better see how the project looks, imagine it is laid out in a matrix-like in Figure 2.14. When the fluid level in the first pump is less than L1, the project begins. When it rises to L2, the project stops. If the fluid level increases to L3, the project is restarted. When the fluid level rises to L4, the project is stopped. And finally, when the fluid level increases to L5, the project continues.

2.8 Design and Simulation of PLC Process Control in Automated Packaging Machines

On the other hand, [7] said that the world embraces industrial automation, and packaging is one of the industries being impacted. Modern industrial facilities use an automated process control system to control the intended process. The programmable logic controller (PLC) is significant for industrial automation in today's corporate environment. An increase in yield from industrial automation substantially influences industrial operations. Numerical control systems may be used in many controlling systems, although PLC control systems are often used. Inspecting the control panel board might find a problem with the circuit. The visual examination makes diagnosing issues easier.

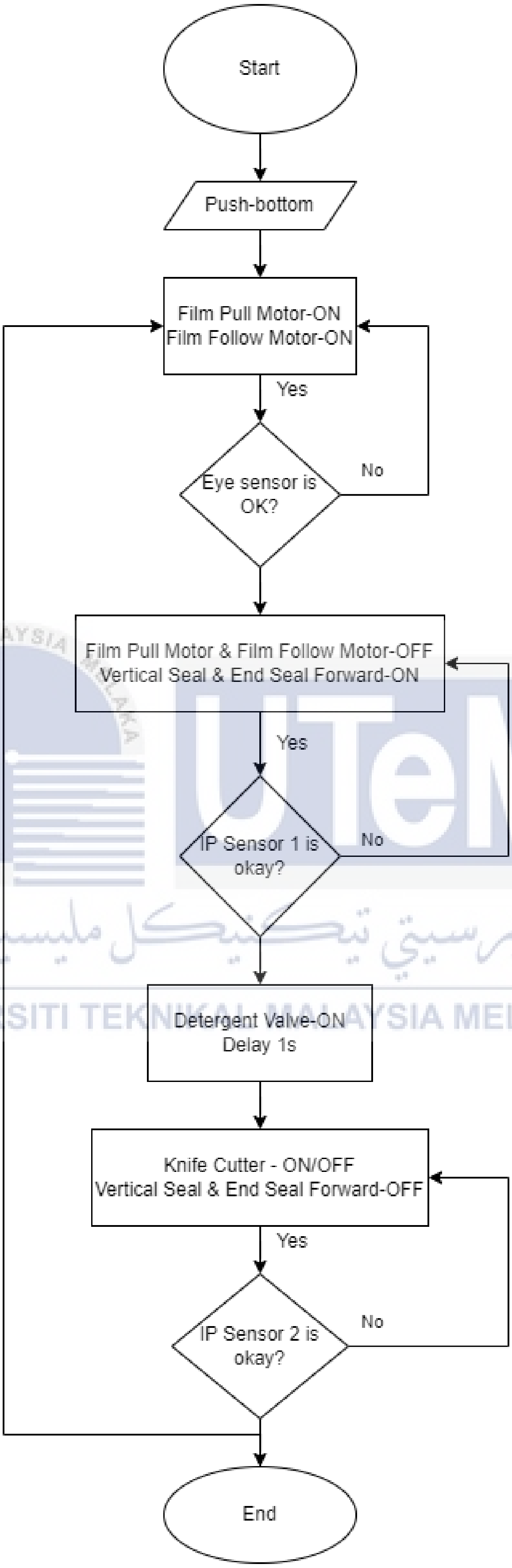


Figure 2.15 Process Flow Chart of Control Program

2.8.1 Parts and Control of Automatic Packaging Machine

This machine is made up of numerous parts that do the packaging by itself (JATON JW-600). The circuitry inside this piece incorporates an emergency stop switch, circuit breaker, servo motor, pneumatics, heat sealer, cutter, and relays. The S7-300 CPU is in charge of managing this system. S7 Graph, Ladder Logic, Statement List, Structured Control Language, and Function Block Diagram supported programming languages.

Packaging Way	Vertical sealing and end sealing
Weight of powder	85kg
Conveyor	Front Roller Conveyor, Rear Belt Conveyor
Scrap Film Speed	0mm-25mm/min (Adjustable)
Power Supply	AC/3-phase 400V,50/60Hz
Air Pressure Source	6kg/cm^2
In-feed Roller Conveyor Motor	AC/3-phase, 400V, 4P,120W (with brake)
Out-feed Conveyor Belt Motor	AC/3-phase, 400V, 4P,120W (with brake)
Film Drive Motor	AC/3-phase, 400V, 4P,90W (with brake)
Heating Element	AC/single phase, 400V, 1200W
Site Heating Element	AC/single phase, 400V, 1100W
Working Table Height	650-680mm
Dimension length(mm)	600mm
Width(mm)	400mm
Height(mm)	120mm
Scrap Retrieve	Unwind film
Shrinkable Film Dimensions	W=750 m/m (max.)

Table 2.2 Operation and Simulation Results

2.9 Labour-intensive Operations Using Color Detection

[8] automation is frequently employed for improved speed, accuracy, and effectiveness in a broad range of sectors and reduces the risk of danger. In general, the manufacturing business utilizes size, weight, form, height, and colour, a material packing and sorting approach. The sorting process in the industry is now commonly handled manually, leading to human error problems. Low-cost and easy-to-consume industrial automation must be created, dependable, convenient to use, and more precise. The Programmable Logic Controller (PLC) is a form of programmable machinery to control the machine's functioning. It is often utilized in industrial applications.

The ladder diagram programming and GX work2 Mitsubishi Melsec PLC are utilized in this article to control multi-Maschine activities using product-sort and product-colour packing. Three DC conveyor engines, single solenoids, proximity sensors, inductive sensors, and limit switches have been employed in multi-machine operations. To identify goods, colour-based proximity sensors are used. The machine contains an emergency button and an alert system to help troubleshoot. HMI is a device control and monitoring interface that enables easy contact with operators and user-friendly applications.

HMI uses a GP-Pro EX4.0 configured Schneider Pro-face. The PLC was equipped with a ladder diagram and hardware tested to imitate the device. MELSEC PLC may communicate for product sorting and packing based on the test findings with the HMI and power multi-operative machines. The machine can colour-select and load metal objects and remotely monitor and control the packaging equipment via an HMI.

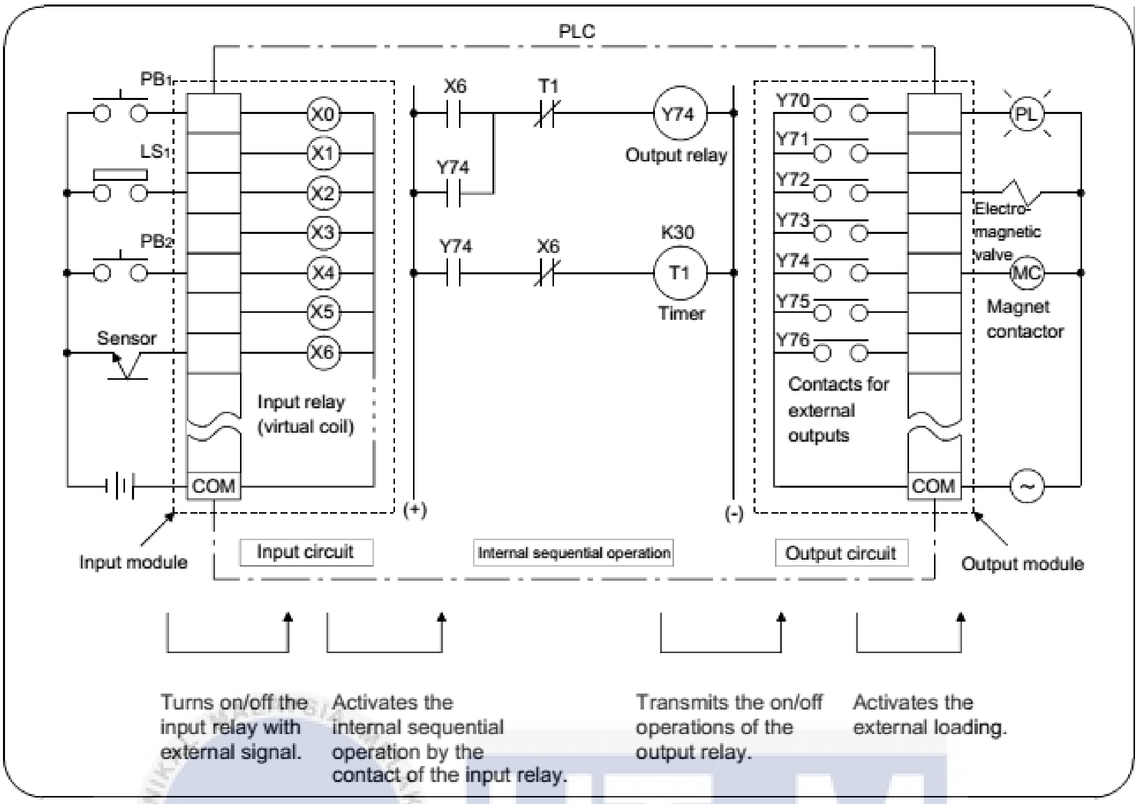


Figure 2.16 MELSEC PLC configuration.

PLCs employ "input" terminals to identify "high" and "low" logical states from sensors and switches. "High" and "low" output terminals are available from which it transmits power signals to switch on and off lights, solenoids, contactors, tiny motors, and other devices. Block schematic of the Pro-face Remote HMI automation packaging equipment is shown in Figure 2.17.

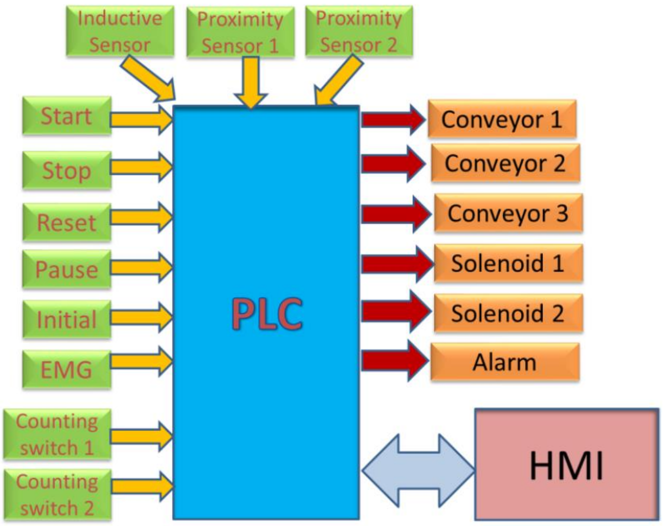


Figure 2.17 Block diagram of automation packaging system Pro-face remote HMI

In figure 2.18, you can see a simulation of the automated packing system using FluidSim. Until then, this application will imitate the sequence diagram.

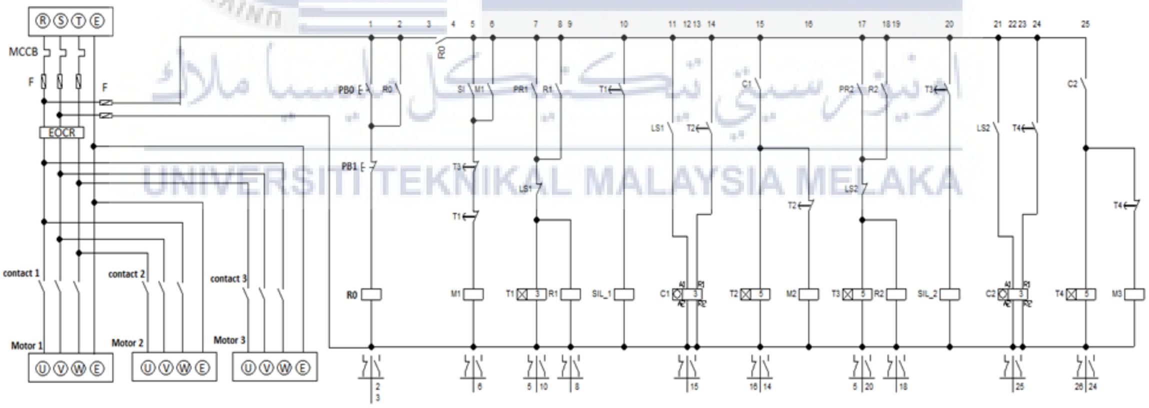


Figure 2.18 Wiring diagram of the designed automation packaging system.

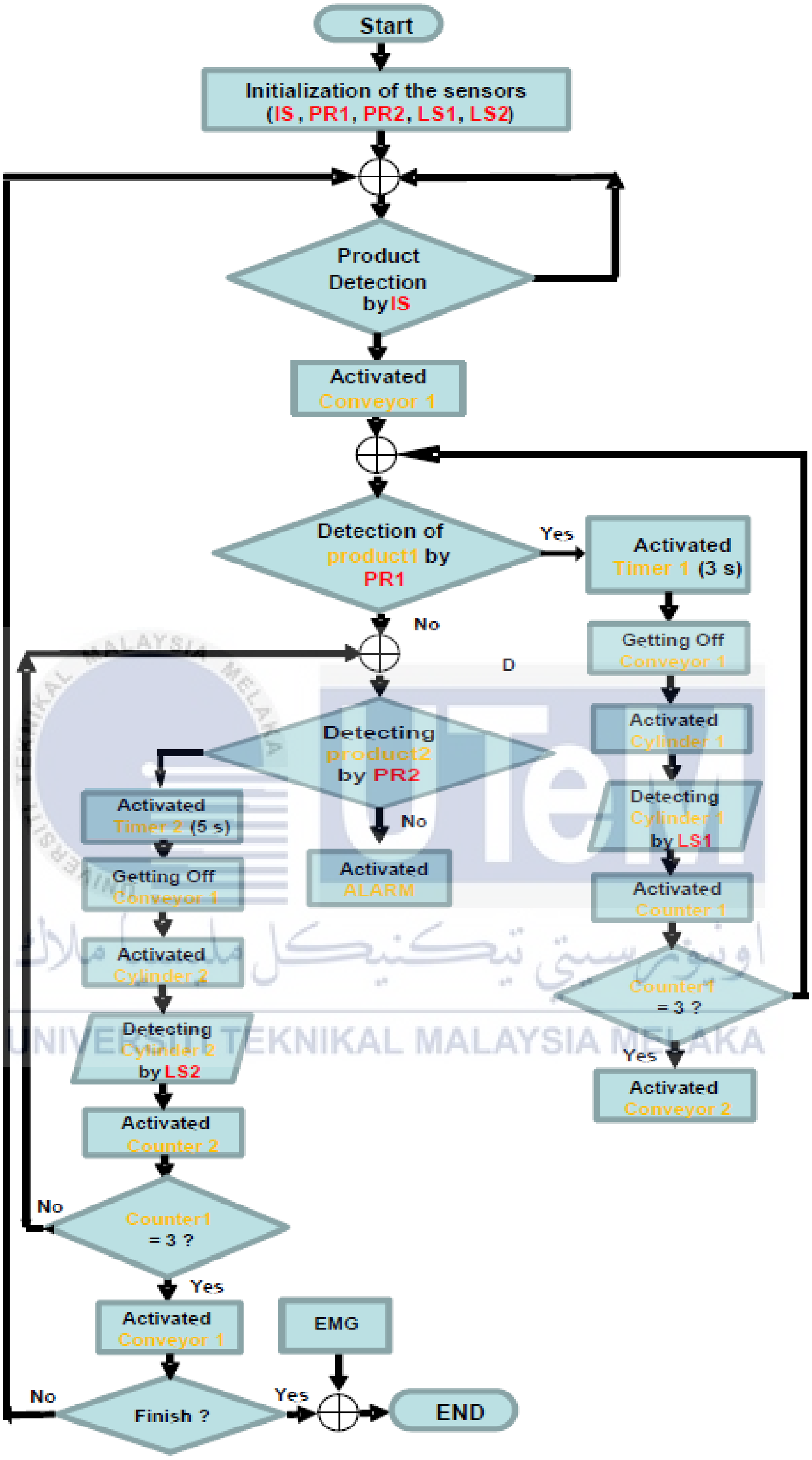


Figure 2.19 Flow chart of the automation packaging system's operation

2.10 Programmable Logic Controller and HMI Were Used to Design the Control and Monitoring System for The Boiler Wastewater Treatment Process (Human Machine Interface)

One of the facilities and systems employed in the manufacturing business, according to this project [9], is the wastewater treatment plant (WWTP). This system treats wastewater from boiler machines, which create steam to assist manufacturing enterprises tire and tube production operations, and is the subject of our study. The effluent from this boiler machine must be cleaned before being released into drains since it is alkaline and includes hazardous substances to the ecology and the atmosphere.

In this situation, the pH standard of water is neutral, ranging from 6 to 9, and it is evident in appearance. The approach does not match the standards; as a result, the consistency of the process water may be compromised, leading to water discharged into drains or bodies of water to breach regulatory standards. Consequently, we investigated the possibility of developing a system for regulating and monitoring the wastewater treatment plant's process autonomously. Sensors and actuators are connected to the control system's modular PLC.

This device may also be connected to a PC (Personal Computer) as a monitoring system, allowing for continuous monitoring of the process. HMI (Human Machine Interface) software created the user interface. Because some characteristics lead to a more attractive look, this is the case. With this technology, the boiler wastewater treatment process is more dependable and effective in keeping pH requirements, and it can be managed in real-time.

