PLC BASED PROCESS MONITORING AND CONTROL USING SCADA

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Under the supervision of

Engr. Saad Rashid

2023

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A project presented to the

Faculty of Engineering Sciences and Technology Hamdard

In partial fulfillment of the requirements for the degree of

Bachelors of Engineering

In

Electrical Engineering

Faculty of Engineering Sciences and Technology

Hamdard University, Karachi - Islamabad Campus,

Pakistan

CERTIFICATE

This project **"PLC BASED PROCESS MONITORING & CONTROL USING SCADA"** presented by SAJID NAWAZ, FARID ULLAH, RIZWAN REHMAN and ALI REHMAN under the direction of their project advisor's and approved by the project examination committee has been presented to and accepted by the Faculty of Engineering Sciences and Technology in partial fulfillment of the requirements for Bachelor of Engineering (Electrical).

Engr. Saad Rashid (Project Supervisor)	Engr. Kamran khan (External 1)
Engr. Talha Riaz (Co-Supervisor)	Engr. Usman Javed (External 2)
Dr.Eng. Asghar khan (Chairman, EE Department)	Dr. Engr. Hassan Raza (Associate Dean, FEST)

Abstract

Industrial automation greatly reduces the involvement of human effort in the manufacturing of a product as well as improves the overall quality of the product. The automated operation of a manufacturing processes also ensures reliability. PLCs and SCADA (Supervisory Control and Data Acquisition) are very helpful in the implementation of industrial automation. The goal is to develop a PLC based system that monitors different industrial parameters that would help in controlling the manufacturing process. Different sensors and actuators integrated with SCADA as well as HMI are used to monitor different parameters as well as trigger a warning if some parameter exceeds the set value.

Final Year Design Project as a Complex Engineering Problem

It is to certify here that the final year design project (FYDP) entitled,

PLC Based Process Monitoring and Control using SCADA

is categorized as a complex engineering problem (CEP) based on the preamble (in-depth engineering knowledge) and involvement of the following attributes.

1. Depth of knowledge required
2. Range of conflicting requirements
3. Familiarity of issues
4. Interdependence

The above listed attributes are thoroughly assessed after conducting meeting on 02nd November 2022, with the following final year students, who proposed the idea of the titled FYDP.

1. Name Sajid Nawaz
   Reg No ECI-IT-19-037
2. Name Farid Ullah
   Reg No ECI-IT-19-036
3. Name Ali Rehman
   Reg No ECI-IT-19-033
4. Name Rizwan Rehman
   Reg No ECI-IT-19-062

This project is going to be conducted in fall semester 2022 and spring semester 2023. Further, it is submitted that the proposed idea is worthy, and the required efforts are up to the level of a final year design project.

FYDP Advisor

Saad Rashid (Lecturer)

Sustainable Development Goals

This section presents a brief overview of all the SDGs and mainly justifies the contribution of the project to the sustainable development goals (SDGs). Detailed justification of the mentioned points is presented in Table 1.

Table 1 SGD Table of the Project

Sr. No	Title	Compliance (Y/N)	Remarks/Justification
1	No poverty	No	Not applicable
2	Zero hunger	No	Not applicable
3	Good health/wellbeing	No	Not applicable
4	Quality education	No	Not applicable
5	Gender equality	No	Not applicable
6	Clean water and sanitation	No	Not applicable
7	Affordable and clean energy	Yes	Not applicable
8	Decent work and economic Growth	Yes	Commercial product will be developed
9	Industry, innovation and Infrastructure	Yes	Will help students to understand and improve industrial infrastructure
10	Reduced Inequalities	No	Not applicable
11	Sustainable Cities and Communities	No	Not applicable
12	Responsible consumption and Production	Yes	Automating the production will improve its quality and reduce wastage of materials
13	Climate action	No	Not applicable
14	Life below water	No	Not applicable
15	Life on land	No	Not applicable
16	Peace, Justice and strong Institutions	No	Not applicable
17	Partnerships for the goals	No	Industry can be provided and system can be made according to their

			requirements

1.7 Complex Engineering Problem

This project satisfies the attributes of the complex engineering problem, in the given context, this section presents the justification that how the presented work addresses different attributes of the complex engineering problem. The details are presented below:

Mapping

Sr. No	Attribute	Justification
1	Preamble - In-depth engineering knowledge	The project requires in depth knowledge of Electronics Devices & Circuits and Instrumentation & Measurements
2	Range of conflicting requirements	Performance, range, and cost are the balancing factors involved
3	Depth of analysis required	The project requires in depth analysis of different industrial scenarios and transducers involved in them.
4	Depth of knowledge required	Knowledge of different PLCs is required as well as different industrial standards that are currently in practice.
5	Familiarity of issues	Establish communication between different devices like SCADA, HMI and PLC
6	Extent of applicable codes	Safety and legal compliance must be considered
7	Extent of stakeholder involvement and level of conflicting requirement	The project involves coordination with industry
8	Consequences	Efficient automation process leads to low energy consumption and reduced cost.
9	Interdependence	PLC, Transducer, HMI and SCADA

Acknowledgment

Acknowledgment is due to **Hamdard Institute of Engineering and Technology** for support of this project highly appreciated achievement for us at the undergraduate level.

We wish to express our appreciation to the **Engr. Saad Rashid** who served as our supervisor. We would like to express our heartiest gratitude for their keen guidance, sincere help, and friendly manner which inspires us to do well in the project and make it a reality.

We thank **Engr. M. Talha Riaz** who served as our co-supervisor. We would like to express our hearties to gratitude for their keen guidance and assistance in keeping my progress on schedule.

Many people, especially classmates and team members themselves have made valuable comments and suggestions on this project which gave us the inspiration to improve the project. We thank all the people for their help directly and indirectly to complete the project.

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Abbreviations

I/O	Input/ Output
GND	Ground
V	Voltage
A	Ampere
PLC	Programmable Logic Controller
SCADA	Supervisory Control and Data Acquisition
IOT	Internet of Things
DC	Direct Current
AC	Alternating Current
PC	Personal Computer
HMI	Human Machine Interface
TIA	Totally Integrated Automation
Profinet	Process Field Network
IP	Internet Protocol
CAD	Computer-Aided Design
VFD	Variable Frequency Drive
LED	Light Emitting Diode
DVM	Digital Volt Meter
OB	Organizational Block
FC	Function Coil
TCP	Transmission Control Process

Chapter 1

INTRODUCTION

Industrial automation is target of many studies that aim at increasing the performance level of the processes along with reducing their complexity. Among the various automation techniques, (Programmable Logic Controller) PLC is replacing the traditional relay controls due to its reliability, stability, flexibility and ease of programming. Automation reduces the probability of an error occurrence and provides energy and resource conservation.

Therefore, the recent shift towards the utilization of automated systems demands the newer and more advanced technologies that can improve efficiency, accuracy and flexibility of processes in the industrial environment. Industrial automatic control and monitoring is becoming more and more significant since it is reliable, consistent, and effective than manual inspections. Automation is a control system that controls machinery, processes in a factory with minimal human interaction. PLCs play an important role in automation. PLC-(Supervisory Control and Data Acquisition) SCADA can regulate the dynamic state of the devices and improve the overall precision of the system. It can help in quick error detection and improvement in communication between various systems.

1.1 Motivation

Industrial automation systems are securing their position in the sector day by day. PLC-SCADA systems are commonly used in industry because they have many benefits, such as standard product output, reduced mistake rates, the capacity to receive real-time statistical data, and automatic control. It is a need of time that the students should be familiar with the industrial trends and latest industrial technologies.

For this purpose, a plc-based control system is made through which student can learn and practice PLC programming and simulates industrial scenarios in lab environment. The main aim is to make a trainer that would help us to implement industrial systems and simulate industrial scenarios by using PLC and SCADA system.

1.2 Problem Statement

- Lack of familiarization with industrial process.
- Understanding of system on running process might affect production.

- By providing real time industrial process monitoring and control.

1.3 Significance and Proposed Solution

PLC and SCADA (Supervisory Control and Data Acquisition) system are the only solution for industrial automation. By designing PLC and SCADA control system it is possible to implement and control various industrial scenarios. There are numerous potential advantages of the plc system. The potential application of this system is.

- The plc-based control system can help students to get familiar with the industrial processes and it is the perfect training aid for teaching students about how a process is controlled in the industry
- It can help students in leaning about PLC programming and simulating industrial scenarios by using PLC and SCADA
- The students can simulate the operation of the controller and generates digital, analog, outputs that can be connected to real-world devices such as relays, sensors, weight module and (Human Machine Interface) HMI etc.

1.4 Aims and Objectives

With the given time frame and some other limitation, it is an important step to declare the basic goals and aims in this project. These targets are described as

- Monitoring of pressure, flow rate and weight
- Design of SCADA and HMI interface for different parameters.
- Implementation of PID Controller for Temperature Control
- Control and monitoring of temperatures

1.5 Report Organization

This report describes the full development and the implementation of PLC and SCADA based industrial system with webpage enabled process monitoring and control. The report is divided into the many stages of development. The upcoming chapters are going to provide further details about PLC and SCADA base industrial control system and how it is an accomplished. Chapter 2 covers the literature review. Chapter 3 describes the experimental setup and procedure of the project. Chapter 4 describes material and components used in the project. Chapter 5 covers the software and hardware implementation of the project. Chapter 6 explain the results and discussion of the project and chapter 7 covers the conclusion and future recommendation.

1.6 Sustainable Development Goals

This section presents a brief overview of all the SDGs and mainly justifies the contribution of the project to the sustainable development goals (SDGs). Detailed justification of the mentioned points is presented in Table 1.1 shows the SDGs.

Table 1.1: SDGs Table of the Project

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1.7 Complex Engineering Problem

This project satisfies the attributes of the complex engineering problem, in the given context, this section presents the justification that how the presented work addresses different attributes of the complex engineering problem. The details are presented in Table 1.2 shows the CEP attributes mapping.

Table 1.2: CEP Attributes Mapping

Sr. No	Attribute	Justification
1	Preamble - In-depth engineering knowledge	The project requires in depth knowledge of Electronics Devices & Circuits and Instrumentation & Measurements
2	Range of conflicting requirements	Performance, range, and cost are the balancing factors involved
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7	Extent of stakeholder involvement and level of conflicting	The project involves coordination with industry requirement

8	Consequences	Efficient automation process leads to low energy consumption and reduced cost.
9	Interdependence	PLC, Transducer, HMI and SCADA

Chapter 2

LITERATURE REVIEW

2.1 Related Research

Numerous researchers have dedicated their efforts to enhancing the monitoring and control of industrial environments by leveraging a variety of technologies, some of which we will discuss in this section. Furthermore, a substantial body of literature has been devoted to automating industrial processes through the use of (Programmable Logic Controller) PLC and (Supervisory Control and Data Acquisition) SCADA systems and their effective management. Increasing global consumer expectations and heightened competition have driven the demand for more intelligent, faster, and more potent technologies. Traditional manual handling of industrial processes was prone to errors and proved to be both time and cost-intensive.

However, automation, achieved through the integration of multiple systems (processes, machinery, and software) that collaborate to deliver flexibility, enhanced product quality, and shorter production cycles in an economically efficient manner, has been the solution to these challenges. Automation not only conserves energy and resources but also reduces the risk of errors. Therefore, faster and more reliable automated technologies are currently replacing inefficient manual operations as the prevailing trend in various industries.

2.1.1 An industrial 4.0 approach configuration of a bottling process PLC and SCADA

To develop auto parameter configuration of a bottling process in a small to a medium industry using plc and SCADA. Modern manufacturing trends, such as Industry 4.0 (I4.0), are striving to supplant existing manual systems with self-controlled, reconfigurable processes to enhance overall production systems. This paper outlines a strategy for closely monitoring production, reducing manual intervention, and efficiently supervising the bottling process in a small beverage plant by implementing fundamental Industry 4.0 concepts such as decentralization and real-time data analysis.

The simulation of a bottling process is executed using a Siemens S7-1200 PLC connected via Ethernet TCP/IP to a ZENON SCADA (Human Machine Interface) HMI. The proposed strategy, which models the bottling production as a function of time, frees supervisors from manual configuration of bottling process parameters, allowing them to monitor production steps directly on SCADA with relevant information. This optimization enhances production efficiency by reducing human intervention in the overall process [1]. Figure 2.1 shows bottling process using PLC and SCADA.

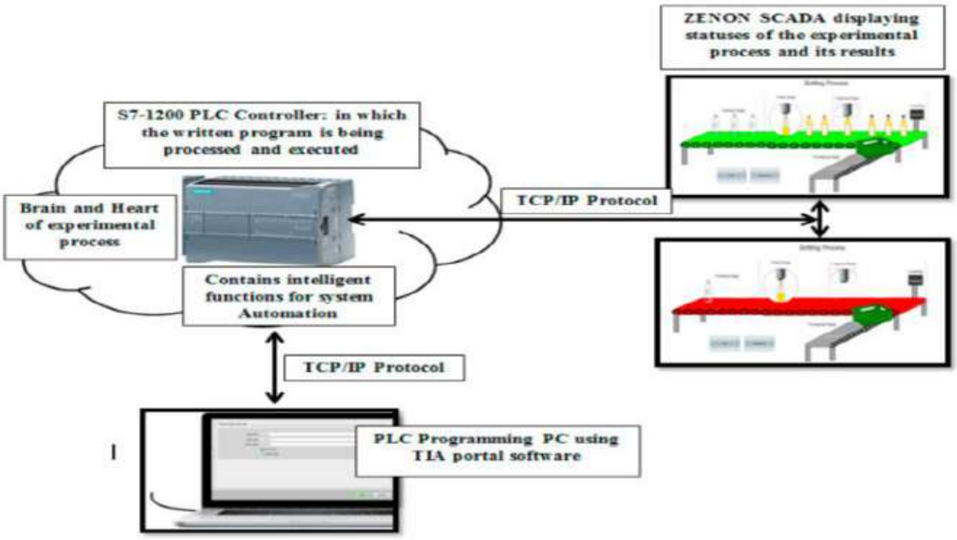

Figure 2.1: Bottling process using PLC and SCADA [1].

2.1.2 Implementation of a Temperature Control Process

Trainer through PID Controller Designed with Siemens S7-1200 PLC and HMI. This section discusses the development of a temperature control process trainer integrated with a Siemens S7-1200 PLC and KTP-700 Basic HMI. The setup includes a temperature control trainer with both on-off and PID controllers mounted on the instrumentation panel. It also features a voltage-to-current converter for transforming 0-10 V to 4-20 mA, a temperature-to-voltage converter based on the RTD PT-100 sensor, a PLC-based PID controller, and an HMI. The section initially demonstrates the efficiency, robustness, speed, and effectiveness of the process control system through experimental results, which are then compared with simulation outcomes.

Process control, an integral aspect of control systems, encompasses the mechanisms and algorithms required to maintain the output of a process within a specific range. Temperature control, a common branch of process control, is exemplified with a model of a temperature controller, particularly a PID controller, which is a device used for temperature control [2]. Figure 2.2 shows the complete process of temperature control through PID controller.

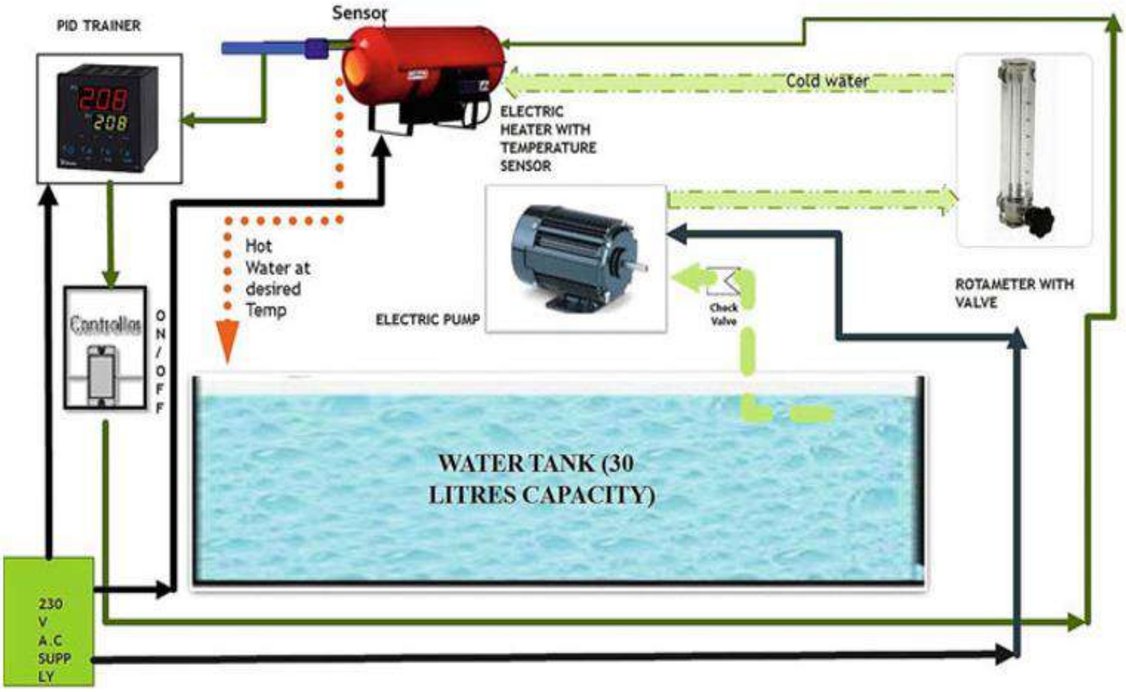

Figure 2.2: Temperature control trainer through PID controller [2].

2.1.3 Design of Automatic Feeding Control System

With the rapid advancement of microelectronics technology and the influence of science and technology, programmable logic controllers (PLCs) have found widespread application in the automation of the chemical industry. This section presents a system based on the Siemens PLC S7-1500 module, with the central control unit being the CPU1515-2. The system connects the tank area and four production workshops, enabling the automatic transportation of nine different materials.

The Windows Control Center (WinCC) configuration software is utilized for real-time monitoring, displaying process parameters, data overviews, flowcharts, curves, alarm notifications, and more on the human-machine interface. Additionally, it automatically stores material quantities in the SQL Server 2012 database, simplifying process analysis and production management. Compared to traditional manual feeding methods, this automated approach enhances accuracy, stability, and safety, reducing the potential for accidents and saving time [3]. Figure 2.3 shows complete process of automatic feeding on WinCC configuration.

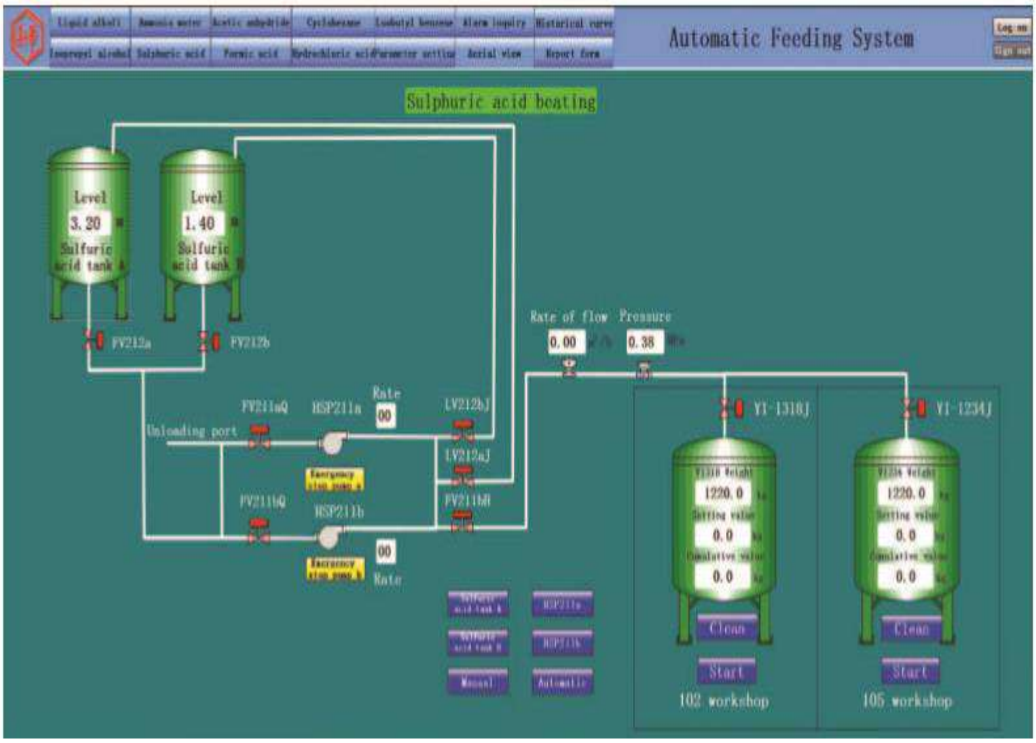

Figure 2.3: Complete process of automatic feeding on WINCC [3].

