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RFID Based Door Lock System

Shradha karikatti[1], Rani devaraddi[2], Ruthika Bandekar[3], R Sai Meghana[4]

[123] *B.Tech 2nd Year, Dept. of Electronics and Communication Engineering, Visvesvaraya Technological University, Belagavi, Karnataka, India.*

[4]*Junior Research Fellow, Dept. of Electronics and Communication Engineering, Visvesvaraya Technological University, Belagavi, Karnataka, India.*

Abstract - *The rapid advancement of embedded systems and automation technologies has significantly improved the security of residential, commercial, and industrial environments. Conventional mechanical door locking systems are vulnerable to key duplication, unauthorized access, and key misplacement, creating the need for more secure authentication mechanisms. This paper presents the design and implementation of an RFID-Based Smart Door Lock System using an ARM-based microcontroller. The proposed system utilizes an STM32F103C8 microcontroller as the main controller, an RFID-RC522 module for user authentication, a 16×2 LCD for displaying system status, a servo motor for door actuation, and LED indicators for visual feedback. When a valid RFID card is detected, the controller verifies the card identity and unlocks the door by rotating the servo motor while displaying an "Access Granted" message on the LCD. Unauthorized RFID cards are rejected, and the system displays an "Access Denied" message while keeping the door locked. Due to the absence of compatible RFID libraries in the Proteus simulation environment, a keypad-based authentication system using the LPC2138 ARM7 microcontroller was developed to simulate the authentication logic. Experimental evaluation confirms that the proposed system provides reliable authentication, rapid response, and secure access control while maintaining low implementation cost. The proposed architecture can be further enhanced by integrating IoT communication, cloud-based monitoring, and biometric authentication for advanced security applications.*

Key Words: RFID, STM32F103C8, ARM Cortex-M3, Smart Door Lock, Access Control, Embedded Systems, Servo Motor.

1. INTRODUCTION

Security is one of the primary requirements in residential buildings, industries, educational institutions, laboratories, and commercial organizations. Conventional mechanical lock systems depend entirely on physical keys, which can be duplicated, lost, or stolen, thereby increasing the possibility of unauthorized access. With the advancement of embedded systems and wireless identification technologies, smart access control systems have become increasingly popular because they provide higher security, flexibility, and ease of operation.

Radio Frequency Identification (RFID) technology has emerged as an effective solution for secure authentication due to its contactless operation, fast response time, and low power consumption. RFID systems consist of an RFID reader and RFID tags that communicate using electromagnetic waves. Each RFID card possesses a unique identification number that can be verified by a microcontroller before granting access.

The proposed RFID-Based Smart Door Lock System utilizes the STM32F103C8 ARM Cortex-M3 microcontroller as the central controller to process RFID authentication requests and control the door locking mechanism using a servo motor. A 16×2 LCD provides user feedback by displaying authentication status, while LEDs indicate successful or failed authentication. Since the Proteus simulation environment does not support the RFID-RC522 module directly, a keypad-based authentication system was implemented using the LPC2138 ARM7 microcontroller to demonstrate the access control algorithm.

- To design and develop a smart door lock system using ARM-based microcontrollers.
- To implement RFID-based user authentication for secure access control.
- To display authentication status using a 16×2 LCD display.
- To control door locking and unlocking using a servo motor.
- To prevent unauthorized access and improve overall security.

2. LITERATURE SURVEY

Divya and Mathew (2017) presented a comprehensive survey on automatic door lock access control mechanisms. The authors compared conventional key-based systems with RFID, password-based, biometric, and smart card technologies. Their study concluded that RFID-based authentication provides higher security, faster access, and improved user convenience compared to traditional locking systems. The survey also highlighted the importance of combining RFID technology with additional authentication methods to improve overall system security and reliability [1].

Gao, Meng, and Dai (2019) proposed an RFID-based electronic door lock system using a microcontroller, RFID reader, LCD display, and electronic locking mechanism. The system authenticates users by comparing the scanned RFID card identification number with stored authorized credentials. Experimental results demonstrated reliable authentication, quick response, and efficient access management, making the proposed system suitable for offices, laboratories, and institutional security applications [2].