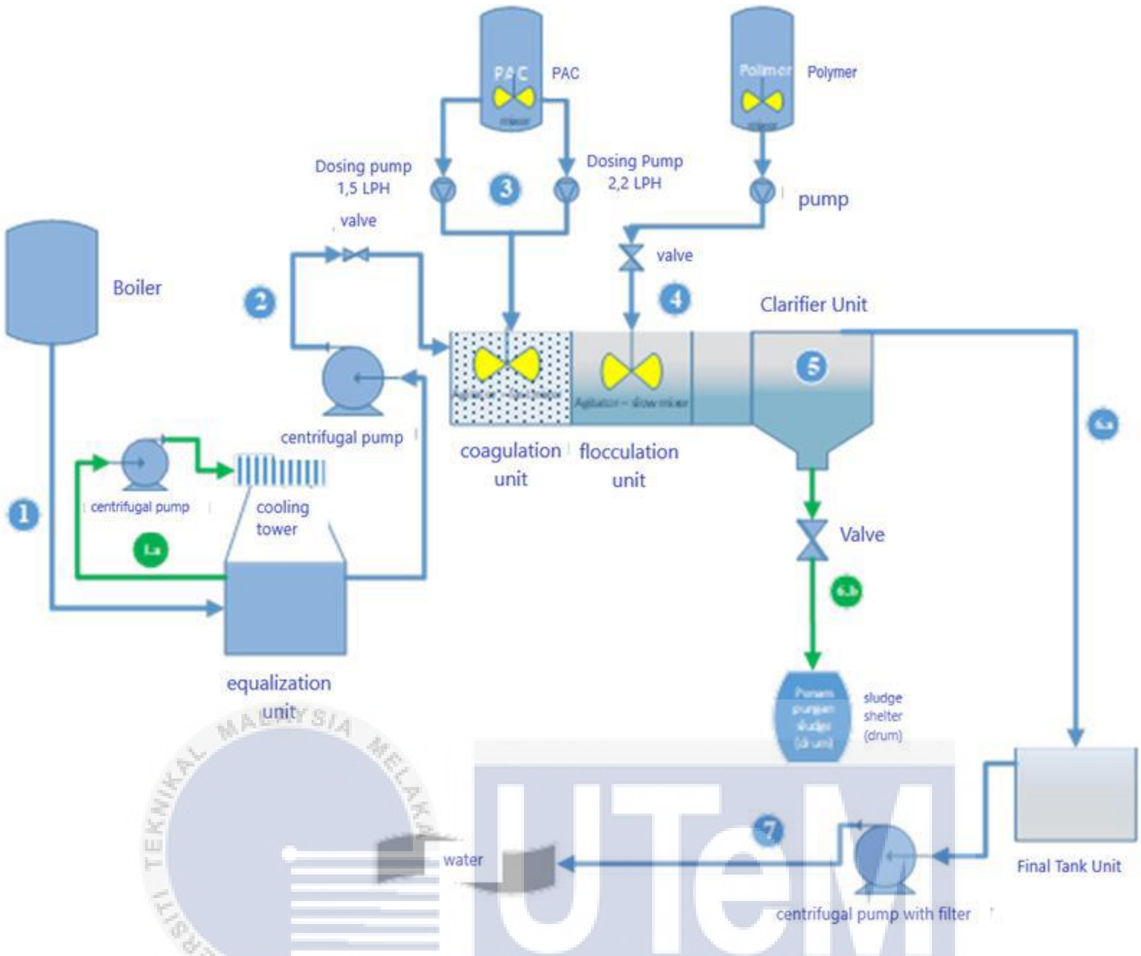


Figure 2.20 Work Process Flowchart

Boiler wastewater treatment systems include wastewater treatment tools and treatment units. The wastewater treatment unit has equalization, coagulation, flocculation, clarifier, and final tank units. Figure 2.21 shows a job flowchart.

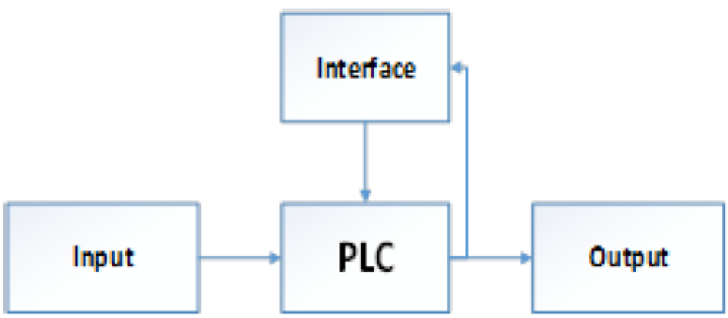


Figure 2.21 Diagram Block of Control System Design

PLC design, electrical design, and module and device requirements all go into the design of the control system. The block diagram in Fig. 2.22 illustrates a control device construction.

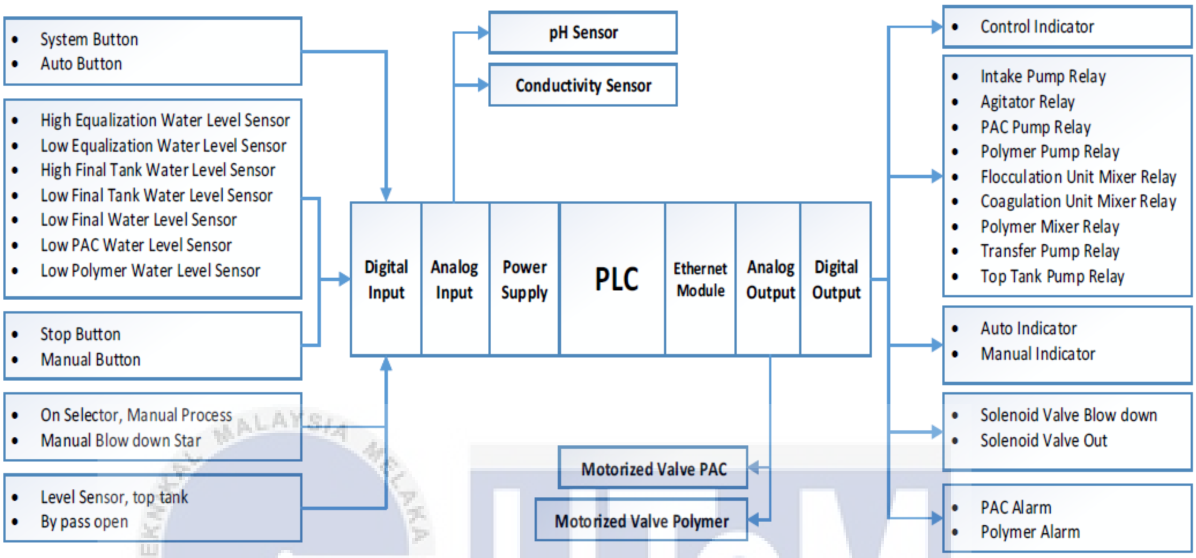


Figure 2.22 Input-Output Block Diagram of PLC

2.11 PLC and SCADA are Used to Automate Pressure Monitoring and Control

In many industrial processes, it has been shown that pressure control and management are more significant. [10] However, the analysis and monitoring of the site of the leaking of pipes are presently challenging for enterprises. The facility must thus be shut down and maintained extensively. The automated PLC and SCADA operations are crucial to the continued running of the system. Pipeline protection by pressure transmission in a 1-meter pipe is given in this project. To measure the flow rate, connect the pressure transmitters at the beginning and finish of the tube.

This may be converted into an analogue signal using pressurization transmitters. A level-based PLC can regulate the load. By monitoring readings and every step using a pressure transmitter to detect the issue, the whole system is sent to the automation system through PLC and SCADA.

The fundamental components shown in the figure below are:

a) Air compressor

b) PLC (Programmable Logic Controller)

c) SCADA or HMI and Pressure transmitter

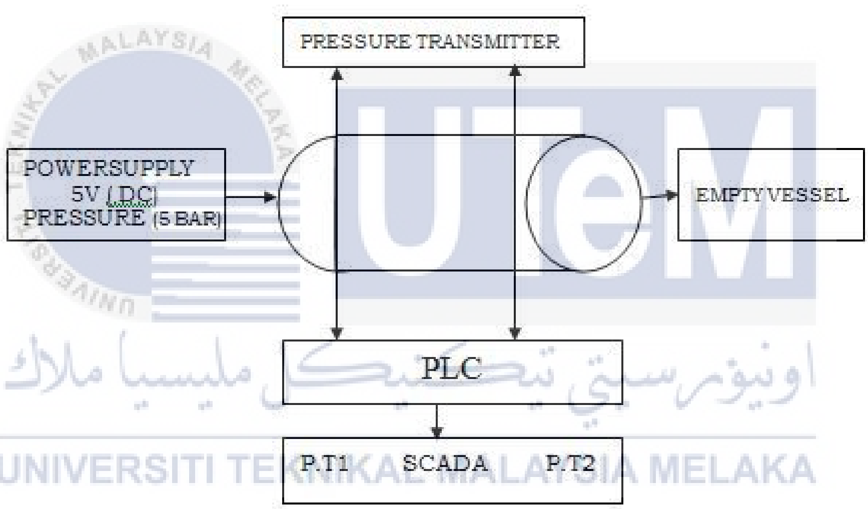


Figure 2.23 Block Diagram of Proposed System

PLC Working:

a) Step 1: Testing input status

b) Step 2: Programming execution

c) Step3: Checking and Correction of output status

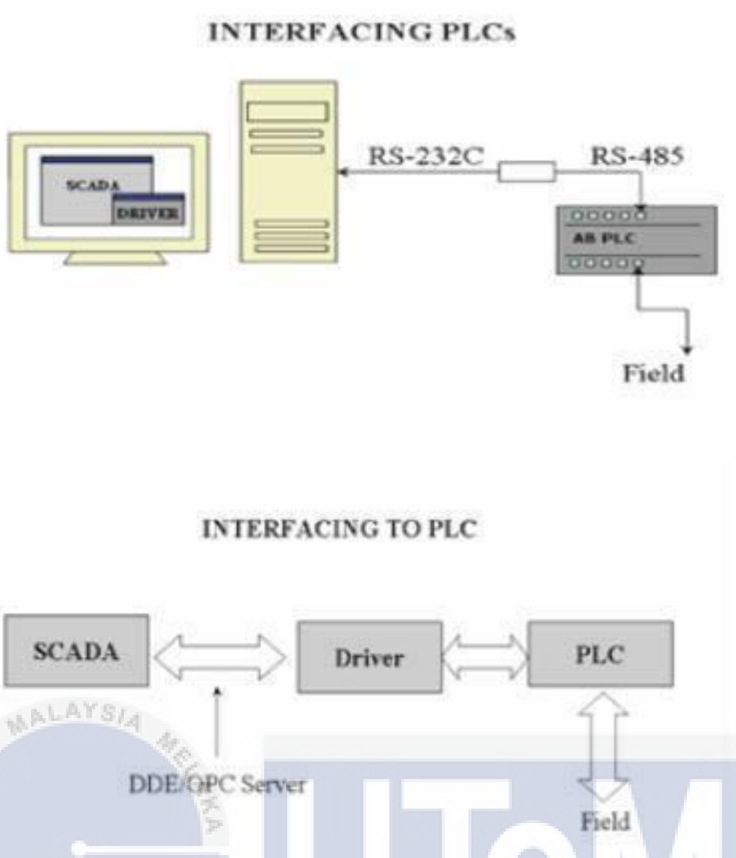


Figure 2.24 Interfacing PLC

Figure 2.23 shows the interface between the input field and the PLC and the interaction between the PLC and the SCADA through the motor. In this scenario, the input field is connected to the PLC through the cable, whilst the driver is connected to the PLC through the RS-485 cable and the SCADA device through the RS-232 connection.

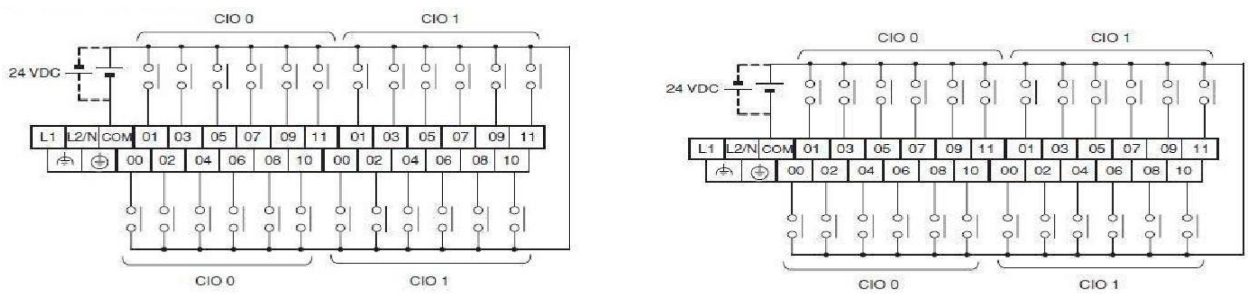


Figure 2.25 Upper Terminal Block & Lower Terminal Block

Upper and lower terminal block input wiring is shown in Figure 2.24. All 24-way, standard inputs for the X and XA CPU Units. Use a sufficiently enough powerline to power the COM terminals. Terminals with different port numbers are great for simple wiring.

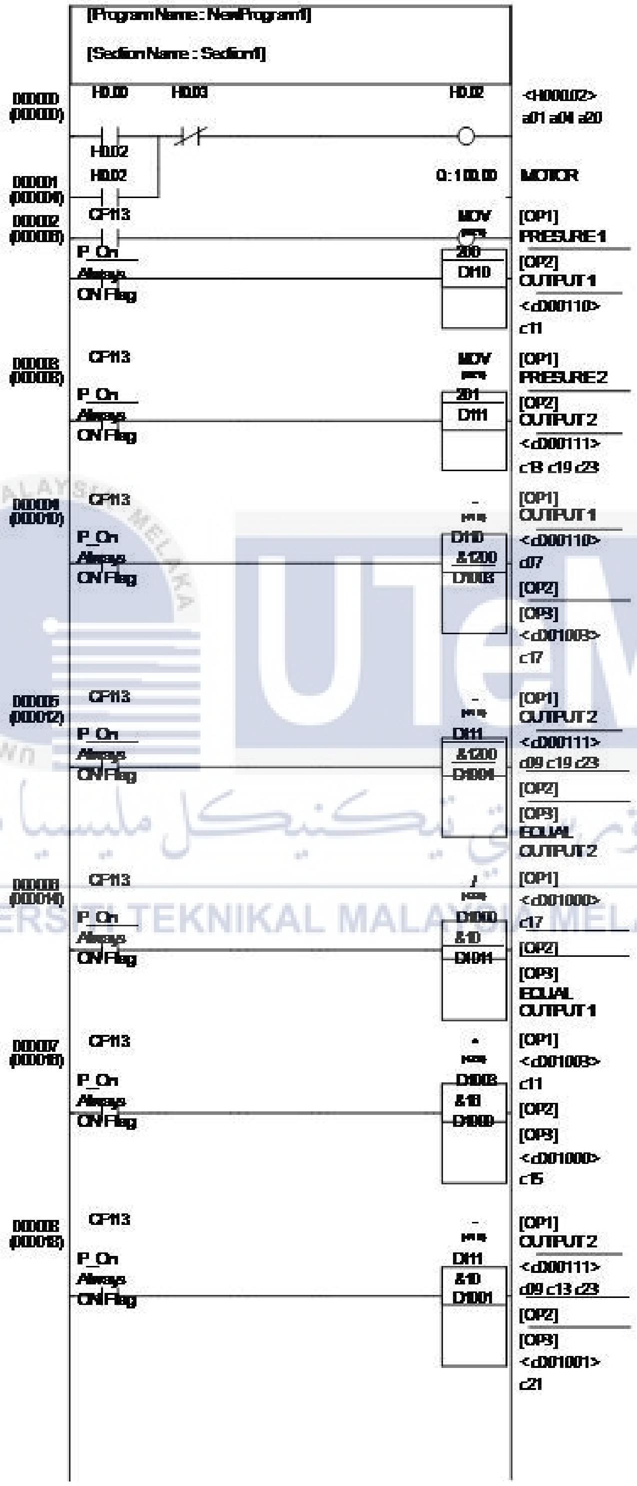


Figure 2.26 PLC Program

2.12 Summary Related Work

Table 2.3 Summary Related Work

Author	**Title**	**Software**	**Sensor / Hardware**	**Controlling and Monitoring System**	**Function**
Eammaraja B, Vignesh M, Arikrishnan M, Shimoni M	Monitoring and Controlling of Components in a Conveyor using PLC and SCADA	Wonderware Intouch SCADA	Delta PLC, Conveyor Belt, DC Motor, Proximity Sensor, Switch Mode Power Supply, Relay, Miniature Circuit Breaker, Switch.	Delta PLC, Wonderware Intouch SCADA	Using a PLC and SCADA to Control Components on a Conveyor

Nur Alif Mardiyah, A. Hakam Sudraja2, Amrul Faruq	PLC Human Machine-Interfaces Based System for Vietnam Drip Coffee Maker Application	CX-Programmer, NB-Designer	Omron CPM2A-60CDR-A PLC, PLC, HMI Omron NB7W-TW00B	Omron PLC, Human-Machine Interface (HMI)	Making the Drip Coffee Application System for Vietnam
Raihan bin Mofidul, Md. Shahadath Hossain Sabbir, Mohammad Shaifur Rahman, Amit Kumer Podder	Design and Implementation of Remote Controlling and Monitoring System for Automatic PLC Based Packaging Industry	LOGO! Soft V8	DC Motor, Arduino Uno, Bluetooth Module, Conveyor Belt, IR sensors	Siemens LOGO! 230 RCE PLC, Android-based PLC, Mobile application	A Process Control System for Automatic, Programmable PLC-Based Packaging Plants

Amanpreet Kaur, Er. Pardeep Singh	Paper Machine Automation using PLC, VFD's and HMI	PLC	PLC, VFD's, HMI	PLC, HMI or SCADA	Operation of a Paper Machine on an Automated Basis
Shreenivas Pai, Neha Bansal, Karna Desai, Archana Doshi, Devendra Moharkar, Mihir Pathare	Intelligent PLC-based Transformer Cooling Control System	PLC	50 W SMPS, PLC, 8 Contact Relays (24V DC), Indicators, 1.7W 3100 Rpm Brushless DC Fans, And 24V DC Toggle Switches.	Programmable Logic Controller (PLC), MODEL NO: SCHEMATIC S7-200 SMART ST20	Temperature Control System

Awadallah Sulieman Rahama, Dr. Dalia Mahmoud	Control of Induction Motors by Using Programmable Logic Controllers (PLC)	Siemens ladder logic programming S7-200	HL Sensor, L-L Sensor, PLC, Motor Starter, Motor	Programmable Logic Controller (PLC),	Induction Motor Control and Regulation
Hnin Yu Lwin, U Hla Myo Htay	Design and Simulation of Automated Packaging Machine Process Control by Using PLC	TIA Portal	Emergency Stop Switch, Circuit Breaker, Servo Motor, Pneumatics, Heat Sealer, Knife (Cutter) And Relays.	S7-300 CPU	Automated Packaging Machine Process Control

F Fathahillah, M Siswanto, M Fauziyah, R Parlindungan, R I Putri and Y-G Roh	Implementation of Programmable Logic Controller in Multi-Machine Operations with Product Sorting and Packaging Based on Color Detection	GX work2, GP-Pro EX4.0.	Three DC Motors Used for Conveyors, Two Single Solenoids, Proximity Sensors, Inductive Sensors And Limit Switches.	Mitsubishi Melsec PLC, (HMI)	Multi-Machine Operations with Color-Based Product Sorting and Packaging
Syahril Ardi, Sirin Fairus, Sekar Sukmaningrum	Design of Control and Monitoring System for Boiler Wastewater Treatment Process Using	HMI Wonderware Intouch	Sensors and Actuators	PLC with A Modular Type, PC (Personal Computer)	Wastewater Treatment System to Control and Monitor the Boiler Wastewater Treatment Process

Ande Venuprasad, Yeole Shivaraj Narayan	Automatic Monitoring and Controlling of Pressure using PLC and SCADA	HMI	Omron Sysmac CP1H	PLC and SCADA	Pipeline Pressure Is Monitored and Regulated Automatically.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This part will clarify the representation and justification of the segment, practical methods and techniques toward the endeavor, startup plan, and strategy used to achieve a machine sorting system. Henceforth, a better and straightforward explanation will be represented in the flowchart, which clarifies progress. Similarly, the material used and presentational data on how well the enterprise's sorting machine design work will be discussed.

