
**KULLIYAH OF ENGINEERING**

**MCTA 3203**

**MECHATRONICS SYSTEM INTEGRATION**

**SEMESTER 1 2025/2026**

**SECTION 1**

**GROUP 10**

**WEEK 7: PLC interfacing with microcontroller and PC over Ethernet/IP**

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ABSTRACT

This experiment focuses on developing and testing a Start–Stop control circuit using the OpenPLC Editor and an Arduino microcontroller. A ladder diagram representing the Start–Stop logic was created, compiled, simulated, and uploaded to the Arduino. The corresponding hardware circuit—consisting of two push buttons and an LED—was assembled to verify system behavior. The results confirmed that the Start–Stop ladder diagram operated correctly, demonstrating proper latching, variable mapping, and PLC-style control using microcontroller hardware

## INTRODUCTION

Start–Stop control circuits are fundamental building blocks in industrial automation, commonly used for controlling motors, actuators, and other electromechanical components. They rely on a simple latch mechanism: a **Start** input energizes the output and keeps it latched, while a **Stop** input breaks the latch and turns the output off.

In this experiment, the Start–Stop control logic is implemented using the **OpenPLC Editor**, an open-source platform for building ladder logic. The program is then uploaded to an Arduino microcontroller, demonstrating how PLC-style logic can be executed on low-cost embedded hardware. The objective is to understand variable mapping, ladder logic latching, and the functional behavior of a Start–Stop control circuit when integrated with physical hardware.

## MATERIALS & EQUIPMENT

The following hardware and software were required to complete the experiment:

### Hardware

- Arduino microcontroller board
- 2push button switches (Start & Stop)
- LED (output actuator)
- Resistors
- Jumper wires
- Breadboard

### Software

- OpenPLC Editor software
- USB cable / communication interface
- OpenPLC pin mapping documentation for Arduino

## EXPERIMENTAL SETUP

The experiment involves implementing a **Start–Stop Control Circuit** using the OpenPLC Editor and uploading the ladder logic program to an Arduino microcontroller. The goal is to demonstrate how PLC-style ladder logic can be executed on a microcontroller through Ethernet/IP-based workflow.

The required hardware and software include:

- **OpenPLC Editor software**
- **Arduino board**
- **Two push-button switches (Start and Stop)**
- **LED indicator**
- **Resistors and jumper wires**
- **Breadboard for prototyping**

The physical circuit wiring follows the configuration shown in Fig. 4 and Fig. 6, where the Start button provides a latch signal for the coil, and the Stop button breaks the circuit to reset the output.

