

**MCTA 3203**

**MECHATRONIC SYSTEM INTEGRATION**

**SECTION 1**

**SEMESTER 2 2024/2025**

**LECTURER:**

**SIR WAHJU SEDIONO**

**SIR ZULKIFLI BIN ZAINAL**

**LAB REPORT 4B:**

**SERIAL COMMUNICATION (RFID)**

**GROUP 6**

**DATE OF SUBMISSION: 7 APRIL 2025**

|  |  |
| --- | --- |
| **GROUP MEMBERS** | **MATRIC NUMBERS** |
| **Muhammad Nabil Iman bin Abd Rahman** | **(2313551)** |
| **Muhammad Nazhan bin Mohamed Nadzri** | **(2313703)** |
| **Muhammad Haziq Ajmal bin Md Kamal** | **(2312821)** |

# ABSTRACT

This project aims to develop a fundamental RFID authentication system controlled by Python and Arduino, which operates a servo motor. An RFID card reader, connected via USB, authenticates RFID tags against a list of pre-registered UIDs. The system then grants or denies access by controlling a servo motor based on this authentication. JSON data handling was incorporated to structure the data more effectively, allowing for easy addition or modification of registered UIDs. This project, therefore, implements RFID technology in security systems, with a primary focus on integrating structured data handling, visual feedback, and hardware control for enhanced functionality and user-friendliness.

# TABLE OF CONTENT

[ABSTRACT 2](#_TOC_250008)

[TABLE OF CONTENT 3](#_TOC_250007)

[INTRODUCTION 5](#_TOC_250006)

[MATERIALS AND EQUIPMENT 5](#_TOC_250005)

[EXPERIMENTAL SETUP 6](#_TOC_250004)

[CONCLUSION 6](#_TOC_250003)

[RECOMMENDATIONS 8](#_TOC_250002)

[ACKNOWLEDGEMENT 11](#_TOC_250001)

[STUDENT’S DECLARATION 11](#_TOC_250000)

# INTRODUCTION

In contemporary mechatronic systems, the integration of sensors and actuators with microcontrollers via serial and USB communication is vital for creating responsive and intelligent applications. This laboratory exercise focuses on establishing a real-time RFID-based authentication system using an Arduino microcontroller and a USB RFID card reader. The main objective is to demonstrate secure access control using RFID technology while commanding a servo motor based on the detection of authorized or unauthorized cards. The experiment utilizes serial communication between the computer and the Arduino board, as well as USB Human Interface Device (HID) communication to interact with the RFID reader. Upon detection of a valid RFID card, the system activates a servo motor to a specific position, and can be further expanded to include visual indicators and customizable behavior. This hands-on approach enables students to explore device interfacing, serial data processing, and hardware control using both Python and Arduino programming environments.

# MATERIALS AND EQUIPMENT

|  |  |
| --- | --- |
| **ITEM** | **AMOUNT** |
| LED | TBD |
| ARDUINO UNO MEGA | 1 |
| BREADBOARD | 1 |
| 220 OHM RESISTANCE | 7 |
| JUMPER WIRES | 9 |
| RFID CARD READER | 1 |
| RFID TAGS OR CARDS | 1 |
| SERVO MOTOR | 1 |
| USB CABLE | 1 |
| MOUNT FOR SERVO | TBD |

# EXPERIMENTAL SETUP

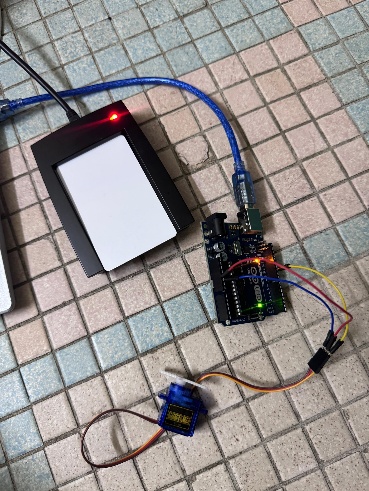
**Hardware Connections**

* **RFID Reader:** Connected to the computer via USB. No extra power wiring is necessary as it receives power through the USB connection.
* **Servo Motor:**
  + Power (Red) → Connected to Arduino 5V
  + Ground (Brown/Black) → Connected to Arduino GND
  + Signal (Yellow/Orange) → Connected to Arduino Digital Pin 9
* **Arduino Board:** Connected to the computer using a USB cable for both power and serial communication.
* **Common Ground:** A shared ground connection was ensured between the Arduino and servo motor to complete the circuit.

**Software and Programming**

* **Arduino Code:** Configured to control the servo motor based on serial input received from the computer. When an authorized RFID card is detected, a specific character ('A') is sent via serial to rotate the servo; otherwise, a different command ('D') resets it to a neutral position.
* **Python Script:**
  + Utilizes the pyusb library to interface with the USB RFID reader.
  + Detects and reads RFID tag data.
  + Compares tag data with a list of authorized IDs.
  + Sends corresponding commands to the Arduino over serial to control the servo motor.
  + Can be expanded with LED indicators and JSON-based configuration handling.

**RESULT**

****A hand holding a card next to a small electronic device

AI-generated content may be incorrect.

