MECHATRONICS SYSTEM INTEGRATION

EXPERIMENT 4:
PLC INTERFACING WITH MICROCONTROLLER AND PC OVER ETHERNET/IP

GROUP NUMBER: A

PROGRAMME: MECHATRONICS

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Abstract

The experiment involves interfacing an open Programmable Logic Controller (PLC) with an Arduino microcontroller. The aim is to create a fundamental ladder diagram using the open PLC software and then upload this diagram onto the Arduino microcontroller. This process integrates the functionalities of both the open PLC and Arduino, potentially demonstrating the compatibility and collaborative operation between these two systems. The ladder diagram likely represents a foundational control logic, showcasing the communication and interaction between the PLC and the Arduino for broader applications in automation and control systems. The experiment focuses on the synergy between an open Programmable Logic Controller (PLC) and an Arduino microcontroller. It involves the design and implementation of a basic ladder logic diagram using open PLC software. This diagram serves as a control program, outlining logic-based control functions. The integration process entails transferring this ladder logic from the open PLC to the Arduino microcontroller. This transfer likely involves translating the ladder logic into a format compatible with Arduino's programming environment, enabling Arduino to execute control instructions based on the defined logic.

Table of Contents

Objectives

1. To implement PLC and microcontroller integration
2. To demonstrate ladder diagram creation and simulation
3. To test the functionality of start-stop control circuit

Introduction

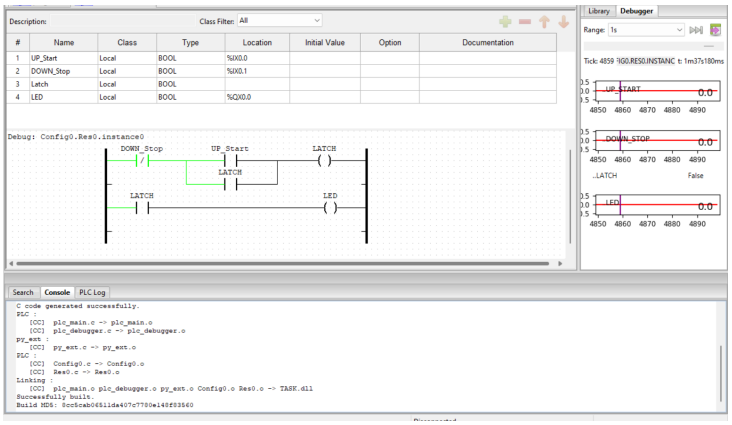
This lab report focuses on the integration of a Programmable Logic Controller (PLC) with an Arduino microcontroller by utilising OpenPLC Editor software. The main goal is to create a ladder diagram within the software, simulate its functionality, and transfer it onto an Arduino for practical applications. This experiment is based around the development of a Start-Stop Control Circuit using ladder logic. Using this circuit, the initial part of the experiment involves creating a ladder diagram to control the blinking of an LED. Later on, the experiment will introduce a timer block to regulate the blinking time interval of the LED which shows how time-based control elements can be integrated for different applications.

Material and Equipment

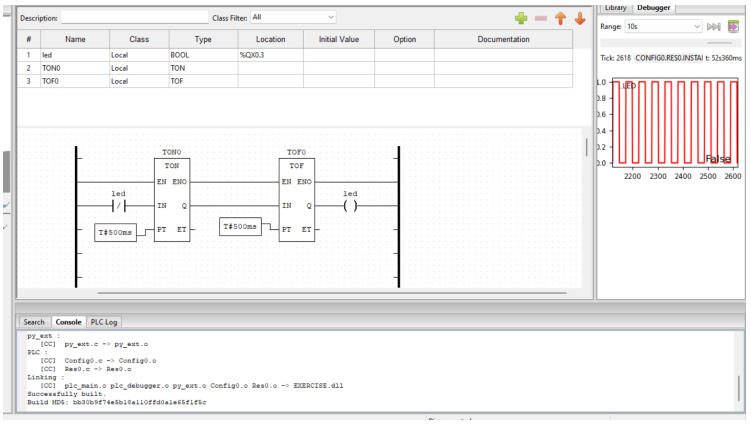
- Open PLC Software
- Arduino Board
- 2 Push Button Switches
- Jumper Wires
- LED
- Resistors
- Breadboard