2.1.4 WINCC-Based Process Simulation

To enable system integrators to verify the correctness and effectiveness of a supervisory control and data acquisition (SCADA) system's functions before on-site installation and actual commissioning, this section introduces a process simulation employing a software-in-the-loop technique with VBScript in WinCC for virtual commissioning. The design involves integrating an existing control loop in a water tank process within a pharmaceutical manufacturing plant into a new SCADA system. This process includes components such as inlet water pumps, inlet control valves, level transmitters, and outlet water pumps, all controlled by a proportional-integral-derivative (PID) algorithm in a programmable logic controller (PLC) to maintain hydrostatic pressure in the water tank.

The simulation allows for manual and automatic control of the process, and it includes the option to simulate device failures that cannot be replicated in the real process, ensuring SCADA fault notification based on failure modes and effects analysis (FMEA). The section also includes experimental results that assess whether the human-machine interface (HMI) screens of the SCADA system meet functional design specifications [4]. Figure 2.4 shows the virtual commissioning of SCADA system integration.

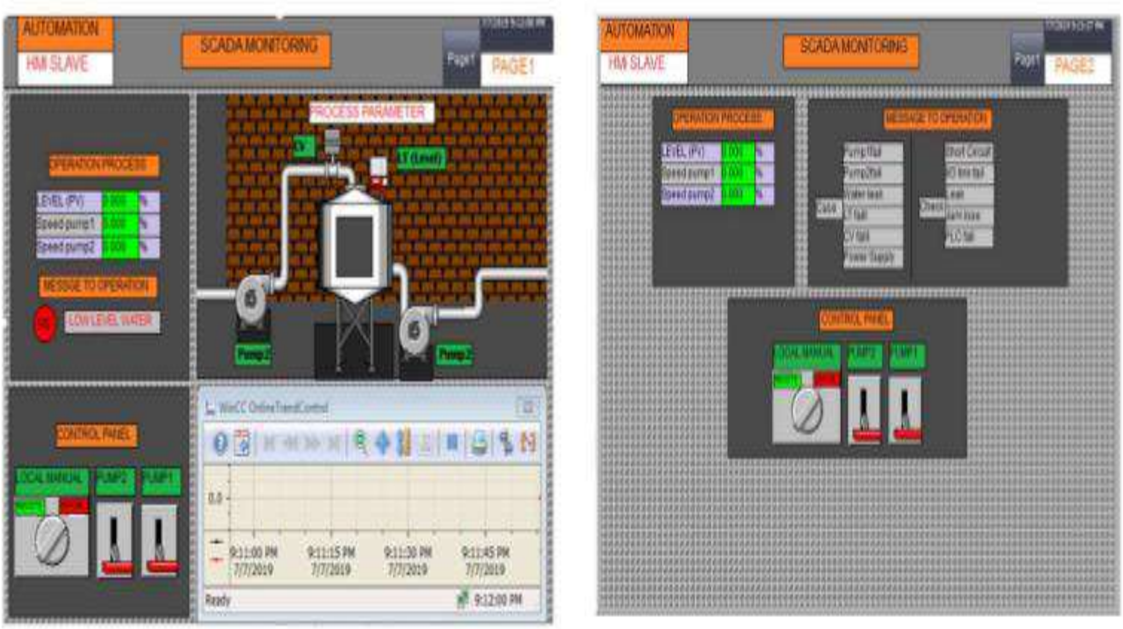

Figure 2.4: Virtual commissioning of SCADA system integration [4].

2.1.5 Design of continuous hydrogenation control system

The automatic control system comprises two core components: The WinCC configuration software and the SIEMENS PLC, with the SIEMENS PLC S7-300 module serving as the central control unit. This module regulates the opening levels of each valve using PID control, managing the flow of various raw materials, reactor temperature, pressure, liquid levels, and other crucial parameters to ensure a continuous hydrogenation reaction. Real-time monitoring and control on the PC side are facilitated through the PC software WinCC. Simultaneously, the system automatically records monitored data in the SQL Server 2005 database, enabling real-time access to this data through electronic reports, trend curves, and the ability to export and print the information as needed [5].

2.1.6 Intelligent Microclimate Control System Using PLC and SCADA

The pursuit of automation in diverse production processes represents a significant stride in the ongoing scientific and technological evolution of our society. Automation not only enhances labor productivity but also liberates individuals from direct involvement in production activities. Consequently, it elevates product quality, effectively catering to the ever-increasing societal demands. The cornerstone of modern automation hinges on the concept of technology that operates autonomously and adapts with minimal human intervention. This autonomous, adaptable technology is viewed as a means to achieve highly automated production processes, either with minimal human involvement or none at all.

The notion of flexible technology plays a pivotal role in eliminating product-related constraints or significantly reducing them. It substantially reduces the preparatory work required when transitioning to a new technology. Flexible technology fosters a high degree of automation in the production of various items, thereby enabling the swift and automated production of new products. Consequently, the development of a robust system architecture is a paramount scientific objective [6].

Chapter 3

EXPERIMENTAL SETUP AND PROCEDURE

3.1 Introduction

Supervisory Control and Data Acquisition (SCADA) system assists us in monitoring the process, controlling the operations, and quickly identifying any issues within the processes to minimize downtime. A (Programmable Logic Controller) PLC serves as the foundation of the SCADA's basic architecture. A PLC uses input terminals to monitor the status of switches and sensors, and based on that status, it sends commands to the output devices via output terminals. A PLC is a type of microprocessor that interacts with field devices such valves, pumps, sensors, (Human Machine Interface) HMIs, and other endpoints. PLC sends all of the data gathered from endpoints to SCADA systems. The SCADA software will then apply the scenarios with the PLC and present the data on the HMI to increase the operator's understanding of the current situation.

3.2 Phases of Project

The project is divided into four phases.

- Project Hardware
- PLC Programming
- HMI Programming
- SCADA Programming

3.2.1 Project Hardware

The first phase of the project, is to make hardware structure of the project. In this step a list of hardware equipment and materials is made that is required to complete the project.

Project hardware means all materials, supplies, apparatus, equipment, machinery, tools, parts, instruments and equipment to be integrated into the project.

3.2.1.2 Trainer Sheet

The trainer hardware is built by using acrylic sheet material. Acrylic sheet is used because it is stronger than glass and about ten to twenty times more impact resistant. Acrylic therefore clearly wins the durability debate with glass, which cracks and breaks easily. Acrylic also shatters into large, blunt-edged pieces, compared to glass, which shatters into typically smaller pieces. Cutting on the sheet is done by the laser machine. Figure 3.1 shows the acrylic sheet used for the trainer.

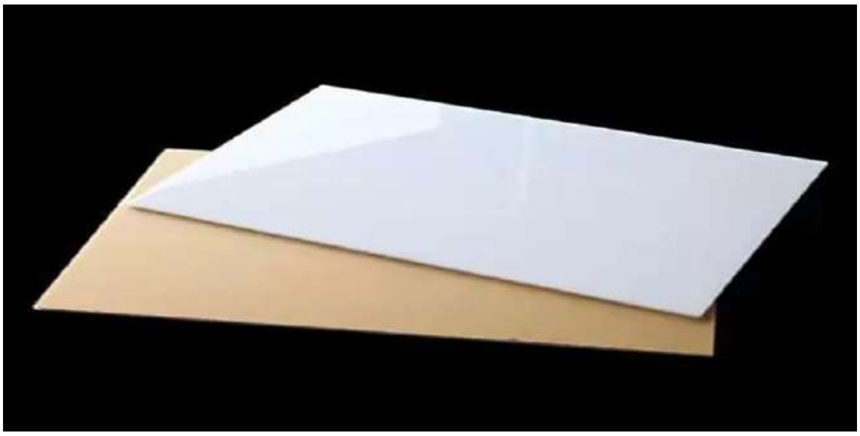

Figure 3.1: Trainer Sheet

3.2.1.3 Sheet Layout Diagram

The sheet layout diagram is made on AutoCAD. Then this diagram is implemented on the acrylic sheet by using laser cutting machine. The cutting on acrylic sheet is done according to this AutoCAD layout diagram. Figure 3.2 shows the AutoCAD layout diagram.

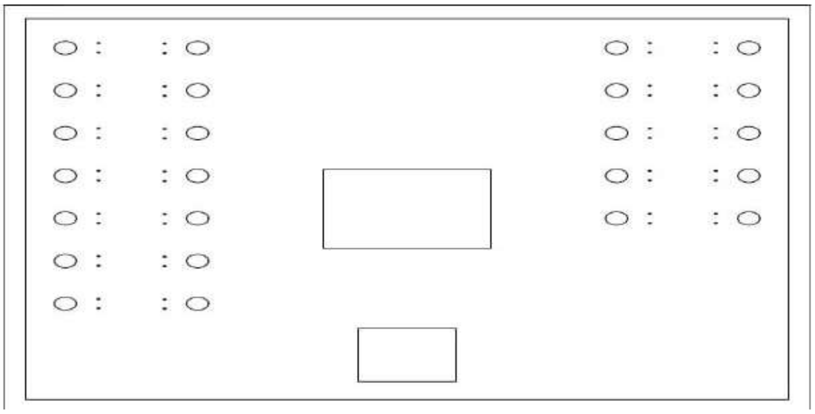

Figure 3.2: Sheet Layout diagram

3.2.1.4 Trainer Stand

Trainer stand is made up of iron stand and wooden sheet. The trainer sheet is then attached to the stand. Iron is used as the material for this stand because of some of the properties it has. It is strong, durable and tough, making it ideal for holding things in place. It is also extremely heat resistant. Figure 3.3 shows the iron and wooden stand made for the trainer.

Figure 3.3: Trainer Stand

3.2.1.5 Trainer Wiring

Trainer circuit carries electricity from two power sources, one source is 24V DC battery and then the 2nd one is 220V AC Supply. 24V DC supply is used as the input supply of the HMI, PLC and converter card which converts 24V DC to 10V DC. Also, a 12V DC power supply is for water pump. In the wiring procedure the connection will be as five loads and one neutral wire so that loads can be handled quite easily. The current usually gets into a circuit from hot wires (phase wire) and current exits through neutral wires. These wires are in red and yellow color for easy identification. We have used red as hot wire and yellow as neutral wire. Figure 3.4 shows the back side of trainer where wiring is done.

Figure 3.4: Trainer Wiring

3.2.2 PLC Programming

PLC programming is vital part of scheming and implementing control applications based on the needs of the consumer. A PLC program is a set of instructions, which symbolize the logic that is implemented for controlling industrial scenarios.

3.2.2.1 Programmable Logic Controller (PLC)

Programmable Logic Controller (PLC) is a microcomputer system that processes the data received from sensors in accordance with a program and then sends the processed information to working components. It was designed to address the drawbacks of relay control systems.

Early on, PLC was developed, and its use was expanded to cover a wide range of industrial control functions, including sequence control, motion control (linear and rotary motion control), process control (temperature, pressure, humidity, and speed), and data management (data collection, monitoring, and machine or process reporting).

3.2.2.2 Siemens S7-1200 1214C DC/DC/Rly

In order to fulfill the needs for automation, the S7-1200 controller has the adaptability and power to control a variety of devices. The S7-1200 is the ideal choice for managing a wide range of applications thanks to its small size, adaptable setup, and robust instruction set. The CPU builds a strong controller from a microprocessor, an integrated power supply, input and output circuits, built-in PROFINET, high-speed I/O motion control, and built-in analog inputs. The CPU keeps track of inputs and modifies outputs in accordance with user program, which may include Boolean logic, timing, counting, complex mathematical operations, and communication with additional smart devices. For communication over the PROFINET network, the CPU offers a PROFINET port. Additional modules are available for communication via PROFIBUS etc. Figure 3.5 shows the Siemens S7-1200 PLC.

Figure 3.5: Siemens S7-1200

3.2.2.3 TIA Portal

The Totally Integrated Automation Portal (TIA Portal) is mainly used for automation purposes; it also provides an engineering framework for implementing automation in all industries worldwide. The TIA portal is basic software that is used for programming of PLC and HMI. In this project Siemens PLC is used so, TIA Portal is required for its programming. Figure 3.6 shows the welcome screen of TIA portal.

Figure 3.6: TIA Portal

3.2.2.4 Create New Project

To add a project in TIA Portal, open TIA Portal V13 and click on the create new project. Give a name to the project and click on 'Create'. Figure 3.7 shows the project creation window of TIA portal.

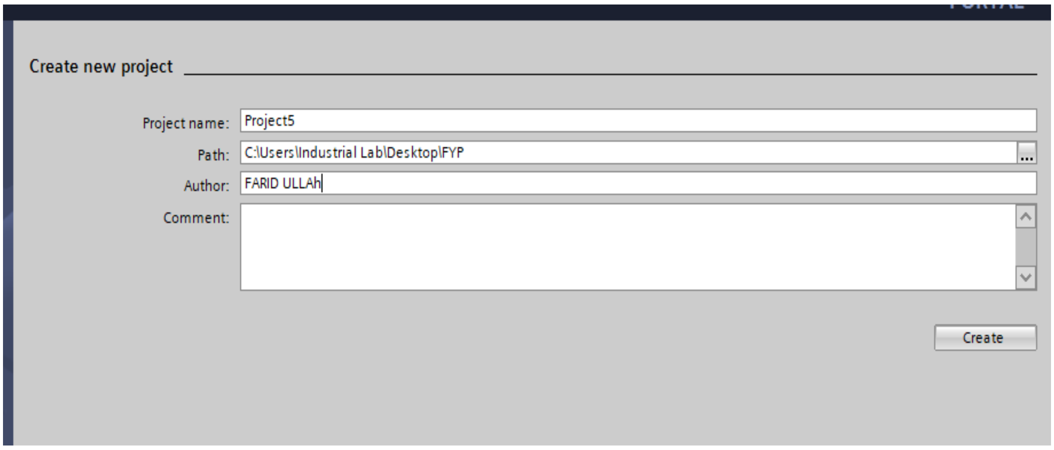

Figure 3.7: Create New Project

3.2.2.5 Configure a Device

After creating new project, a new screen appears on the software. Different options will appear on this screen. To connect PLC with the software, click on “Configure a device”. To write a program without connecting PLC click on “Write PLC Program”. There is an option of connecting HMI with software but only Siemens HMI can be connected with TIA Portal. In order to view the project before device configuration click “Open the project view”. Figure 3.8 shows the starting window of TIA Portal.

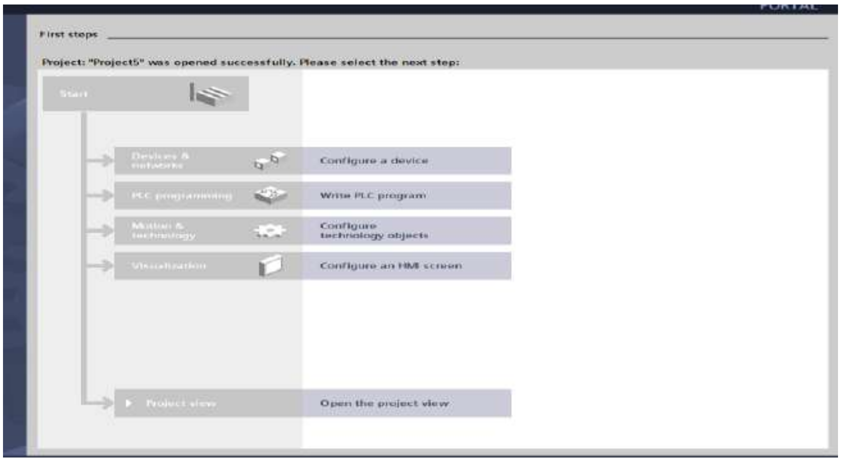

Figure 3.8: Configure a Device

3.2.2.6 Add New Device in Controller

To connect PLC with TIA portal, click on Add new device, click on Controller, in this tab, a list of controllers will appear. In controller’s tab, there are different options of PLC controller models. The PLC model used in the project is SIMATIC S7-1200. Figure 3.9 shows the window of TIA portal in which different types of controllers can be added into TIA Portal.

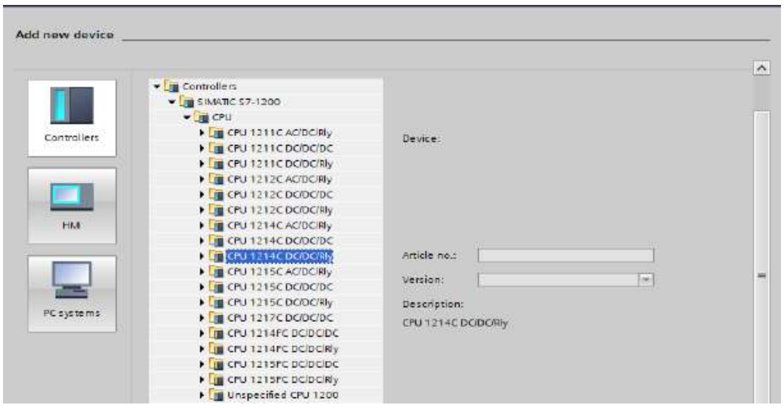

Figure 3.9: Add New Device

3.2.2.7 Select PLC Model and Click on Add

In SIMATIC S7-1200 Tab, click on CPU and go to PLC model. The PLC model is "1214C DC/DC/Rly 6ES7 214-1HG40-0XB0". Select PLC Version 4.0 or above and click on add. Figure 3.10 shows the model number of PLC used in the project.

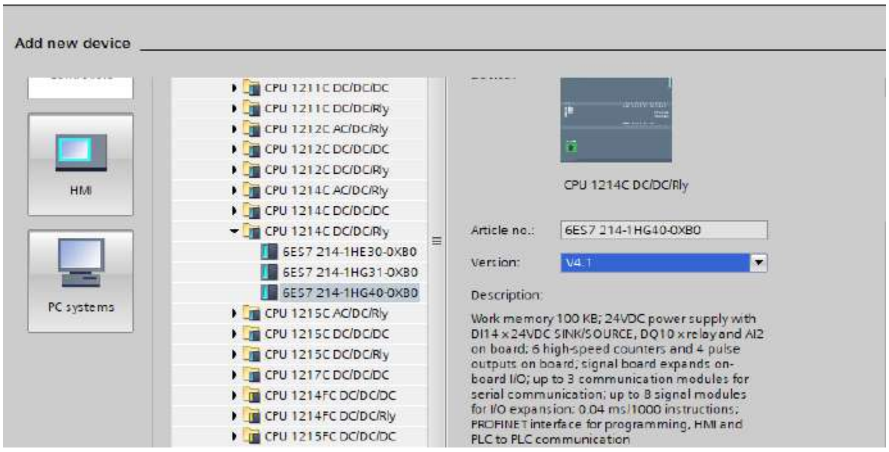

Figure 3.10: Select PLC Model

3.2.2.8 PLC Online Access

To connect PLC with TIA Portal, in main window, click on online and diagnosis and go to online access tab. In online access tab, select the type of interface available for connecting PLC with TIA portal. In ProfNet, Ethernet option select PN/IE interface. ProfNet or process field network is an industry technical standard for data communication over Ethernet. ProfNet is designed to collect data from and control equipment in industrial systems, with particular strength in delivering data under tight time constraints. Figure 3.11 shows the types of connection types that can be used for connecting PLC with software.