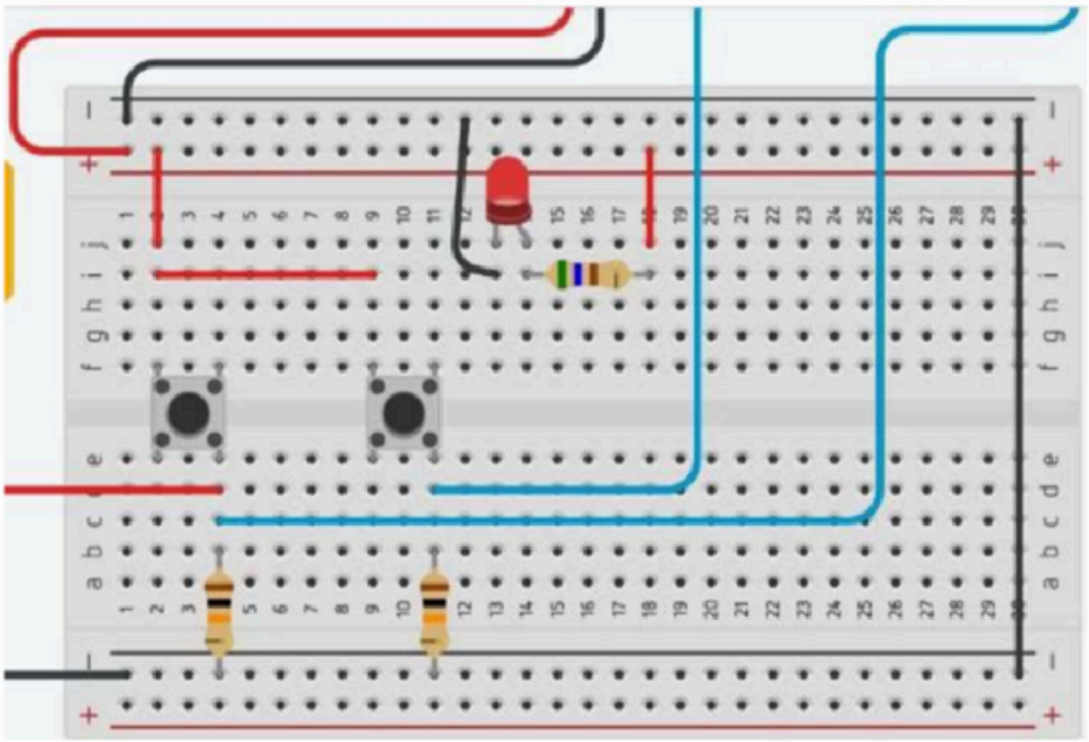


**Fig. 6**

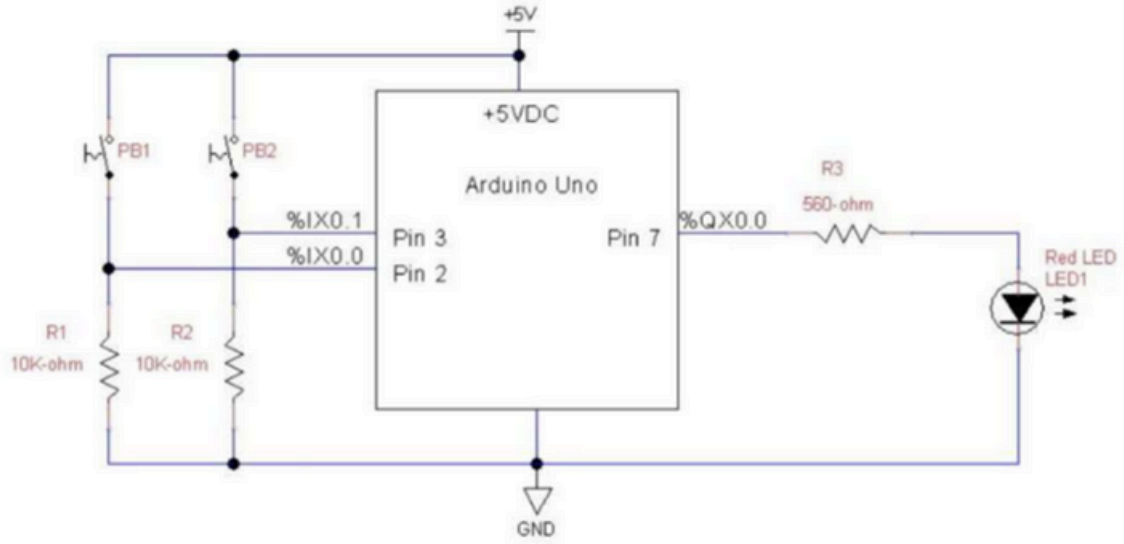



**Fig. 4**: Start-Stop Control Circuit

METHODOLOGY

The following steps were carried out to complete the experiment, based on the instructions in the lab sheet:

**1 Ladder Diagram Development**

1. A new OpenPLC project was created using LD (Ladder Diagram) as the programming language.
2. All necessary variables (Start, Stop, Output_LED) were declared as **BOOL** under "local" class.
3. The Start–Stop control logic was constructed following Fig. 5, consisting of:
    - A normally-open Start contact
    - A normally-closed Stop contact
    - A latch (self-holding) branch
    - An output coil representing the LED

**2 Simulation**

4. The ladder diagram was compiled, and the internal simulation was observed within the OpenPLC Editor to confirm correct logical behavior.

**3 Uploading the Program to Arduino**

5. Pin addressing was configured using OpenPLC Physical Addressing rules (example: %QX0.0 for digital output on Arduino).
6. The Arduino board was connected, COM port identified, and the program was transferred using OpenPLC's "Transfer to PLC" function.

**4 Hardware Testing**

7. The physical circuit was assembled according to Fig. 6 using push-buttons, LED, and resistors.
8. The system was tested by pressing the Start button (to latch LED ON) and Stop button (to turn LED OFF).

DATA COLLECTION

The data collected for this experiment focuses on verifying the functional behavior of the Start–Stop control circuit after uploading the ladder diagram to the Arduino board and assembling the physical hardware.