3.2 Project Planning

Project planning is a systematic phase in project management where documentation is necessary to achieve the target mission. The project plan defines clearly how to execute, monitor, control and finalize the project. In addition, documentation covers all activities needed to categorize, prepare, and organize additional project process flow plans.

3.3 Project Flow Chart

A flow chart is a graphical or symbolic representation of a process. A different image corresponds to each step of the method and provides a concise explanation of the process step. The flow chart symbols are connected by bolts that indicate the operation's flow heading. One of the most significant advantages of a flowchart is its ability to visualize various stages and process steps in a single document. People throughout an organization can easily understand the work process while determining which steps are unnecessary and which progress should be improved. The flowcharts in Figures 3.2 and 3.3 depict the project process flow.

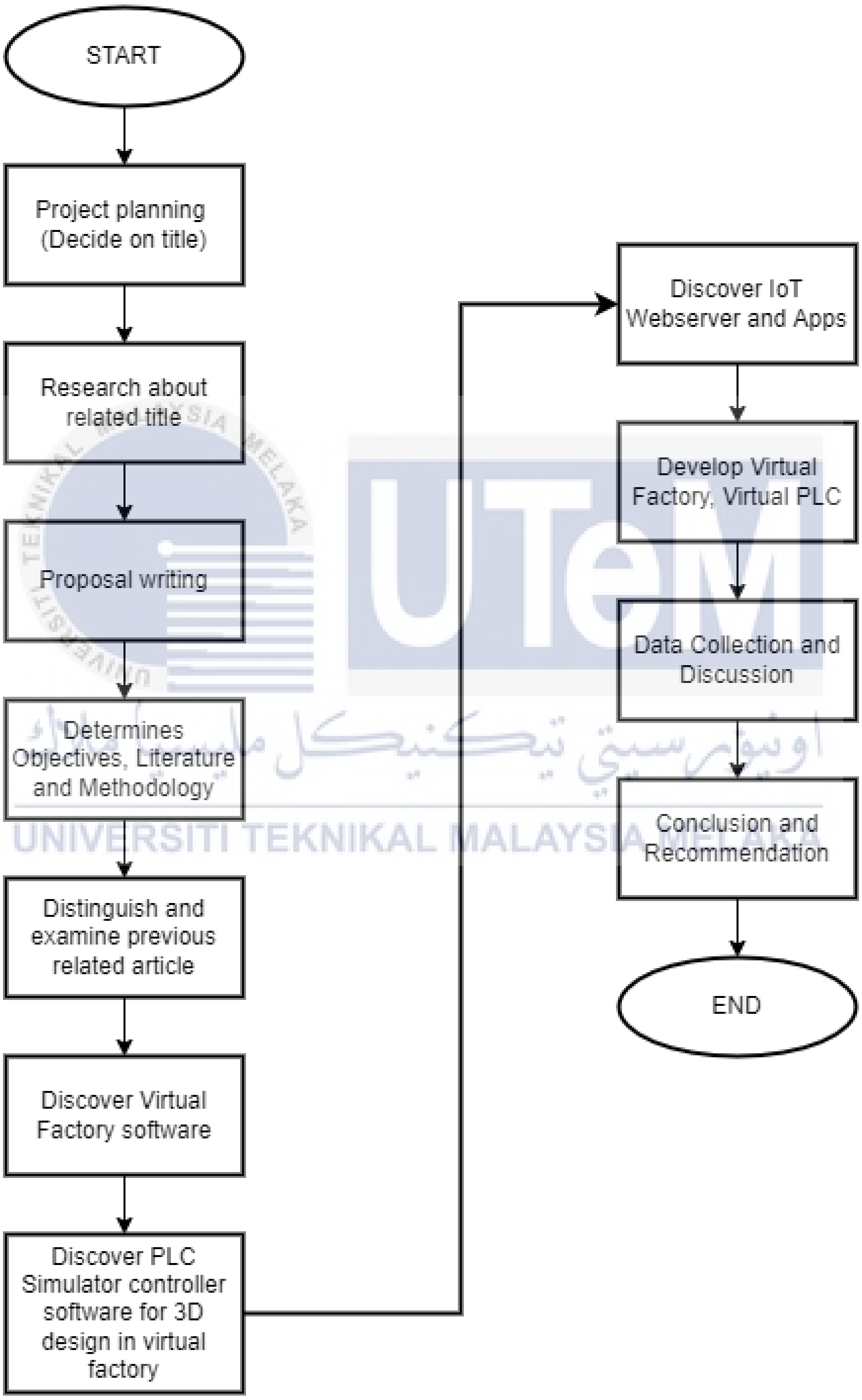
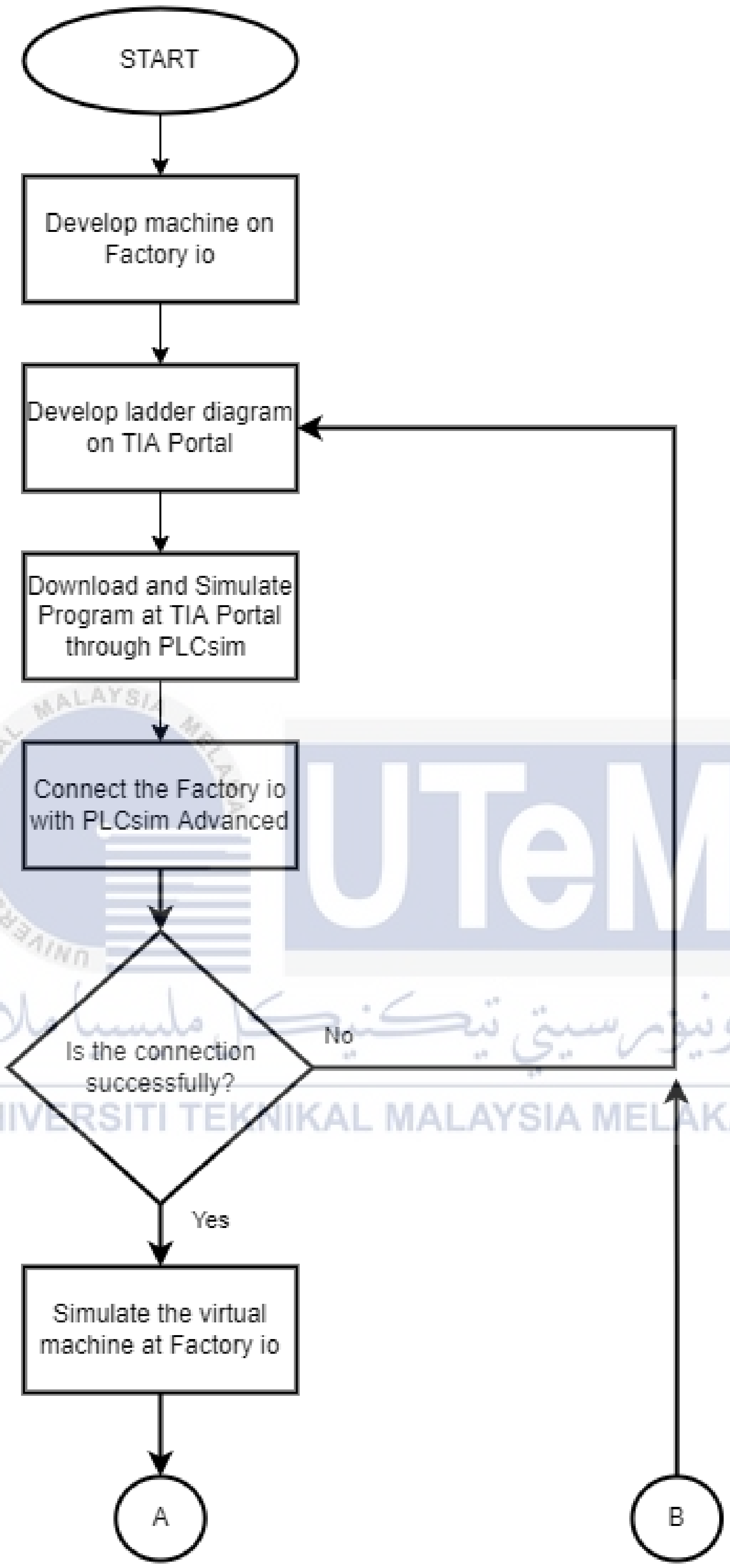


Figure 3.1 Project Flowchart


START
Develop machine on Factory io
Develop ladder diagram on TIA Portal
Download and Simulate Program at TIA Portal through PLCsim
Connect the Factory io with PLCsim Advanced
Is the connection successfully?
No
Yes
Simulate the virtual machine at Factory io
A
B

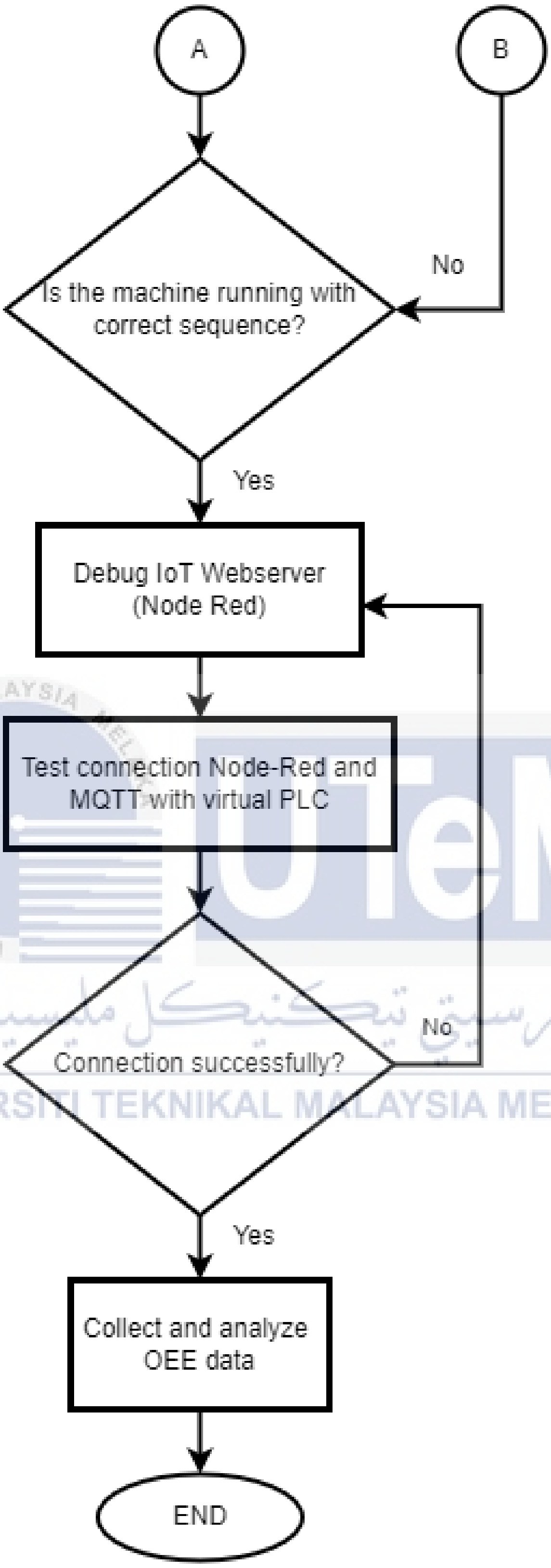


Figure 3.2 Project Process Flowchart

3.4 Project Design

The project design discusses the machine designed at the factory io, the virtual controller, and the Internet of Things (IoT) that has been integrated into the project.

3.4.1 Virtual Factory

The MAP 201 machine has been designed using Factory io software, as seen in Figure 3.3. It consists of two heights, high and low, settings. There are have one roller conveyor of 4-meter-long act as the product transportation. Therefore, the project design also has two pneumatic cylinders that will sort the product high or low height to the chute conveyor low. In addition, three low conveyor chutes were used, two of them for route products rejected. The rest, for route products that had been accepted. Next, a light emitter and light receiver were also used to recognize the product's height. Furthermore, the project design has two diffuse sensors used to detect high and low height products. After that, the main controller for the MAP 201 machine consists of the start push button and stop push button, as shown in Figure 3.4.

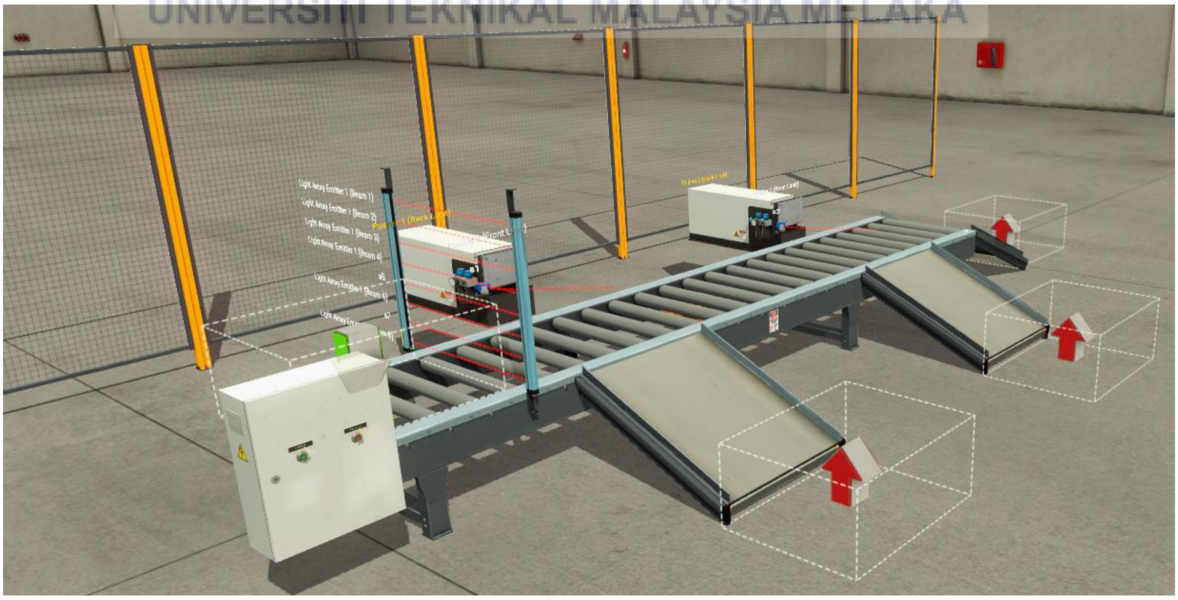


Figure 3.3 MAP 201 machine designed at Factory I/O

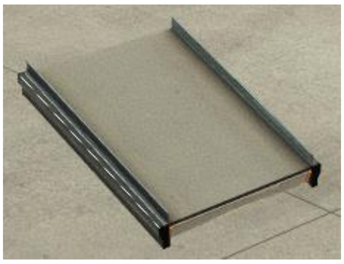
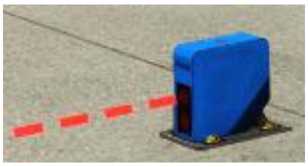
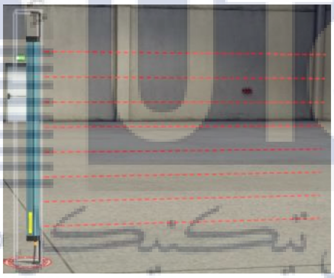
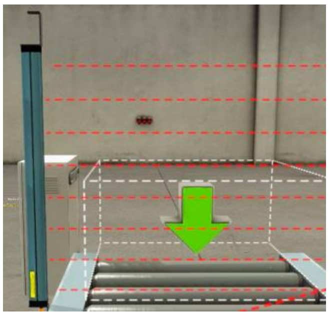
Figure 3.4 Main controller for MAP 201 machine

3.4.1.1 List of the equipment, sensors, and push buttons

Table 3.7 shows the list of the equipment and type of the sensor and the type of the push button used in the design of the virtual sorting machine.

Table 3. 1 List of the main equipment and sensor used

List of the equipment	Diagram	Function
Roller Conveyor 4m		Box or collection product transportation
Pneumatic Cylinder		To sort the high or low height product

Chute Conveyor Low		The product sorted will be slide on this slider
Diffuse Sensor		Detect the presence of the product. It can be used as a product counter
Light Emitter		The emitted light is interrupted or reflected by the sensing object, and it changes the amount of light that arrives at the Receiver
Light Receiver		Detects the change at the emitter and converts it to an electrical output

Start Push Button		To run the machine
Stop Push Button		To stop the machine

3.4.1.2 Type of product

The type of material used is seen in Table 3.2. Two types of material will be sorted: non-metal material and metal material. Therefore, stackable boxes store the product sorted and deliver it to the end process.