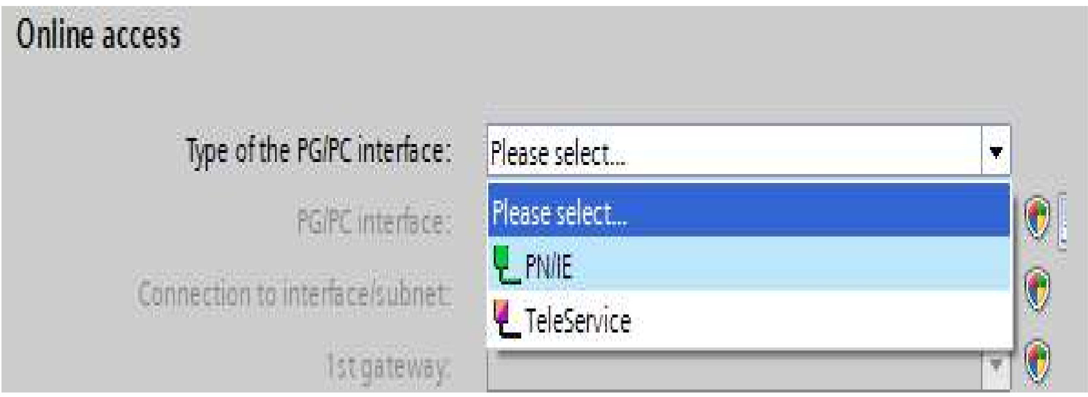

Figure 3.11: Click on Online Diagnosis

3.2.2.9 Go Online

In TIA portal there are different types of interfaces available: PLCSIM and PLCSIM S7-1200 are for simulation purposes. To connect PLC S7-1200 through Ethernet cable, select your network driver. After selecting device click on go online. Figure 3.12 shows different types of interface option that can used with PLC.

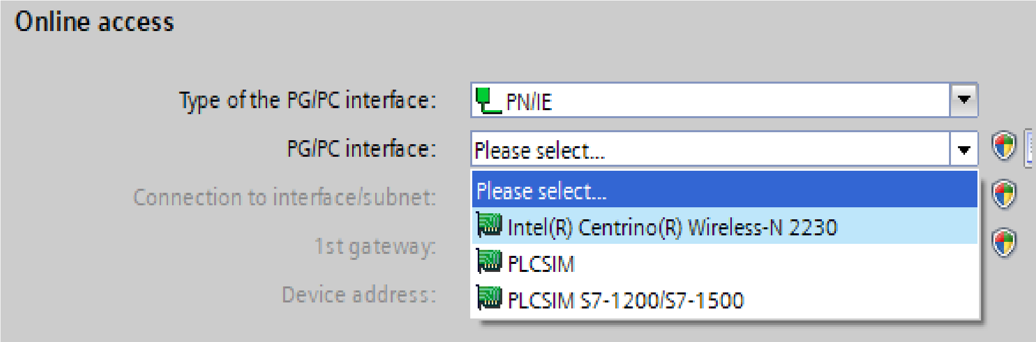

Figure 3.12: Select Interface

3.2.2.10 Internet Connections

To change the IP address of the PC system, go to control panel, select network and internet and click on network connections. The communication between PLC and PC system is provided through Ethernet cable so right click on Ethernet and go to Ethernet properties. In Ethernet properties, go to internet protocol version 4 (TCP/IPv4) and click on properties. Figure 3.13 shows the Ethernet properties in which there are an option to change the IP address of the PC system.

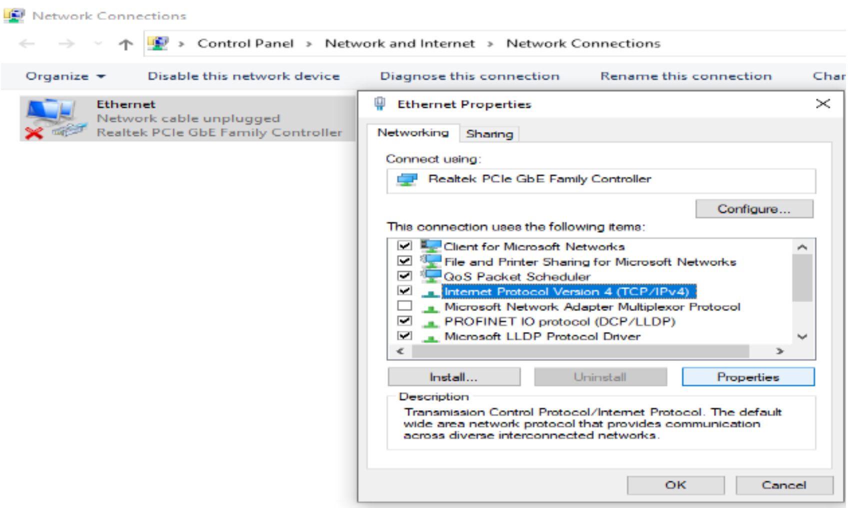

Figure 3.13: Internet Connection

3.2.2.11 Change IP Address of PC System

In TCP/IPv4 Properties, change the IP address from dynamic to static address. The main reason to change IP address from dynamic to static is that dynamic IP addresses are changed automatically, sometimes instantly.

Dynamic host configuration protocol (DHCP) servers assign dynamic addresses as necessary. A static IP address, however, is just one that doesn't change. Normally, once a device is given a static IP address that number won't change unless the device is retired or the network architecture is changed. Servers and other significant equipment typically use static IP addresses. Figure 3.14 shows the IP address of PC system that is changed from dynamic to static.

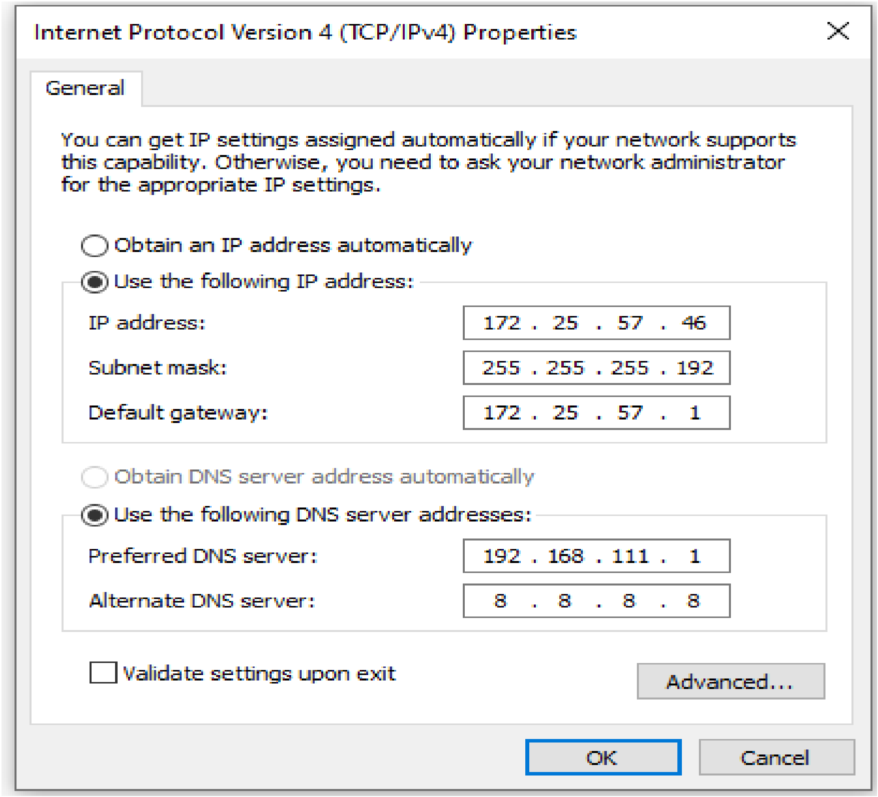

Figure 3.14: Change IP Address

3.2.2.12 Change PLC IP Address

After changing PC system IP address from static to dynamic. In TIA portal, go to "Device Configuration" and click on Ethernet address.

In IP protocol, there is an option to set IP address in the project. In this option, change the IP address. Figure 3.15 shows the IP address of PLC in TIA Portal.

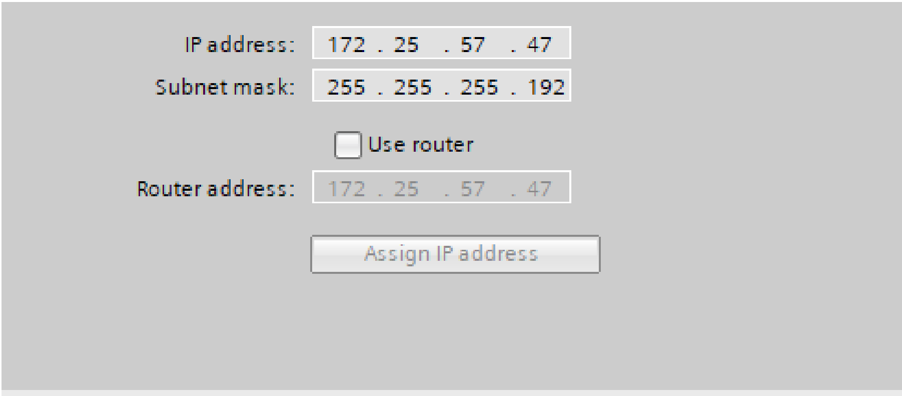

Figure 3.15: Change PLC IP Address

3.2.2.13 After Changing IP Address, Go Online

After changing PLC IP address, click on "Go online" to connect PLC with PC system through Ethernet connection. Figure 3.16 shows the online connection window of TIA Portal.

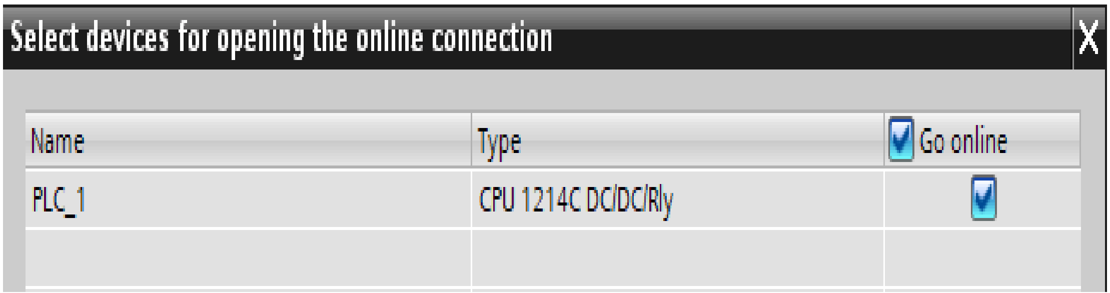

Figure 3.16: After Changing the IP Address Click on Go Online

3.2.2.14 Add New Block

To write a program in TIA Portal, first you need to add program block.There are four types of program blocks in TIA Portal and each block have its own specific function.Types of programming blocks in TIA portal and their functions are.

- **Organization Block (OB):** The main programming block that includes networks and components that control specific tasks
- **Function Block (FB):** Create function blocks
- **Function (FC):** A subroutine that performs a specific task, this block is called by the organization block
- **Data Block (DB):** An archive where a distinct set of tags and data is stored; is used with functions

In this program the main code is written in the organization block. In add new block window, select organization block and as the program will be executed cyclically so, select “Program Cycle”. A "Program cycle" OB is executed cyclically and is the main block of the program. This is where you place the instructions that control the application, and call additional user blocks. Figure 3.17 shows the new block window of TIA Portal. In this window new programming blocks can be into main program.

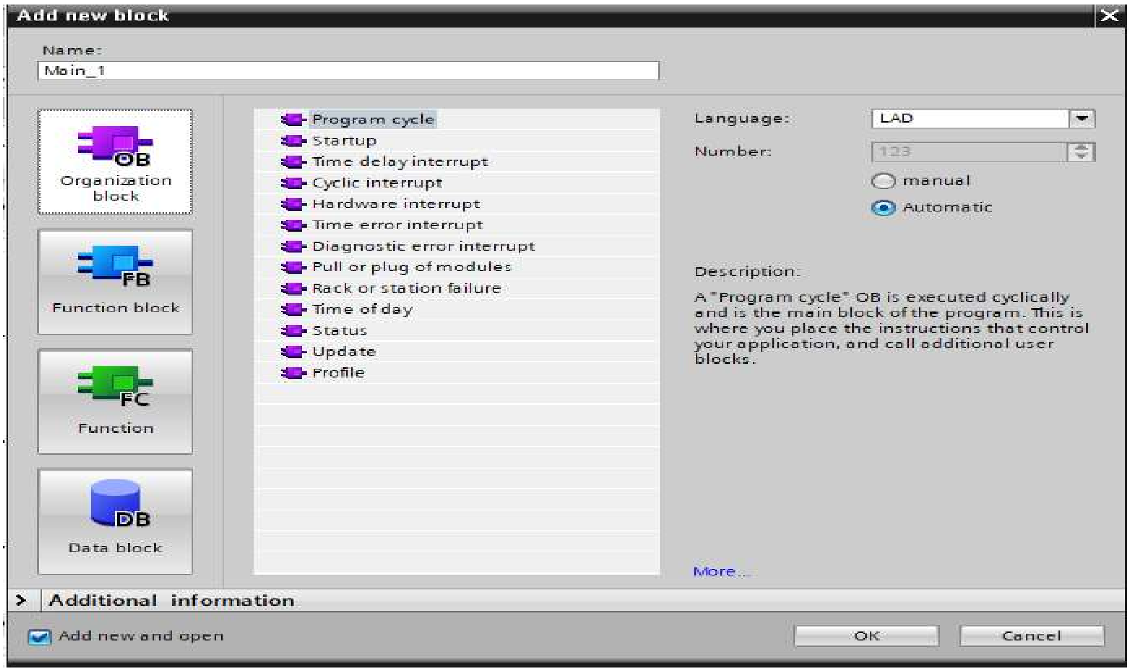

Figure 3.17: Add New Block

3.2.2.15 Ladder Logic of Network 1 (Pressure)

In Network 1, A normally open switch is used to “Turn On” red lamp and the program block. This switch has PLC digital input address I0.0. The switch can be used with PLC to “Turn On” the program block. There is another normally open switch, M0.0 is latching which is for turning on program from HMI. This switch is in parallel with PLC switch.

Means the lamp and program block can be turned on either by PLC input or HMI input. The input that is also stored in the data block which is for controlling the red lamp through SCADA software.

Both of these switches are in parallel with each other. Then we used three blocks NORM_X SCALE_X CONVERTER and COMPARATOR at the end of the rung, an alarm is used for the safety purpose and will trigger when the pressure exceeds a set value. The alarm is given a PLC digital output address of “Q0.0”. We did this programming for pressure monitoring purpose. Figure 3.18 shows the ladder logic of “OB1 Network 1”.

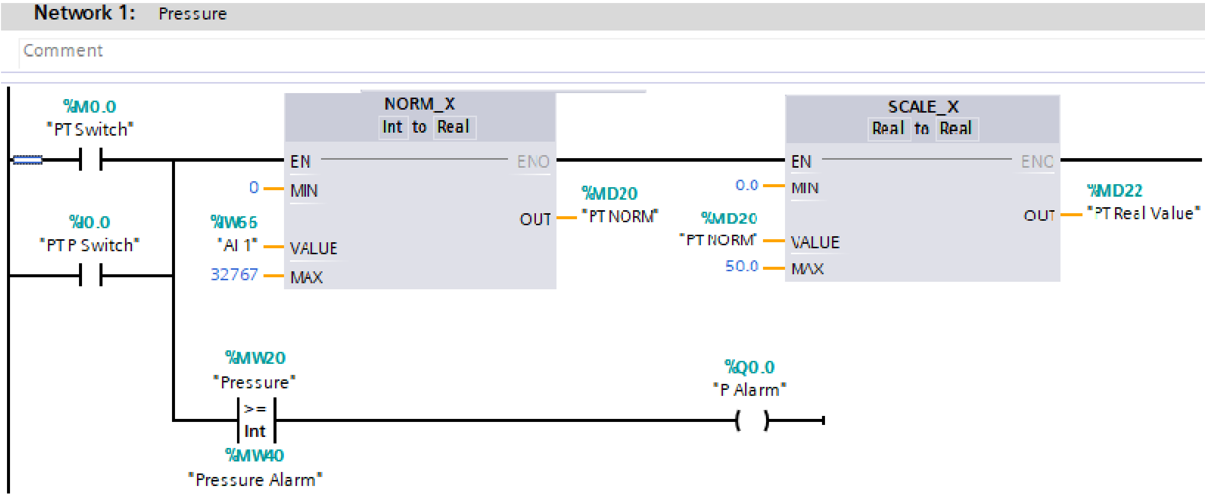

Figure 3.18: OB1 Network 1

3.2.2.16 Ladder Logic of Network 2 (Weight)

In Network 2, a normally open switch is used to “Turn On” red lamp and the program block. This switch has PLC digital input address I0.0. The switch can be used with PLC to “Turn On” the program block. There is another normally open switch, M0.0 is latching which is for turning on program from HMI. This switch is in parallel with PLC switch.
Means the lamp and program block can be turned on either by PLC input or HMI input. The input that is also stored in the data block which is for controlling the red lamp through SCADA software.

Both of these switches are in parallel with each other. Then we used three blocks NORM_X it converts the integer value to real value SCALE_X it just scales the value CONVERTER it converts the real value into integer value and COMPARATOR it campier the output value of convertor at the end of the rung, an alarm is set and it will have triggered when the weight exceeds a set value. The alarm is given a PLC digital output address of “Q0.1”. We did this programming for weight monitoring purpose. Figure 3.19 shows the ladder logic of “OB1 Network 2”.

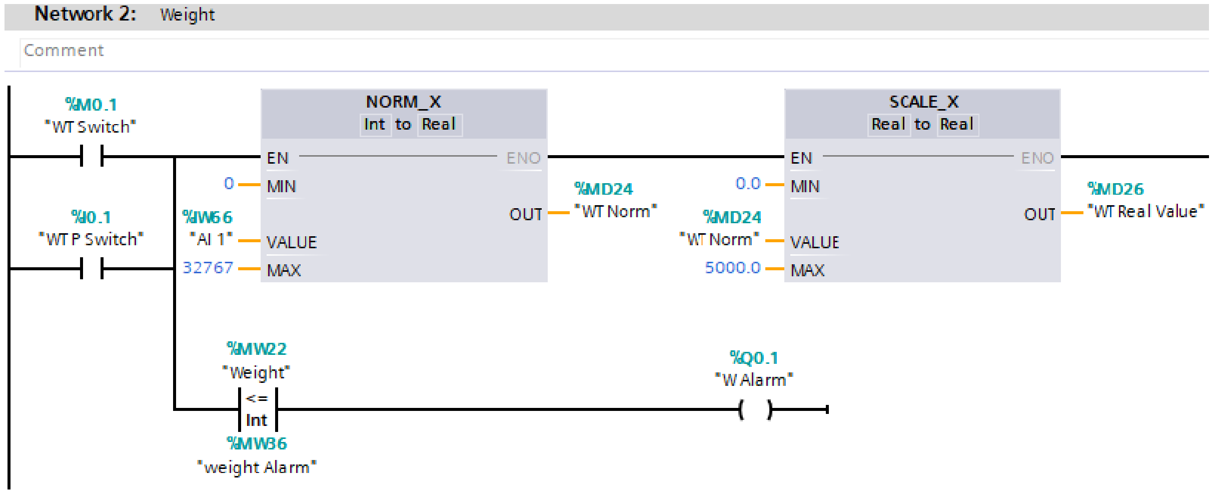

Figure 3.19: OB1 Network

3.2.2 .17 Ladder Logic of Network 3 (Temperature)

In Network 3, A normally open switch is used to "Turn On" red lamp and the program block. This switch has PLC digital input address I0.0. The switch can be used with PLC to "Turn On" the program block. There is another normally open switch, M0.0 is latching which is for turning on program from HMI. This switch is in parallel with PLC switch.

