Design Of IO Hardware Training Module Board for Implementation of PLC

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***Abstract*—Design of input/output Hardware Training Module for Implementation of Plc Logic. This Project aims to design and develop in interactive i/o hardware training module tailored for the efficient implementation and understanding of programmable logic controller (PLC) logic. The training module is developed with the goal of providing a hand-on learning platform for students & Professional to explore, test, and analyze ladder logic. PLC hardware connectivity, and practical logic implementations.**

I. INTRODUCTION

In Modern industrial Automation Systems, programmable Logic Controllers (PLCs) play a vital role in controlling and monitoring various processes. To understand PLC programming and implementation effectively, it is essential to have a practical training module that demonstrates real-time input and output operations. This project, "Design of Input/Output Hardware Training Module for Implementation of PLC Logic", Focuses on Developing a user's-friendly hardware setup that allows students and trainees to interface different input and output devices with a PLC. The module Helps in treating and understanding various control logics such as ON/OFF control, timer, counter, interlocking, and sequence control.

The designed hardware Module acts as a bridge between theoretical learning and practical application. It provides hands-on experience in wiring, logic development, troubleshooting, and execution of industrial control operations. Such a system enhances the understanding of PLC fundamentals and prepares students for real-world industrial automation tasks.

II. LITERATURE SURVEY

2.1. Preamble / Introduction / Opening remark

Programmable Logic Controllers (PLCs) are the backbone of modern industrial automation systems. They are widely used for controlling, monitoring, and automating various industrial processes. To understand the implementation of PLC logics effectively, it is essential to have hands-on experience with input and output (I/O) hardware modules. A well-designed I/O hardware training module helps students and engineers visualize the functioning of sensors, actuators, and control signals in real-time. This chapter reviews various research studies, design approaches, and training methodologies related to PLC based automation and hardware interfacing for educational and industrial applications.

2.2. Literature pertaining to topic

Several researchers and industries have focused on developing PLC training setups to bridge the gap between theoretical knowledge and practical implementation. PLCs in Education: Many academic institutions have integrated PLC-based training modules into their laboratory curriculum to provide practical exposure. These setups typically include digital and analog input/output devices such as push buttons, limit switches, LEDs, relays, and sensors that allow students to implement basic control logics like start-stop, latching, and interlocking. Hardware Interfacing Modules: Studies highlight that modular I/O hardware allows easy connection with various PLC brands (Siemens, Allen Bradley, Mitsubishi, etc.), enhancing system flexibility. Proper design ensures signal isolation, voltage compatibility, and protection of PLC ports from electrical faults. Simulation and Real-Time Control: Some works propose using PLC simulation software (like TIA Portal, RS Logix, or Delta WPL Soft) combined with physical hardware modules to create a hybrid learning environment. This combination improves understanding of PLC program execution, timing diagrams, and fault diagnosis. Training Kits and Industry Practices: Industries use similar I/O training setups to train technicians and engineers in control logic implementation before actual field deployment. Such training modules replicate real industrial systems in a simplified and safe manner, improving learning outcomes and minimizing risk. Recent Developments: Advanced modules now integrate microcontrollers and communication protocols (such as Modbus, Profibus, or Ethernet) to demonstrate modern automation trends and enhance compatibility with SCADA or HMI systems.9

2.3. Concluding remarks on literature review from the reviewed literature

It is evident that designing an I/O hardware training module significantly enhances understanding of PLC logic implementation. Existing systems primarily focus on flexibility, safety, and educational value. However, there is still a need for compact, cost-effective, and user-friendly training modules that can be used in academic laboratories. The proposed project aims to design such a module that provides practical exposure to input/output interfacing and helps students learn the fundamental concepts of PLC programming and automation control efficiently.

III. METHODOLOGY

3.1. Introduction/ Opening Remark

The methodology adopted for this project focuses on the systematic design and development of an Input-Output (I/O) hardware training module to demonstrate the implementation of basic and advanced PLC logics. The project aims to provide a practical platform for students and trainees to understand how various sensors and actuators interact with a Programmable Logic Controller in real-time control applications. The development process involves conceptual design, hardware selection, circuit development, wiring, programming, and testing. Each stage is carefully planned to ensure modularity, safety, and compatibility with standard PLC systems.

3.2. Detail methodology – which should elaborate

3.2.1.Requirement Analysis

The first step involves identifying the requirements of the training module. The main goal is to design a compact, low-cost, and easily understandable system that can be used in laboratories for PLC logic implementation. Inputs such as push buttons, limit switches, and sensors, and outputs such as LEDs, relays, and buzzers were chosen to demonstrate real-time automation scenarios.

3.2.2.Design of Input Section

The input section consists of multiple digital input devices such as:

Push buttons (Start/Stop) On/Off switches

Proximity sensors (optional)

These inputs are interfaced to the PLC through a signal conditioning circuit ensuring proper
voltage levels and electrical isolation.11

3.2.3.Design of Output Section The output section includes: LEDs for indication

Relays for switching higher loads Buzzer for alarm indication

These outputs are connected to the PLC's digital output ports. Relay driver circuits are used to interface low-voltage PLC outputs with higher-power loads, ensuring reliable operation.

