

# PLC Based Tank Level and Temperature Control System

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**Abstract:** The increasing adoption of automation in industrial processes has created a need for practical training systems that demonstrate real-time process control concepts. This paper presents the development of a Mini Process Control Plant based on an Allen-Bradley Micro820 Programmable Logic Controller (PLC) and Human Machine Interface (HMI). The developed setup integrates three important process variables, namely temperature, level, and flow, into a single educational platform. Temperature regulation is achieved using a heating element controlled through a Solid State Relay (SSR), while level control is performed using a water tank, pump, and level sensing arrangement. Flow measurement is carried out using a flow sensor interfaced with the PLC. The system supports both manual and automatic operating modes and provides real-time monitoring, alarm handling, and operator interaction through the HMI dashboard. Experimental observations demonstrate satisfactory control performance and reliable system operation. The proposed setup offers a cost-effective alternative to commercial training systems and serves as a useful platform for learning industrial automation and process control principles.

**Keywords:** PLC, HMI, Process Control, Micro820 PLC, Temperature Control, Level Control, Flow Control, Industrial Automation, Educational Trainer.

## 1. INTRODUCTION

Industrial automation has become an essential part of modern manufacturing and process industries. Efficient monitoring and control of process parameters such as temperature, level, pressure, and flow are necessary to achieve safe operation, improved productivity, and consistent product quality. Programmable Logic Controllers (PLCs) are widely used for such applications because of their reliability, flexibility, and ease of implementation.

Although students learn process control concepts through theoretical courses, access to industrial-scale systems is often limited because of high installation and maintenance costs. Educational trainer systems provide an effective solution by allowing students to understand automation concepts in a practical environment.

The objective of this work is to design and develop a compact Mini Process Control Plant capable of monitoring and controlling temperature, level, and flow parameters using an Allen-Bradley Micro820 PLC. The system includes sensing devices, control hardware, actuators, and an HMI dashboard for visualization and operation. The developed setup provides practical exposure to industrial automation techniques while remaining economical and suitable for laboratory use.

## 2. LITERATURE REVIEW

Several studies have demonstrated the application of Programmable Logic Controllers in industrial automation and educational training systems. PLC-based control systems are commonly used for process monitoring, machine automation, and supervisory control because of their robustness and real-time performance.

Researchers have developed laboratory-scale process control setups for studying temperature regulation, liquid level control, and flow measurement. These systems provide practical understanding of industrial control strategies while reducing the cost associated with full-scale industrial plants. Human Machine Interface (HMI) technology has also been widely adopted to improve process visualization and operator interaction.

Recent developments in automation training platforms focus on integrating multiple process variables into a single system to provide comprehensive learning opportunities. Inspired by these developments, the present work combines temperature control, level regulation, and flow monitoring within a single PLC-based experimental setup using Allen-Bradley Micro820 technology.

### 3. OBJECTIVES

The objectives of the proposed system are:

1. To design and develop a PLC-based process control trainer.
2. To implement temperature monitoring and control.
3. To implement automatic level control.
4. To measure and display flow rate.
5. To provide manual and automatic operating modes.
6. To develop HMI-based process monitoring and operation.
7. To implement alarm and safety functions.
8. To provide a low-cost educational platform for automation training.

### 4. SYSTEM ARCHITECTURE

The developed system consists of sensing elements, control hardware, actuators, and operator interface devices. Major Hardware Components

Sr. No.	Component	Function
1	Micro820 PLC	Main Controller
2	HMI	Process Monitoring and Control
3	Temperature Sensor	Temperature Measurement
4	Heater	Heating Element
5	Solid State Relay (SSR)	Heater Switching
6	Water Tank	Process Vessel
7	Water Pump	Level Regulation
8	Level Sensor / Float Switches	Level Detection
9	Flow Sensor	Flow Measurement
10	24 V DC SMPS	Power Supply