Table 3.2 Type of the Product

Type of product	**Diagram**	**Function**
High box product (L)		A product that needed to sort

Low box product (M)		A product that needed to sort
Pallet		Carry the product and delivery it to the end process

3.4.1.3 List of input and output for the machine designed

The input and output for the machine design have been listed by following the specific address at the Factory io software where (I) stands for digital input, (M) stands for memory use for sequence, (Q) stands for the digital output as shown at Table 3.3.

Table 3.3 List Input and Output of the machine

BIL	INPUT	ADDRESS	OUTPUT	ADDRESS
1	Start Button	I0.0	Silo	Q0.0
2	Stop Button	I1.2	Conveyor	Q0.1
3	Light Emitter for low box product = S7	I10.1	Pusher 1 = Cylinder 1	Q0.3
4	Light Emitter for high box product = S5	I10.2	Pusher 2 = Cylinder 2	Q0.4

5	Inductive Sensor 1 = S1	I10.4		
6	Inductive Sensor 2 = S2	I10.5		
7	Pusher 1 (Front Limit) = Cyl1_F	I10.6		
8	Pusher 2 (Front Limit) = Cyl2_F	I10.7		
9	Pusher 1 (Back Limit) = Cyl1_R	I1.0		
10	Pusher 2 (Back Limit) = Cyl2_R	I1.1		
11	Step 0	M0.0		
12	Step 1	M0.1		
13	Step 2	M0.2		
14	Step 3	M0.3		
15	Step 4	M0.4		
16	Step 5	M0.5		
17	Step 6	M0.6		
18	Step 7	M0.7		
19	Memory Initial Start	M100.0		
20	Memory All Stop	M40.0		
21	NR Start Button	M1100.0		
22	NR Stop Button	M1200.0		
23	Tag_1	M1000.0		

3.4.1.4 Grafcet Sorting by Height Machine Sequence

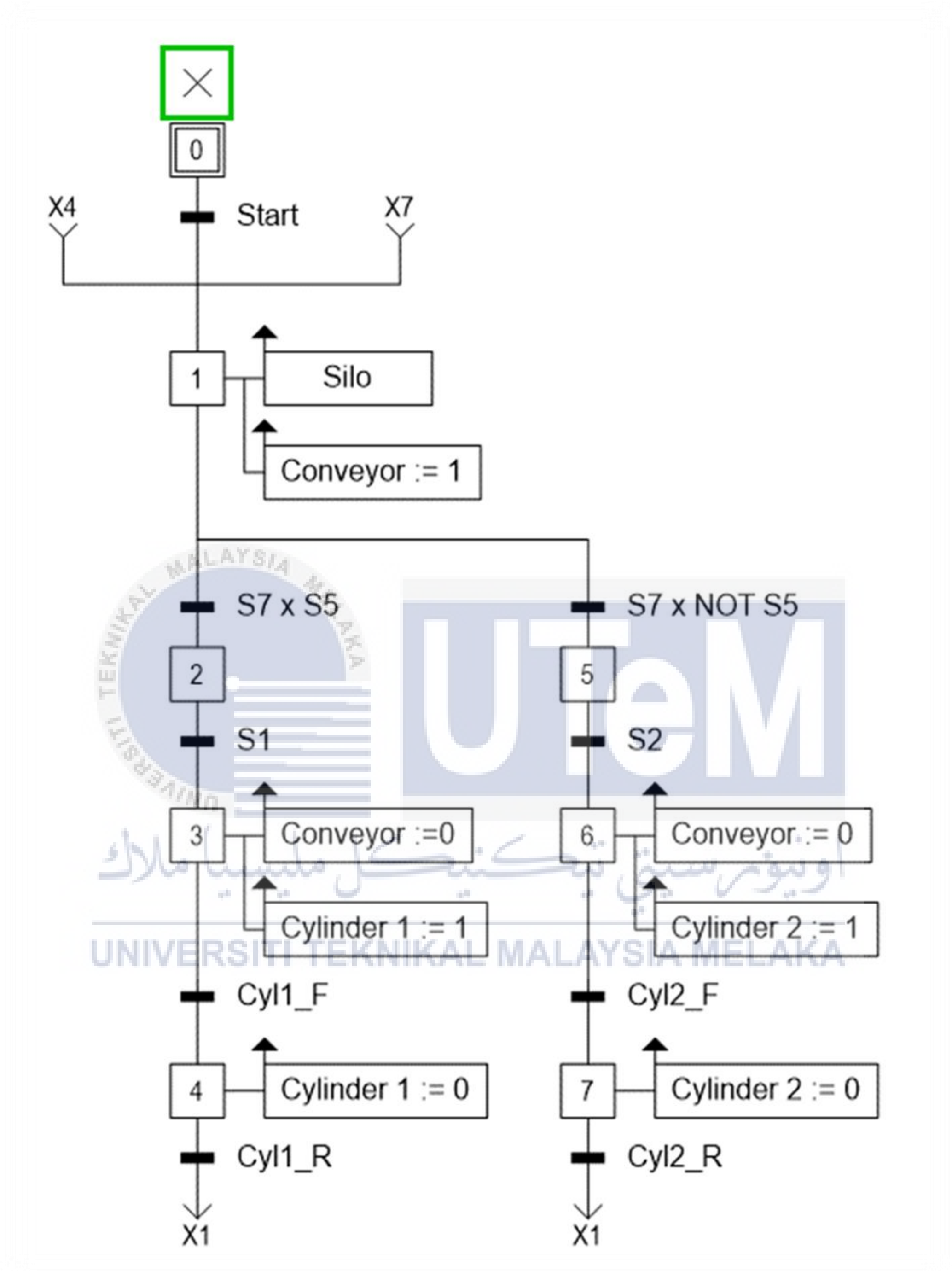


Figure 3.5 Grafcet Sorting by Height Machine

The Sorting by Height Machine has been designed, as shown in figure 3.7. There are seven sequences, nine transitions and eight actions. First, the machine will start operation from step 0 to step 1. Next, step 1 will do 2 actions, silo and conveyor will be turned on. Then, it will divide into two parts; go to step 2 and step 5 to recognize the height of the product. Proceed with step 2, and it will go through transition S7 x S5 means it will recognize the high box product (L). Also with step 5, it will go through transition S7 x $\overline{S5}$ means it will recognize the low box product (M). Following the transition, S1 means the diffuse sensor will detect the high box product (L), while transition S2 detects the low box product (M). It will go through steps 3 and 6, which step with actions the conveyor will be turn off, and pusher extend to sort the product. Afterwhile, they will undergo the transition Cyl1_F and Cyl2_F to go to step 4 and step 7. The actions will make the pusher will retract. Lastly, following transition Cyl1_R and Cyl2_R, they will go back to step 1 and loop the sequence.

3.4.2 Virtual Controller

The virtual controller is a virtual Programmable Logic Controller (PLC) that works in the same way as a real PLC. As illustrated in Figure 4.6, Siemens (Tia Portal) software is used to develop or create a program for the machining process. The program will then be downloaded to (Siemens) PLCSIM Advanced, provided with a virtual PLC to control the machining process. As a result, Figure 3.7 depicts the two software's interactions.

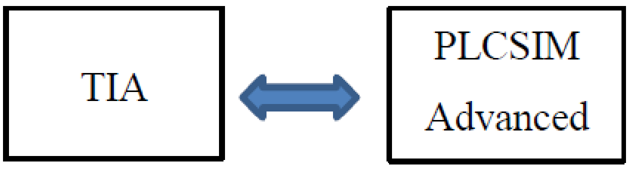


Figure 3.6 Virtual Controller Block Diagram

3.4.2.1 Siemens (Tia Portal) Software

As shown in Figure 3.8, the PLC module S7-1200 version was used to act as a virtual PLC for the machine. There are two digital input slots (16x24VDC) and one analogue input slot (8U/I/RT).

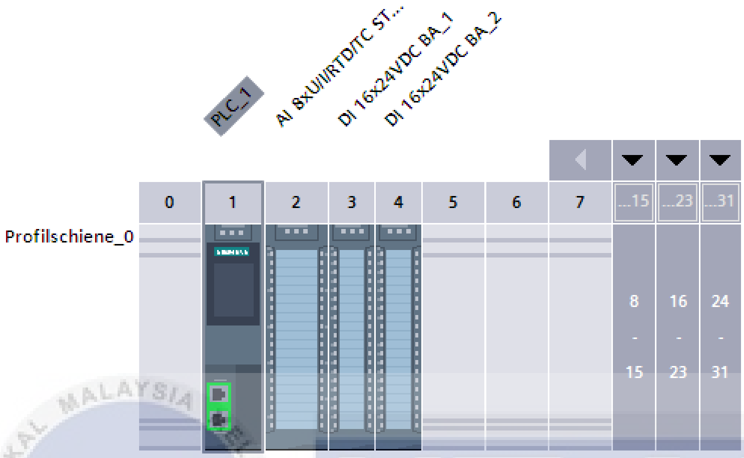
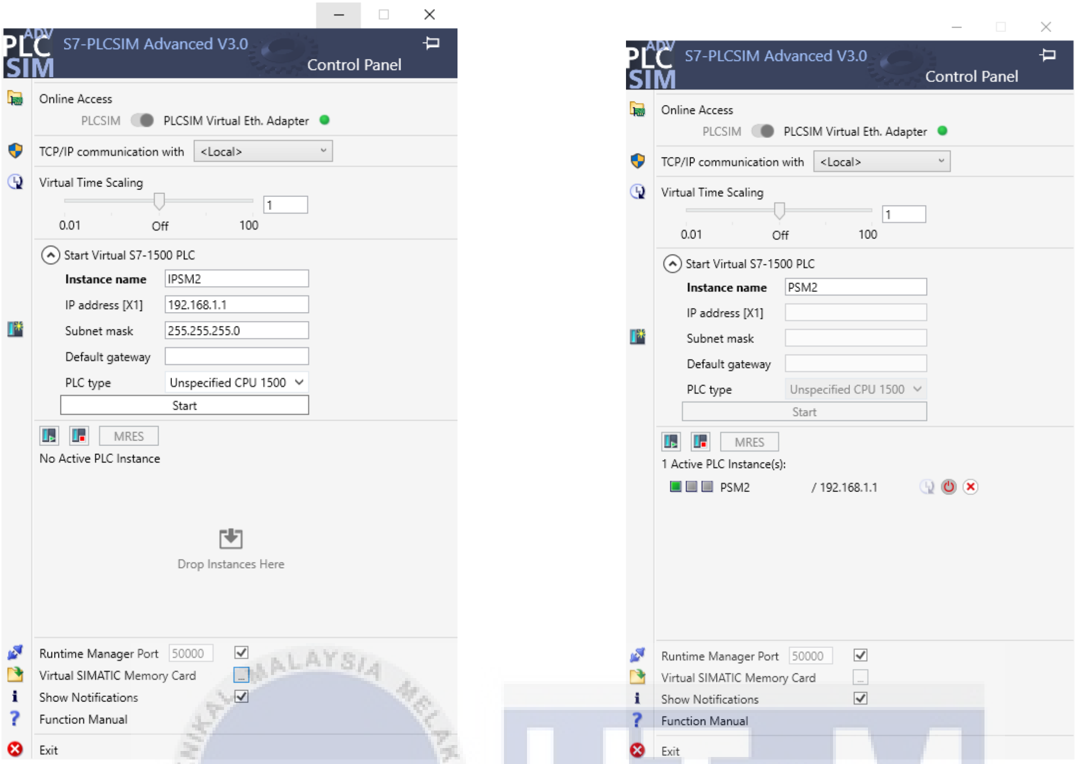


Figure 3.7 Siemens S7 1500 Virtual PLC

3.4.2.2 Siemens (PLCSIM Advanced) setup

In the PLCSIM Advanced V3.0, there are two types of online access: PLCSIM and PLCSIM Virtual Ethernet Adapter, as shown in Figure 3.13. If PLCSIM were chosen, the IP address for the PLC would be unable to connect to the internet, necessitating using an extension software such as Net-to-PLCSim software. As a result, if the PLCSIM Virtual Eth. The adapter was chosen, the IP address of the virtual PLC will be automatically accessible via the internet. Furthermore, the instance name was changed to PSM2, and the IP address and subnet mask were changed to 192.168.1.1 and 255.255.255.0, respectively. Furthermore, the IP address and subnet mask that has been configured must match the PLC configuration on TIA Portal. After all of the configuration was completed, the Start button was pressed, and the virtual PLC, which functions similarly to a real PLC, was created.



(a) (b)

Figure 3.8 PLCSIM Advanced setup (a) and Active PLC (b)

3.4.3 Virtual IoT Gateway

Virtual IoT Gateway is a high level of interoperability, redundancy, connectivity, pre-processing of data, aggregation of data, remote control, and management leads to the requirement for gateways such as Node-Red webserver.

3.4.3.1 Node-Red Webserver

Firstly, the Node-Red command was entered at Command Prompt (CMD) to run the Node-Red webserver, as seen in Figure 3.14. After that, the Node-Red server will be automatically running at http://127.0.0.1:1880/ as shown in Figure 3.11.

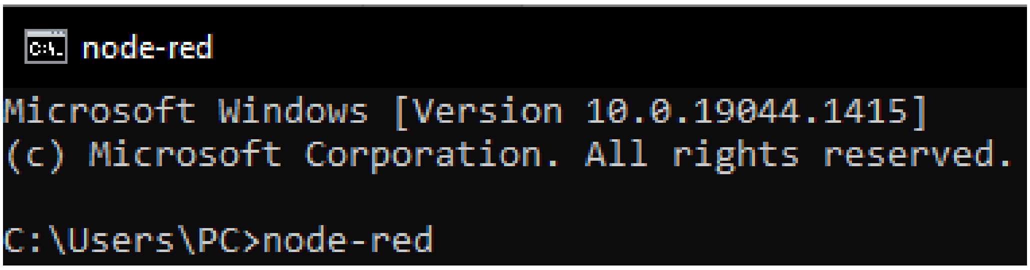


Figure 3.9 Node-Red command in Command Prompt (CMD)

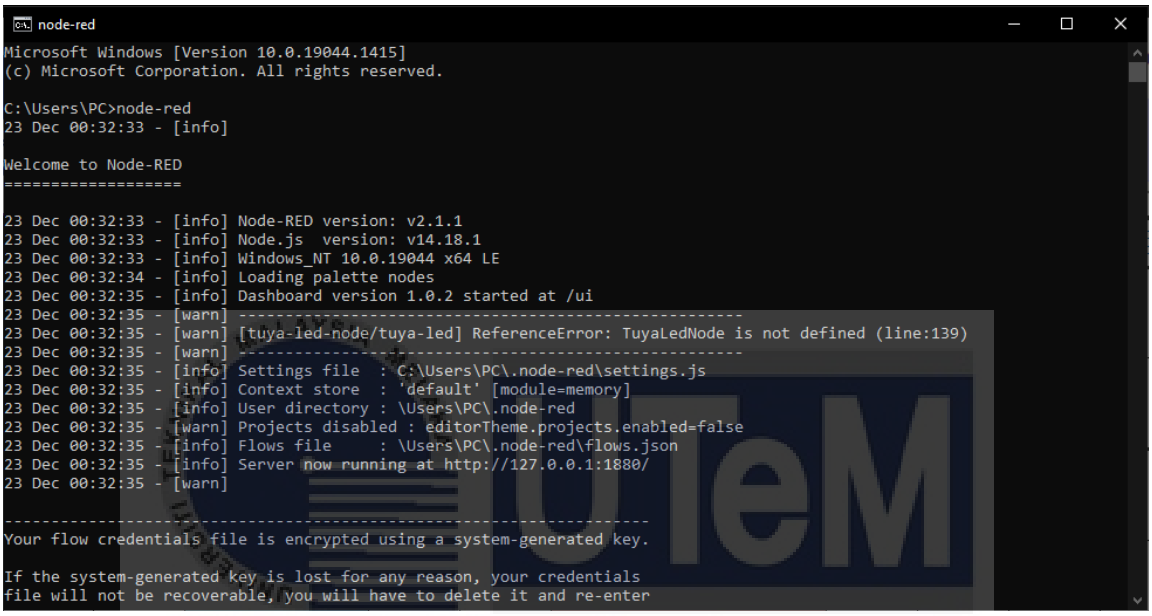
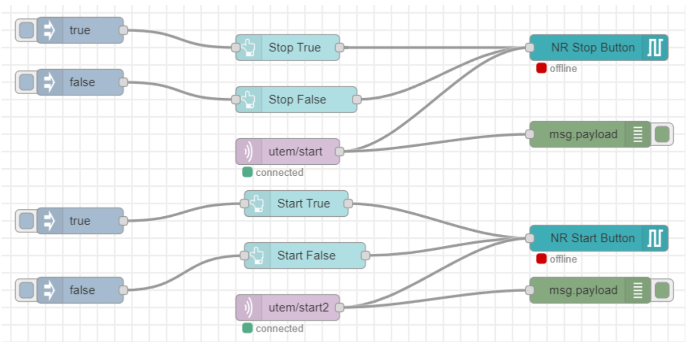
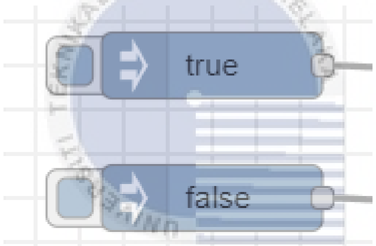
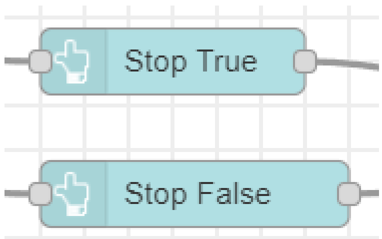
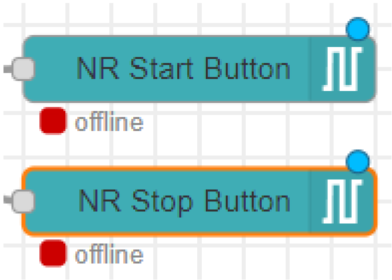
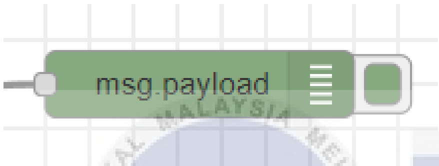
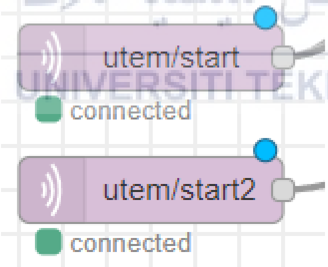


Figure 3.10 Server running for the Node-Red

3.4.3.2 Node-Red Webserver Nodes Flow

Table 3.4 Node-Red flow nodes

Node-Red nodes flow Diagram	Function
	
	**Inject node** The inject node's function will inject condition true or false at s7 out through button nodes. In other words, it injects a message into a flow either manually or at regular intervals. The message payload can be of various types, including strings, JavaScript objects or the current time.
	**Button** Adds a button to the user interface. It will display on the Node-RED dashboard. Rename the button to start, stop for true and false conditions.