Means the lamp and program block can be turned on either by PLC input or HMI input. The input that is also stored in the data block which is for controlling the red lamp through SCADA software.

Both of these switches are in parallel with each other. Then we used three blocks NORM_X it converts the integer value to real value, SCALE_X and just scales the value, CONVERTER and converts the real value into integer value and COMPARATOR it compares the output value of convertor at the end of the rung, an alarm is used and it will be triggered when temperature exceeds the set value. The alarm is given a PLC digital output address of "Q0.2". We did this programming for temperature monitoring purpose. Figure 3.20 shows the ladder logic of "OB1 Network 3".

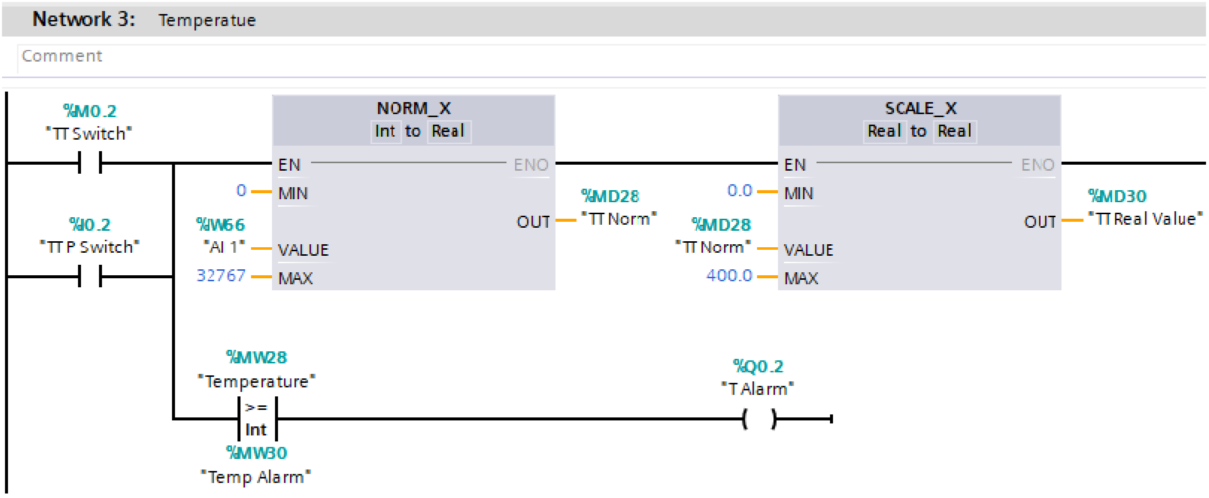

Figure 3.20: OB1 Network 3

3.2.2.18 Ladder Logic of Network 4 (Flow Rate)

In Network 4, a normally open switch is used to "Turn On" red lamp and the program block. This switch has PLC digital input address I0.0. The switch can be used with PLC to "Turn On" the program block. There is another normally open switch, M0.0 is latching which is for turning on program from HMI. This switch is in parallel with PLC switch.

Means the lamp and program block can be turned on either by PLC input or HMI input. The input that is also stored in the data block which is for controlling the red lamp through SCADA software.

Both of these switches are in parallel with each other. Then we used three blocks NORM_X it converts the integer value to real value SCALE_X it just scales the value CONVERTER it converts the real value into integer value and COMPARATOR it campier the output value of convertor at the end of the rung, an alarm is used and it will trigger when the flow rate exceeds the set value. The alarm is given a PLC digital output address of "Q0.3" We did this programming for flow monitoring purpose. Figure 3.21 shows the ladder logic of "OB1 Network 4".

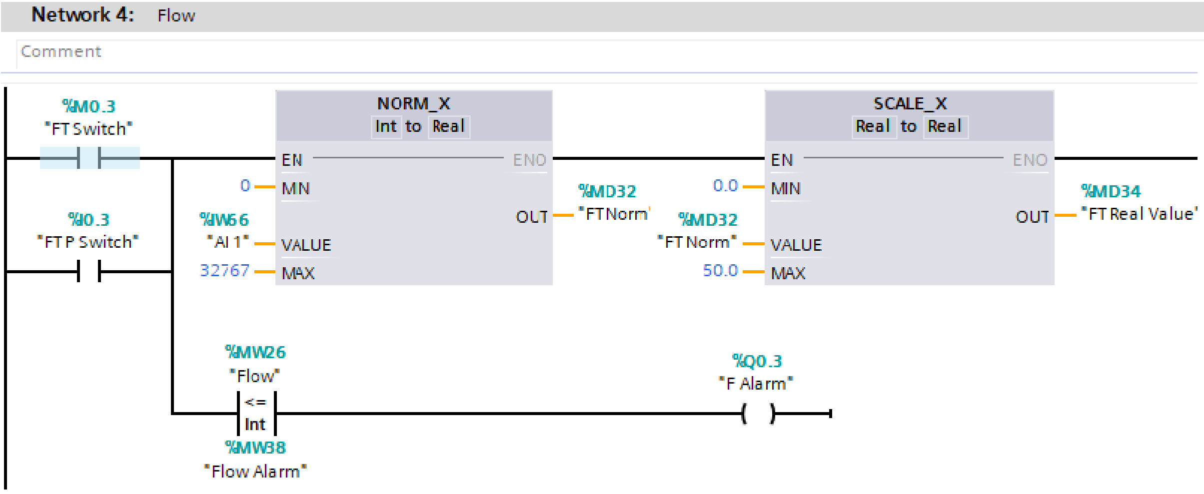

Figure 3.21: OB1 Network 4

3.2.2.19 Ladder Logic of Network 5 (HMI Output control)

In Network 5 we used a MULTIPLY block which control the HMI output and scale the value. The move command is used for moving scale input from the output value of "MUL'' scale value which is from PLC analog input "MW32" into another register that "MW34" this register will be used as analog input of HMI and SCADA. Figure 3.22 shows the ladder logic of "OB1 Network 4".

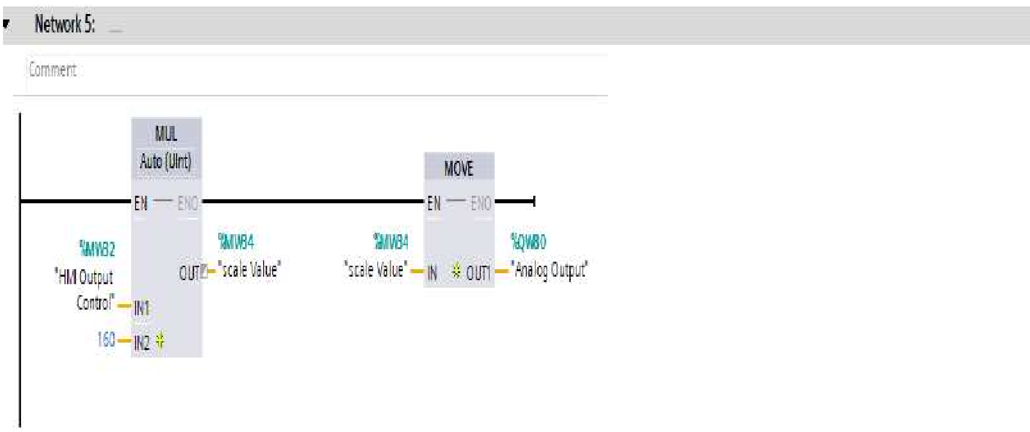

Figure 3.22: OB1 Network 5

3.2.2.20 Ladder Logic of Network 6 (PID Controller)

PID controller is used to control temperature. It has different pins on the input side as well as output side. We have used two pins on the input side namely Set point and Input. We have assigned the "Temperature" tag at the input and "Temp_SV" at the set point value of the

PID controller. At the only output pin used i.e.; Output, we are getting "OUTPUT_Scale" used to control the heater. Figure 3.23 shows the ladder logic of "OB1 Network 6".

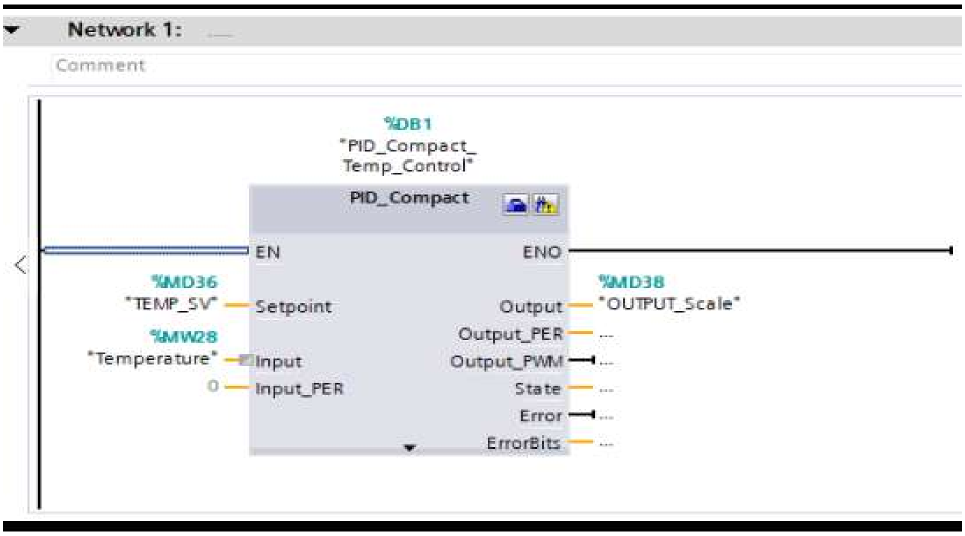

Figure 3.23: OB1 Network 6

3.2.2.21 Startup Block

In the Organization block, add a new block "Startup". A "Startup" OB will execute one time when the operating mode of the PLC changes from STOP to RUN. After completion, the main "Program cycle" OB will begin executing. Figure 3.24 shows the "Add new block" window of TIA Portal. In this screen, new programming blocks can be added into the main program.

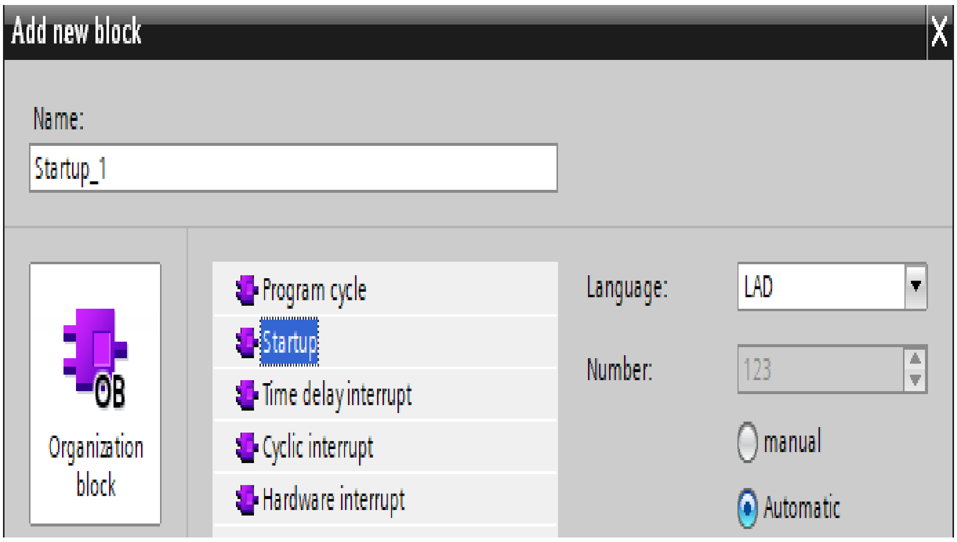

Figure 3.24: Startup Block

3.2.2.22 Function Coil

Functions are code blocks or subroutines without dedicated memory. The FC function is used in PLC programming where a function or task is used over and over again. Figure 3.25 shows the window of TIA Portal in which there is an option to add new function block in the program.

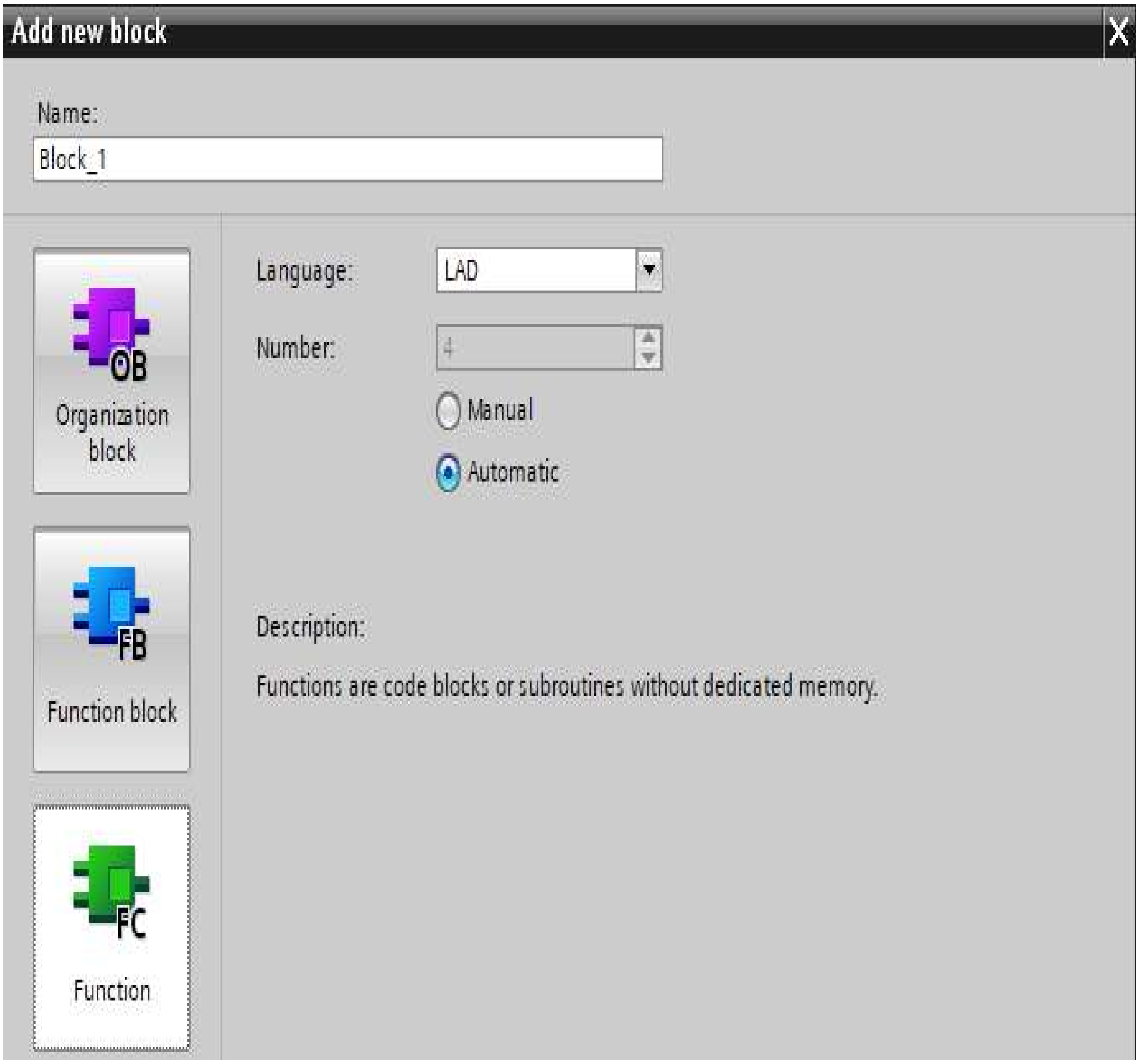

Figure 3.25: Add Function Coil

3.2.2.23 PLC TAGs

A “TAG” is a name that you assign to a device/PLC address. It is also called "variable" or "symbol" depending on the device/PLC type. In order to configure the tags, select the PLC tags configuration tool on the device/PLC. Figure 3.26 shows all the tags used in TIA Portal.

		Name	Data type	Address	Retain	Visibl...	Acces...
22		PT NORM	Real	%MD20	☐	☑	☑
23		Tag_5	Int	%MW0	☐	☑	☑
24		PT Real Value	Real	%MD22	☐	☑	☑
25		Pressure	Int	%MW20	☐	☑	☑
26		WT Norm	Real	%MD24	☐	☑	☑
27		WT Real Value	Real	%MD26	☐	☑	☑
28		Weight	Int	%MW22	☐	☑	☑
29		TT Norm	Real	%MD28	☐	☑	☑
30		TT Real Value	Real	%MD30	☐	☑	☑
31		Temperature Raw	Int	%MW24	☐	☑	☑
32		FT Norm	Real	%MD32	☐	☑	☑
33		FT Real Value	Real	%MD34	☐	☑	☑
34		Flow	Int	%MW26	☐	☑	☑
35		Temperature	Int	%MW28	☐	☑	☑
36		Temp Alarm	Int	%MW30	☐	☑	☑
37		scale Value	Int	%MW34	☐	☑	☑
38		weight Alarm	Int	%MW36	☐	☑	☑
39		W Alarm	Bool	%Q0.1	☐	☑	☑
40		T Alarm	Bool	%Q0.2	☐	☑	☑
41		Flow Alarm	Int	%MW38	☐	☑	☑
42		F Alarm	Bool	%Q0.3	☐	☑	☑
43		HMI Output Control	Word	%MW32	☐	☑	☑
44		Analog Output	Int	%QW80	☐	☑	☑

Figure 3.26 PLC Tags

3.2.2.24 Compile

After writing the program, the next step is "compiling program". Compiling is done to check if there are any errors in the main program. After compiling the errors are highlighted in the main window after removing errors compile again. Figure 3.27 shows the tab in which has the option to compile the program.

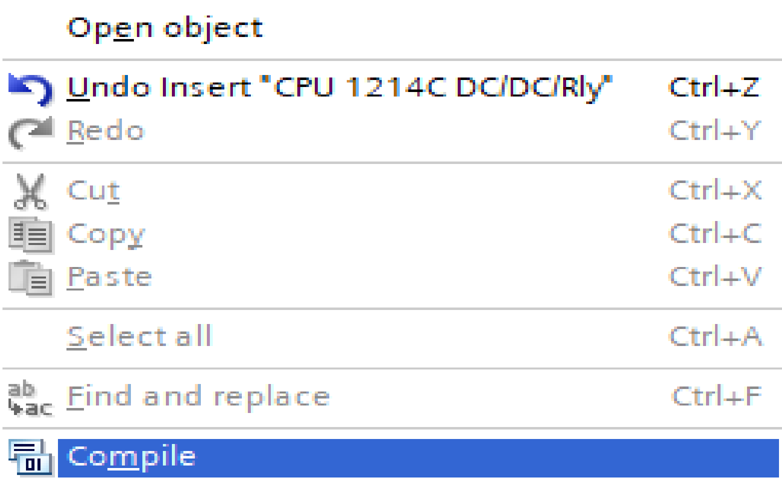

Figure 3.27: Compile

3.2.2.25 Download to Device

In the project tree, right-click on the name of the PLC device and select "Download to device". A window will appear that shows a list of available, compatible or with the same IP address based on the selection. Click start Search to connect to the device. Figure 3.28 show the option to download program into PLC.

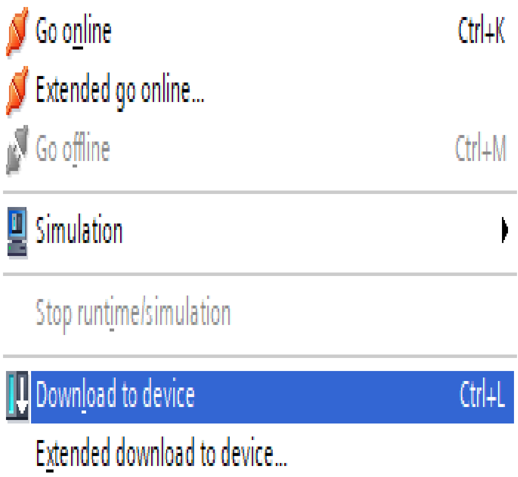

Figure 3.28: Download to PLC

3.2.3 HMI (Human Machine Interface)

HMI, or human-machine interface, is a user interface or control panel that links a person to a machine, system, or device. HMI is most frequently used in relation to an industrial process, even though the term can technically be applied to any screen that enables a user to interact with a device.