Aldawira et al. (2019) developed a smart home security system based on the ESP32 microcontroller integrated with RFID technology. The proposed system combines RFID authentication with wireless communication to provide secure and convenient access control. The study demonstrated that the ESP32 platform offers low-cost implementation, real-time operation, and the capability for future IoT integration, making it suitable for smart home security applications [3].

Khabarlak and Koriashkina (2021) proposed a secure mobile access control system that combines RFID technology with facial verification. Instead of relying solely on RFID authentication, the system performs additional biometric verification using image recognition techniques. Experimental analysis showed that integrating RFID with facial recognition significantly improves security while maintaining fast authentication and user convenience [4].

Bianco, Occhiuzzi, Panunzio, and Marrocco (2021) presented a comprehensive review of RFID technology and its applications in embedded systems and IoT. The authors discussed RFID architecture, communication protocols, access control techniques, and recent developments in smart identification systems. The study concluded that RFID remains one of the most reliable and cost-effective technologies for secure identification and automated access control applications [5].

Muzaki, Amal, and AlFarisi (2024) designed and implemented a digital smart door lock using the RC522 RFID reader and Arduino Nano microcontroller. The developed system authenticates RFID cards before controlling an electronic door lock mechanism. Experimental testing confirmed accurate authentication, reliable system operation, and simple hardware implementation, demonstrating that RC522-based systems are highly suitable for low-cost embedded security applications [6].

Fernández-Caramés, Fraga-Lamas, Suárez-Albela, and Castedo (2024) investigated the security vulnerabilities of commercial RFID systems used in IoT applications. The authors analyzed cloning attacks, replay attacks, and unauthorized access methods while proposing several countermeasures to improve RFID security. Their work emphasizes the importance of secure authentication algorithms when designing embedded RFID access control systems [7].

Adithyan, Unni, and Nalinakshan (2025) reviewed recent developments in RFID-based door lock access control systems. Their study discussed embedded controllers, wireless communication, cloud integration, and multi-factor authentication techniques. The authors concluded that RFID technology provides an efficient and scalable solution for modern access control while recommending IoT integration and enhanced cybersecurity for future systems [8].

Pratama (2025) developed an IoT-enabled laboratory door security system using the RC522 RFID reader module. The proposed system integrates RFID authentication with wireless monitoring to provide secure laboratory access and remote supervision. Experimental results demonstrated reliable user authentication, efficient access management, and improved monitoring capabilities through IoT technologies [9].

The study titled Design and Implementation of the Intelligent Door Lock System Based on STM32 (2025) introduced a smart access control system using the STM32 microcontroller and RC522 RFID reader. The system employs SPI communication for RFID authentication and controls an electronic locking mechanism after verifying user credentials stored in memory. Experimental results showed high authentication accuracy, low response time, and reliable operation, confirming that STM32-based embedded systems are highly suitable for intelligent door security applications [10].

3. METHODOLOGY

The RFID Based Smart Door Lock System was developed to provide a secure and automated access control solution using ARM-based embedded technology and its process is illustrated in Fig.1. The implementation was carried out in two stages: software simulation and hardware implementation. Since the RFID-RC522 reader is not supported in the Proteus simulation environment due to library compatibility limitations, the authentication logic was first verified using a keypad-based access control system implemented with the LPC2138 ARM7 microcontroller. After validating the software logic, the complete hardware prototype was developed using the STM32F103C8 ARM Cortex-M3 microcontroller and RFID module.

3.1 Project Design

The system is designed to authenticate users before granting access to a secured door. During hardware implementation, the RFID-RC522 reader continuously scans RFID cards placed near its sensing area. The unique identification number (UID) of the scanned RFID card is transmitted to the STM32 microcontroller through the SPI communication

interface. The controller compares the received UID with the authorized card IDs stored in its program memory. If the UID matches an authorized record, the controller activates the servo motor to unlock the door and displays "ACCESS GRANTED" on the 16×2 LCD display. Simultaneously, the green LED is turned ON to indicate successful authentication. If the scanned RFID card is not recognized, the controller keeps the door locked, displays "ACCESS DENIED" on the LCD, and activates the red LED. For software verification, the same authentication logic was implemented in Proteus using the LPC2138 ARM7 controller and a 4×3 keypad. The keypad was used to emulate RFID authentication because the RFID module could not be simulated in Proteus. Entering the correct password produced the same output as scanning a valid RFID card, while an incorrect password denied access.

