

Radio Frequency Identification (RFID) Door Security Lock Using Arduino

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Abstract—This paper presents the design and implementation of a cost-effective door security system using Radio Frequency Identification (RFID) technology integrated with an Arduino microcontroller. The system allows access only to authorized users carrying RFID tags registered in the microcontroller memory. Upon identification, the Arduino controls and electromechanical lock mechanism to grant or deny access. The project aims to improve traditional security systems by combining electronic control, RFID communication, and embedded programming, offering reliable, scalable, and efficient door access management. Radio Frequency Identification (RFID) technology provides a contactless solution to access control, enabling electronic authentication using unique tag identifiers. The Arduino microcontroller serves as the brain of the system, processing tag information from the RFID reader and controlling the lock mechanism. The system is designed to be low-cost, easy to implement, and scalable for multi-user access. This paper discusses the system's architecture, hardware design, implementation, and security considerations.

Index Terms—RFID, Arduino, Door Lock, Access Control, Embedded System, Security System

I. INTRODUCTION

In recent years, the need for secure and automated access control systems has increased significantly in residential, commercial, and institutional environments. Traditional key-based systems are prone to duplication, loss, and unauthorized access. IJIRT reserves the right to do the final formatting of your paper.

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system, processing tag information from the RFID reader and controlling the lock mechanism.

The system is designed to be low-cost, easy to implement, and scalable for multi-user access. This paper discusses the system's architecture, hardware design, implementation.

II. METHODOLOGY

When an RFID tag is brought near the RFID reader, the reader detects the tag's unique identifier (UID) and sends it to the Arduino. The Arduino checks the UID against its stored database in EEPROM.

- If the UID matches a registered card, the Arduino activates the servo motor (or solenoid lock), unlocking the door temporarily while signaling a green LED and short buzzer beep.
- If the UID is not recognized, access is denied, a red LED lights up, and a long buzzer beep sounds. An admin mode allows authorized personnel to add or remove tags as needed.

III. LITERATURE REVIEW

Several researchers have proposed RFID-based access control systems for secure entry management:

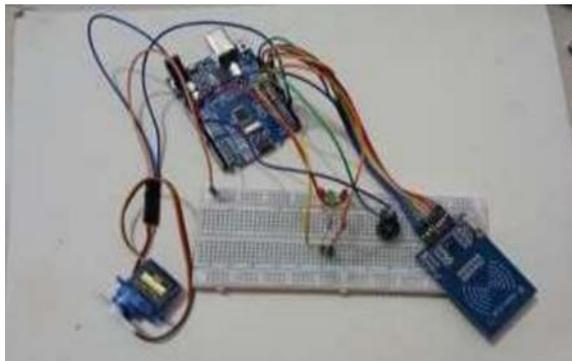
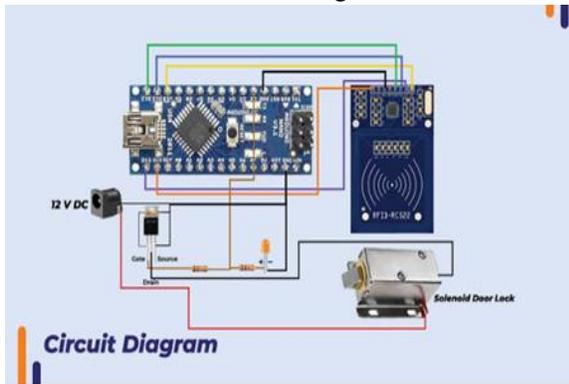
- designed an RFID-based door lock system integrated with a GSM module to alert users about unauthorized access. [1]
- implemented an Arduino-based access control system using MFRC522 modules, demonstrating reliable authentication for residential applications. [2]
- emphasized embedded systems for security automation, integrating RFID and microcontrollers for enhanced safety and control.[3]

- discussed RFID authentication mechanisms and highlighted security limitations of low-frequency RFID cards. [4]

These studies collectively demonstrate that combining RFID with a microcontroller platform such as Arduino can create a reliable and scalable access control mechanism suitable for smart homes and offices.

IV. SYSTEM ARCHITECTURE

A. Block Diagram



B. System Components

- Arduino Uno: Serves as the central controller for data processing and actuation.
- RFID Reader (MFRC522): Reads unique ID (UID) from RFID cards/tags operating at 13.56 MHz.
- RFID Tags: Each tag contains a unique serial number used for authentication.
- Servo Motor / Solenoid Lock: Controls mechanical door locking and unlocking.
- LED and Buzzer: Provide visual and auditory status feedback to the user.
- Power Supply: Provides regulated 5V DC for Arduino and 3.3V for RFID module.