3.2.4.Circuit Design and Simulation

The entire circuit was designed using standard electrical design tools. Proper labelling and wiring conventions were followed to ensure clarity. Before hardware implementation, simulation of signal behaviour and relay activation was carried out to verify correctness of design.

3.2.5.Hardware Development

After simulation, the hardware module was fabricated on a general-purpose PCB or designed PCB. Components such as connectors, terminal blocks, resistors, relays, and LEDs were soldered. The layout was organized to represent a clean educational training kit, with separate input and output sections for better understanding.

3.2.6.PLC Programming and Implementation

Basic and advanced PLC logics were implemented using ladder diagrams. Typical programs include:

Start/Stop control

Latching and interlocking Traffic light control

Conveyor control

Level detection

The PLC was programmed using vendor-specific software (e.g., Delta WPLSoft / Siemens TIA Portal). The designed hardware was connected to the PLC, and each logic was tested to verify functionality.

3.2.7.Testing and Troubleshooting
The hardware was tested for correct operation of inputs and outputs. Voltage levels, response time, and reliability were verified. Fault conditions such as loose connections or wrong wiring were identified and corrected.

3.2.8.Performance Evaluation
The system performance was evaluated based on:
a) Accuracy of PLC response to inputs
b) Stability of output operation
c) Ease of operation for students
d) Safety and modular design
The designed module successfully demonstrated the fundamental concepts of PLC interfacing and logic implementation.

3.2.9.Documentation
Finally, all circuit diagrams, test results, and observations were documented properly. The complete report includes theoretical background, practical implementation, results, and future scope

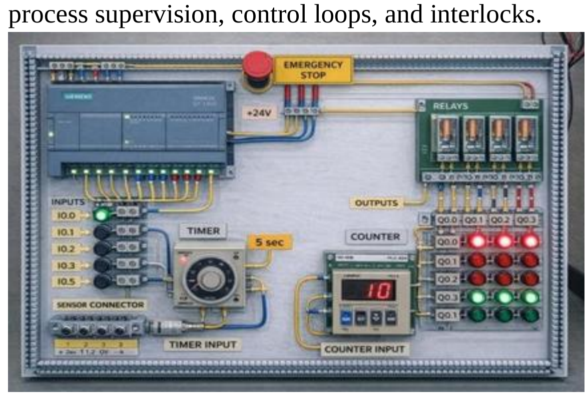
IV. WORKING PRINCIPLE

Fig. 1 S7-1200 PLC

1. PLC
Programmable Logic Controller is as essential component that governs the operation of the system. It is used to automate the control of various functions, including the speed, direction, and extension of the logic. The PLC processes inputs from the operator or sensors and sends command to the drive mechanism.
A Programmable Logic Controller (PLC) is used to control the operation of system.

Fig. 2 800xa Timer

2. Timer
The 800XA timer is an analog timer used for precise control of time dependent operations in
automation systems, offering On Delay and Interval modes, adjust able time ranges, and reliable
relay output for process control. Control Sequencing: Used in automation systems like ABB 800x A to implement timed control sequences for pumps, valves, motors, and other devices, ensuring processes operate in a coordinated manner Delayed Operations: On Delay mode enables operators to activate equipment after a set time, useful for startup delay, interlock sequences, or safety waits. Integration with Control Systems: Can be mounted on DIN rails and connected to industrial automation platforms, integrating smoothly for process supervision, control loops, and interlocks.



3. Control Panel Wiring

This panel is a PLC-based control system used for automation tasks. It contains several key components, each connected through clearly labelled wiring.

Main Components

1) PLC (Programmable Logic Controller):
A Siemens SIMATIC S7-1200 is used here. It processes input signals and controls outputs based on programmed logic.

2) Emergency Stop Button:
A safety feature that cuts power to the control circuit when pressed.

3) Relays:
Electrically operated switches that allow the PLC to control higher power loads.

4) Timer:
A device that delays an action for a set period (here, 5 seconds).

5) Counter:
Counts events or signals and displays the total.

Wiring Layout

- Power Supply (+24V): The panel operates on 24V DC, distributed to the PLC, relays, timer, and counter.
- Inputs (I0.0 to I0.5): These are wired from sensors or switches to the PLC input terminals. The yellow wires carry the signal, and the blue wires are the common/ground.
- Outputs (Q0.0 to Q0.5): These are wired from the PLC to the relay board, which then controls external devices. Red wires indicate active outputs.
- Timer Input: Connected to the PLC to trigger timed operations.
- Counter Input: Receives pulses from sensors or switches to increment the count.

Signal Flow

1. Sensors send signals to the PLC inputs.
2. The PLC program processes these signals.
3. Based on logic, the PLC activates outputs.
4. Outputs drive relays, which control external devices.
5. The timer and counter provide additional control functions.

This wiring setup is typical for training panels or small automation projects, allowing easy visualization of how PLCs interact with inputs, outputs, and auxiliary devices.

V. CONCLUSION

The main aim of this project was to design and develop and output Hardware Training module for learning PLC logics, which was successfully completed. The module helps students understand how PLCs work and how different input and output devices are connected. basic PLC programs like start-stop, latching, interlocking, and worked properly. The design is simple, safe, and easy to use in laboratories for practical learning. The project provides a low-cost and compact setup that gives hands-on experience similar to real industrial systems.

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