	**s7 out** Writes to a memory area in a S7 PLC. These nodes start and stop the button at the TIA Portal ladder diagram, machine at Factory I/O.
	**Debug node** Displays selected message properties in the debug sidebar tab and optionally the runtime log. By default, it displays msg. payload but can be configured to display any property, the entire message or the result of a JSONata expression.
	**MQTT** Connects to a MQTT broker and subscribes to messages from the specified topic. Set the server to broker.hivemq.com and the port to 1883. Next, rename the MQTT as utem/start and utem/start2.

3.4.4 Controlling and Monitoring Apps or Software

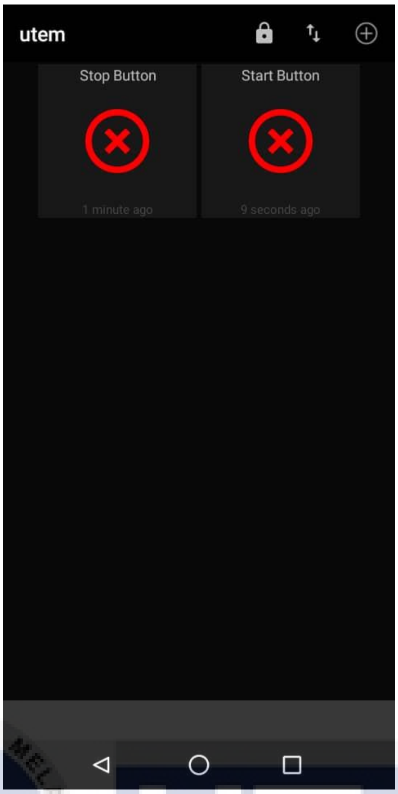
There are two ways to control and monitor this project: via Smart Devices or Web-Based. The Node-Red MQTT was used as a smart devices platform to control and monitor the machining process; besides, the computer users is to lock the OEE analysis data into the specific file target location that has been set at the Node-Red webserver in excel format.

3.4.4.1 Node-Red MQTT

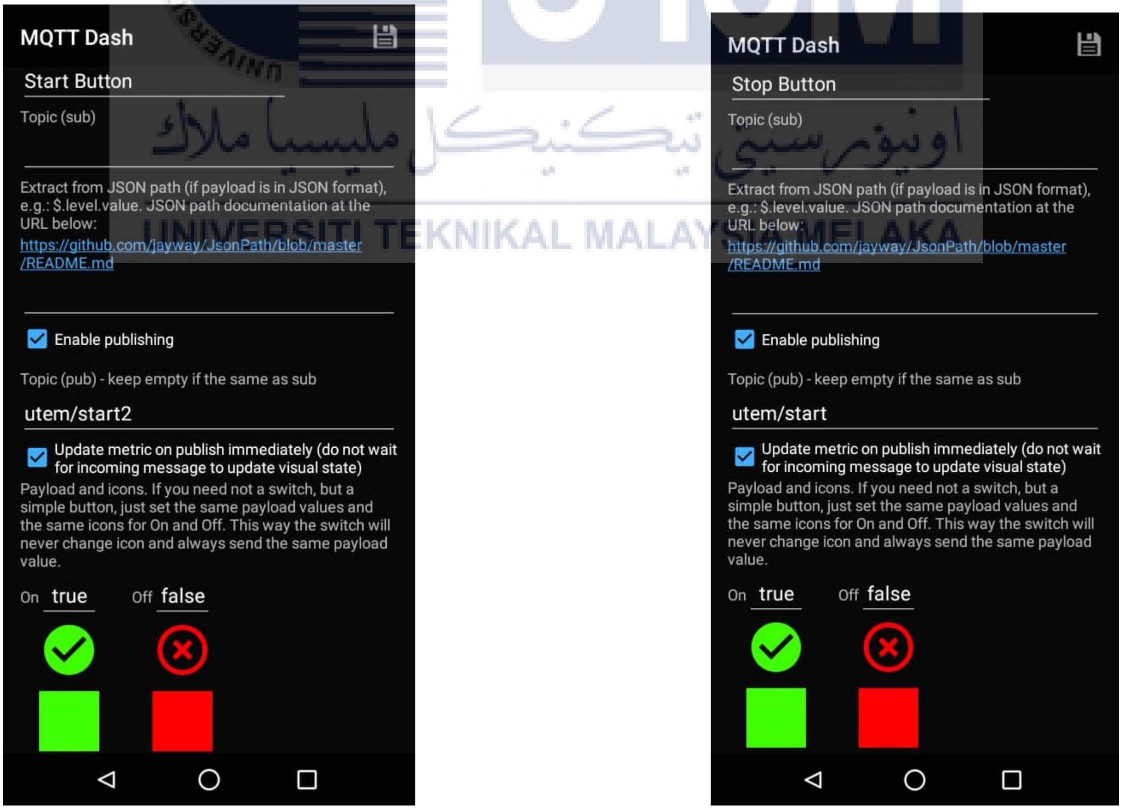
The configuration for the Node-Red MQTT has been set, as shown in Figure 3.13. The widget box of Button, LED, and Value Display was used. There are two buttons used: Start PB and Stop PB to start and stop the machining process. Therefore, two Led was used to act as an indicator for the machine, which means when the machine is running, the Green LED will be turned on, but when the machine is stopped, the Red LED will be turned on. The LED condition is shown at Table 3.5.

Table 3.5 Indicator Condition

Machine Status	Condition	Green Color	Red Color
System Run	High	ON	OFF
System Stop	High	OFF	ON



(a)



(b)

Figure 3.11 MQTT Dash Display (a) and MQTT Dash Configuration (b)

3.4.4.2 Node-Red Dashboard

One design at the Node-Red Dashboard is 'PSM II' as seen in Figure 3.15. Besides, the layout configuration for 'Controlling of the Machine Process' consists of (Machine Run/Stop), as shown in Figure 3.16.

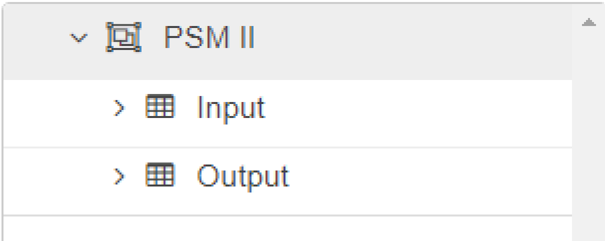


Figure 3.12 Node-Red Dashboard selection display

Figure 3.13 Controlling Machine Process Layout

3.5 Virtual Software Implementation Planning

The software used to achieve the goal is referred to as software implementation planning. The software was discovered while researching virtual factories and virtual PLC simulators relevant to this project.

3.5.1 Factory I/O Software

Factory I / O is the world's first flexible virtual factory 3D simulation software, taking industrial system simulation to new heights. This is due to Factory I / O's cutting-edge graphics, dynamic sound, and physics to entertain users in a realistic 3-Dimensional industrial environment. Users can also use this real-time sandbox to modify existing industrial systems or create new ones. The systems are then highly interactive and can be controlled by various new technologies such as PLC Simulator and Modbus. Figure 3.10 depicts the main menu of Factory I/O. Figure 3.11 depicts libraries containing virtual components such as a conveyor belt, raw material, sensor, and others.

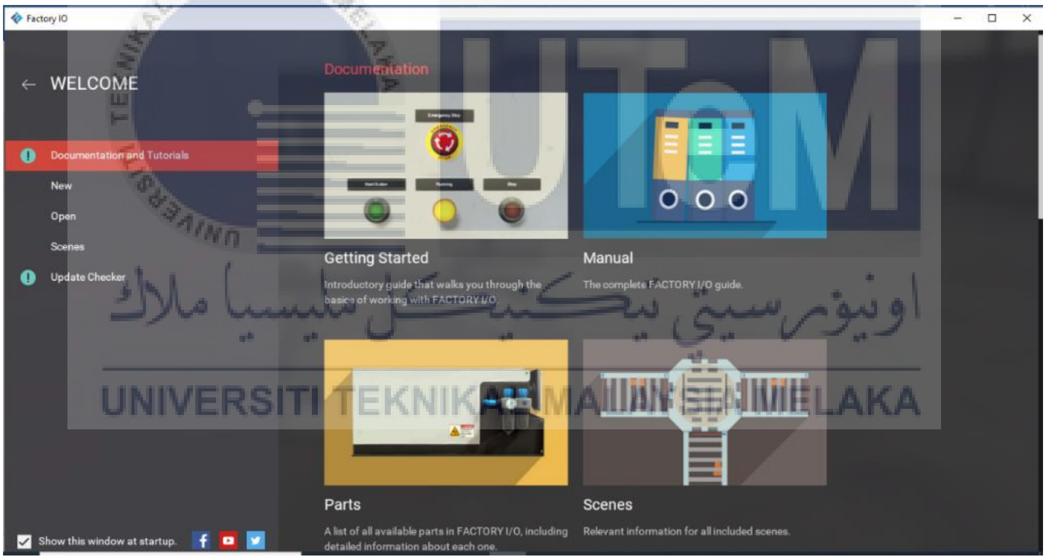


Figure 3.14 Factory IO Display Menu

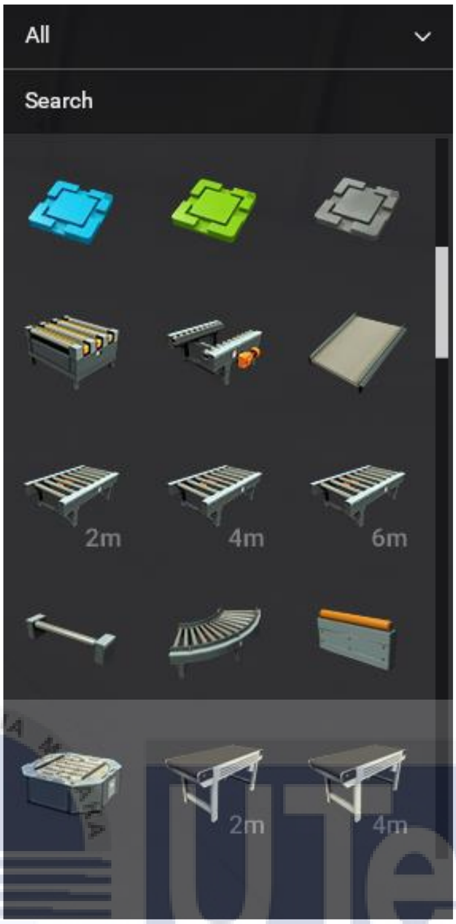


Figure 3.15 Factory IO Libraries

3.5.2 Tia Portal Software

Tia Portal is the Siemens Factory automation platform, which means it is designed to automate all machines or units in and around the factory. This PLC simulator (PLCSIM Advanced) will connect or link with the Factory I/O to run the virtual machine that has been designed, as shown in Figure 3.13. The logic on this virtual PLC can be tested, and this software allows for flexibility in executing ladder logic without using a real PLC.

Figure 3.16 TIA Portal (Siemens)

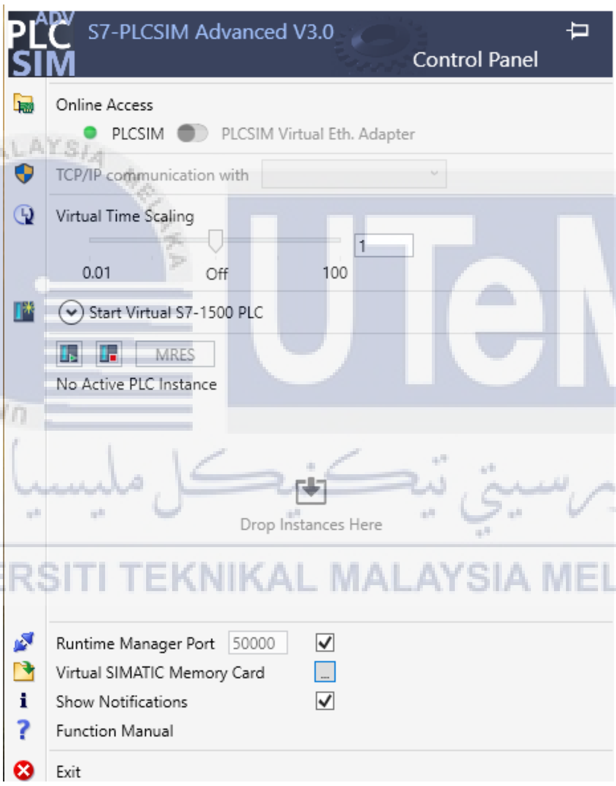


Figure 3.17 Siemens (PLCSIM Advanced)

3.5.3 Virtual IoT Gateway Software

3.5.3.1 Node-Red Web Server Software

Node-RED is, in fact, a platform for programming hardware, APIs, and web resources in tandem. It is primarily a visualization tool for the Internet of Things, but it can also be used for a variety of other applications to integrate flows with various services. The IBM Emerging Tech Organization was founded as an open-source project. It is included in IBM Blue mix Node's IoT starter framework kit. A JS program can be used to deploy Node-RED on its own. Node-RED is a project of the JS Foundation. Node-Red assists users in assembling web services, hardware, and a visual drag-and-drop operating system by substituting typical low-level coding tasks (such as simple serial port service). A flow is created by connecting different Node-RED components. Another less critical code is generated automatically.

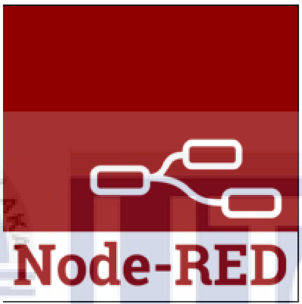


Figure 3.18 Node-Red Webserver

3.5.3.2 Node-Red MQTT

As shown in Figure 3.16, MQTT is a simple messaging protocol designed for constrained devices with low bandwidth. So, it's the perfect solution for Internet of Things applications. MQTT allows you to send commands to control outputs, read and publish data from sensor nodes and much more. Residing on top of the TCP/IP network stack, MQTT is a lightweight publish/subscribe messaging protocol designed for low-bandwidth, high latency, unreliable networks. MQTT's features make it an excellent option for sending high volumes of sensor messages to analytics platforms and cloud solutions.

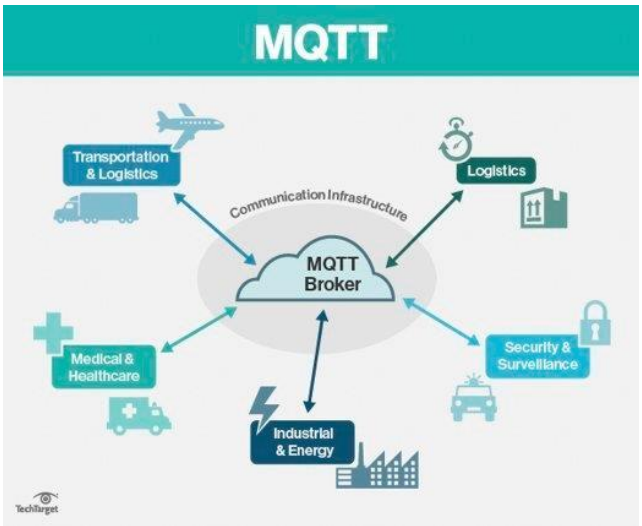


Figure 3.19 MQTT Broker

3.5.3.3 NetToPLCsim - Network extension for Plcsim

NetToPLCSim, as shown in figure 3.17, was used to connect TIA Portal with Node-Red. NetToPLCsim allows accessing the PLC-Simulation S7-Plcsim from our network via TCP/IP (Iso-On-TCP) communication, using the network interface of the PC on which the simulation is running. It's useful for testing a client application (SCADA, HMI, etc.) together with S7-Plcsim, without a real PLC.

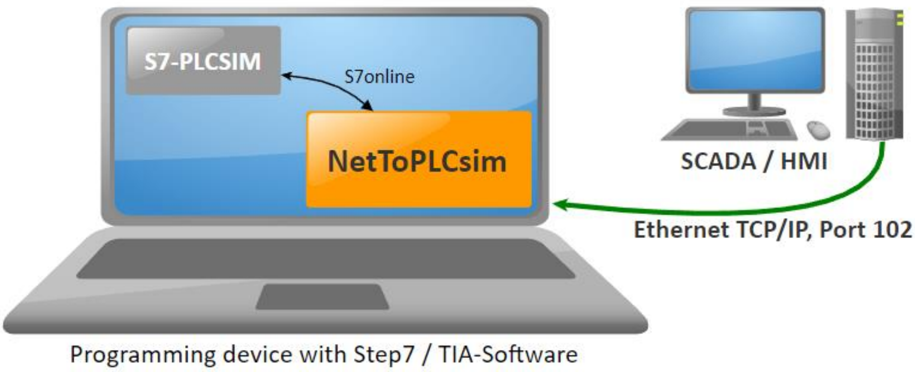


Figure 3.20 NetToPLCsim

3.6 Block Diagram of the project

Figure 3.16 illustrates the project block diagram, including a virtual controller, virtual machine, virtual IoT gateway, smart device apps, and a web-based control and monitoring system. Tia Portal will first download the data to the PLCSIM Advanced, and the PLCSIM Advanced will create a virtual PLC that will function similarly to a real PLC. The Factory io will then be connected to the PLCSIM Advanced controller to control the machine's behaviours. The data from the virtual PLC is then sent to the Node-Red IoT Webserver Platform for control and monitoring of the machining process using the Node-Red Dashboard and Blynk apps. Finally, the data on Overall Equipment Effectiveness (OEE) will be saved in Microsoft Excel format on a computer or other device.