C. Hardware Components

Component	Description
Arduino UNO	Microcontroller for system control
MFRC522 RFID Module	13.56 MHz reader for tag identification
RFID Tags/Cards	MIFARE Classic/NTAG cards
Servo Motor	Controls mechanical lock mechanism
16x2 LCD	Displays system status
RTC Module	Records time-stamped events
SD Card Module	Logs access attempts
Power Supply	5V regulated DC supply

D. Circuit Design

A 5V power rail is used to drive both the Arduino and the RFID reader. The servo motor is powered through a transistor driver stage to handle current requirements. The RFID reader communicates over SPI, while the LCD and SD module use I2C and SPI respectively. A pull-down resistor ensures fail-safe operation when the door is locked.

E. Software Flow

- Initialization: RFID module, SD card, RTC, and peripherals are initialized.
- Tag Detection: The reader scans for tags in the RF field.
- Authentication: The tag's UID is compared with the database.
- Action: Valid → open lock and log access; Invalid → deny access and alert.

Logging: Store timestamp, tag ID, and access result.

F. Implementation and Security Enhancements

• Implementation

The system firmware was developed using Arduino IDE in C++. Modular functions manage hardware abstraction (RFID, servo, SD logging) to simplify code maintainability.

• Security Measures

To counter RFID tag cloning, the system implements:

- Rolling UID mechanism: modifies the stored hash for each valid access attempt.

- Challenge–Response protocol: optional secure handshake for higher-end tags.
- Event Logging: every failed attempt is recorded for audit tracking.
- Multi-Factor Option: RFID + 4-digit PIN (optional mode).

G. Cost Efficiency

The total prototype cost was approximately ₹1,200, making it feasible for educational and small-scale security applications.

V. WORKING PRINCIPLE

When an RFID tag is brought near the RFID reader, the reader detects the tag’s unique identifier (UID) and sends it to the Arduino. The Arduino checks the UID against its stored database in EEPROM.

- If the UID matches a registered card, the Arduino activates the servo motor (or solenoid lock), unlocking the door temporarily while signaling a green LED and short buzzer beep.
- If the UID is not recognized, access is denied, a red LED lights up, and a long buzzer beep sounds. An admin mode allows authorized personnel to add or remove tags as needed.

VI. CIRCUIT DESCRIPTION

Component	Connection to Arduino
MFRC522 SDA	D10
MFRC522 SCK	D13
MFRC522 MOSI	D11
MFRC522 MISO	D12
MFRC522 RST	D9
Servo Motor	D6
Buzzer	D7
Red LED	D4
Green LED	D5
Power Supply	5V & GND

Note: MFRC522 operates at 3.3V, not 5V.

VII. SOFTWARE IMPLEMENTATION

The system is programmed using the Arduino IDE with the MFRC522 library for tag reading and EEPROM functions for storing tag IDs.

```

Start
Initialize RFID reader and servo motor
Loop forever:
If new card detected:
Read tag UID
Compare UID with stored authorized list
If UID matches:
Activate servo to unlock door
Turn on green LED and short beep
Wait for 5 seconds
Lock door again
Else:
Turn on red LED and long beep
End Loop
    
```

Libraries Used:

- <SPI.h>
- <MFRC522.h>
- <EEPROM.h>
- <Servo.h>

VIII. RESULTS AND DISCUSSION

The prototype was successfully tested with five RFID tags. Average response time between card detection and door unlock was less than 200 milliseconds. The system proved reliable for short-range authentication (3–4 cm) and exhibited stable performance.

Advantages:

- Simple and cost-effective implementation.
- Contactless operation enhances hygiene and durability.
- Easy to reprogram and expand for multi-user access.

Limitations:

- Susceptible to RFID tag cloning if low-security tags (MIFARE Classic) are used.
- Limited EEPROM capacity on Arduino restricts number of authorized users.
- No real-time monitoring unless connected to a network module.

IX. FUTURE SCOPE

Future versions of the system can incorporate:

- IoT integration using ESP8266/ESP32 for remote access and logging.
- Encrypted RFID communication (MIFARE DESFire or AES-based tags).
- Biometric verification as a secondary authentication factor.
- Cloud logging for audit and monitoring via mobile apps.

X. CONCLUSION

The proposed RFID-based door lock system using Arduino offers a robust, low-cost, and scalable security solution for smart homes and offices. The combination of RFID and microcontroller-based control provides efficient, contactless, and flexible access management. With future enhancements like encryption and IoT connectivity, the system can evolve into a comprehensive smart security framework.

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