The HMI is programmed using the easy builder pro software. It is used for a variety of various industrial applications, including packaging machines, processing plants, water treatment plants, and many more, Easy builder pro offers a large number of high-quality graphics libraries. We use HMI model 8071iE in this project.

3.2.3.1 HMI Programming

Easy builder pro software is used for the programming of HMI. Easy builder pro guides you through the process of editing an HMI project all with ease and performs project supervision such as, device supervision, file supervision, or log supervision. Figure 3.29 shows easy builder pro screen.

Figure 3.29: Easy Builder Pro

3.2.3.2 Select Device

The first step after opening "EASY BUILDER PRO" is to create "New Project" and go to device selection window.

In list of HMI Models, click on "i.e." Series in this series select MT8071iE/MT0101iE.Figure 3.30 shows the model selection tab of easy builder pro software.

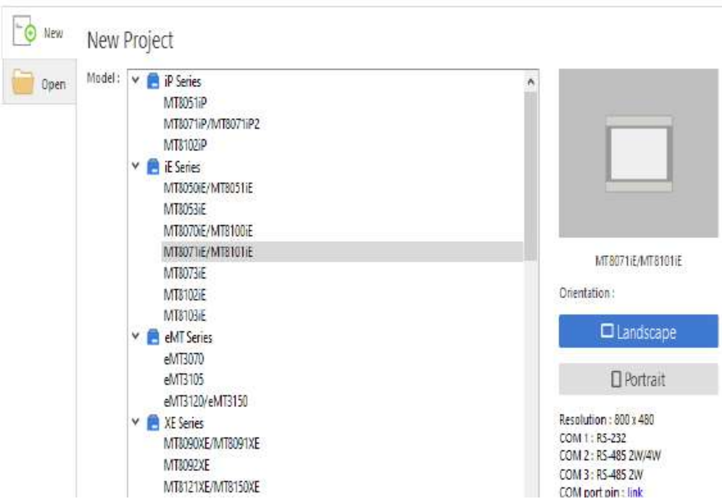

Figure 3.30: Select HMI

3.2.3.3 HMI Screen 01 (Introductory Screen)

The easy builder pro software is used for the programming of HMI. After selecting HMI Go to main window and click on "Home Tab". In home tab, there is a list of icons, buttons that can be used for various functions in "HMI". After selecting HMI Go to main window and click on "Home Tab". Figure 3.31 show the main window of HMI.

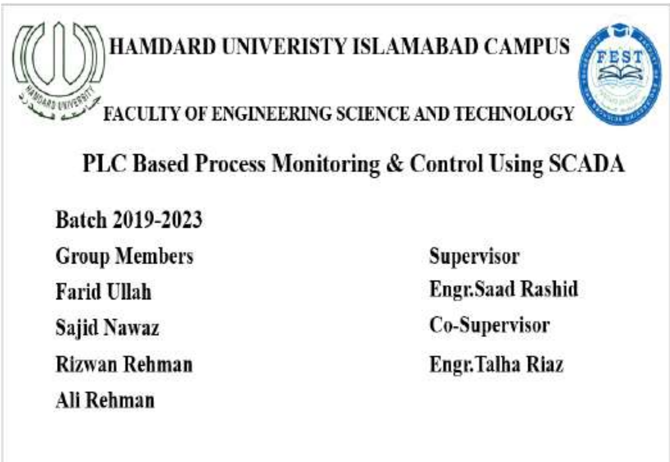

Figure 3.31: HMI Main Screen

3.2.3.4 HMI Screen 02 (Home Screen)

In screen, there is a list of icons, buttons that can be used for various functions in "HMI". In this scenario, two "Set Word" are added into main screen. One set word is used for turning on "Red Lamp" and the second one is used for turning off "Red Lamp". Figure 3.32 shows HMI main window.

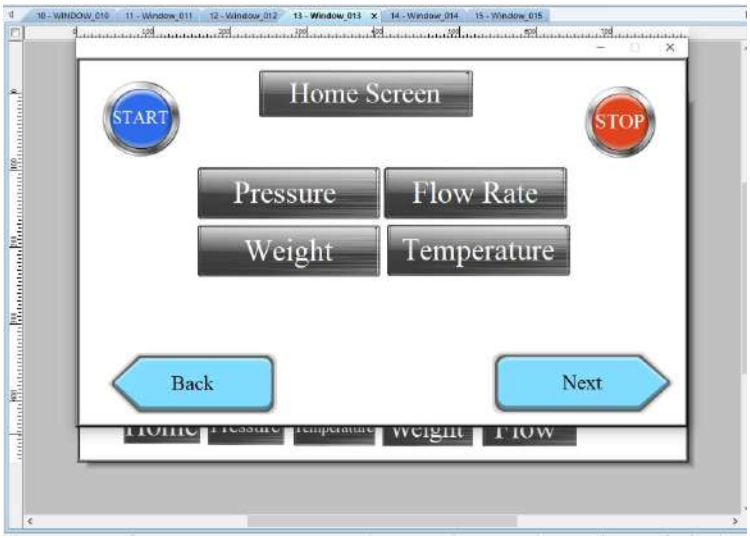

Figure 3.32: HMI Main Screen

3.2.3.5 HMI Screen 03 (Pressure)

In screen 3, there is a list of icons, buttons that can be used for various functions in "HMI". In this scenario, two "Set Word" are added into main screen. One set word is used for "START" and the second one is used for STOP 'Figure 3.33 shows for pressure window.

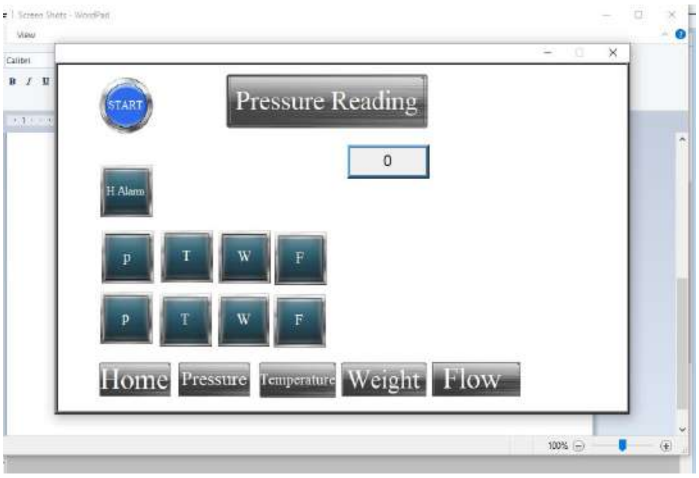

Figure 3.33: HMI pressure window

3.2.3.6 HMI Screen 04 (Flow)

In screen 4, there is a list of icons, buttons that can be used for various functions in "HMI". In this scenario, two "Set Word" are added into main screen. One set word is used for "START" and the second one is used for STOP'. Figure 3.34 shows flow window.

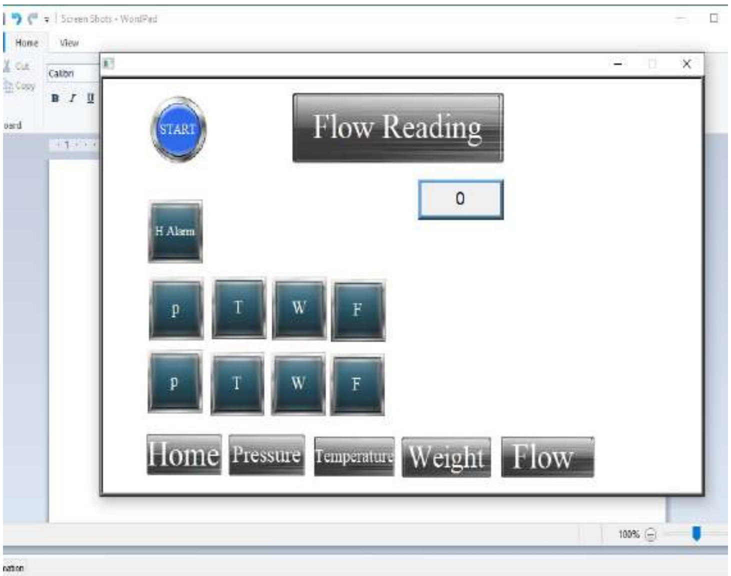

Figure 3.34: HMI flow window

3.2.3.7 HMI Screen 05 (Weight)

In screen 5, there is a list of icons, buttons that can be used for various functions in "HMI". In this scenario, two "Set Word" are added into main screen. One set word is used for "START" and the second one is used for STOP' Figure 3.35 shows weight window.

Figure 3.35: HMI weight window

3.2.3.8 HMI Screen 06 (Temperature)

In screen 6, there is a list of icons, buttons that can be used for various functions in "HMI". In this scenario, two "Set Word" are added into main screen. One set word is used for "START" and the second one is used for STOP. Figure 3.36 shows for temperature window.

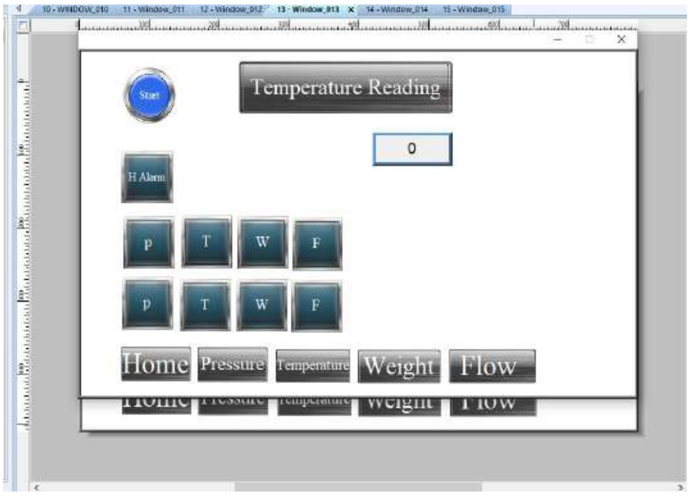

Figure 3.36: HMI temperature window

3.2.4 SCADA (Supervisory Control and Data Acquisition)

Supervisory Control and Data Acquisition (SCADA) is a set of hardware and software components enable industrial companies to.

- Control industrial processes locally or at remote locations
- Real-time monitoring, data collection and processing.

- Directly communicate with equipment like sensors, valves, pumps, motors, and more using software for human-machine interfaces (HMI).

SCADA systems are critical for industrial organizations to maintain efficiency, process data for better choices, and notify system issues to help reduce downtime. A control system architecture known as supervisory control and data.

Acquisition (SCADA) uses computers, network data connections, and graphical user interfaces to provide high-level supervision of equipment and processes. It also comprises sensors and other equipment connected to a process or piece of machinery, including programmable logic controllers. For high-level supervision of devices and processes, the control and data acquisition are a control system architecture including computers, network data connections, and graphical user interfaces.

A SCADA system is a combination of hardware and software that enables the automation of industrial processes by capturing operational technology data. SCADA connects sensors that monitor equipment such as motors, pumps and valves to local or remote server. SCADA systems acquire data from sensors and network devices connected to the PLC. It measures parameters such as speed, temperature, mass, flow, gaseous emissions and pressure. This raw data is then sent to the PLC for processing and then to the HMI where the human operator analyzes and makes decisions as needed. SCADA software processes, distributes and displays data, helping operators and other staff analyzes data and makes important decisions.

3.2.4.1 WinCC SCADA

WinCC supervisory is the best SCADA software for monitoring and data storage of industrial processes. It can be used with OPC client, Profaned, Modbus RTU etc. Figure 3.37 shows the welcome screen of WinCC.

Figure 3.37: WinCC

3.2.4.2 Advantages of WinCC SCADA Software

"Development and Runtime" are the two portions of the WinCC SCADA program. The following choices are available in WinCC SCADA.

The user can be notified by email and SMS when an alarm or warning occurs, and it can be seen on the screen in real time as well.

- Create detailed reports from historical data with ease, then save them in excel.
- When using recipe, previously saved values for tags are instantly transferred to the device.
- WinTr stations can be run synchronously via the internet using the server-client option, and screens may be viewed on distant computers using web browsers like Google chrome.

3.2.4.3 WinCC SCADA Programming

WinCC software is used for SCADA programming. In the main screen of the SCADA program, four button is used as “pressure” “flow” “weight” and “temperature” after pressing these buttons enable the option to that specific window though SCADA. Figure 3.38 shows the main window of SCADA WINCC.

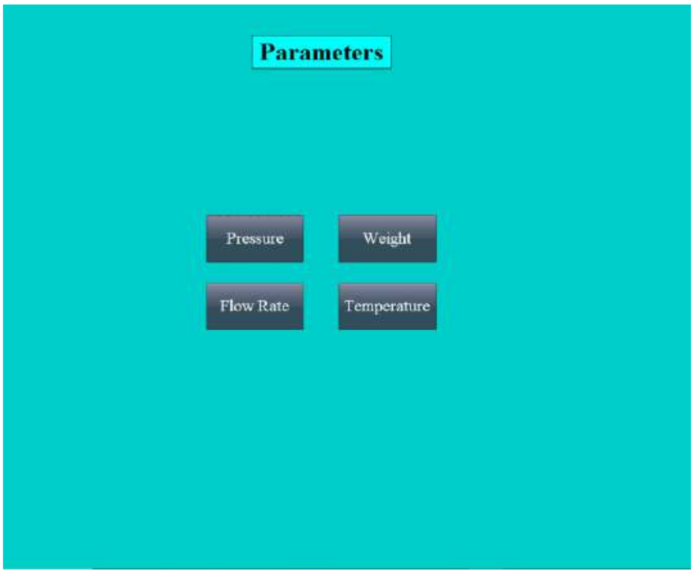

Figure 3.38: SCADA WINCC main window

3.2.4.4 WINCC Pressure window

In this window we used 15 switches. At the top corner side, a virtual switch is used for virtually enabling and controlling the trainer. Four virtual and four physical switches for controlling physically and virtually controlling that window. Pressing any one button will operate only that specific scenario and all three switches will off. An alarm is also used for safety purposes whenever the value is up or below the range than the alarm will indicate. And a meter is placed for measuring the value of pressure. And five button at the bottom. Pressing any button in the bottom five will go that specific window. And graph is also given for showing the result of the pressure. Figure 3.39 shows the WinCC pressure window.

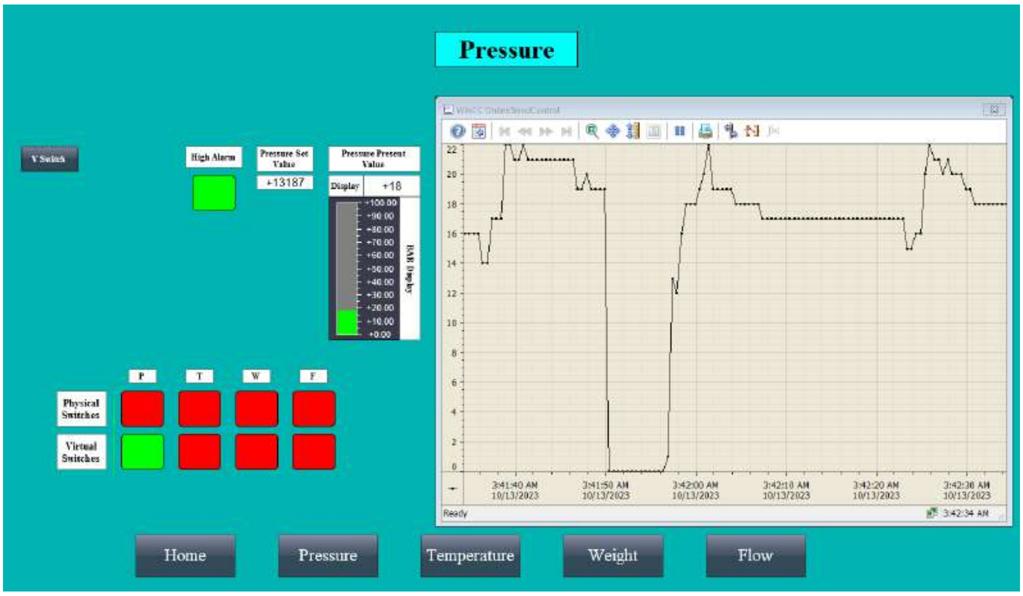

Figure 3.39: WinCC Pressure window

Figure 3.40 shows the SCADA WINCC Temperature window.

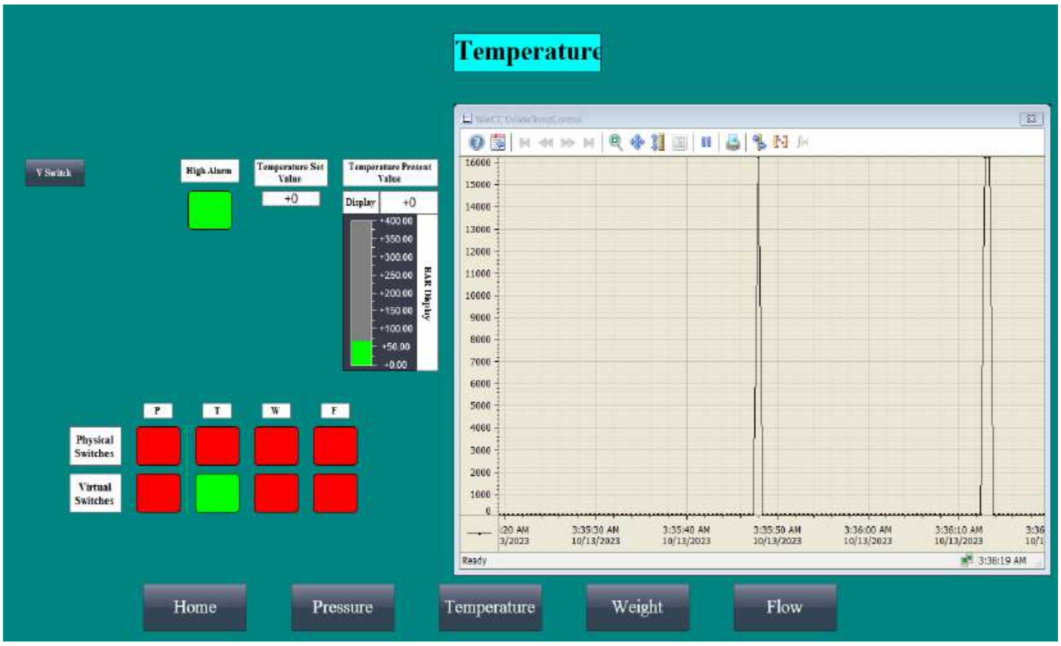

Figure 3.40: WinCC Temperature window

Figure 3.41 shows the SCADA WINCC Temperature window.