1. Variable and Pin Assignment

| Variable Name | Function | Assigned Pin | PLC Address |
|---|---|---|---|
| StartBtn | Start push button input | Digital Input Pin (e.g., D2) | %IX0.0 |
| StopBtn | Stop push button input | Digital Input Pin (e.g., D3) | %IX0.1 |
| LED_Out | Output LED | Digital Output Pin (e.g., D7) | %QX0.0 |

2. Functional Test Observations

| Test No. | Action Performed | Expected Behavior | Observed Behavior | Pass/Fail |
|---|---|---|---|---|
| 1 | Press **Start** button | LED turns ON and stays latched | LED turned ON and remained ON after releasing start button | Pass |
| 2 | Press **Stop** button | LED turns OFF immediately | LED turned OFF immediately | Pass |
| 3 | No button pressed | LED remains OFF | LED stayed OFF | Pass |
| 4 | Start button held down | LED remains ON | LED remained ON | Pass |
| 5 | Rapid alternating Start → Stop → Start | LED toggles according to logic | LED followed Start–Stop logic correctly | Pass |

3. Simulation Output (OpenPLC Editor)

| Parameter | Observation |
|---|---|
| Program compilation | Successful, no errors |
| Ladder simulation | Output coil energized when Start contact activated; de-energized when Stop activated |
| Latch behavior | Proper self-hold mechanism observed in simulation |

4. Hardware Circuit Verification

| Component | Check | Result |
|---|---|---|
| Wiring continuity | All button and LED connections secured | Verified OK |
| Button debounce effect | Minimal; no false triggering observed | Acceptable |
| USB/COM communication | Correct COM port detected | Verified OK |
| Program transfer | Successful via OpenPLC upload | Completed |

DATA ANALYSIS

Since this experiment focuses on PLC ladder logic simulation and hardware testing rather than numerical measurement, the analysis is based on the observed system behavior during simulation and physical execution.

For the Start–Stop control circuit, the analyzed data was the logical response of the system:

- Pressing the Start button caused the output coil to latch and keep the LED ON.

- Pressing the Stop button broke the latch condition and switched the LED OFF.

These observations show that the internal coil (self-holding coil) worked as intended. The significance of these results is that they confirm the correct implementation of fundamental industrial control logic concepts including latching and momentary inputs using the OpenPLC environment.

## RESULTS

After constructing the ladder diagram for the Start–Stop control circuit (Fig. 5) and assigning variables to the appropriate Arduino pins, the program was compiled and successfully uploaded. The physical circuit was assembled as shown in Fig. 6.

The observed results were:

- Pressing the **Start button** energized the LED and activated the latch logic, causing the LED to remain ON even after releasing the button.
- Pressing the **Stop button** deactivated the latch, turning the LED OFF immediately.
- The system responded consistently and matched the behavior expected of a standard industrial Start–Stop control circuit.

The ladder program, simulation, and hardware implementation all aligned with the intended design, confirming successful execution of the task.

## DISCUSSION

The experiment successfully demonstrated how ladder logic interacts with real hardware through the OpenPLC environment. The expected results matched the observed behavior:
- The Start–Stop circuit functioned like a standard industrial latching control system.

There were no major discrepancies, but small issues could arise, such as the Start button not responding because of loose wiring. This are typical limitation when working with breadboard setups and external microcontrollers.

Possible sources of error include:

- Incorrect %IX or %QX addressing when assigning Arduino pins.

- Wrong COM port selection during uploading.

- Software compilation errors due to missing variables.

- Mechanical issues like unstable push button contacts.

Despite these limitations, the results show that OpenPLC is a reliable platform for teaching PLC fundamentals using low-cost hardware like Arduino.

## CONCLUSION

The experiment achieved all objectives successfully. Students were able to create, simulate, and upload ladder logic to an Arduino microcontroller, and the system responded exactly as programmed. The Start–Stop circuit demonstrated proper latching behavior.

The findings support the hypothesis that PLC logic can be effectively implemented on microcontroller hardware using the OpenPLC Editor. The experiment also provided valuable experience in troubleshooting physical connections and understanding PLC-to-hardware interfacing.
Overall, the experiment demonstrates the broader application of PLC logic in automation, where similar start–stop systems are used in motor control, manufacturing lines, and safety circuits.

## RECOMMENDATIONS

Based on the experiment outcome, several improvements can be made:

1. Hardware Enhancement

Use debouncing circuits (RC filter or software debounce) to ensure cleaner button input for more advanced tasks.
Replace the breadboard with a more secure prototyping board to minimize loose connections.

2. Ladder Logic Improvements

Add an indicator for system fault or reset to create a more industrial-like control system.

3. Network Integration

Expand the experiment to include Ethernet/IP communication between PC, PLC runtime, and Arduino for remote monitoring.

