Wyatt Bordeaux

30 July 2025

RFID Lock Box

Abstract

Cylinder locks have long been the standard for securing homes and businesses; however, they possess inherent vulnerabilities such as susceptibility to lock picking, unauthorized key duplication, and brute force attacks. This paper proposes a project utilizing Radio Frequency Identification (RFID) technology to minimize the reliance on physical keys, thereby enhancing convenience and efficiency. This is accomplished by integrating an RFID module with an Arduino microcontroller to construct a system that grants access via a key card or smartphone. This paper explores the design, implementation, and potential of RFID technology as a modern replacement for the traditional cylinder lock.

Introduction

The traditional cylinder lock is a mechanism characterized by its cylindrical housing, within which lies a series of pins that must align for the key to turn. This design gained widespread adoption in the mid-19th century due to its compact size, security features, and the ease of mass production afforded by the technology of the era. Prior to this, locking mechanisms—such as simple barricades or sliding bolts—were highly vulnerable to brute force and lacked the convenience of external access. Consequently, the cylinder lock superseded these primitive techniques, becoming the global standard.

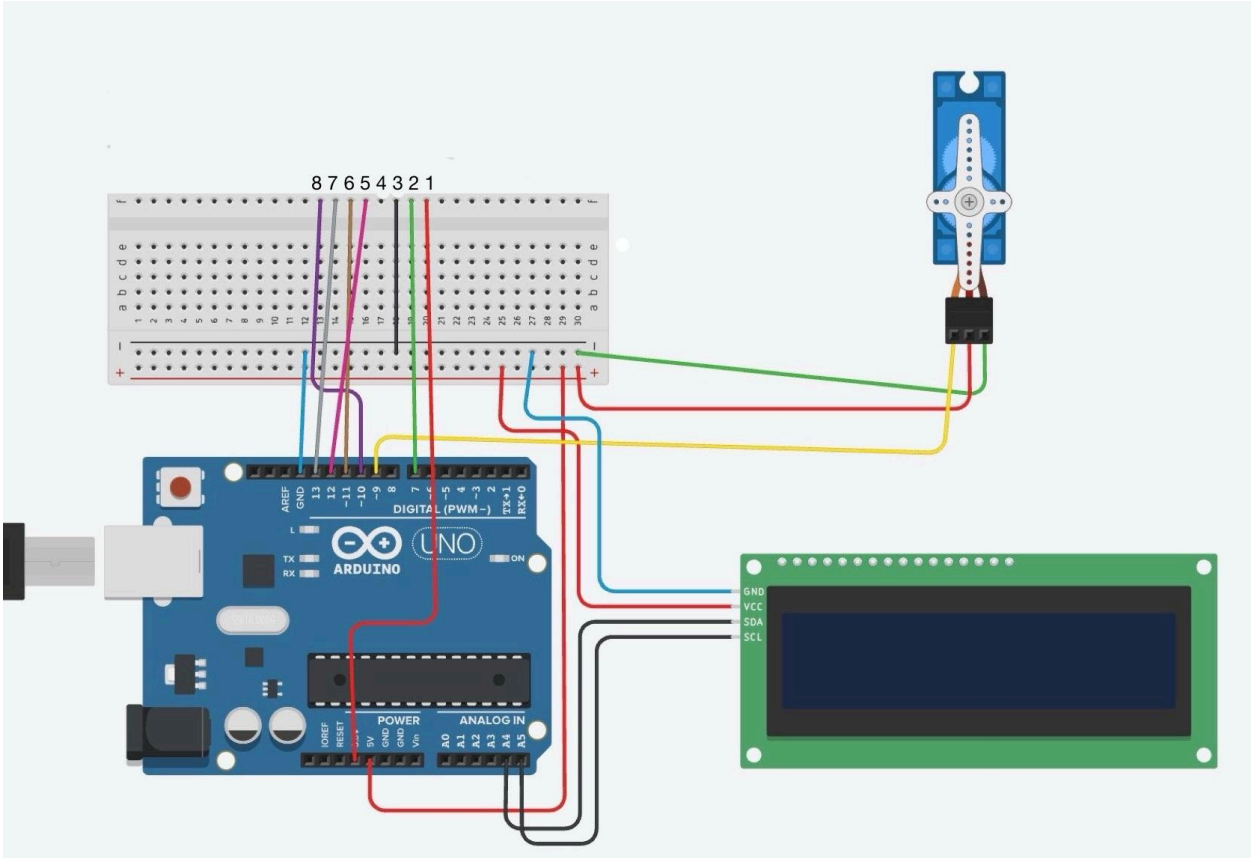
Despite its prevalence, the mechanical cylinder lock retains significant security flaws. Brute force attacks can shatter the internal gear system, causing the lock to fail. More concerning are non-destructive vulnerabilities; sophisticated intruders can utilize tension wrenches to bypass the mechanism or scan a physical key to create an unauthorized duplicate. These flaws pose a significant security risk, as they allow intruders to enter and exit undetected.