Figure 1. Overall System Architecture

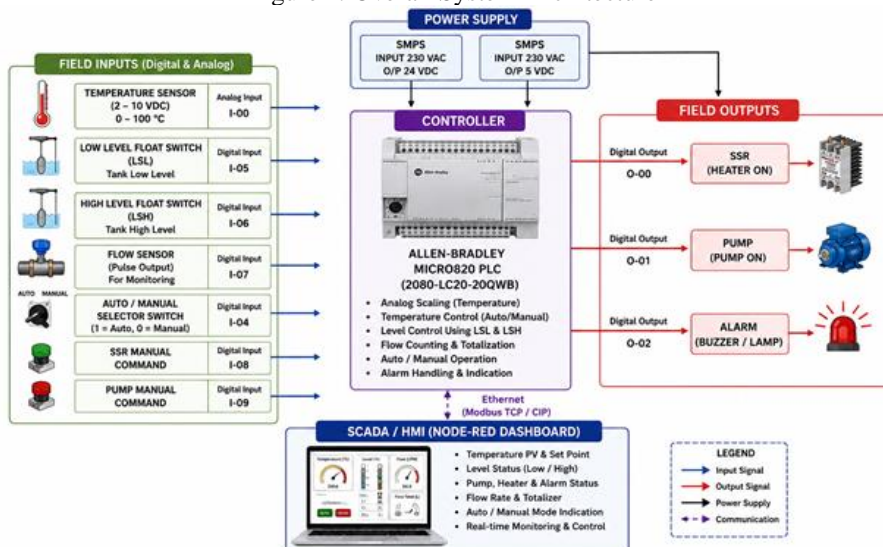
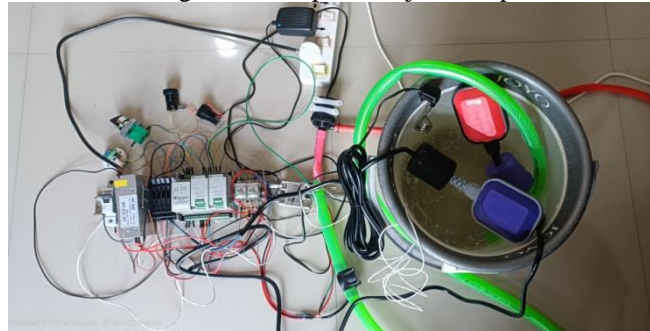


Figure 2. Complete Project Setup



## 5. SYSTEM WORKING PRINCIPLE

The Mini Process Control Plant consists of three major process loops:

### A. Temperature Control Loop

The temperature sensor continuously measures the process temperature and sends the signal to the PLC. The PLC compares the measured temperature with the operator-defined set-point.

When the temperature falls below the set-point, the PLC energizes the SSR, which switches ON the heater. When the desired temperature is achieved, the PLC turns OFF the heater.

### B. Level Control Loop

The level control system utilizes a storage tank, pump, and level sensing arrangement.

When the level falls below the minimum permissible value, the PLC automatically starts the pump. The pump continues to operate until the desired level is achieved.

Once the upper level limit is reached, the PLC stops the pump.

### C. Flow Measurement Loop

The flow sensor generates pulse signals proportional to the flow rate.

The PLC counts these pulses and calculates:

- Instantaneous Flow Rate
- Totalized Flow Quantity

The calculated values are displayed on the HMI.

Figure 3. Tank &amp; Level Control Assembly



## 6. PLC INPUT OUTPUT MAPPING

### Digital Inputs

Address	Description
I0.0	Auto/Manual Selector
I0.1	Low Level Switch
I0.2	High Level Switch
I0.3	Pump Manual Start
I0.4	Heater Manual Start

### Digital Outputs

Address	Description
O0.0	Pump Control
O0.1	SSR Control

### Analog Inputs

Address	Description
AI0	Temperature Transmitter

Figure 4. Control Panel Setup



## 7. CONTROL STRATEGY

### Automatic Mode

In automatic mode, the PLC performs all control actions automatically.

#### Temperature Control Logic

If:

Process Temperature < Set point

Then:

Heater ON

If:

Process Temperature  $\geq$  Set point

Then:

Heater OFF

#### Level Control Logic

If:

Level  $\leq$  Low-Level Setpoint

Then:

Pump ON

If:

Level  $\geq$  High-Level Setpoint

Then:

Pump OFF

#### Flow Monitoring Logic

PLC continuously calculates:

Flow Rate =  $K \times$  Pulse Frequency

Where:

K = Calibration Constant

## 8. Node-red Dashboard (HMI)

The HMI acts as the operator interface.