4. Documentation & Analysis

Compare ladder logic with other PLC programming languages (e.g., ST, FBD) for educational enhancement.

REFERENCES

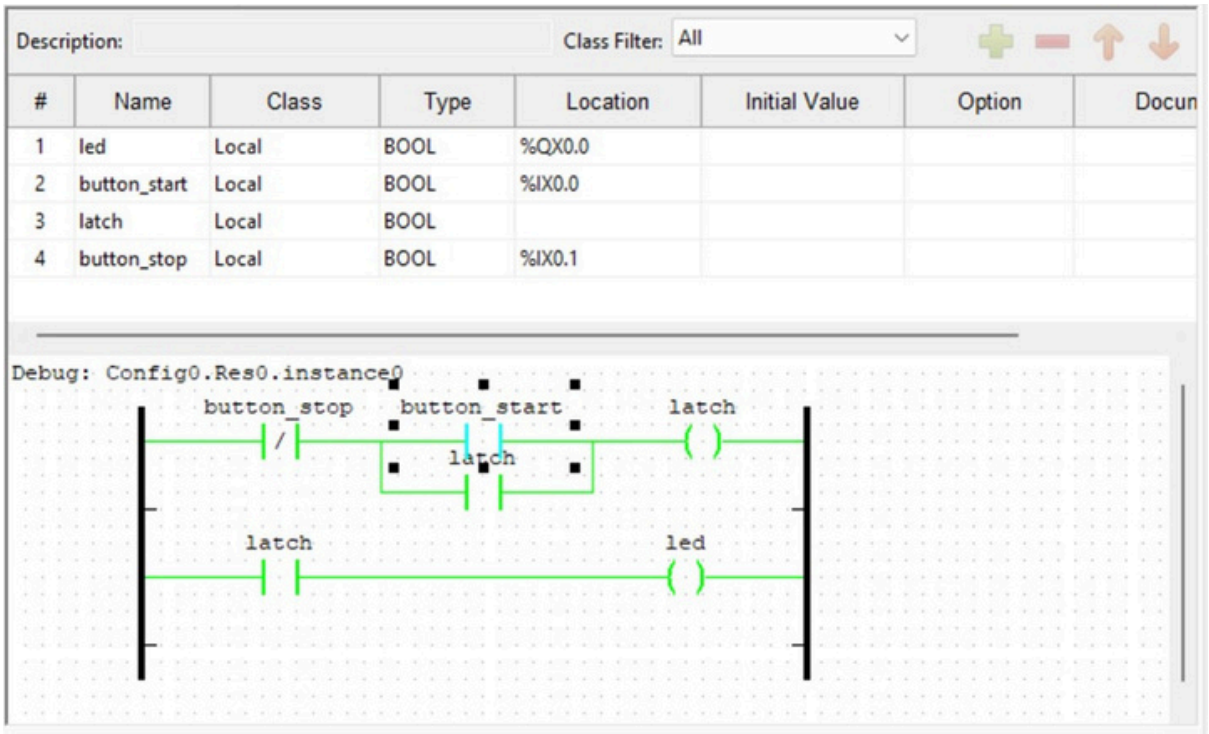
[1] Autonomy Logic – OpenPLC Editor.

[2] “PLC Ladder Logic on an Arduino – Introduction to OpenPLC,” Control.com.