Experimental Setup

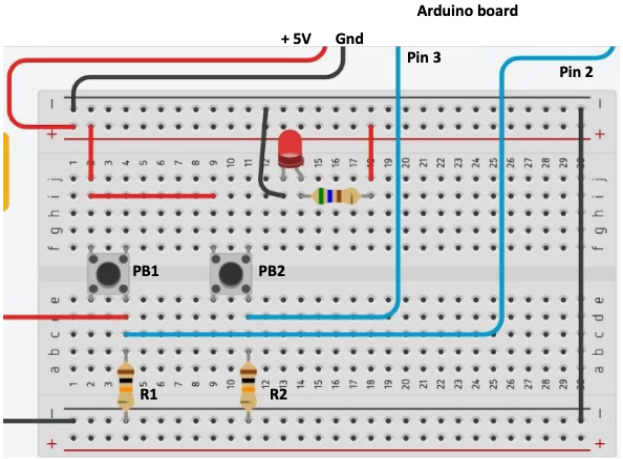
The setup begins by creating this ladder diagram for the start-stop control circuit in OpenPLC Editor by specifying all the variables using their respective data types and locations according to the pins they will be connected to in the arduino microcontroller. Additionally, in order to control the LED blinking time, there is an addition of timer block into the ladder diagram



With timer block:

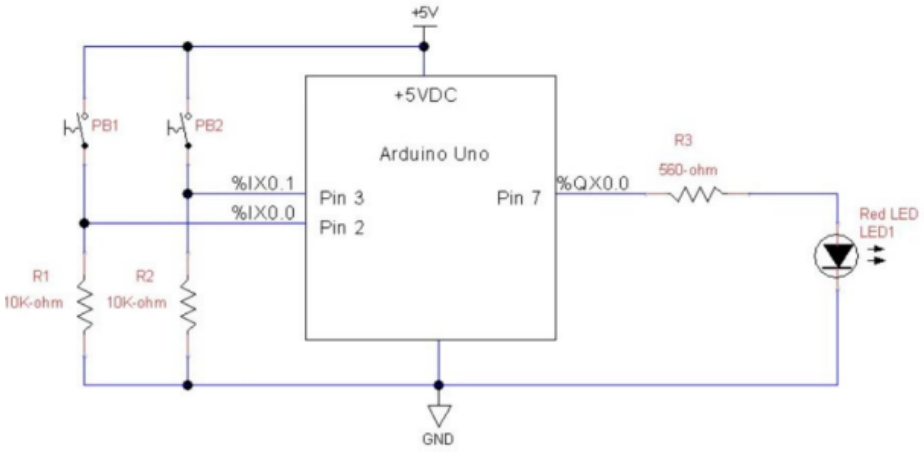


After uploading the ladder diagram to the Arduino board and ensuring to select the correct COM port number as well verify all pin associations between OpenPLC variables and the Arduino board, this circuit was created on the breadboard and tested:



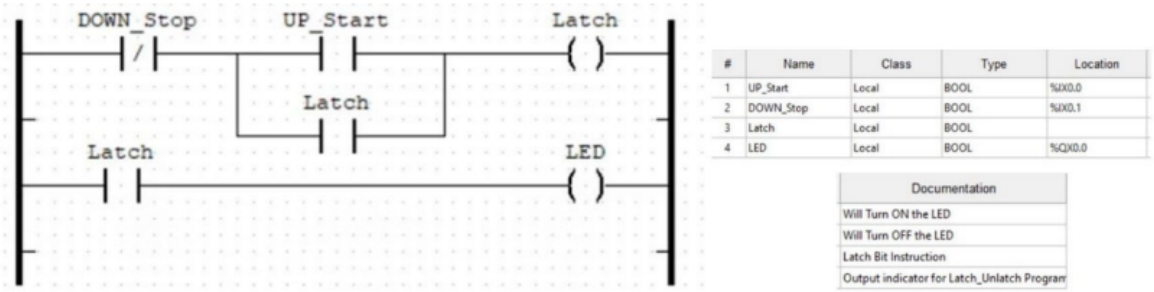
Methodology

In this experiment, we develop a Start-Stop Control Circuit by using a ladder diagram created in OpenPLC, compile, simulate, and transfer the ladder diagram program to the Arduino Board. The circuit with pin configuration is shown



Start-Stop Control Circuit

Using an Arduino UNO board, the push buttons are connected to pins 2 and 3. This needs to be typed into the location of the variable associated Digital Output pin on the OpenPLC Editor which is %IX0.0 and %IX0.1 respectively. The same goes for LED going to Pin 7 associated with location %QX0.0. The latch in the ladder diagram function ensures that once the motor LED is light, it remains running until a stop command is given



Ladder Diagram for the Start-Stop Control Circuit

Data Collection

As for the data collection, the behaviour of the LED that was controlled by the ladder diagram's logic, was visually observed during the simulation within the OpenPLC Editor upon transfer to the Arduino board. The focus was on observing the functionality and response of the LED under different ladder diagram applications, such as the addition of the timer and with that the modifications to the blinking time interval.