**DISCUSSION**

The RFID-based authentication system developed in this lab effectively illustrates the integration of sensor input (RFID reader) and actuator control (servo motor) through serial and USB communication using Python and Arduino. The project successfully demonstrates a simple access control mechanism where the detection of an authorized RFID card prompts a servo motor to actuate, simulating physical access control like opening a door or activating a device. A key learning outcome was comprehending how USB Human Interface Devices (HID), such as RFID readers, communicate differently from standard serial devices. This necessitated the use of the pyusb library in Python to directly read card data from the HID stream, showcasing an important concept in modern embedded systems: device-specific interfacing. On the Arduino side, the servo motor responded accurately to commands received over the serial connection. This highlights the robustness and reliability of serial communication for real-time control tasks. By mapping specific characters ('A' for allow, 'D' for deny) to motor positions, the system remained simple yet functional, ideal for prototyping and educational environments

**Challenges encountered included:**

* Identifying the correct vendor and product IDs for the RFID reader, which are essential for USB communication.
* Managing serial communication timing, specifically ensuring the Arduino was prepared to interpret incoming characters without delay or misreading.
* Ensuring a stable power supply for the servo motor, which can draw more current than the Arduino can safely provide under load.

To enhance the system's feedback capabilities, LEDs can be incorporated to visually indicate authentication results—green for granted access and red for denied. Moreover, by introducing structured data handling (e.g., JSON), the system could become more flexible and scalable, enabling dynamic updates to authorized card lists and servo angle control through user-defined parameters. Overall, the experiment effectively combines software and hardware components to achieve a practical application. It not only reinforces concepts of serial and USB communication but also encourages consideration of real-world deployment factors, such as reliability, safety, and user interaction.

# CONCLUSION

This experiment successfully demonstrated the integration of an RFID card reader with an Arduino and Python to create an access control system featuring servo motor actuation. By leveraging USB HID communication and serial data exchange, the system effectively authenticated RFID cards and triggered servo movements based on predefined authorization rules. The inclusion of visual feedback through LEDs further improved user interaction, providing immediate status indications for granted or denied access. This setup highlights the practicality of combining RFID technology with microcontroller-based control systems for secure and automated applications. The use of structured JSON data handling, as suggested in the task, would enhance the system's flexibility, allowing for easier management of authorized card IDs and servo angle configurations. Such an approach facilitates dynamic adjustments without requiring code modifications, making the system more adaptable to diverse use cases. Additionally, incorporating user-defined servo angles adds a layer of customization, broadening the system's applicability in scenarios like door locks, robotic arms, or other position-based mechanisms. Through careful hardware configuration and software validation, issues such as preventing signal noise in the servo motor wiring or ensuring reliable USB connectivity with the RFID reader were addressed. Future improvements could include wireless communication for remote monitoring or database integration for comprehensive card management. These enhancements would significantly simplify the scalability and functionality of the system. In summary, this experiment underscores how software logic and hardware elements collaborate in mechatronics systems. Beyond showcasing the versatility of Arduino and Python in designing interactive, sensor-driven systems, it provides a fundamental illustration of how RFID technology can be employed for secure access management. The concepts discussed herein, emphasizing the value of modular design and user-centric features, are applicable to more intricate automation projects.

# RECOMMENDATIONS

To further enhance the effectiveness, reliability, and usability of the RFID-based authentication and servo control system developed in this experiment, several significant recommendations are proposed. These recommendations aim to improve both the technical robustness and user experience of the system and foster continued learning and development in mechatronic integration.

Firstly, it is highly recommended to improve the scalability and security of the authentication process. Instead of hardcoding authentic card IDs directly into the Python code, a more dynamic and scalable solution would involve storing and managing user information in an external JSON file or even a simple database like SQLite. This approach would allow for easier updates and better data handling as the system expands to accommodate more users or different access levels.

Secondly, strengthening the visual feedback mechanism can significantly improve system usability. While green and red LEDs for granted and denied access are beneficial, adding an LCD or OLED screen to display status messages (e.g., "Access Granted", "Access Denied", or "System Ready") would provide more prominent communication to end-users. Additionally, incorporating audible feedback, such as a buzzer, can offer another intuitive feedback mechanism.

Another important recommendation is the inclusion of error-handling routines and logging functions within the Python code. Such additions would assist in diagnosing issues like USB connection failures, recognition of unknown devices, or incorrect readings. Implementing proper exception handling would make the system more stable and responsive even under unexpected conditions.

Additionally, to enable broader use cases and increase flexibility, it is advisable to include an option for a user input mechanism to dynamically configure the servo motor angle. Providing a graphical user interface (GUI) or command-line input for entering and displaying the servo angle would allow users to customize the motor's behavior in real-time, offering an even wider range of potential applications.

Lastly, for improved hardware safety and performance, it is suggested that an external power source be used for the servo motor if higher torque or extended operating times are required. The Arduino's onboard power supply may not be sufficient for high-usage servo applications, potentially leading to unstable behavior or damage. Overall, implementing these recommendations would not only enhance the current experimental setup but also serve as a foundation for developing a more complete and real-world applicable mechatronic system. These upgrades facilitate ongoing learning, encourage innovation, and promote best practices in system design and integration.

# ACKNOWLEDGEMENT

We would like to express our sincere gratitude to Sir Wahju Sediono for their guidance and support throughout this project. Our thanks also extend to the teaching assistants, for their

constructive feedback and assistance,which greatly contributed to the completion of this work.

# STUDENT’S DECLARATION

# 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.**