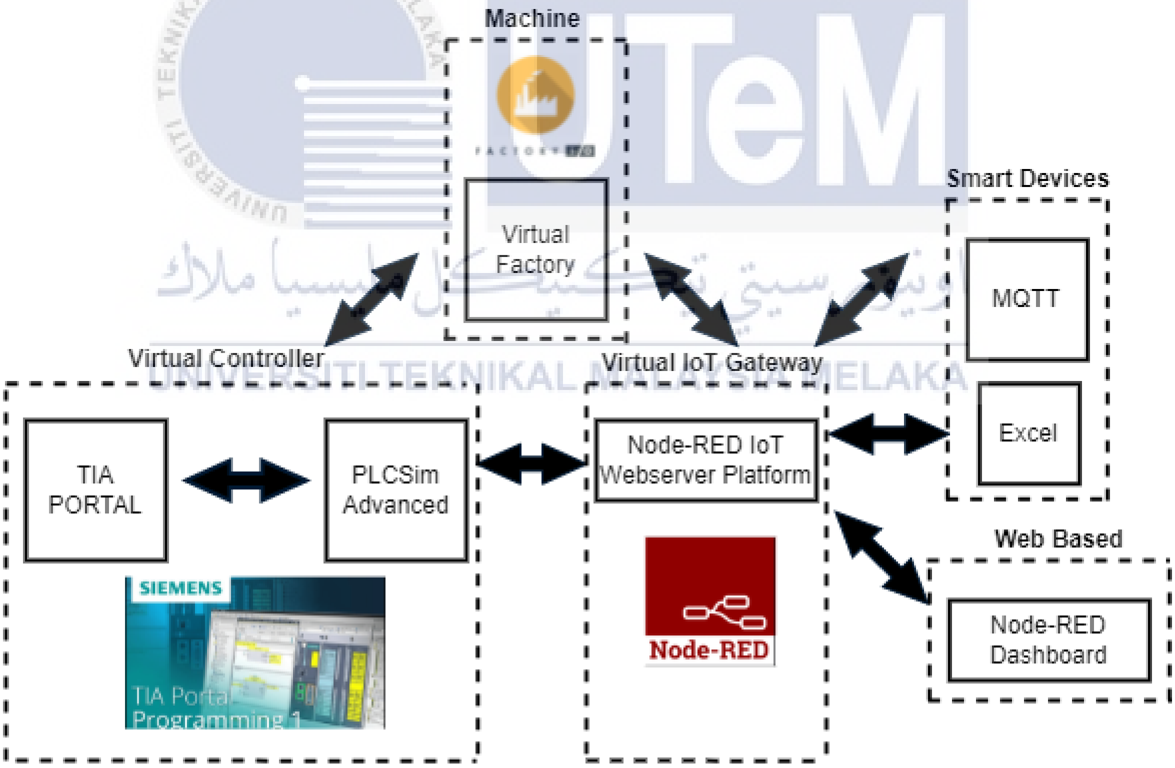


Figure 3.21 Project Block Diagram

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Introduction

This section will demonstrate the overview of the virtual sorting machine output performed and the OEE analysis that has been developed. After brief research and studies about the proposed system and project, it should come to expected outcomes and results that are still aligned with the project's objectives mentioned in chapter 1.

4.2 Project Results

The status connection at the Tia Portal software was a green indicator, as seen in Figure 4.1, which means all program has been successfully loaded at PLCSIM Advanced (virtual PLC). Therefore, Figure 4.2 shows the Active PLC Instance created with a green indicator means that the virtual PLC is already in running condition.

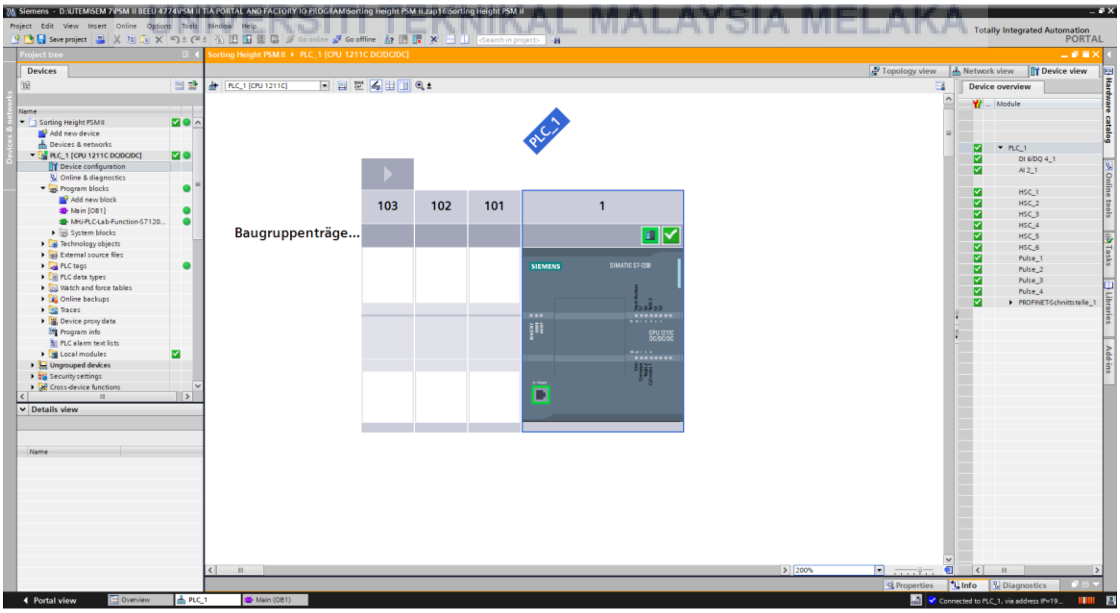


Figure 4.1 TIA Portal status

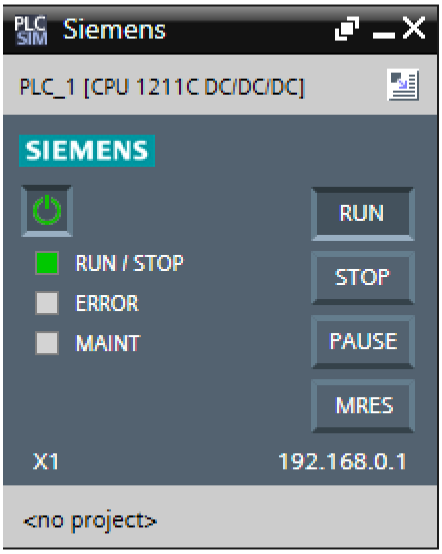


Figure 4.2 PLCSIM with Active PLC Instance

The driver connection was selected to Siemens S7-PLCSIM. The connection between the PLC with Factory io software has been successfully connected, as seen in Figure 4.3 and Figure 4.4. Besides, Figure 4.5 shows the main controller with start and stop buttons, which means the connection was satisfied.

Figure 4.3 Factory io Driver Connection

Figure 4.4 Factory io Driver Configuration

Figure 4.5 Main controller at Factory io

After that, connect TIA Portal with Node-Red using the NetToPLCsim - Network extension for Plcsim. Set network IP Address to follow the Node-RED server IP Address 127.0.0.1. Next, set the Plcsim IP Address to 192.168.0.1. Lastly, set the Plcsim rack and slot to 0 and 1 as shown in figure 4.6, then it will start the server as displayed in figure 4.7. Besides, the indicator condition when the push button was pressed is based on Table 4.1.

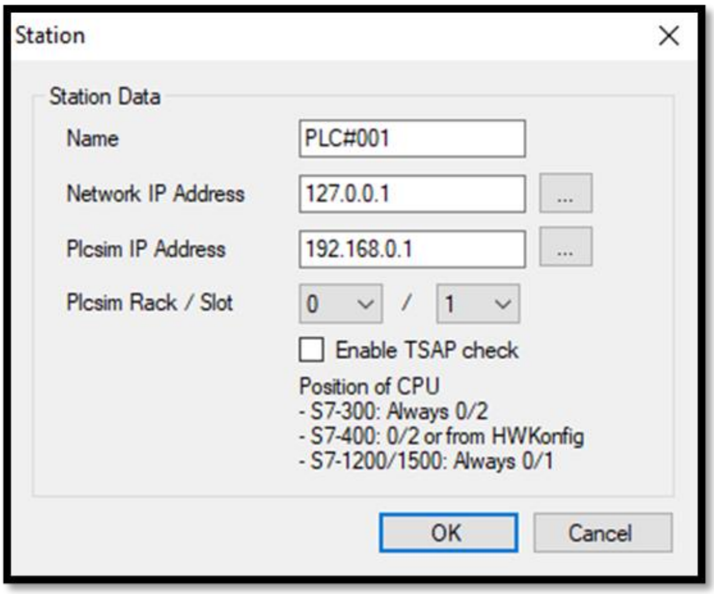


Figure 4.6 NetToPLCSim station

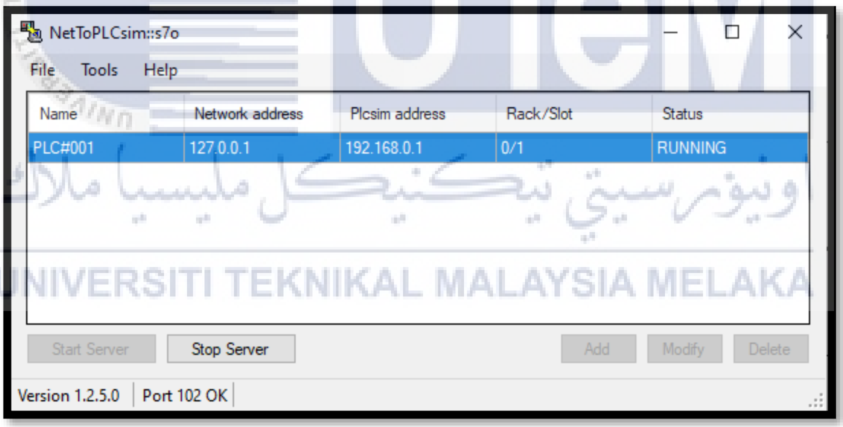
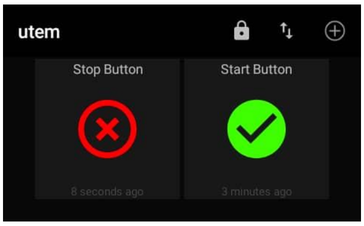
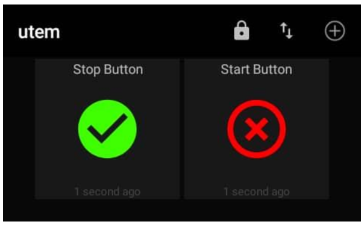
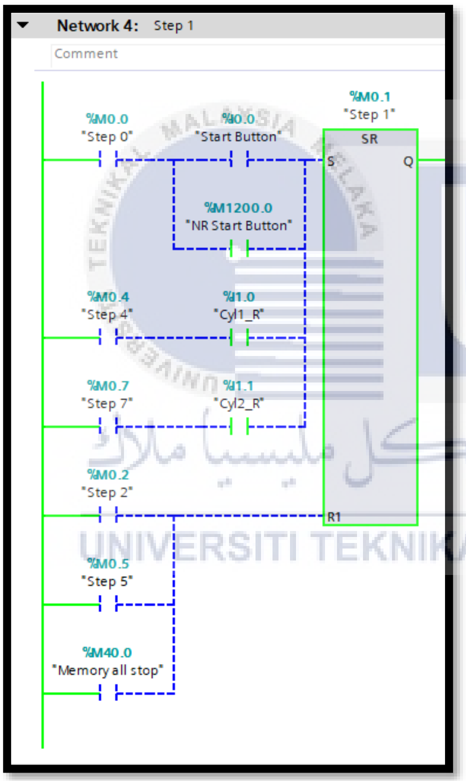


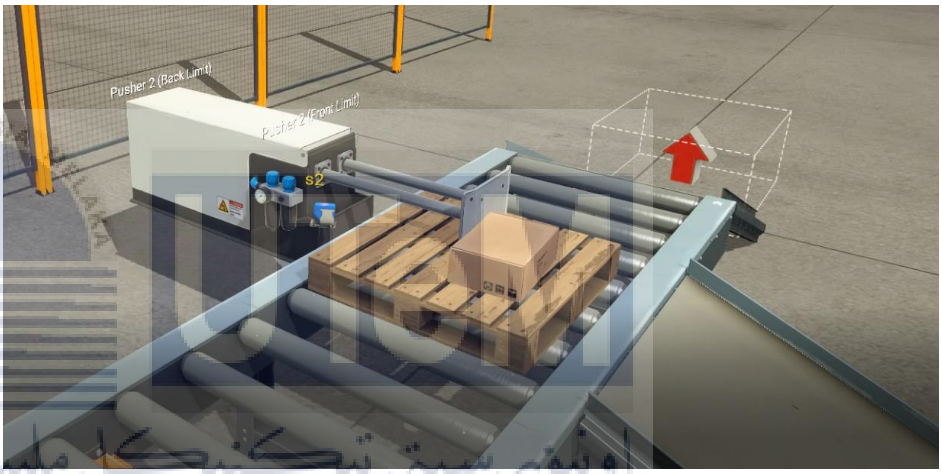
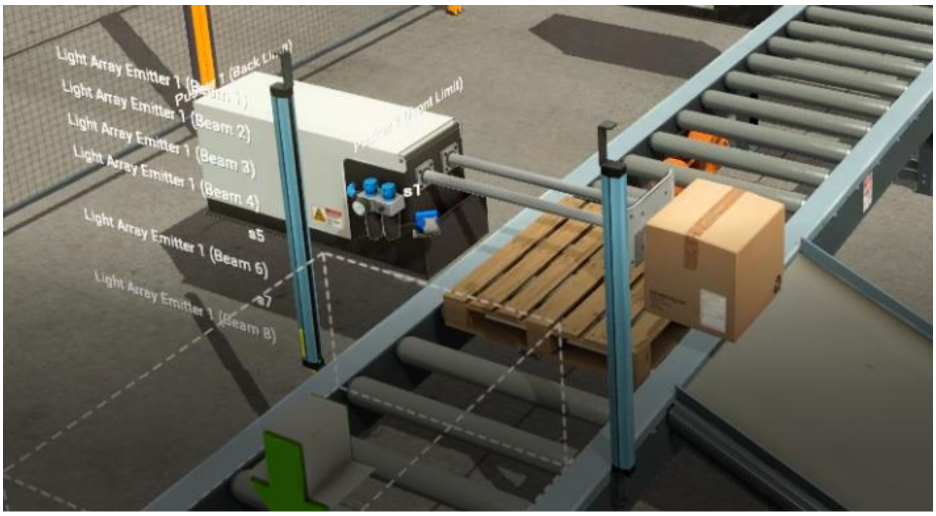
Figure 4.7 NetToPLCSim start server

Table 4.1 Indicator condition when PB was pressed

Type	Start Push Button	Stop Push Button
An indicator at MQTT Dash		
An indicator at TIA Portal		
An indicator at Node-Red Dashboard		

When the Start Push Button has been pressed, the conveyor will be turned on and carry the incoming box product. After the light emitter and light receiver recognize the box product, the diffuse sensor will detect the product that follows its height, high box and low box products—the condition and diagram as shown in Table 4.2.

Table 4.2 Machine Process condition for the first cycle

Condition	**Diagram**
The machine sorts the low box product height with a pneumatic cylinder (pusher).	
The machine sorts the high box product height with a pneumatic cylinder (pusher).	

4.2.1 Data Analysis

This section will explain how analysis has been made. Based on third objective, OEE (Overall Equipment Effectiveness) is a record to pass judgment on creation run as far as machine availability, production rate and quality rate of the item. For TPM (Total Productive Maintenance) and Lean Manufacturing programs, OEE is a key measurement. In general Equipment Effectiveness is a Loan Manufacturing Tool. There have 3 parameters have been set for OEE:

a) Availability

b) Performance

c) Quality

All data will be taken every second to analysis the machine output ratio of the machine performance process performed in a 5 minutes or 300 seconds. The result shows the total product that has been sorted are 23 units where High Box Product and Low Box Product to 12 and 11 units respectively. The first parameter was Availability. The meaning for this term is a machine available duration for manufacturing. Also, Availability was in Breakdown Losses. This terms meaning is a situation or incident that straight to stoppage of planned production for the time has been scheduled. For example, where equipment has failed it will affect the duration of manufacturing. Based on my manual data its show in Table 4.3.

Date	Actual Operation Time/Seconds	Planned Operation Time/Seconds	System Down Time/Seconds
21-Dec	283	300	17
22-Dec	275	320	15
23-Dec	280	350	12
24-Dec	267	315	10

Table 4.3 Availability Data

From this table we assume to take 21 December to do the Availability calculation. The calculation shows as below:

Availability (%) = $\frac{Actual\ Operation\ Time}{Planned\ Operation\ Time}\ x\ 100\%$

Actual Operation Time = Planned Production – System Downtime

Actual Operation Time = 300s – 17s = 283s

Availability (%) = $\frac{283}{300}x\ 100\% = 94.33\%$

The second parameter was Performance. This terms meaning is excess time taken for industry manufacturing compared to basic operation time. The Performance has been counted in Speed Losses. The Speed Losses incorporates any variable that heaps to working creation with more process duration than greatest admissible. Based on my manual data its show in Table 4.4.