The HMI provides:

#### Monitoring Functions

- Temperature Display
- Level Display
- Flow Rate Display
- Totalized Flow Display
- Alarm Status Display

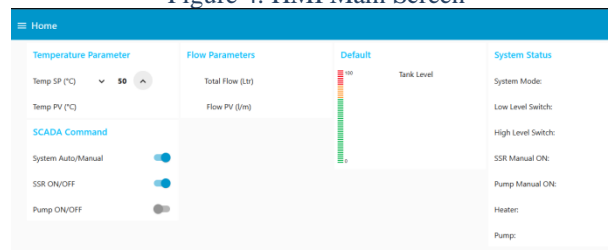
#### Control Functions

- Auto/Manual Selection
- Pump Start/Stop
- Heater Start/Stop
- Set-point Adjustment

#### Alarm Functions

- High Temperature Alarm
- Low Level Alarm
- Sensor Failure Alarm
- Communication Failure Alarm

Figure 4. HMI Main Screen



## 9. PLC PROGRAM DEVELOPMENT

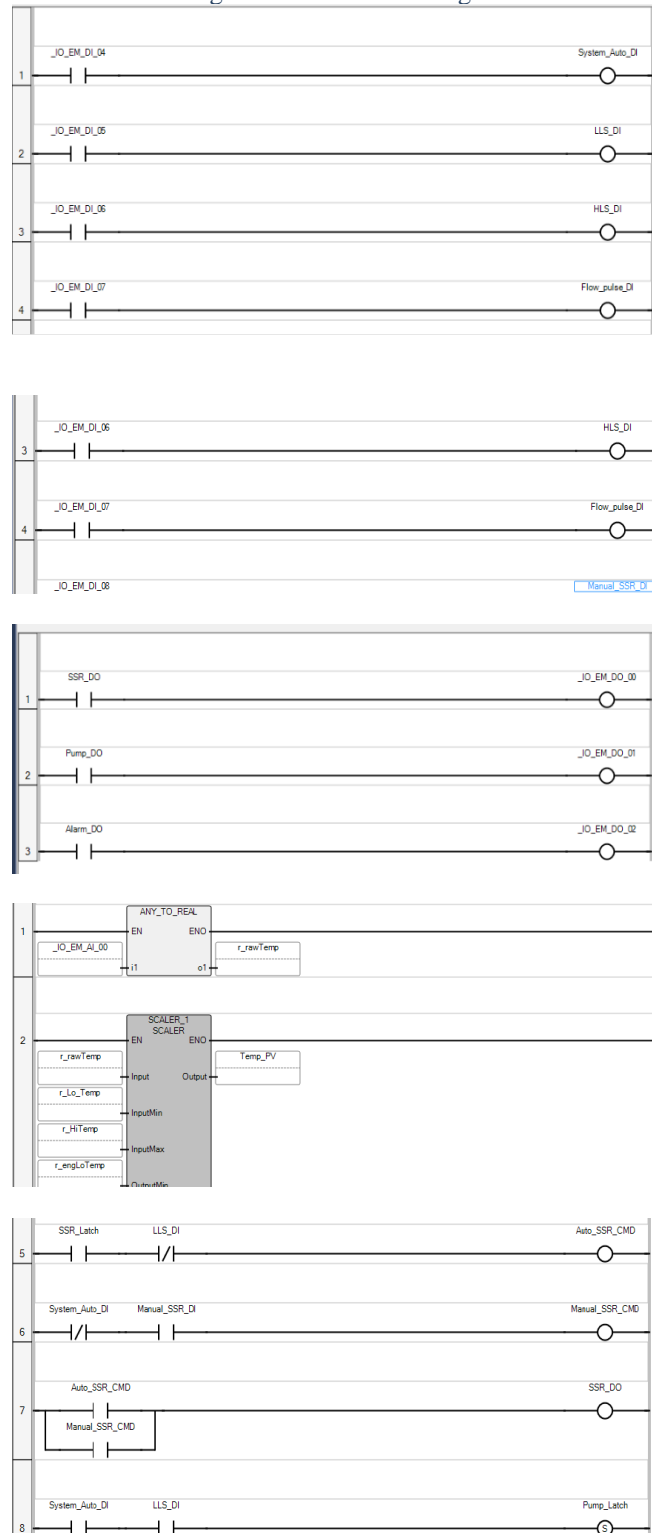
The PLC program was developed using Connected Components Workbench (CCW).