Data Analysis

For example, after we created the ladder diagram in the OpenPLC and uploaded it onto Arduino, we can observe that the LED was blinking rapidly. Therefore, in the exercise part, we have modified the ladder diagram by adding the block timer to increase and control the time interval between each blink. We can detect that the blinking of the LED is more slower than the first part as the timer gives some delay to the LED.

The operation of the Start-Stop control circuit was checked by engaging with the push buttons and observing the LED's behaviour. Pressing the Start push button should start the process, and pressing the Stop push button should stop it. The start push button will turn on the LED if pressed and the stop push button will turn off the LED if it was pressed.

Result

The blinking LED ladder diagram was successfully modified, and the timer block was effectively regulated to control the blinking time interval. The Start-Stop control circuit was successfully developed, and the ladder diagram that governs its behaviour was successfully uploaded to the Arduino board without any error. During testing, pressing the Start push button was supposed to start the process, and pressing the Stop push button was supposed to stop it. As we already expected and predicted, If the start push button is pressed, the LED will turn on, and if the stop push button is pressed, the LED will turn off.

In short, this experiment exhibits a successful synergy of open-source PLC programming (OpenPLC), ladder logic diagrams, and Arduino-based microcontroller technology, demonstrating a smooth integration for operating a physical circuit. This successful integration demonstrates OpenPLC's usefulness as a programming platform for

controlling industrial processes, as well as the Arduino board's suitability as a microcontroller in this configuration.

Discussion

- **Arduino UNO**

The experiment utilises the Arduino UNO board as the central hardware platform. Connected to this board are two push buttons, strategically wired to pins 2 and 3. Additionally, an LED is connected to Pin 7 on the Arduino UNO board, serving as an output device.

- **Software Configuration - OpenPLC Editor**

To interface the hardware with the control logic, the OpenPLC Editor is employed. The push buttons, acting as input devices, are mapped to specific digital input pins in the OpenPLC Editor, namely %IX0.0 and %IX0.1. Simultaneously, the LED, functioning as an output device, is associated with a digital output pin, identified as %QX0.0. This software configuration enables communication between the physical world (Arduino) and the control logic programmed in the OpenPLC Editor.

- **Ladder Diagram and Latch**

The ladder diagram incorporates a latch mechanism to ensure a robust Start-Stop functionality. When the "Start" push button is pressed, the associated digital input is activated (%IX0.0), initiating the latch and turning on the LED (%QX0.0). Importantly, this latch ensures that even if the "Start" push button is released, the LED, representing a motor, remains powered.

Conclusion

In conclusion, the experiment successfully demonstrated the integration of an open Programmable Logic Controller (PLC) with an Arduino microcontroller. By creating a basic ladder logic diagram using open PLC software and uploading it onto the Arduino, the experiment showcased the interoperability and collaborative potential of these two distinct control systems.

Effective integration of an open Programmable Logic Controller (PLC) with an Arduino microcontroller is demonstrated through experiments, which supports the theory. A seamless

control logic implementation demonstrated on the Arduino platform confirms that ladder logic diagrams can be transferred and implemented from open PLC software to Arduino. The results match the predictions, showing that it is possible and functional to integrate these two control systems.

The experiment underscores the potential for open-source platforms to collaborate effectively. This could lead to increased adoption of open-source control solutions in industrial settings, where traditionally proprietary systems have dominated.

Recommendation

The need for improvement is always needed to make sure the accuracy, reliability, and adaptability of the experiment results. For this particular experiment, there was not much of an error or problem encountered except further improvements and suggestions to yield more reliable results and cut down the error. Even to gain as much knowledge as possible related to this experiment.

1. **Expand and Diversify Control Logic:**
   Additional features and functionalities could be integrated into the control logic which involved adding more sensors and implementing more complex control algorithms into the experiment. This will provide a broader understanding of the capabilities of OpenPLC and Arduino in industrial automation to generate the output desired.