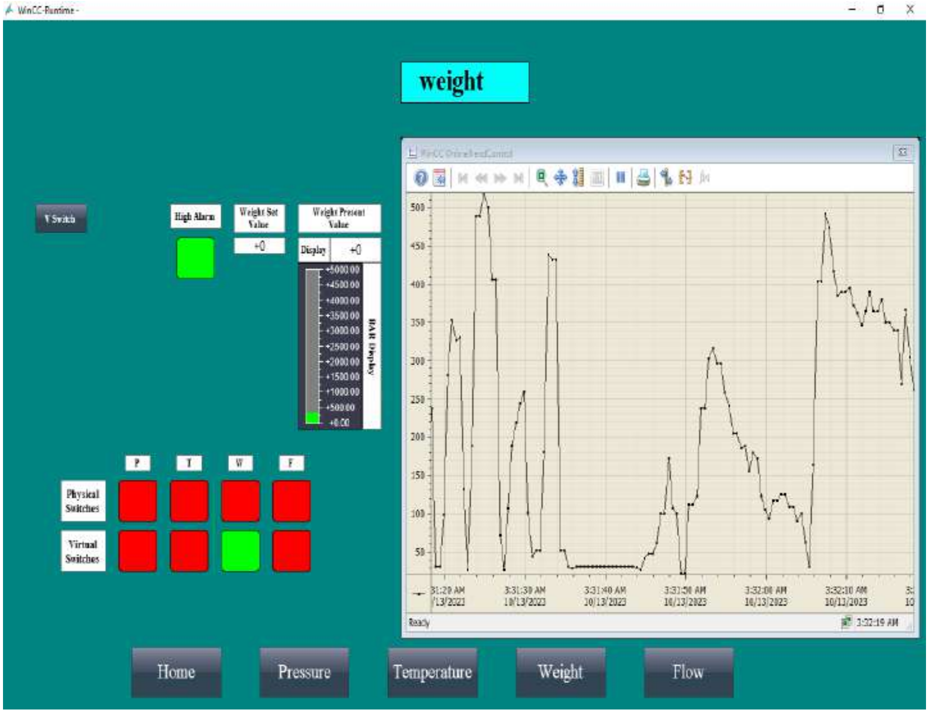

Figure 3.41: WinCC Weight window

Figure 3.42 shows the SCADA WINCC Flow window.

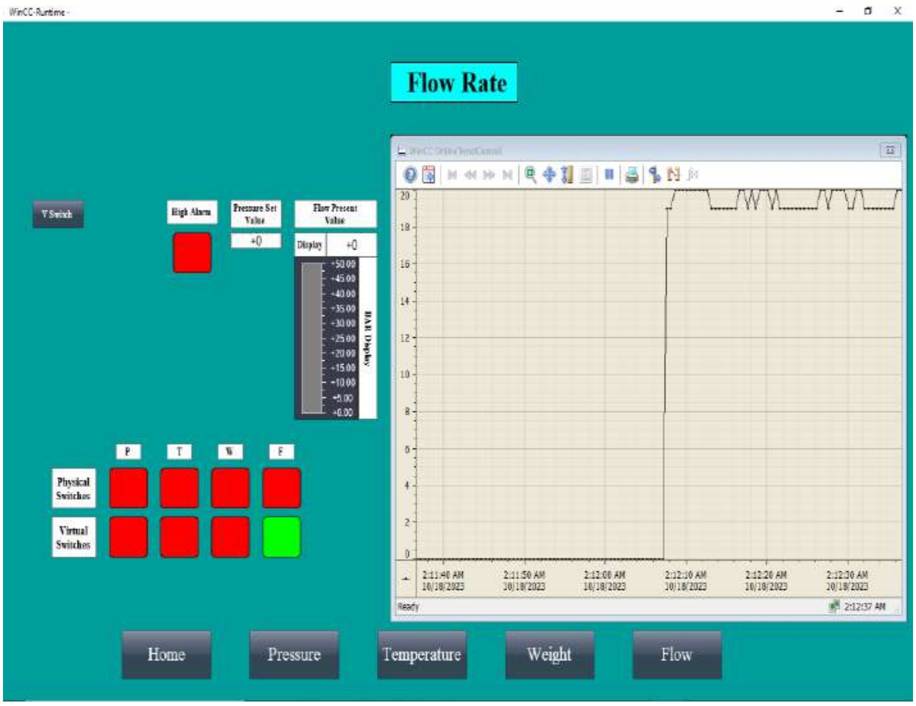

Figure 3.42: WINCC Flow window

3.2.4.5 WINCC SCADA IP Address

For connecting WinCC SCADA with PLC change the IP address in WinCC. To change IP address in WinCC, click on connection manager. In this tab, click on “ProfNet connection” and right click to add a “network”.

Then go to station net properties and click on IP address. PLC and WinCC should have same IP address for better connection. Figure 3.43 shows the network properties tab in WinCC software.

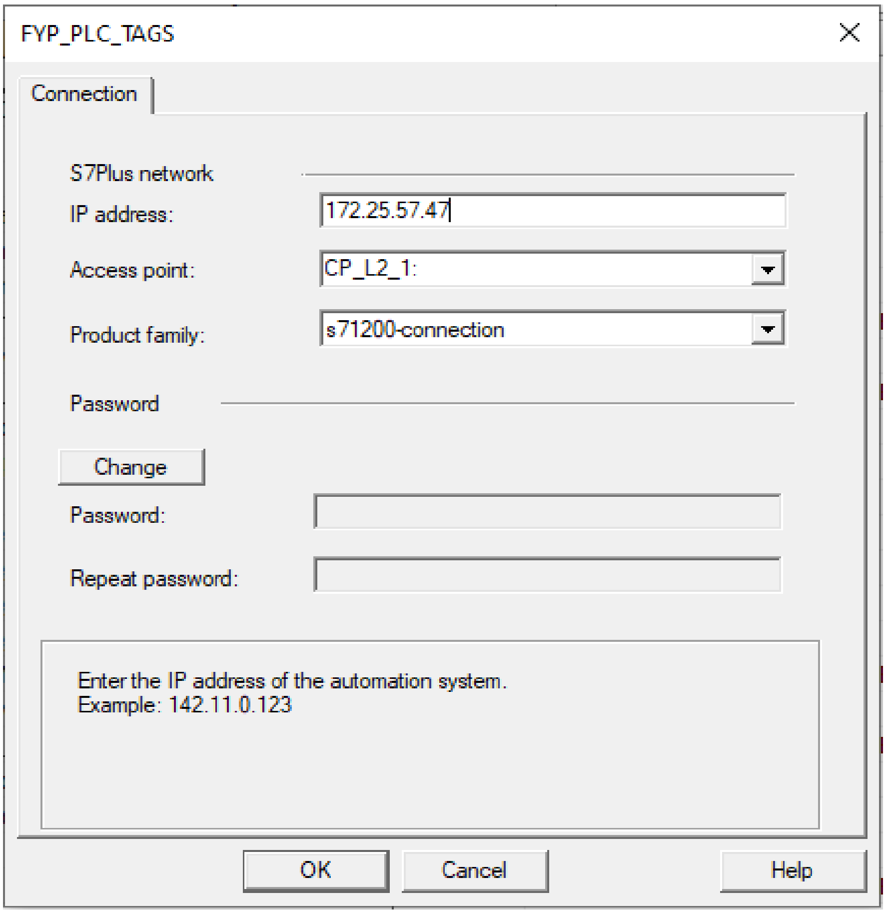

Figure 3.43: WinCC IP Address

Chapter 4

MATERIAL AND COMPONENTS

4.1 VFD (Variable Frequency Drive)

A VFD (Variable Frequency Drive) is a type of electrical appliance that modifies the input voltage of an electric motor to regulate its speed. Pumps, fans, conveyor belts, and other types of equipment are managed by VFDs in industrial plants. The low voltage inverter from the INVT good drive series has complete specifications, great performance, and a wealth of features. It is widely employed in more than 80 foreign nations and a variety of application industries, and customers largely accept it. Figure 4.1 shows the image of INVT VFD CHF-100A.

Figure 4.1:VFD

4.2 Circuit Breaker

Two hot wires linked by one neutral conductor make up the three-pole circuit breakers. As a result, both hot pole wires will shut down if one of them is shorted. Both a single 240-volt circuit, such as your central AC circuit, and two independent 120-volt circuits can be served by these breakers. Figure 4.2 shows the image of two pole circuit breaker.

Figure 4.2: Circuit Breaker

4.3 Load cell

A load cell functions as a sensor or transducer, converting applied force into an electronic signal. Depending on the specific load cell and circuitry employed, this electronic signal can manifest as a change in voltage, current, or frequency. Figure 4.3 shows the image of load cell.

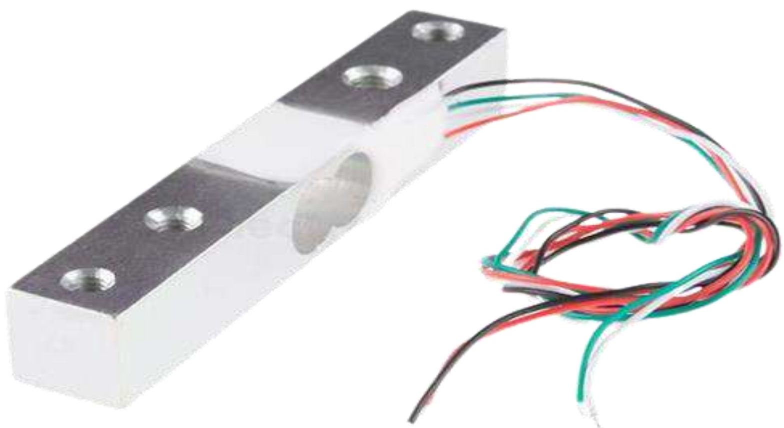

Figure 4.3: Load cell

Table 4.1: Load Cell (Pin Configuration)

RED	+ INPUT
WHITE	_ OUTPUT
BLACK	_ INPUT
GREEN	+ OUTPUT

4.4 Air compressor

During the operation of an air compressor, air is drawn into the pump chamber through the inlet when the piston ascends. As the chamber fills with air, it depressurizes. Subsequently, when the piston descends, it compresses the air and closes the inlet, allowing compressed air to exit through the outlet. Figure 4.4 provides a visual representation of an air compressor.

Figure 4.4: Air compressor

4.5 Rotary DC Switches

A DC switch is a type of electrical component that allows an electrical circuit to either join or disconnect conductive paths. An electric current can be stopped or switched from one conductor to another using a switch. A rotary switch can be configured to operate many contacts simultaneously at one switch position and is used to control multiple electrical circuits with a single switch. Figure 4.5 shows the image of a DC switch.

Figure 4.5: Switches

4.6 LED Indicator Lights

LEDs are used to illuminate various things and even spaces. Due to its small size, low power requirement, long service life, and adaptability in terms of use in many applications, it is applied everywhere. Figure 4.6 shows the image of LED indicator lights.

Figure 4.6: Lights

4.7 DC Power Supply

An electrical device known as a DC power supply provides electricity to an electrical load. Converting electric current from a source to the proper voltage, current, and frequency to power the load is the main job of a power supply. Electric power converters are another name for power suppliers. Figure 4.7 shows the image of DC Power Supply.

Figure 4.7: Power Supply

4.8 Banana Connector

A single-conductor (one wire) electrical connector known as a male banana plug, female banana plug, or banana socket is used to attach wires to equipment. Figure 4.8 shows image of banana connectors.

Figure 4.8: Banana Connector

4.10 Electrical Cables

Flexible cables are electrical cables that are specially designed to handle the small bends and physical stresses associated with moving applications such as indoor cable trainers etc. Figure 4.9 shows the image of electrical flexible cables.

Figure 4.9: Electrical Cables

4.11 Force Measuring System (EMGZ306A)

The EMGZ306A series serves as a signal channel analog tension measuring amplifier, equipped with two connected force sensors. Its settings are conveniently accessible from the front and feature 20-turn trimmers. The amplifier offers a standardized ±10V tension output and a switchable 0-20mA or 4-20mA current output through jumpers. This version even includes a pushbutton for simulating 50% of the nominal sensor load, facilitating calibration through calculation rather than physical tension simulation. For signal filtering, capacitors can be added, and options include a 10VDC sensor supply voltage and compound-filled versions with additional vibration protection for applications like stranding machines. Figure 4.10 shows the image of FMS force measuring system.

Figure 4.10: Force Measuring System

4.11.1 EMGZ306A Wiring Diagram.

Figure 4.11 shows the wiring diagram of FMS

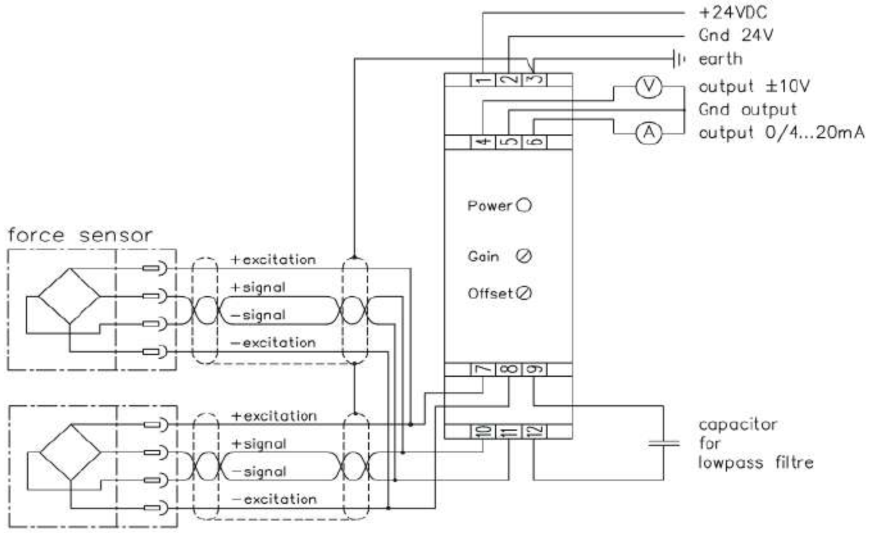

Figure 4.11: Wiring Diagram

Table 4.2: EMGZ306A Series Technical Data

Sensor supply voltage	5VDC 30mA high precision (option 10 VDC)
Offset range	±9Mv
Gain factor range	500...5000
Linearity error	< 0.1%
Temperature drift offset	< 0.01%/K
Tension output	±10V min. 1000Ω
Current output	0/4...20mA max. 500Ω
Low pass cut off frequency	adjustable, ca. 1...1000Hz
Power supply	24VDC (18...36VDC) max. 0.1A, galvanic ally isolated
Power Consumption	Max. 2.5W
Temperature range	–10...+60°C
Protection class	IP20

4.12 Pressure Transmitter (PC-305A)

Pressure sensors convert pressure into an analog electrical signal. These instruments have evolved from mechanical bourdon tube gauges, which visually indicated pressure during the steam age, to modern electronic pressure transducers and pressure switches. Figure 4.12 shows the image of pressure transmitter.

Figure 4.12: Pressure Transmitter.

Table 4.3 Pressure Transmitter Pin Configuration

Sr. #	Pin Name	Use For
1	A	DC Power Supply (12 to 26 V)
2	B	Not Use
3	C	Com (0 V DC)
4	D	Not Use
5	E	utput Signal for Pressure (0-5V)
6	F	Not Use

4.13 Temperature Sensor [4 to 20 mA]

A 4 to 20 mA transmitter, an essential device in various industries, converts sensor signals into a suitable format. These transmitters operate within dedicated loops, with 4 mA representing the low end of the configured span and 20 mA representing the high end. This configuration maintains a live zero to detect cable faults or loop issues. For example, in a temperature transmitter with a 0°C to 1000°C range, 4 mA corresponds to 0°C, and 20 mA corresponds to 1000°C. These transmitters typically require 24 VDC with 20 mA current. Figure 4.13 shows the image of temperature sensor.

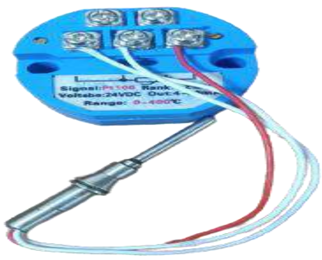

Figure 4.13: Temperature Sensor

4.14 Flow Sensor

4.14.1: Function

- The unit detects flow based on the calorimetric measuring principle.
- As additional process values the unit detects the medium temperature.
- The unit can be operated in SIO mode (standard input-output) or in IO-Link mode.
- The unit displays the current process values.
- The unit has many self-diagnostic options.
- The unit generates two output signals according to the parameter setting.

4.14.2: Output selection options

- Switching signal flow
- Frequency signal flow
- IO-Link 4.2 Output selection options
- Switching signal flow
- Switching signal temperature
- Analogue signal flow
- Analogue signal temperature

• Frequency signal flow

• Frequency signal temperature

• Input for external teach signal (remote adjustment)

4.14.3: Electrical connection

The unit must be connected by a qualified electrician. Observe the national and international regulations for the installation of electrical equipment. Voltage supply according to SELV, PELV. u Disconnect power. u Connect the unit as follows:

Table 4.4 Electrical Connection

1	BN L+
2	WH Out 2
3	BK Out 1/IO-Link
4	BU L-

Table 4.5 Pin Configuration

Pin	**Connection**
1	L+
3	L-
4(Out1)	• Switching signal flow • Frequency signal flow • IO-Link

2(Out2)	Switching signal flow • Switching signal temperature • Analogue signal flow • Analogue signal temperature • Frequency signal flow • Frequency signal temperature • Input for external teach signal (remote adjustment)

Figure 4.14 shows the image of flow sensor.

Figure 4.14: Flow Sensor

4.15 Water pump

A 12 Volt water pump is a DC electric motor-driven pump that operates with a 12V direct current power supply. It utilizes centrifugal force generated by a high-speed rotating impeller to boost, transfer, lift, or circulate liquids such as water and oil. Figure 4.15 shows the image of water pump.

Figure 4.15: Water Pump

Chapter 5

METHODOLOGY AND BLOCK DIAGRAM

5.1 Proposed Methodology

The (Supervisory Control and Data Acquisition) SCADA system allows us to monitor and control processes, and easily detect any issues within the system. A (Programmable Logic Controller) PLC monitors the status of switches and sensors via input terminals and sends commands to output devices. PLCs are microprocessors that interact with several types of end devices, including pumps, sensors, (Human Machine Interface) HMI and other field devices. PLC sends all of the data gathered from endpoints to SCADA systems. Then, SCADA software will use PLC to implement scenarios and show the data on an HMIs to help the operator fully understand the current situation. Figure 5.1 shows block diagram of the project.

5.2 Block Diagram

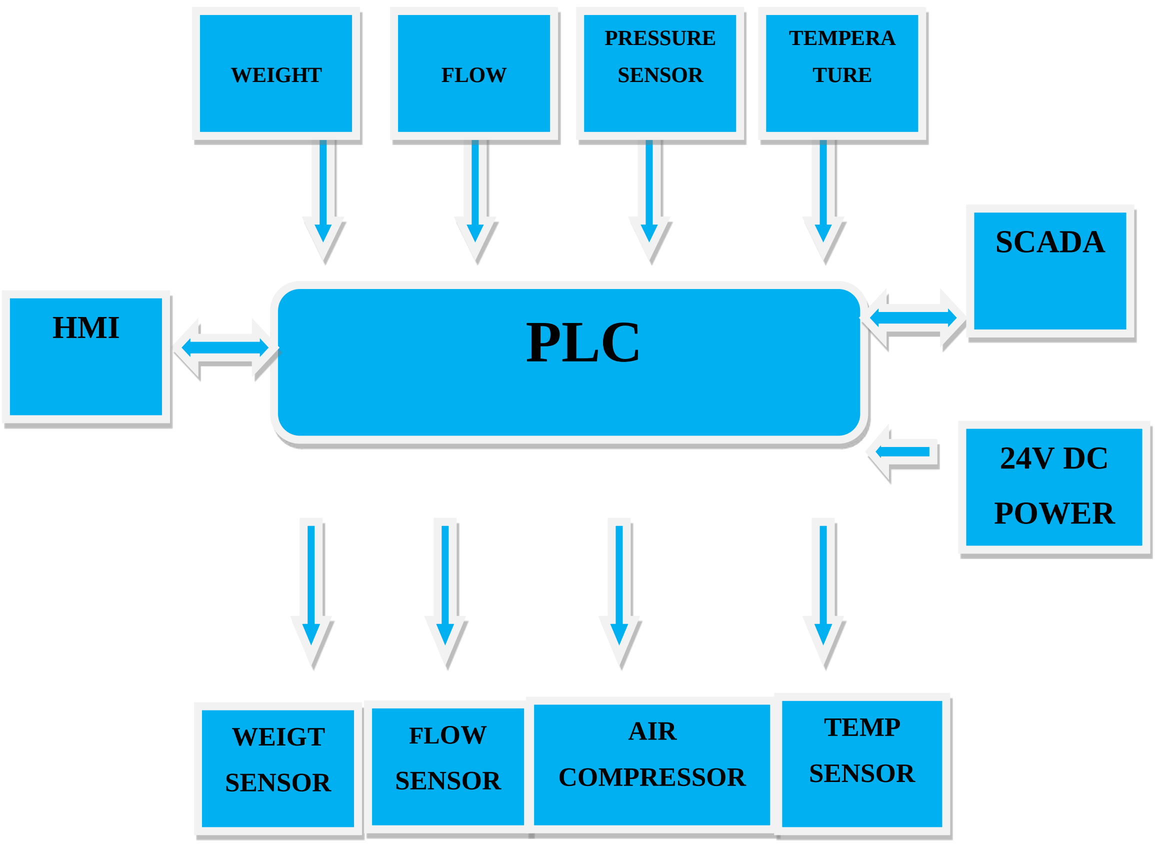

Figure 5.1: Block Diagram

5.3 Explanation

The project process starts with the PLC that is connected with the HMI and SCADA system through Ethernet hub. There are two supply options in the project. The main power supply 220V is for PC system. The 24V DC supply is for the input power supply of PLC and HMI.