As criminal methods become more sophisticated, security systems must evolve. A robust solution to these vulnerabilities is Radio-Frequency Identification (RFID) technology. RFID identifies authorized users through a card, tag, or smartphone, enabling access without a mechanical key. This system is faster, difficult to replicate, and customizable. In this project, we explore the implementation of RFID technology combined with a servo locking mechanism, a digital display, and an Arduino Uno to create a smarter, safer alternative to the traditional lock-and-key system.

Materials

- Arduino Uno R3
- MFRC522 RFID Reader Module
- Servo Motor (SG90)
- LCD Screen with I²C Interface (16x2)
- RFID Key Cards / Tags
- Breadboard
- Jumper Wires
- 9V Battery or USB power supply

Schematic



Schematic: The schematic consists of three main components connected to the Arduino Uno R3: the RFID reader, the LCD with I²C interface, and the servo motor acting as the lock.

RFID Reader: Uses SPI communication protocol.

- SDA → Pin 10
- SCK → Pin 13
- MOSI → Pin 11
- MISO → Pin 12
- RST → Pin 7
- GND and 3.3V for power.

LCD (I²C): Reduces pin usage by using only two data lines:

- SDA → A4
- SCL → A5
- Powered by 5V and GND.

Servo Motor:

- Signal → Pin 9
- Powered by 5V and GND

Construction

The construction begins by mounting the RFID module, servo motor, and I²C LCD onto a breadboard and wiring each component to the Arduino Uno. The RFID scanner is positioned to detect cards from a short distance, while the servo motor is aligned to rotate 90 degrees to disengage the locking mechanism. The LCD is mounted near the RFID module to provide visual feedback regarding the system's status.

The code initializes SPI for the RFID module and I²C communication for the LCD via the SPI.h, MFRC522.h, and LiquidCrystal_I2C.h libraries. Upon the initial scan, the system registers that specific UID tag as the "Master Key." This feature serves as a proof of concept, demonstrating that the module can be programmed to accept different tags dynamically. Once the Master Key is stored in the Arduino’s memory, subsequent scans are compared against it. If a match is found, the servo rotates to unlock the latch, and the LCD displays “Access Granted.” To re-lock the mechanism, the user scans the key again after closing the system. If a scanned tag does not match the original key, the LCD displays “Access Denied.”

Discussion

The RFID-based locking mechanism successfully demonstrates a secure, modern alternative to the mechanical cylinder lock. Requiring unique digital identification instead of a physical key significantly reduces the risk of unauthorized duplication. While the integration of the servo motor serves as a proof of concept for this prototype, a consumer-grade product would utilize high-strength materials for enhanced durability. The LCD provides essential user feedback, which is particularly beneficial for those unfamiliar with RFID technology.

A current limitation of this prototype is power consumption; the 9V battery depletes relatively quickly. Future iterations could include power-saving modes or a hardware switch to conserve battery life while maintaining security. Another consideration is that the authorized UID tags are currently stored in volatile memory; a robust version would utilize EEPROM or an external encrypted database. Additionally, while effective for a prototype, this project does not yet include encryption or multi-factor authentication, which are standard practices in high-security environments.

Despite these areas for improvement, the prototype successfully mitigates the mechanical weaknesses inherent in traditional cylinder locks.

Conclusion

This project effectively demonstrates how RFID technology, paired with a programmable microcontroller, can serve as a superior digital alternative to the traditional cylinder lock. It addresses the flaws of primitive locking mechanisms, specifically the ease of key duplication and

vulnerability to physical picking. This system highlights the potential of modern, scalable home security. While this project is a prototype, it establishes a foundation for future security systems where cloud-based authentication, smartphone integration, and data logging could be implemented for comprehensive protection.

Works Cited

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