2. **Optimization and Efficiency:**
   Evaluate the efficiency of the ladder logic and Arduino code by optimizations to improve the performance of the control system. Improve efficiency, usually involves refining the timer settings, reducing unnecessary delays, or streamlining the ladder diagram for better clarity and functionality.

3. **Documentation and Reproducibility:**
   The ladder diagram and the entire setup could be documented thoroughly including detailed instructions on the experiment's steps. It can serve as a valuable resource for revision and further studies on the use of the connection between the PLC and Arduino.

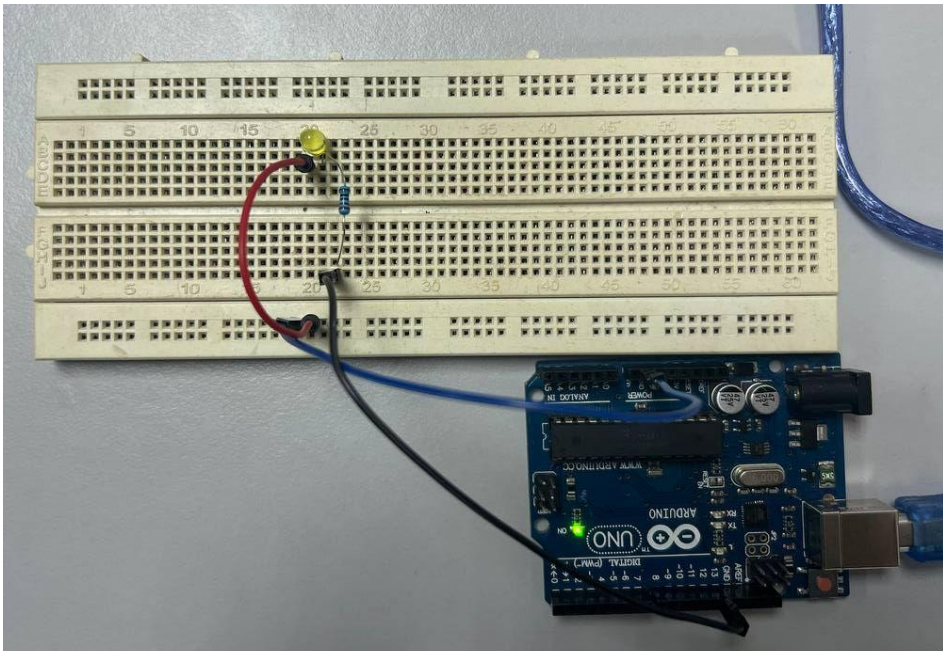
It should be a guide that highlights the key points in the integration process like the specific configurations, settings, or dependencies that might be crucial for success.

By implementing these recommendations, we can improve the system's reliability and efficiency. Hence, it will reduce the errors that might occur in the future.