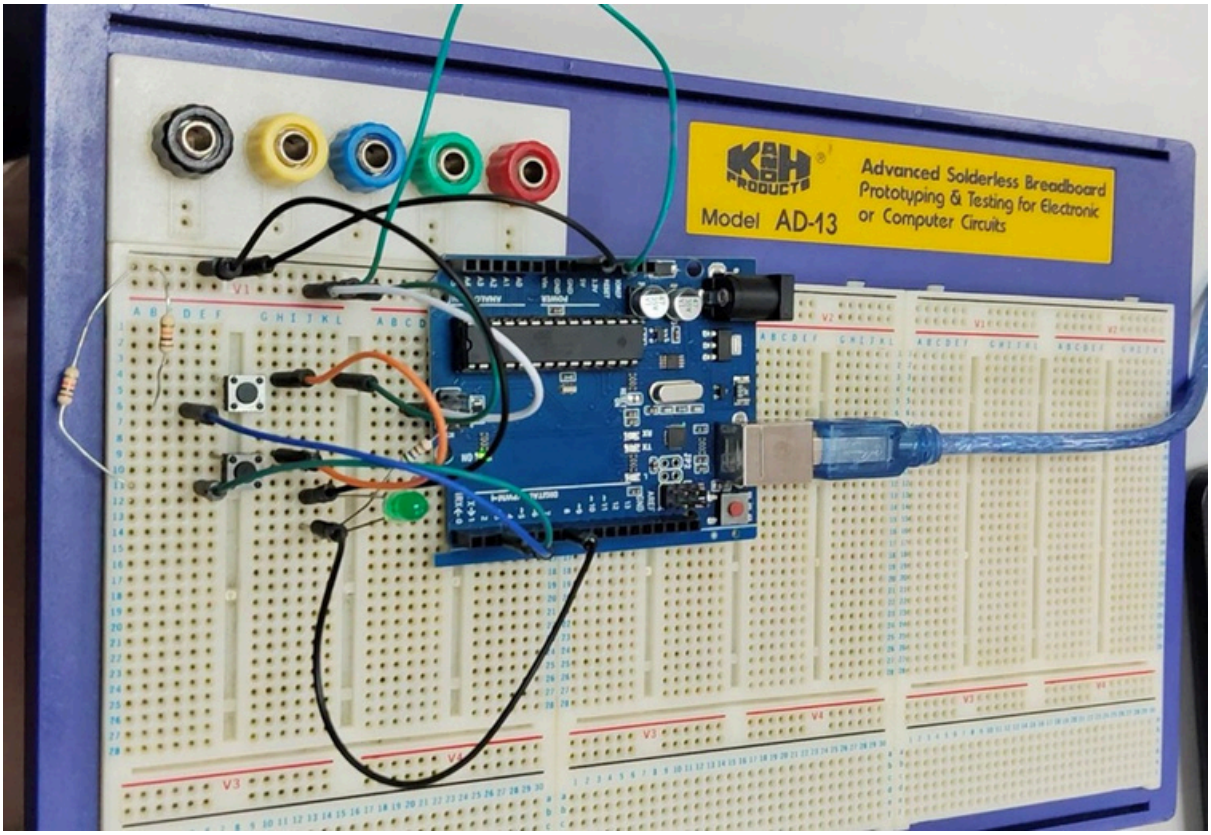
[3] “PLC Ladder Logic on an Arduino – Building a Start–Stop Circuit,” Control.com.

APPENDICES

A. Circuit Diagrams




B. Additional Figures or Graphs


Advanced Solderless Breadboard
Prototyping & Testing for Electronic
or Computer Circuits
Model AD-13

ACKNOWLEDGEMENTS

We would like to express our deepest gratitude to Sir Zulkifli bin Zainal Abidin , our course instructor for *Mechatronics System Integration (MCTA3203)*, for his invaluable guidance, encouragement, and continuous support throughout the completion of this Digital Logic System lab project.

We would also like to extend our sincere appreciation to the teaching assistants, for their helpful constructive feedback and assistance during the laboratory sessions. Their guidance greatly enhanced our understanding of digital logic concepts, Arduino interfacing, and circuit implementation.

Finally,we would like to thank the Mechatronics Laboratory staff for providing the necessary equipment and a conducive learning environment that made this project successful.

## Certificate of Originality and Authenticity

This is to certify that we are responsible for the work submitted in this report, that the original work is our own except as specified in the references and acknowledgement, and that the original work contained herein have not been untaken or done by unspecified sources or persons.

We hereby certify that this report has not been done by only one individual and all of us have contributed to the report. The length of contribution to the reports by each individual is noted within this certificate.

We also hereby certify that we have read and understand the content of the total report and no further improvement on the reports is needed from any of the individual's contributors to the report.

We therefore, agreed unanimously that this report shall be submitted for marking and this final printed report has been verified by us.

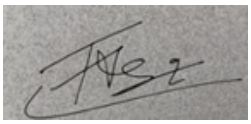
Signature: 

Name: Afnan Hakim bin Adinazrin

Matric Number: 2315987

Contribution: Equipment setup,Methodology,Data analysis
Recommendations

| | |
|---|---|
| Read | / |
| Understand | / |
| Agree | / |

Signature: 

Name: Muhammad Taufiq bin Mukhtar
Matric Number: 2316271
Contribution: Discussion,Conclusion,Appendices
References

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| Read | / |
| Understand | / |
| Agree | / |

Signature: 

Name: Muhammad Danish Farhan bin Amiruddin
Matric Number: 2315423
Contribution: Abstract,Introduction,Materials & Equipment,
Data Collection, Results

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