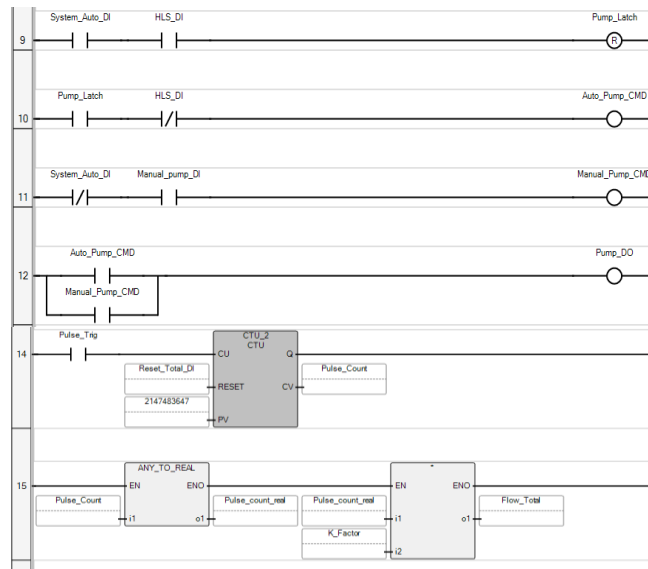
The program consists of:

- Input Processing Logic
- Auto/Manual Selection Logic

- Temperature Control Logic
- Level Control Logic
- Flow Calculation Logic
- Alarm Management Logic
- Output Processing Logic

Figure 5. PLC Ladder Logic





**10. EXPERIMENTAL RESULTS AND DISCUSSION**

The developed system was tested under various operating conditions.

**A. Temperature Control Performance**

Sr. No.	Temperature Setpoint (°C)	Measured Temperature (°C)	Absolute Error (°C)	Percentage Error (%)
1	30	29.6	0.4	1.33
3	40	39.4	0.6	1.50
5	50	49.1	0.9	1.80
7	60	58.9	1.1	1.83

Table 1. Temperature Control Performance

**B. Level Control Performance**

Trial No.	Low-Level Switch Activation (%)	High-Level Switch Activation (%)	Pump Start Response (s)	Pump Stop Response (s)	Result
1	20	90	0.5	0.4	Successful
2	20	90	0.5	0.4	Successful
3	20	90	0.4	0.5	Successful
4	20	90	0.5	0.5	Successful
5	20	90	0.5	0.4	Successful

Table 2. Level Control Performance

**C. Flow Measurement Performance**

Sr. No.	Actual Flow Rate (L/min)	Measured Flow Rate (L/min)	Absolute Error (L/min)	Percentage Error (%)
1	2.0	1.96	0.04	2.00
2	3.0	2.95	0.05	1.67
3	4.0	3.93	0.07	1.75
4	5.0	4.91	0.09	1.80
5	6.0	5.88	0.12	2.00

Table 3. Flow Measurement Performance

**Discussion**

The experimental results indicate that the developed system provides satisfactory accuracy for educational and laboratory applications. Temperature control error remained below 2%, while flow measurement error was maintained within acceptable limits. Level control response was consistent across all trials. These observations demonstrate the suitability of the developed platform for practical automation training and process control studies.

**11. ADVANTAGES OF THE PROPOSED SYSTEM**

- Low implementation cost.
- Easy installation and maintenance.
- Modular architecture.
- Industrially relevant design.
- Suitable for laboratory training.
- Expandable for advanced control strategies.
- Provides practical PLC programming experience.
- Supports both manual and automatic operation.

**12. APPLICATIONS**

The developed system can be used in:

- Engineering Laboratories
- Industrial Training Institutes
- Automation Training Centers
- Research Laboratories
- PLC Programming Courses
- Instrumentation and Control Education

**13. FUTURE SCOPE**

The developed Mini Process Control Plant can be further enhanced by incorporating advanced control techniques and modern communication technologies. Future improvements may include implementation of PID-based closed-loop control for improved process accuracy and stability. Integration with SCADA software can provide advanced monitoring, data logging, and supervisory control capabilities.

Remote access and monitoring features can be implemented using Industrial Internet of Things (IIoT) technologies. Additional sensors and communication protocols may be incorporated to study more complex industrial applications. The platform can also be expanded to support cloud-based data storage, predictive maintenance functions, and Industry 4.0 concepts, making it suitable for advanced automation and research activities.

**14. CONCLUSION**

A PLC-based Mini Process Control Plant integrating temperature, level, and flow regulation has been successfully designed and implemented using an Allen-Bradley Micro820 PLC and HMI. The system effectively demonstrates

fundamental industrial automation concepts, including process monitoring, control logic implementation, alarm management, and operator interaction. The developed setup provides a cost-effective alternative to commercial trainer kits and serves as an excellent educational platform for learning process control and industrial automation. Experimental evaluation confirms the reliability and effectiveness of the proposed system for laboratory and training applications

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