The program is written in main computer on TIA portal V13 software. The ladder logic of this program is written in the PC system then this program is transferred to the Siemens PLC S7-1200 through communication cables. PLC will implement the ladder logic. HMI is used for interfacing human with the system. The trainer also has an option of webpage through which process can be monitored and controlled through SCADA system SCADA system provides an option of data logging of different events.

The trainer has option of 14 digital input and 10 digital outputs. One digital input is used in this scenario that is connected with the switch whereas the digital output is connected with the light. It also has two analog inputs options. And from analog inputs we take two connections from one input which is connected with sensors pressure sensor for pressure measuring solenoid value for flow rate and weight sensor for weight measuring and temperature sensor for temperature measuring. The voltages applied at analog input are between "0V-10V" DC because PLC analog input voltage range is from 0-10V. PLC convert's these voltages into analog input for further processing.

SCADA system is used in this project to monitor, control and process data. SCADA system allows us to quickly identify any problems within the processes, which will help us minimize downtime. PLC (programmable logic controller) serves as the foundation of the SCADA's basic architecture. A PLC uses input terminals to monitor the status of switches and sensors, and based on that status, it sends commands to the output devices. A PLC is a type of microprocessor that interacts with field devices and sends all of the data gathered from endpoints to SCADA systems.

5.4 Flow Chart

A flowchart is a pictorial representation of the steps of a process in specific order. It is a representative view of that can be adapted for a huge variety of purposes and can be used to describe the various processed.

The following is the flow chart diagram of the project. It explains complete process of the project step by step.

Figure 5.2 show the elongated circles, which signify the start or end of a process.

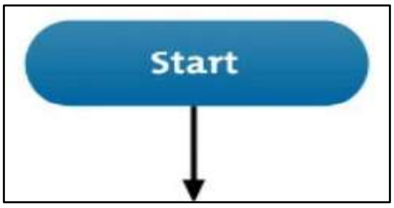

Figure 5.2: Start of Flowchart

Figure 5.3 show the rectangles which shows example of task in flow chart.

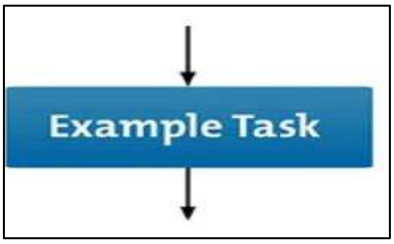

Figure 5.3: Example of Task i.e., Battery Levels

Figure 5.4 show the diamonds, example of decision making in flow chart which highlights where you must make a decision.

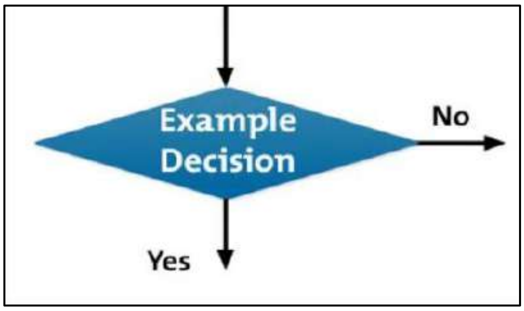

Figure 5.4: Example of Decision Making in Flowchart

5.5 Explanation

When we start a scenario and select a parameter. There are three scenarios temperature limit, temperature display, temperature control value. There are two conditions for temperature scenario if the value increase the limit value the then alarm will indicate and if the temperature value is decreasing the set limit value the heater will turn on. For weight scenario select a parameter. There are two physical and virtual switches are used to turn on and off the scenario of weight, pressure, and flow. There two same conditions for all three scenarios limit value and display value. An alarm is set if the value exceeds the set value, then the alarm will indicate. Figure 5.5 shows the flow chart of temperature and weight modules flow chart.

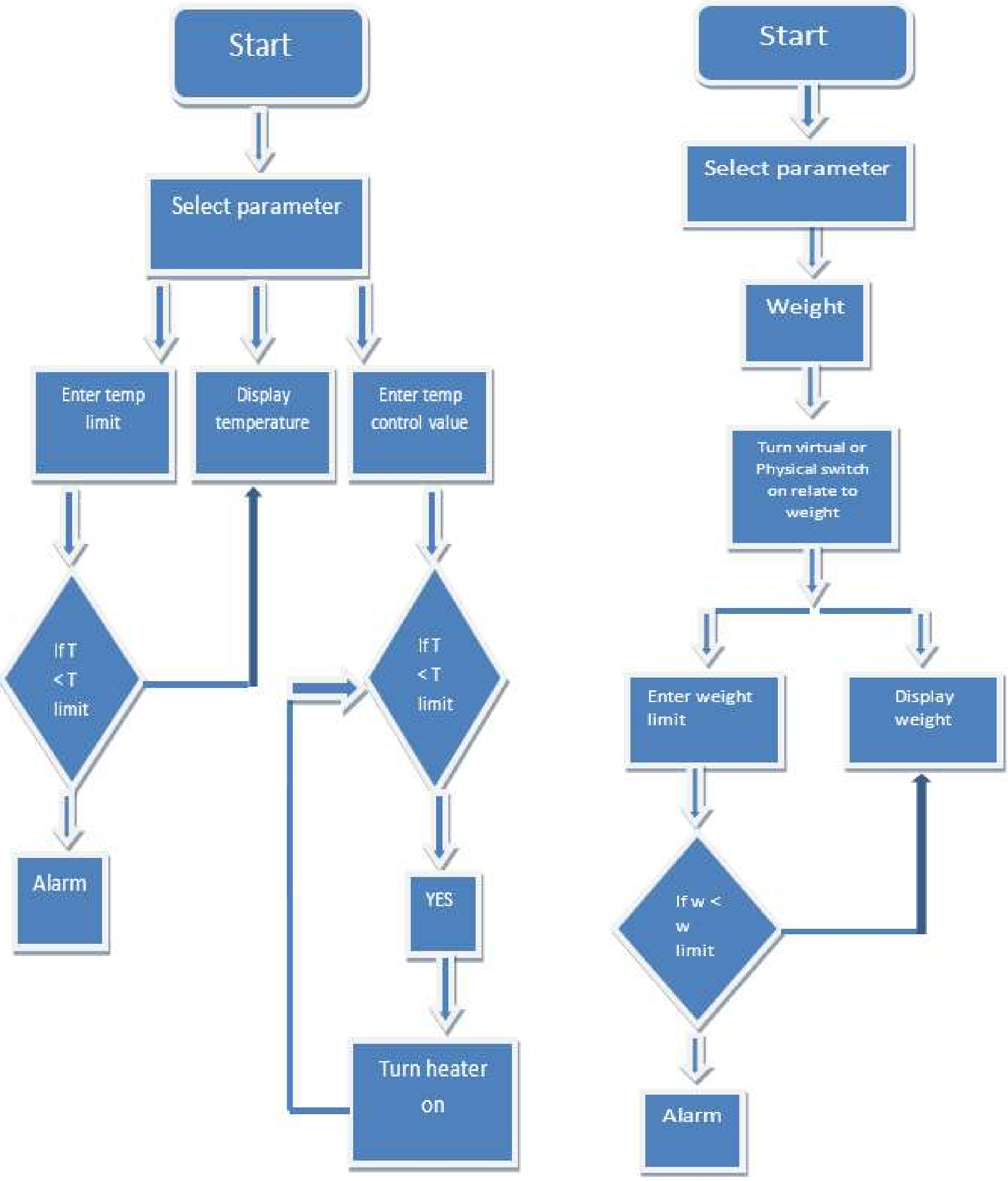

Figure 5.5: Flow chart

Figure 5.6 shows the flowchart of pressure and flow rate.

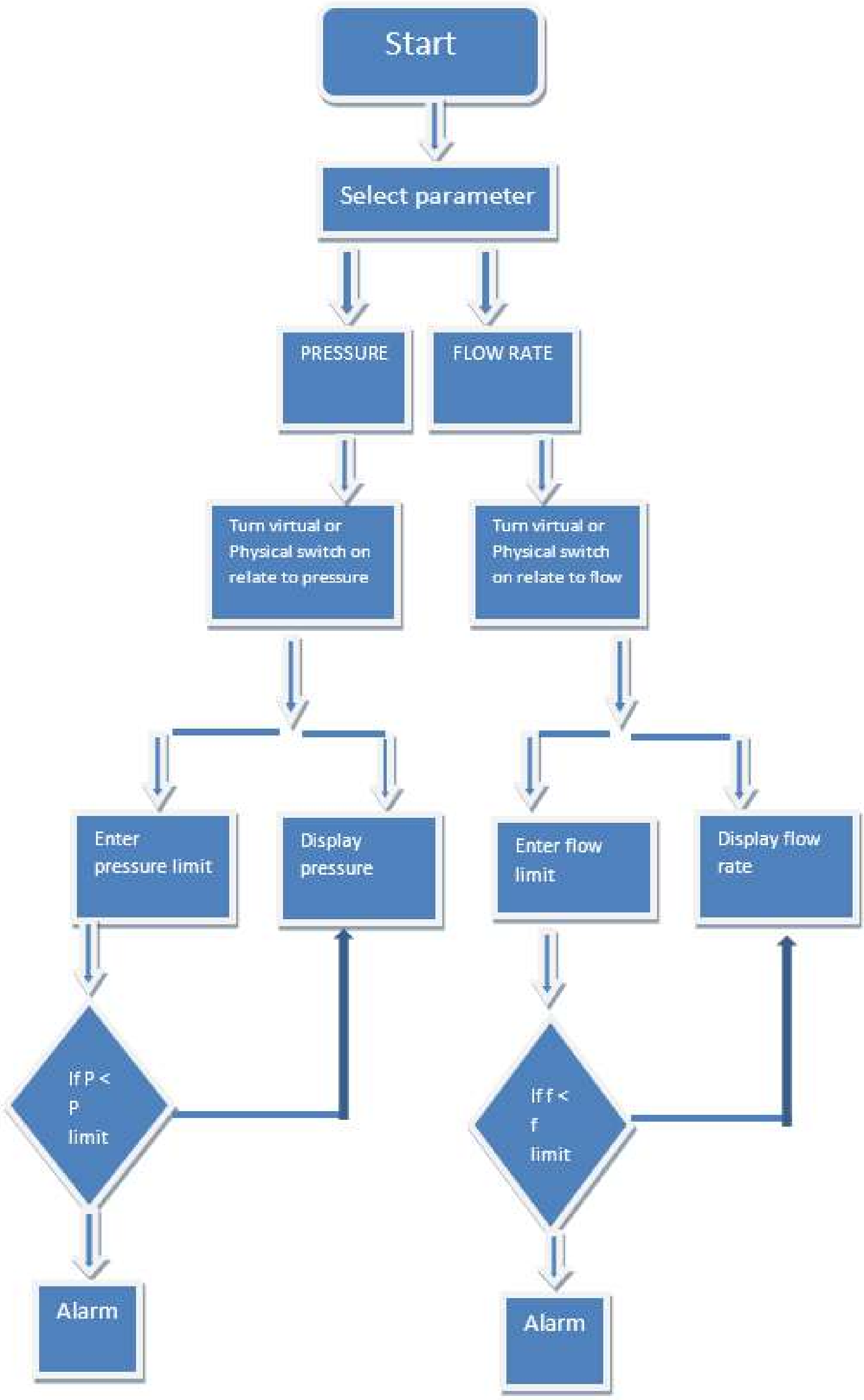

Figure 5.6: Flow chart

Chapter 6

RESULT AND DISCUSSION

6.1 Final Project View

The main goal of the project is to make a (Programmable Logic Controller) PLC-based control and monitoring using (Supervisory Control and Data Acquisition) SCADA system that would enable us to implement and control different industrial scenarios and also the remote monitoring and automation of industrial processes using Supervisory Control and Data Acquisition (SCADA) systems.

This is the final hardware of the trainer through which you can implement and control different industrial scenario. Figure 6:1 shows the final hardware of the project.

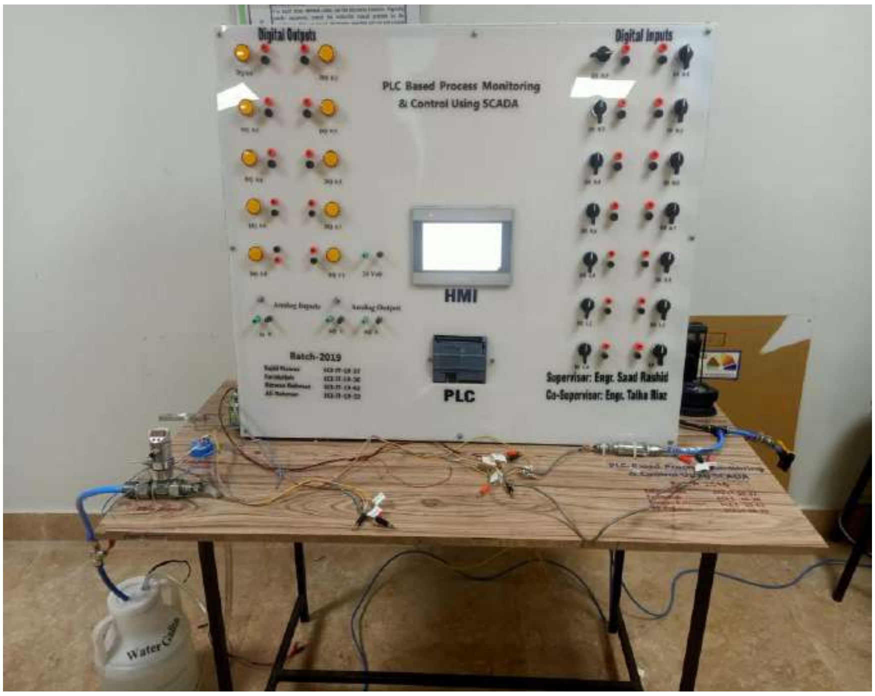

Figure 6.1: Final Project

6.2 HMI Result

In the project, (Human Machine Interface) HMI is used for providing a proper channel for connecting human with the hardware of the project. The inputs and outputs of PLC can be changed through the HMI. Five screens were designed for the HMI, “Main screen” and ‘Temperature Screen’ flow screen ‘weight screen’ ‘pressure screen’.

Main screen will be used for controlling the red lamp and temp screen will be used for controlling and displaying temperature and pressure flow and weight screens will control their scenarios. Figure 6.2 shows the image of HMI screen result for pressure window.

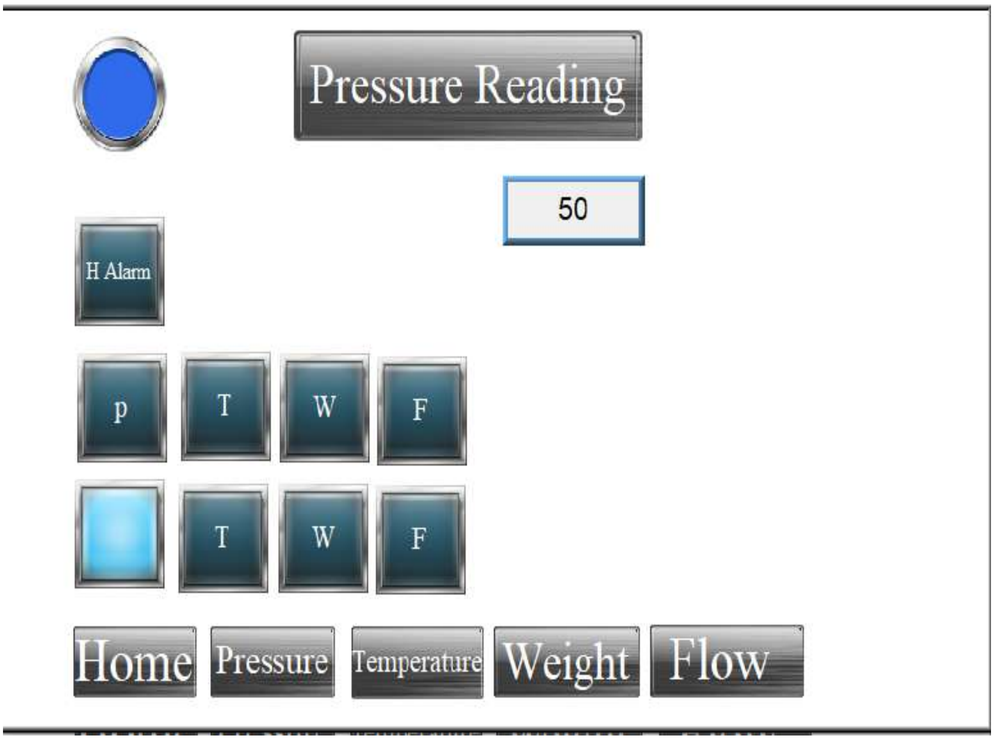

Figure 6.2: HMI Result for Pressure

Figure 6.3 shows the image of HMI screen result for temperature window.

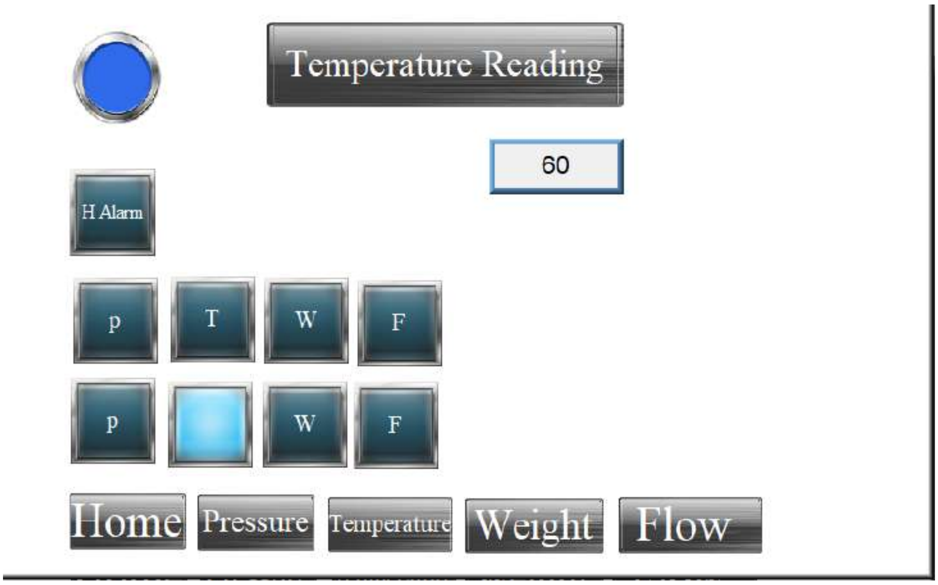

Figure 6.3: HMI Result for Temperature

Figure 6.4 shows the image of HMI screen result for flow window.