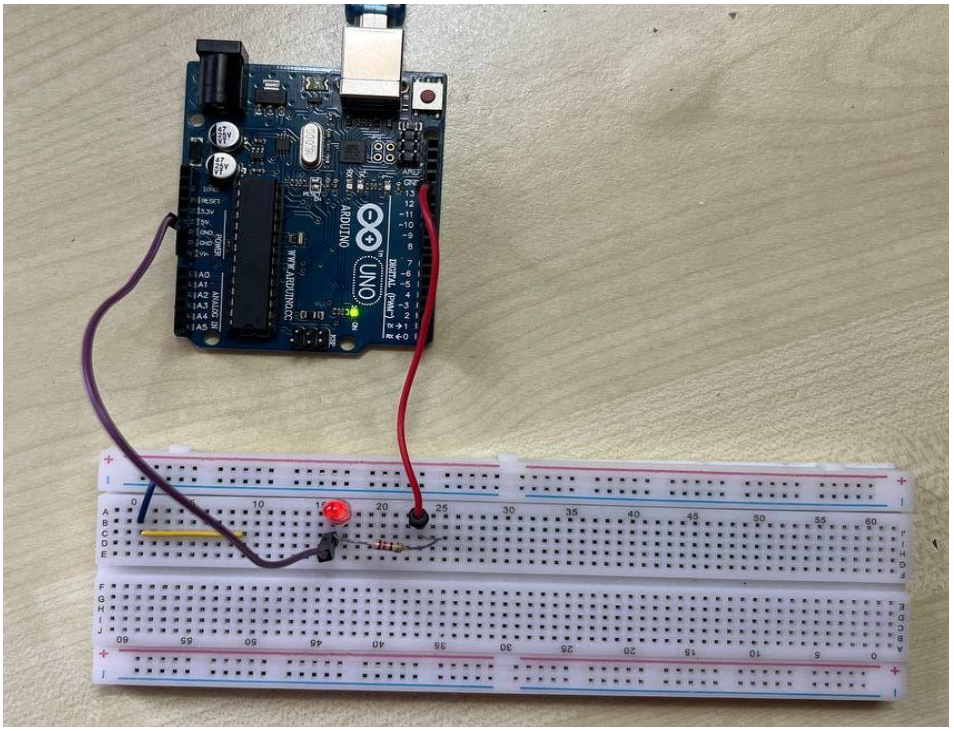
References

Zulkifli. (2014). *Mechatronics Interfacing Lab Manual*, (Rev. ed.). Unpublished Class Materials

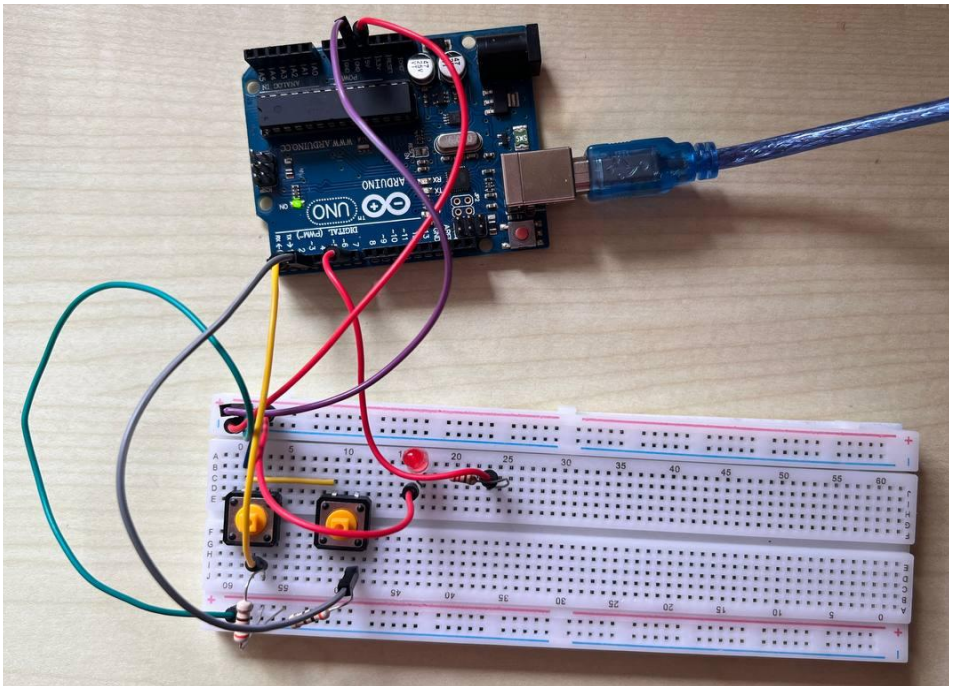
Appendices



The final result for the blinking LED circuit



The final result for blinking LED using timer



The final result for the start-stop control circuit

Acknowledgments

We would like to express our sincere gratitude to the individuals who provided invaluable assistance, guidance, and support during this experiment. First and foremost, we extend our appreciation to Dr. Nadzril bin Sulaiman for their comprehensive instruction and mentorship throughout the experiment. Their insights, feedback, and enthusiasm played an important role in our understanding of Arduino programming.

Our fellow group members also deserve special acknowledgment for their collaboration and support. Our discussions, knowledge-sharing, and problem-solving sessions greatly enriched our understanding of this experiment's concepts and enhanced the overall learning experience. The collective contributions of our group members have not only enriched our learning experience but have also significantly contributed to the successful completion of this project.

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 acknowledgment, and that the original work contained herein has 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 **read** and **understand** the content of the report and no further improvement on the report is needed from any of the individual's contributions 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.**

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Matric Number	2115386	**Understand** ✅
Contribution	- Abstract - Conclusion	**Agree** ✅

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Contribution	-Data Analysis -Result	**Agree** ✅

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Contribution	-Methodology -Discussion	**Agree** ✅

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Contribution	-Introduction -Experimental Setup -Data Collection	**Agree** ✅

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Contribution	- Recommendations -Material and Equipments	**Agree** ✅