Date	High Height Product Rate	Low Height Product Rate
21-Dec	7	8.5
22-Dec	8	7.2
23-Dec	3	6.1
24-Dec	6	9.5

Table 4.4 Performance Data

From this table we assume to take 21 December to do the Performance calculation. The calculation shows as below:

Performance (%) = $\frac{\frac{Actual\ Production\ Time}{Actual\ Operation\ Time}}{Ideal\ Run\ Rate}\ x\ 100\%$

Ideal Run Rate = $\frac{\frac{1}{High\ Height}+\frac{1}{Low\ Height}}{2}$

Ideal Run Rate = $\frac{\frac{1}{7}+\frac{1}{8.5}}{2}$ = 0.1303

$$\text{Performance (\%)} = \frac{\frac{23}{283}}{0.1303} x\ 100\% = 62.37\%$$

The third parameter is Quality. This term meaning its display the result of Good Quality of Product. This been counted in Losses. Quality loss only can be counting due of defecting part and conforming part. Based on my manual data its show in Table 4.5.

Date	Time/Seconds	Good Product	Defect
21-Dec	300	23	0
22-Dec	300	18	0
23-Dec	300	14	0
24-Dec	300	20	0

Table 4.5 Quality Data

From this table we assume to take 21 December to do the Performance calculation. The calculation shows as below:

$$\text{Quality (\%)} = \frac{Good\ Product - Defect}{Good\ Product}\ x\ 100\%$$

$$= \frac{23-0}{23} x\ 100\%$$

= 100%

As the conclusion, when we meet these three parameters. The OEE calculation can be made. The calculation shows as below:

OEE (%) = Availability x Performance x Quality

OEE (%) = (0.9433 x 0.6237 x 1) x 100%

= 58.83%

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

In this chapter 5, this project was concluded based on chapter 1 until chapter 4 that explains the expected progress before starting the project and the details about the result and discussion of the project. This project is successfully done due to the objective stated in chapter 1. But for the third objective, students just used manual calculation to get the OEE results.

5.2 Conclusion

The project is about the Development of IoT Based Control, And Monitoring MAP 201 Using PLC has been designed. Three main designs have been developed: virtual machine, virtual controller, and virtual IoT gateway via the virtual software, as shown in chapter 3. Firstly, the virtual controller, the Programmable Logic Controller (PLC) to control the behaviour of product sorting machine in virtual factory environment based on the actual implementation, has been developed via Siemens (Tia Portal) software and successfully connected with Factory IO software. After that, the Internet of Things (IoT) was developed with full functionality to act as a base controlling and monitoring system for the sorting machine.

Therefore, Node-Red MQTT and web-based (Node-Red Dashboard) control and monitor the sorting machine. Methods of controlling sorting the MAP 201 machine have been developed successfully. But to monitor the OEE was not successfully done at the Node-Red dashboard, but students used a manual calculation to calculate the OEE results. Three main factors are needed to analyze: the Availability, the Performance, and the Quality of the machine productivity. Besides that, the output ratio of the machine performance process performed in a predetermined cycle time has been analyzed using the Overall Equipment Effectiveness (OEE) formula.

5.3 Recommendation

This section will discuss the limitation of this project and the recommendation for this project. This project used a ladder diagram as the primary program language to develop the virtual controller for the machine system. So, this will take time to develop the program. Therefore, the Sequential Function Chart (SFC) language can be used in the Tia Portal software, making this technique more straightforward and more manageable. The error or wrong sequence process can be easier to detect throughout this technique. Lastly, the actual hardware implementation is much better to understand the real communication with each equipment, such as PLC S7 1200 and Simatic IOT 2040.

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APPENDICES

Appendix A Gantt Chart

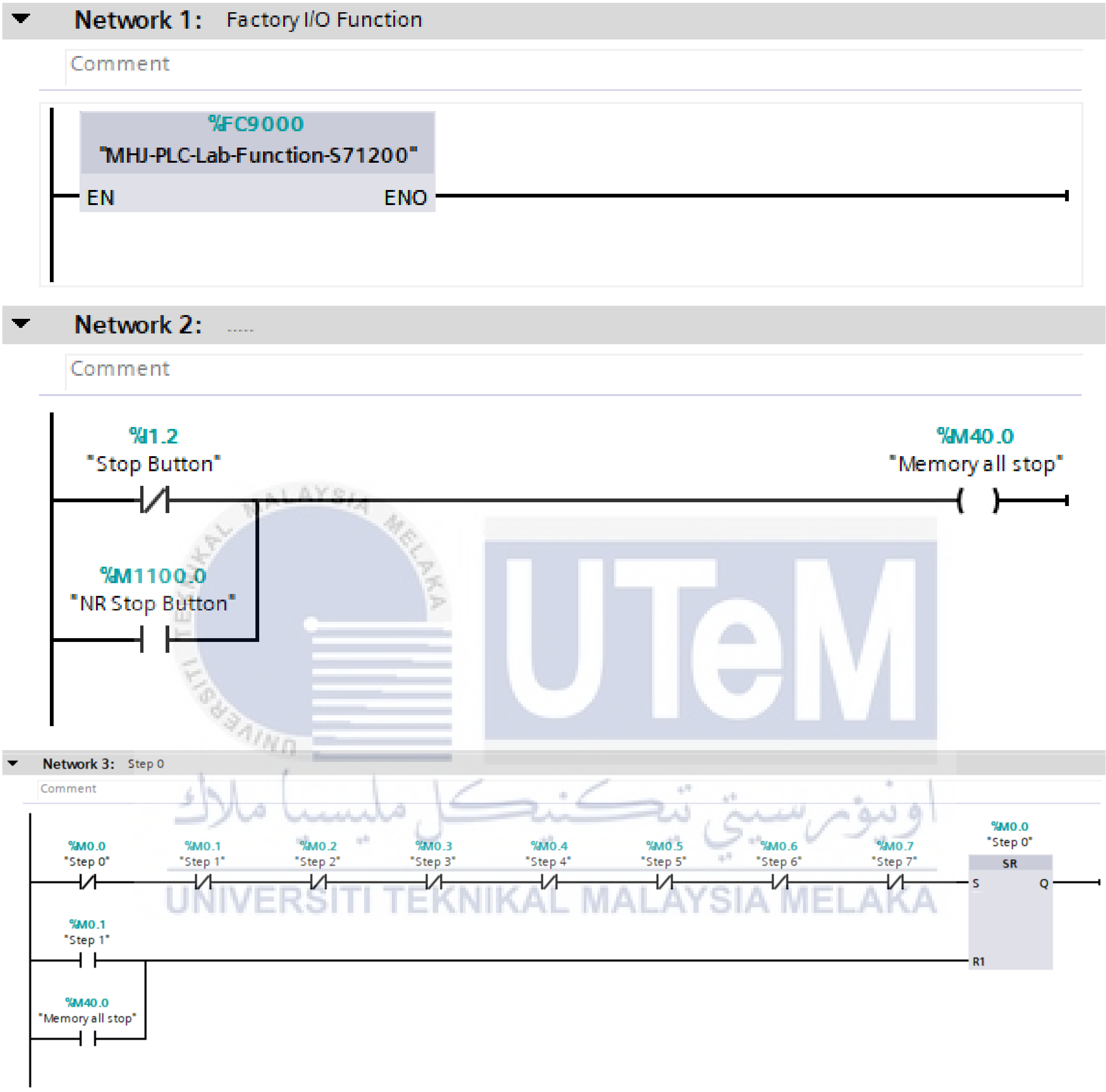
PROJECT PLANNING

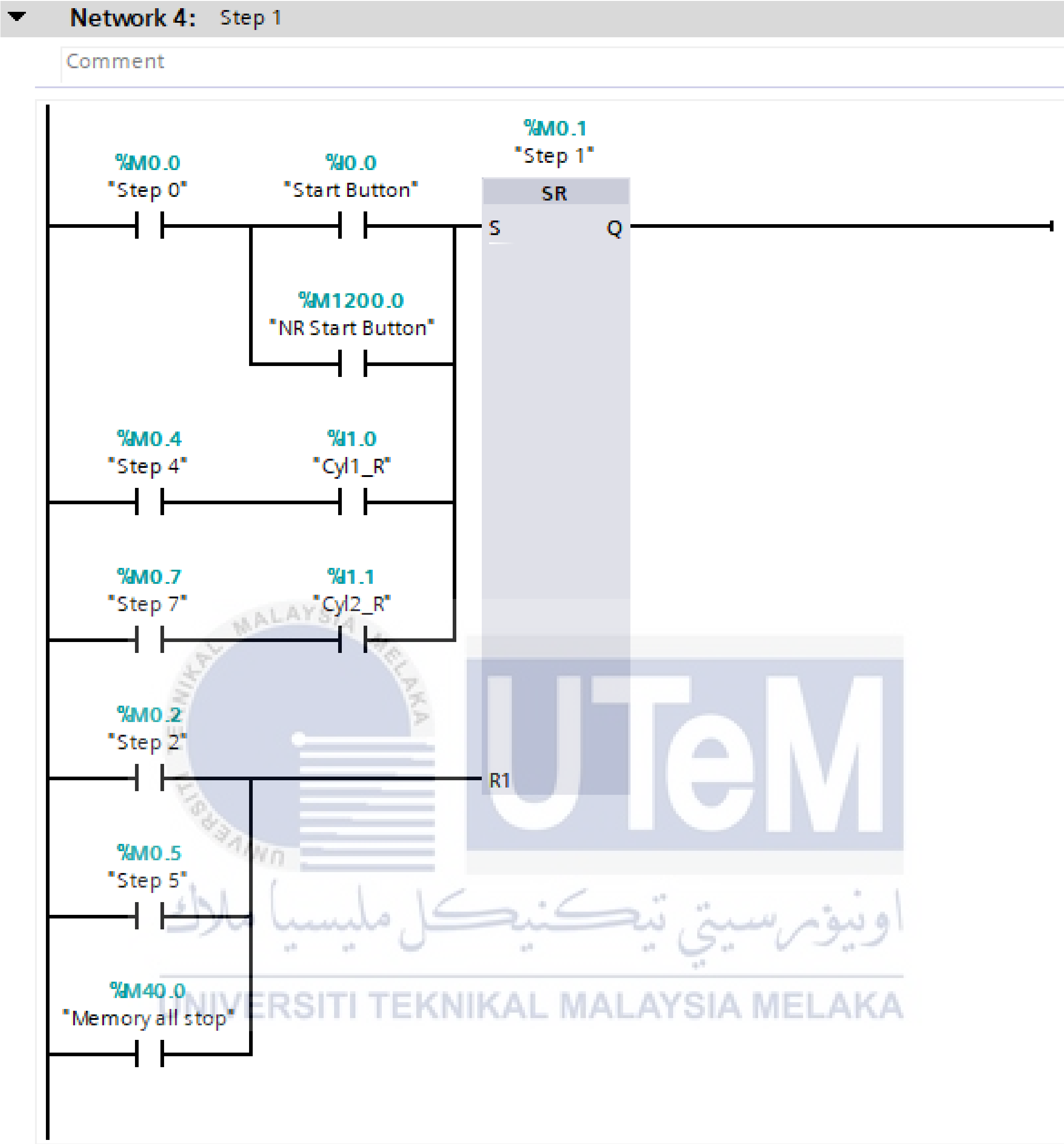
PROJECT NAME: Development of IoT Based Control and Monitoring MAP201 Machine Using PLC

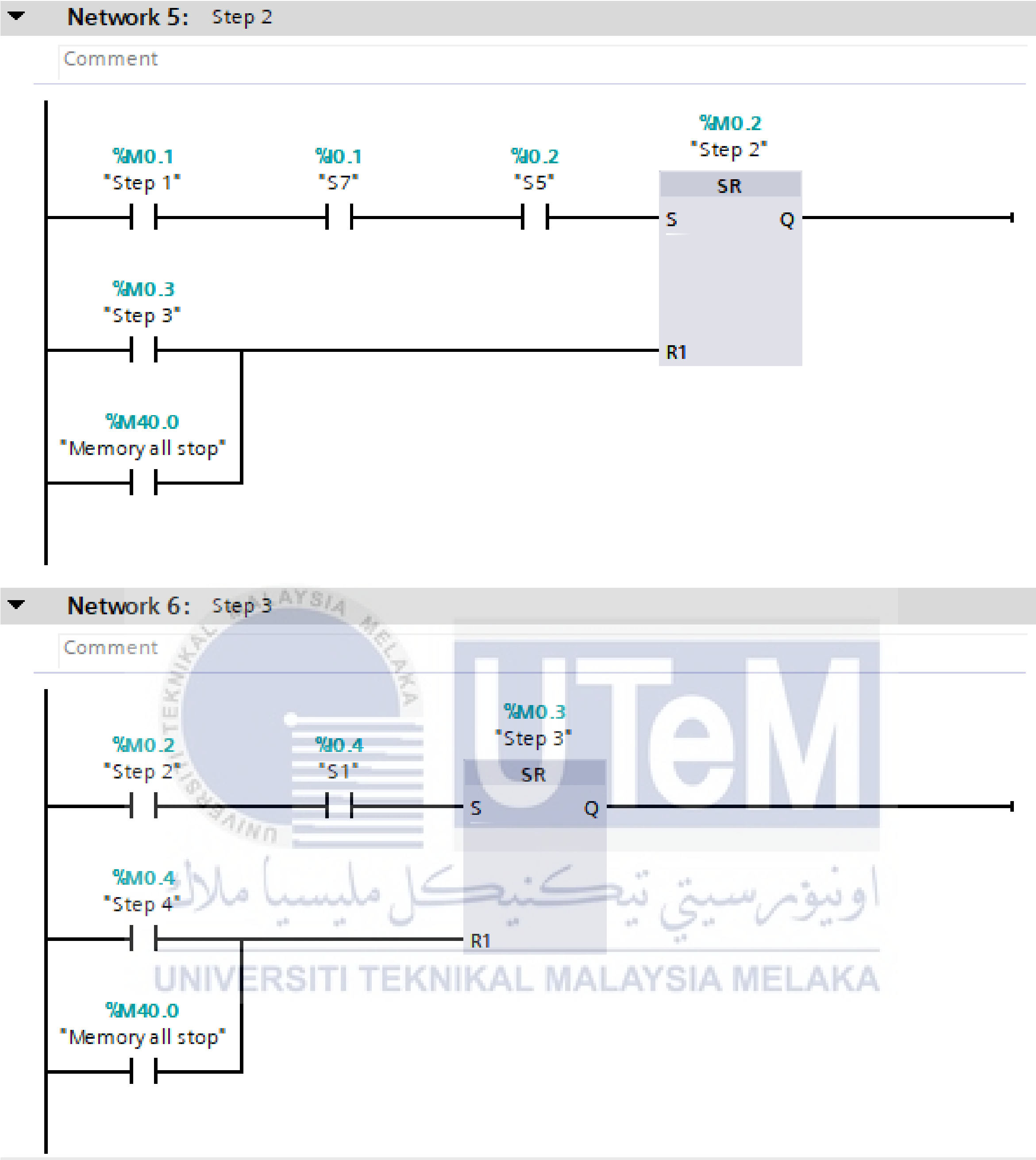
2021 / 2022

Project Activity	**MARCH**			**APRIL**				**MAY**				**JUN**					**JUL**		**A**	**A**	**SEP**			**OCT**					**NOV**				**DEC**					**F**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**X**	**X**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
Literature Review																																						
Project Planning																																						
Proposal Preparation																																						
Study of Virtual Factory Software																																						
Study of PLC Simulator Software																																						
Study Internet of Things (IoT)																																						
Study of OEE Analysis																																						
Design 3D Virtual MAP 201 Machine																																						
Design Grafcet and Build Ladder Diagram at Tia Portal																																						
Make connection Tia Portal with Factory io	BP Briefing								Mid Term Break							Study Week		Final Semester Examination			Semester Break								Mid Term Break							Study Week		Final Semester Examination
Insert Analog Sensor Program																																						
Develop webserver through Node-Red																																						
Develop OEE Analysis																																						
Simulate Virtual Software																																						
Performance Analysis																																						
Thesis Writing																																						
Thesis Correction																																						
Thesis Binding																																						

Appendix B Ladder Diagram

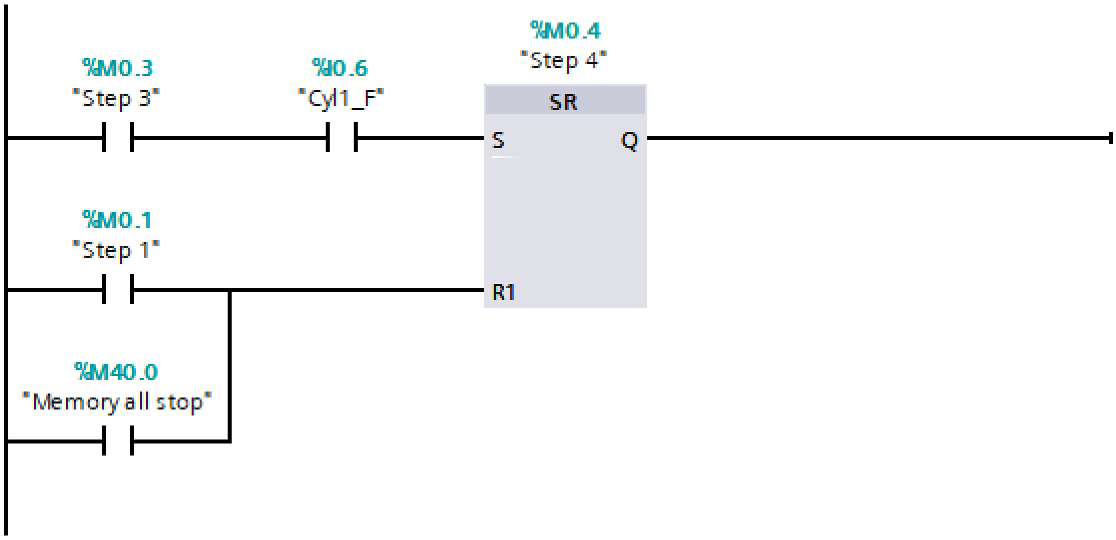



Network 4: Step 1
Comment
%M0.1
"Step 1"
SR
S
Q
R1
%M0.0
"Step 0"
%I0.0
"Start Button"
%M1200.0
"NR Start Button"
%M0.4
"Step 4"
%I1.0
"Cyl1_R"
%M0.7
"Step 7"
%I1.1
"Cyl2_R"
%M0.2
"Step 2"
%M0.5
"Step 5"
%M40.0
"Memory all stop"