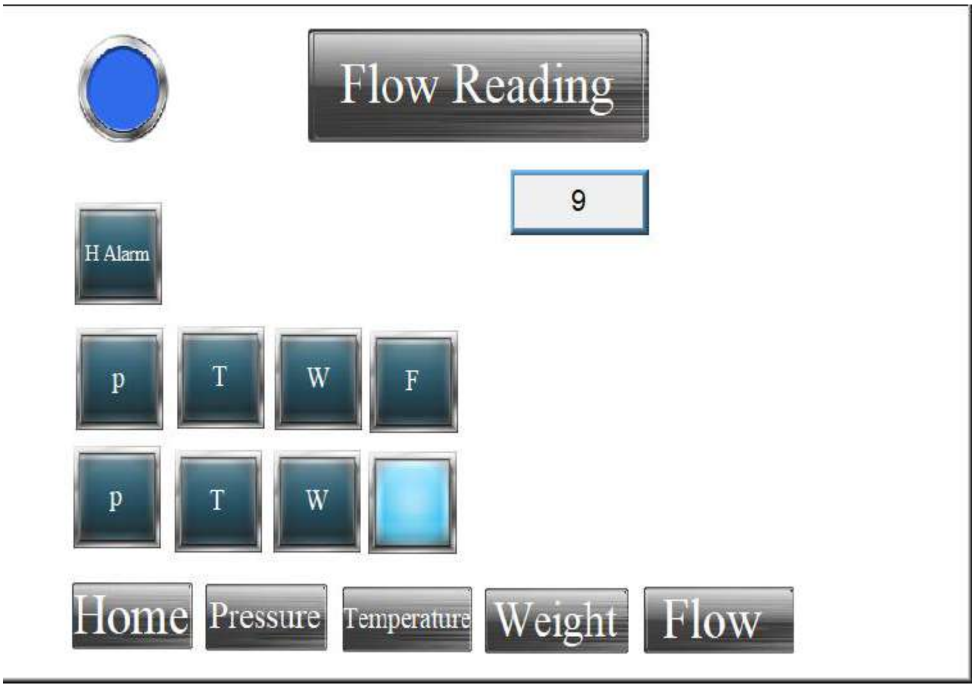

Figure 6.4: HMI Result for Flow

Figure 6.5 shows the image of HMI screen result for weight window.

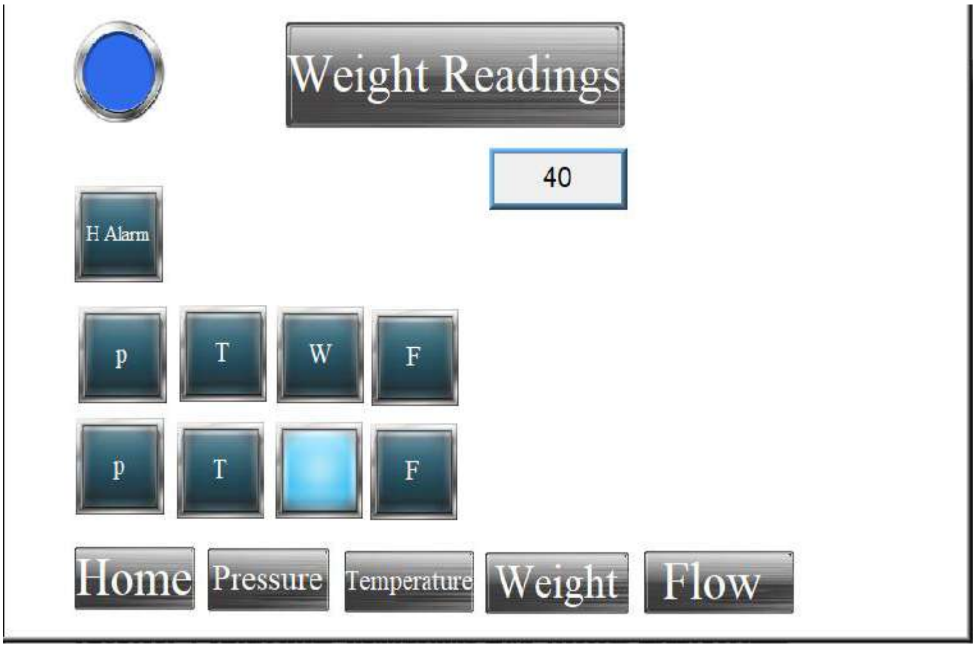

Figure 6.5: HMI Result for Weight

6.3 SCADA (Main Screen)

This is the main screen of SCADA system that is displayed on the webpage. SCADA have an option of controlling scenarios though a remote location. Whenever motor RPM is changed through SCADA motor speed is changed simultaneously. WinCC software is used for SCADA programming. This is the main screen of the SCADA program. Figure 6.6 shows the main screen of SCADA.

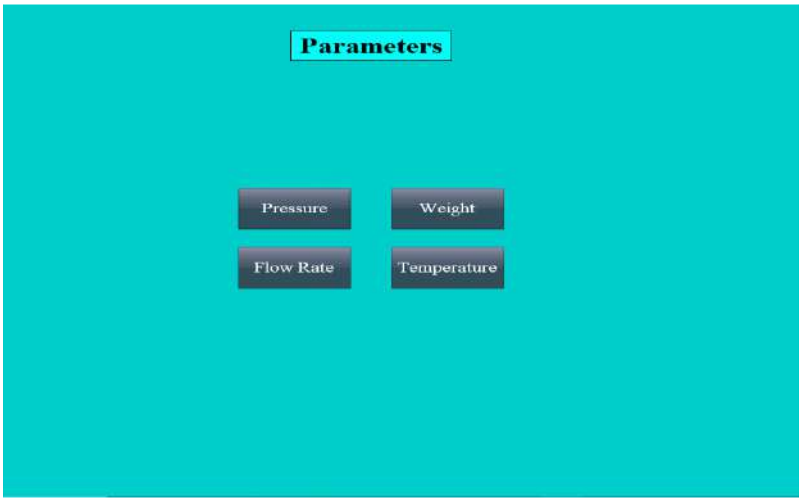

Figure 6.6: SCADA Main Screen

Figure 6.7 shows the image of SCADA Pressure result.

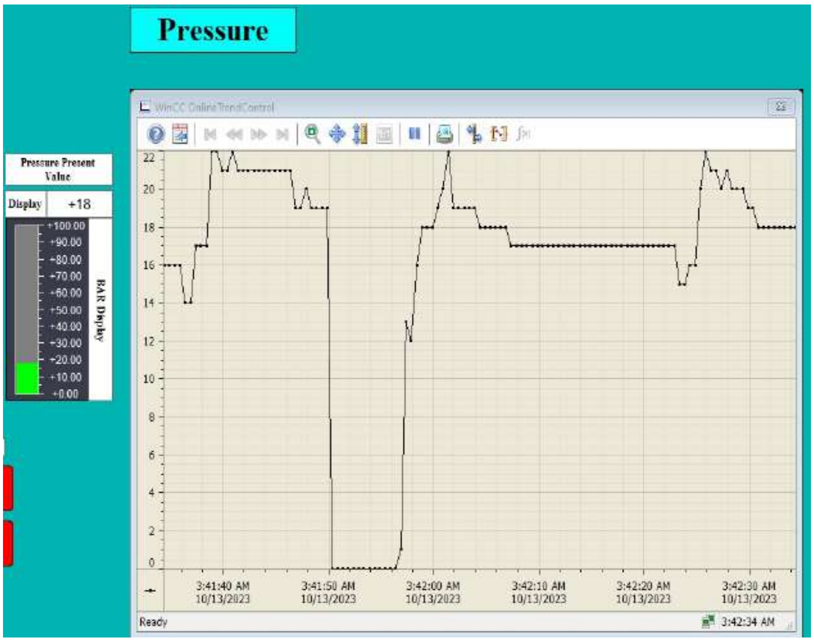

Figure 6.7: SCADA Pressure Result

Figure 6.8 shows the image of SCADA Temperature result.

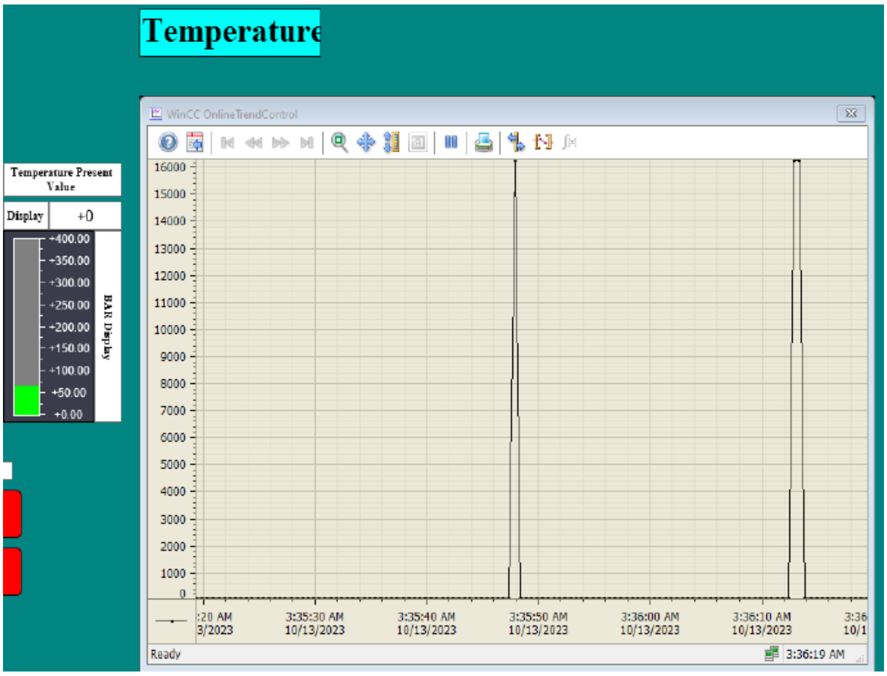

Figure 6.8: SCADA Temperature Result

Figure 6.9 shows the image of SCADA flow rate result.

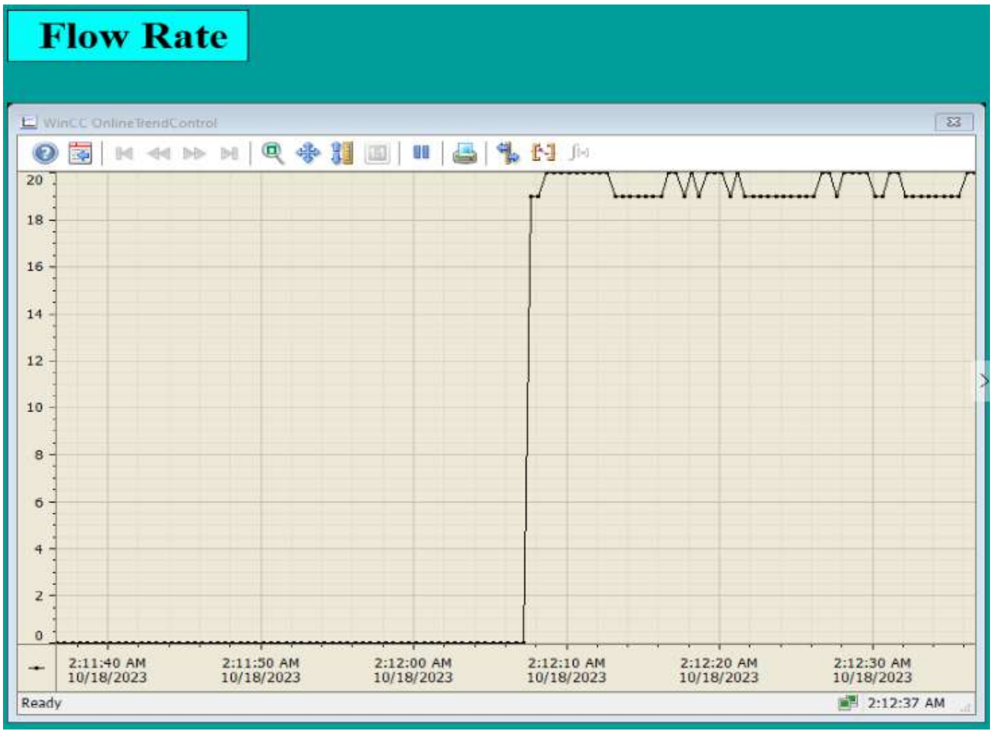

Figure 6.9: SCADA Flow Result

Figure 6.10 shows the image of SCADA weight result.

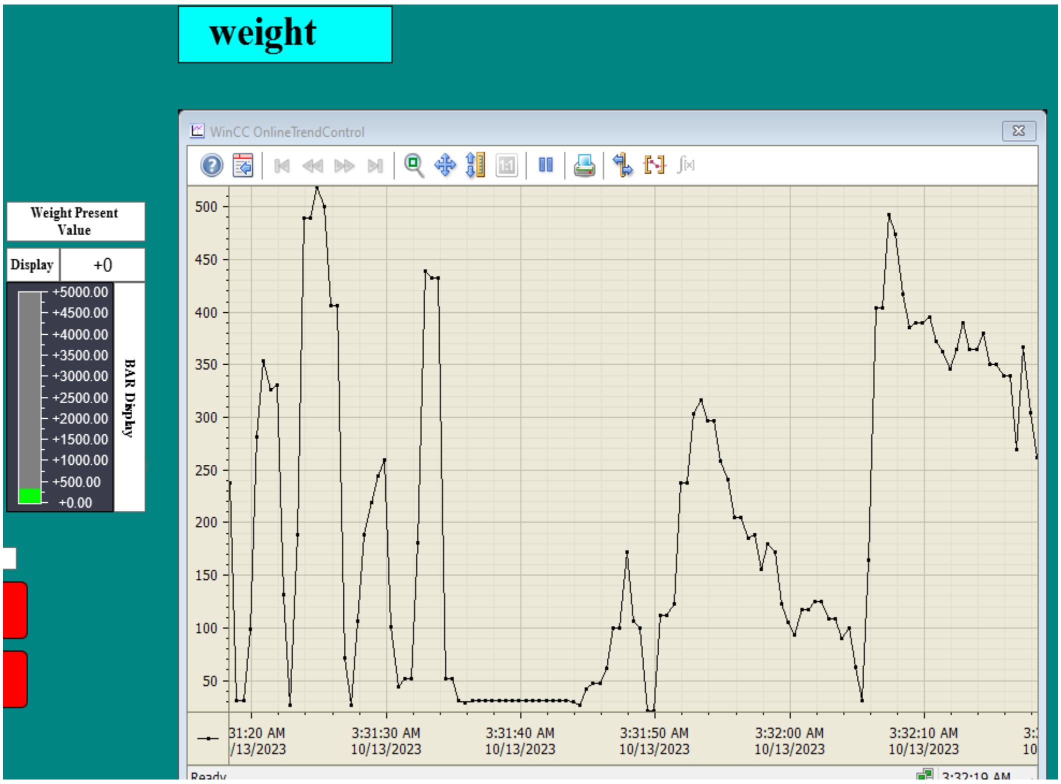

Figure 6.10: SCADA Weight Result

Chapter 7

CONCLUSION AND FUTURE SUGGESTIONS

7.1 Conclusion

(Supervisory Control and Data Acquisition) SCADA system is implemented for controlling and monitoring of all scenarios of the trainer. SCADA system with (Programmable Logic Controller) PLC helped us to regulate the dynamic state of the devices and enhance the overall accuracy of the system. SCADA system is directly connected with the PLC and displayed data from the connected devices. The SCADA interface has the advantages of real-time communication and information tracking. It helped us in early fault detection and improvement in communication between different systems.

SCADA system is used to monitor and manage the processes, reducing human effort in supervision and control while also increasing the efficiency of the operation. Webpage monitoring and data logging also helped us in monitoring and analyzing the scenarios. Remote monitoring and automation of the processes is done by using SCADA systems. The PLC and SCADA system improved communication between different systems. User can implement and control different industrial scenarios by using the trainer system.

7.2 Future Suggestions

The trainer can be used to simulate any industrial scenario within the lab environment. These are the improvements that can be done with the trainer in future:

- Conveyer belt can also be used with trainer to carry different objects and placing them in specific position.
- A mobile application can be developed, which can be used for monitoring and controlling the process from mobile phone.

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APPENDIX

Block Timer and Counter supported by S7-1200

Table 1- 2 Blocks, timers and counters supported by S7-1200

Element		Description
Blocks	Type	OB, FB, FC, DB
	Size	30 Kbytes (CPU 1211C) 50 Kbytes (CPU 1212C) 64 Kbytes (CPU 1214C and CPU 1215C)
	Quantity	Up to 1024 blocks total (OBs + FBs + FCs + DBs)
	Address range for FBs, FCs, and DBs	1 to 65535 (such as FB 1 to FB 65535)
	Nesting depth	16 from the program cycle or start up OB; 4 from the time delay interrupt, time-of-day interrupt, cyclic interrupt, hardware interrupt, time error interrupt, or diagnostic error interrupt OB
	Monitoring	Status of 2 code blocks can be monitored simultaneously
OBs	Program cycle	Multiple: OB 1, OB 200 to OB 65535
	Startup	Multiple: OB 100, OB 200 to OB 65535
	Time-delay interrupts and cyclic interrupts	4[1] (1 per event): OB 200 to OB 65535
	Hardware interrupts (edges and HSC)	50 (1 per event): OB 200 to OB 65535
	Time error interrupts	1: OB 80
	Diagnostic error interrupts	1: OB 82
Timers	Type	IEC
	Quantity	Limited only by memory size
	Storage	Structure in DB, 16 bytes per timer
Counters	Type	IEC
	Quantity	Limited only by memory size
	Storage	Structure in DB, size dependent upon count type • SInt, USInt: 3 bytes • Int, UInt: 6 bytes • DInt, UDInt: 12 bytes

[1] Time-delay and cyclic interrupts use the same resources in the CPU. You can have only a total of 4 of these interrupts (time-delay plus cyclic interrupts). You cannot have 4 time-delay interrupts and 4 cyclic interrupts.

PLC Analog Signal Modules

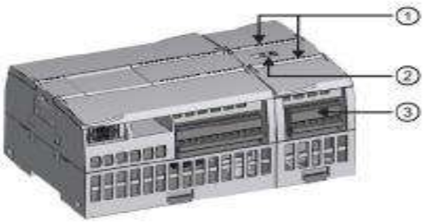
Table 1- 4 Analog signal modules and signal boards

Type	Input only	Output only	Combination In/Out
③ analog SB	• 1 x 12 bit Analog In • 1 x 16 bit RTD • 1 x 16 bit Thermocouple	• 1 x Analog Out	-
④ analog SM	• 4 x Analog In • 4 x Analog In x 16 bit • 8 x Analog In • Thermocouple: – 4 x 16 bit TC – 8 x 16 bit TC • RTD: – 4 x 16 bit RTD – 8 x 16 bit RTD	• 2 x Analog Out • 4 x Analog Out	• 4 x Analog In / 2 x Analog Out

S7-1200 Expansion Modules

S7-1200 modules

Table 1- 3 S7-1200 expansion modules

Type of module	Description
The CPU supports one plug-in expansion board: • A signal board (SB) provides additional I/O for your CPU. The SB connects on the front of the CPU. • A communication board (CB) allows you to add another communication port to your CPU. • A battery board (BB) allows you to provide long term backup of the realtime clock.	 ① Status LEDs on the SB ② Removable user wiring connector
Signal modules (SMs) add additional functionality to the CPU. SMs connect to the right side of the CPU. • Digital I/O • Analog I/O • RTD and thermocouple • SM 1278 IO-Link Master	 ① Status LEDs ② Bus connector slide tab ③ Removable user wiring connector

System Requirements to Install Tia Portal V13

Hardware/Software	**Requirements**
Operating System	Windows 7 64bit or later
Screen resolution	1280 x 720
Network	2 Mbit/s Ethernet or faster
Processor	Intel® Core™ i3
Hard Disk	30GB(Free)
RAM	8GB (Recommended) or more
Graphic Card	2GB (Recommended) or more

Source Code

```
Imports System
Imports System.IO
Imports System. Windows. Forms
Imports Microsoft. Visual Basic

Namespace WinTr
Public Class Main Class
        Public Sub Load
        '------- Script Start Line -------



        '------- Script End Line -------
        End Sub
End Class
End Namespace
```