Network 5: Step 2
Comment
%M0.2
"Step 2"
SR
%M0.1
"Step 1"
%I0.1
"S7"
%I0.2
"S5"
S
Q
%M0.3
"Step 3"
R1
%M40.0
"Memory all stop"
Network 6: Step 3
Comment
%M0.3
"Step 3"
SR
%M0.2
"Step 2"
%I0.4
"S1"
S
Q
%M0.4
"Step 4"
R1
%M40.0
"Memory all stop"

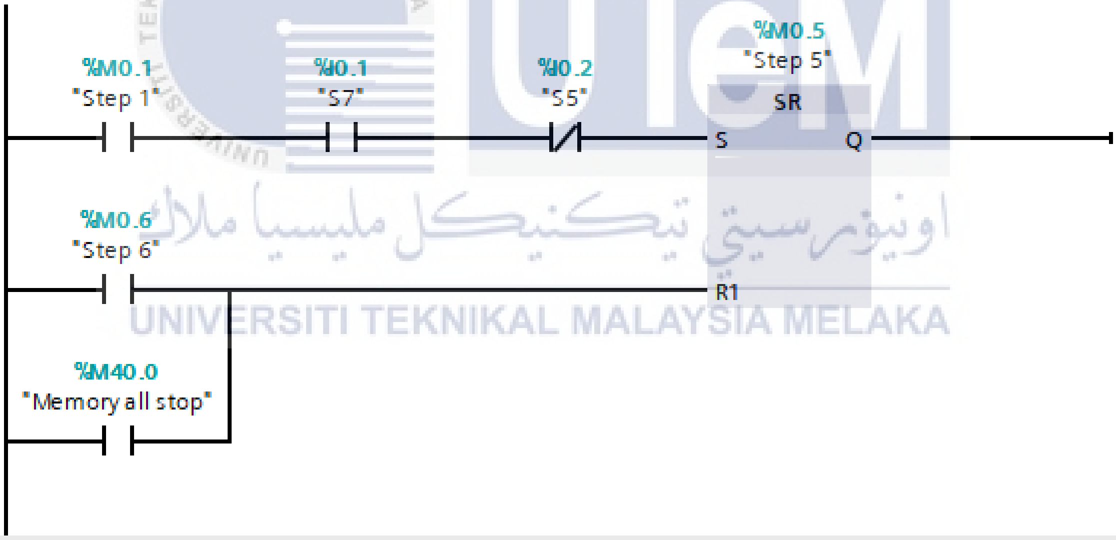
Network 7: Step 4

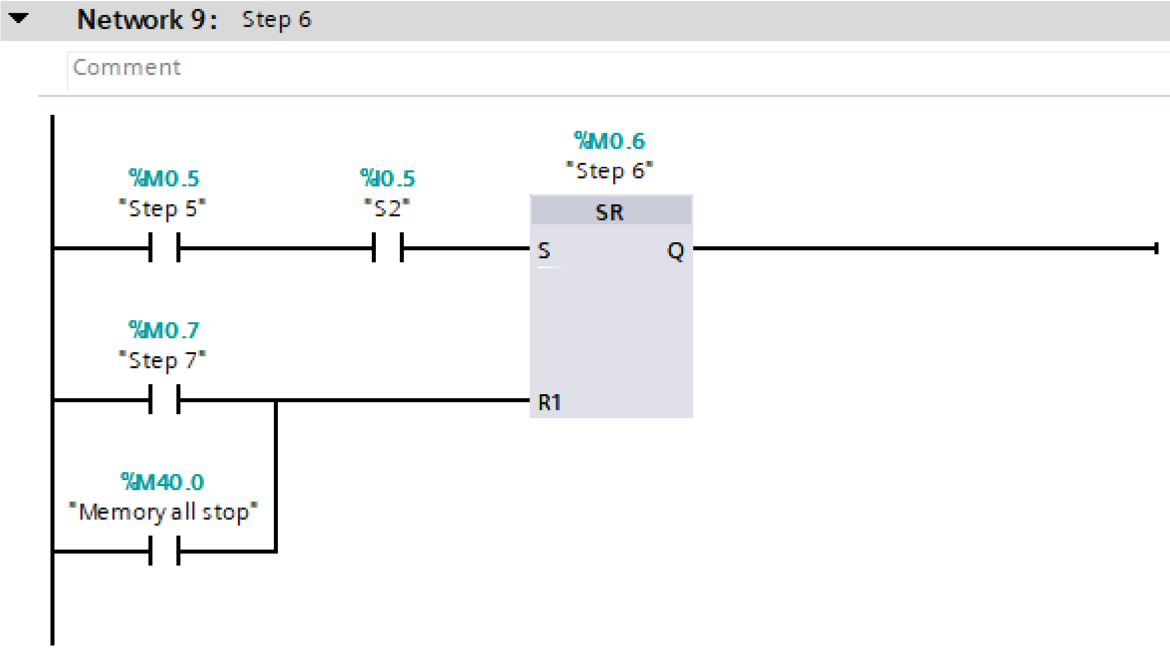
Comment



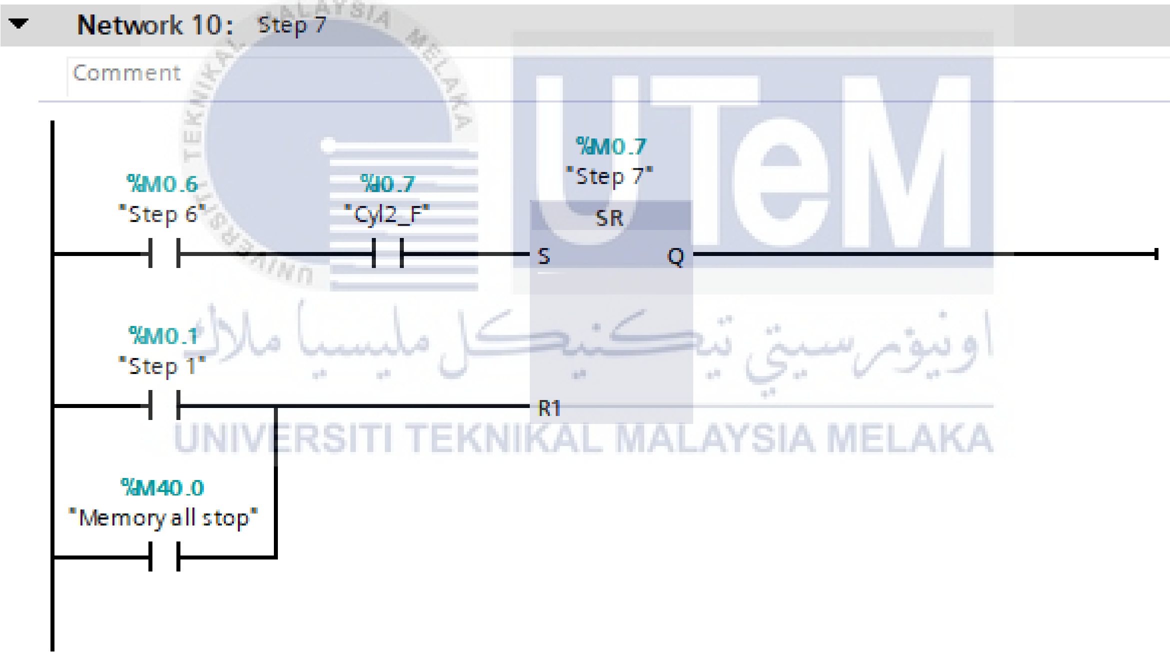
Network 8: Step 5

Comment

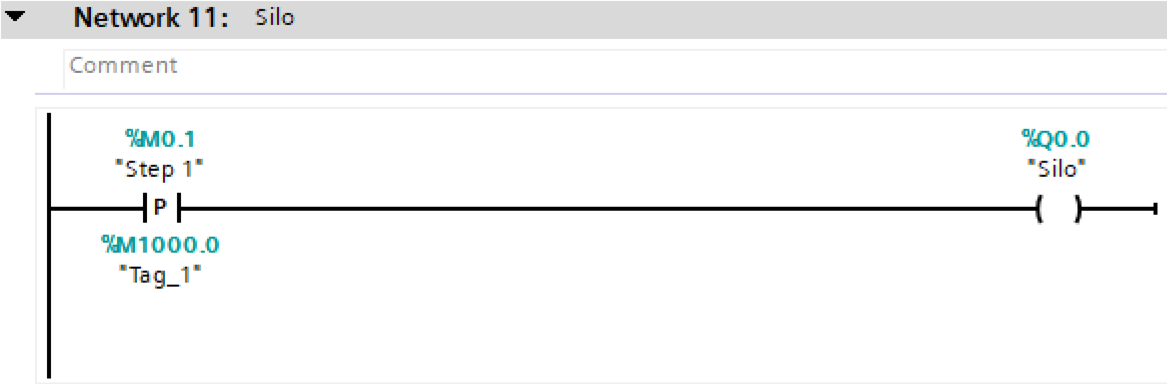


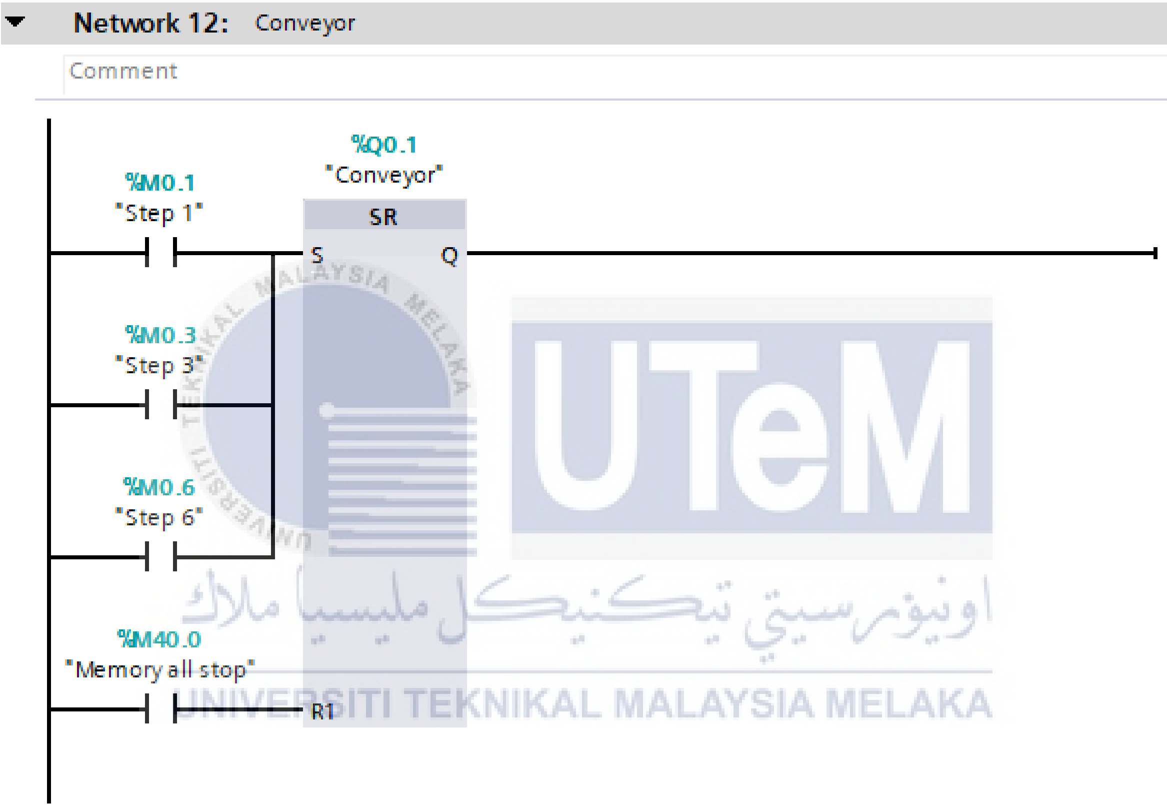


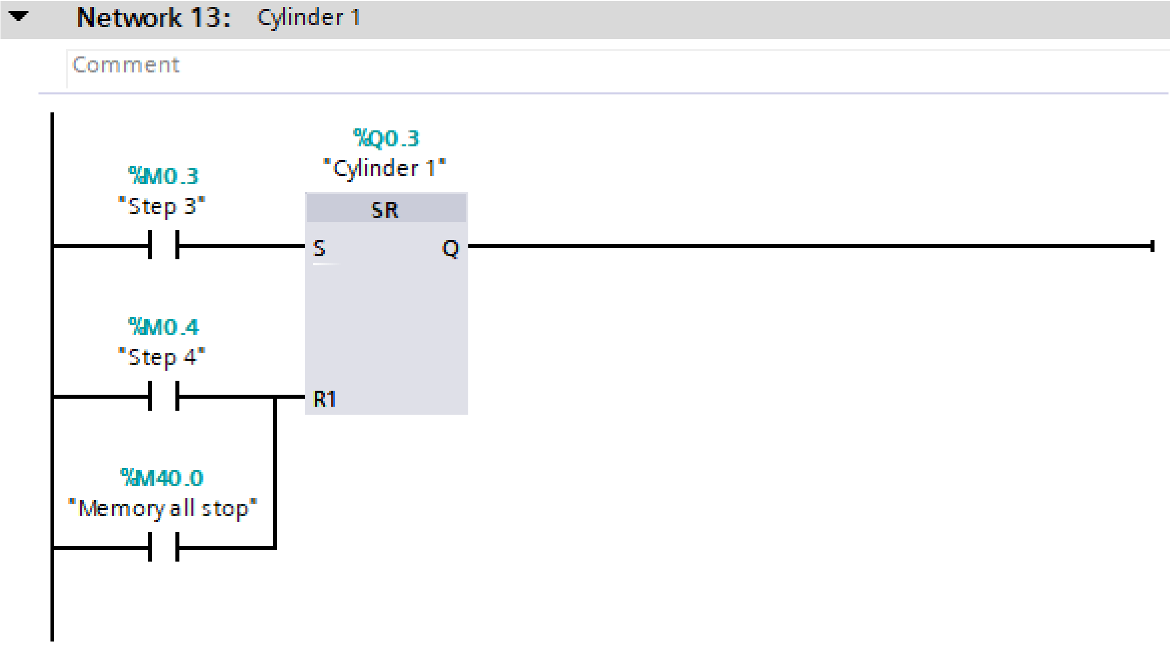
Network 9: Step 6
Comment
%M0.6
"Step 6"
SR
%M0.5
"Step 5"
%I0.5
"S2"
S
Q
%M0.7
"Step 7"
R1
%M40.0
"Memory all stop"

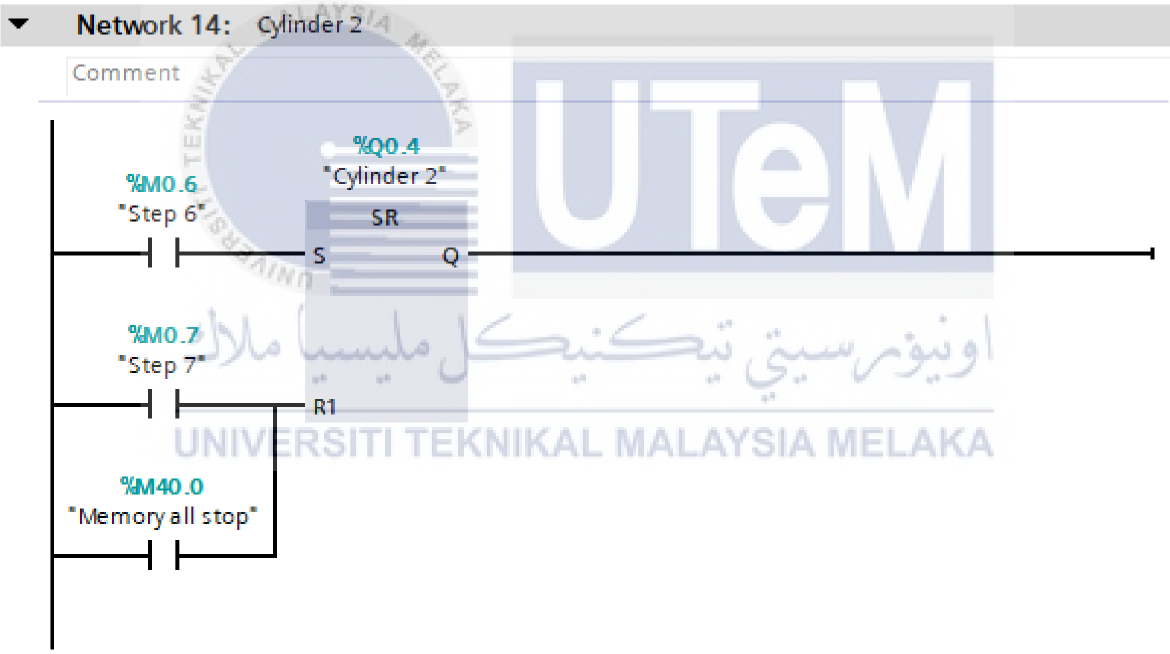


Network 10: Step 7
Comment
%M0.7
"Step 7"
SR
%M0.6
"Step 6"
%I0.7
"Cyl2_F"
S
Q
%M0.1
"Step 1"
R1
%M40.0
"Memory all stop"


Network 11: Silo
Comment
%M0.1
"Step 1"
P
%M1000.0
"Tag_1"
%Q0.0
"Silo"


Network 12: Conveyor
Comment
%Q0.1
"Conveyor"
SR
S
Q
R1
%M0.1
"Step 1"
%M0.3
"Step 3"
%M0.6
"Step 6"
%M40.0
"Memory all stop"


Network 13: Cylinder 1
Comment
%Q0.3
"Cylinder 1"
SR
S
Q
R1
%M0.3
"Step 3"
%M0.4
"Step 4"
%M40.0
"Memory all stop"


Network 14: Cylinder 2
Comment
%Q0.4
"Cylinder 2"
SR
S
Q
R1
%M0.6
"Step 6"
%M0.7
"Step 7"
%M40.0
"Memory all stop"