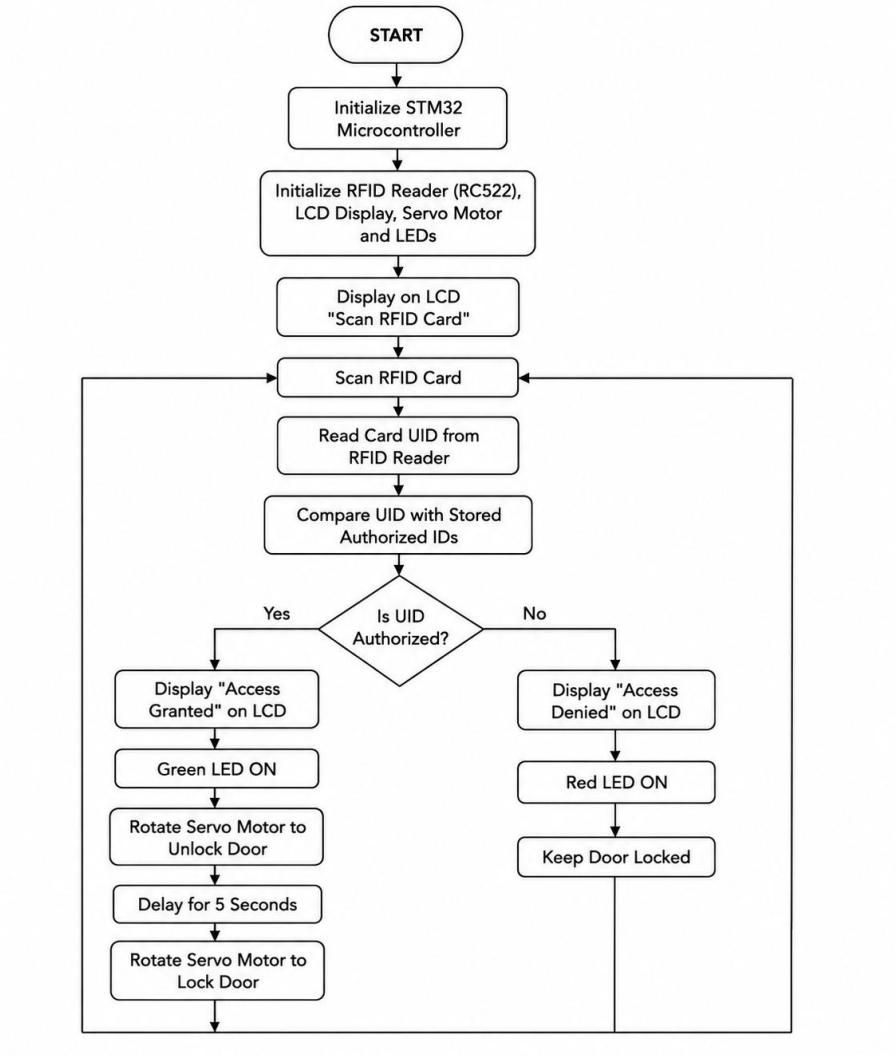

Fig -1: Methodology Flowchart of the RFID-Based Smart Door Lock System Using ARM Controller

3.2 Hardware Implementation

The hardware prototype consists of an STM32F103C8 microcontroller, RFID-RC522 reader, 16×2 LCD display, servo motor, Green LED, Red LED, regulated power supply, and connecting wires. The STM32 functions as the central controller of the system by continuously monitoring the RFID reader and controlling all output devices.

The RFID-RC522 module communicates with the STM32 using the SPI interface. The LCD module is connected in 4-bit mode to reduce GPIO pin usage while displaying authentication messages. The servo motor acts as the door locking mechanism and is controlled using PWM signals generated by the microcontroller. Two LEDs provide visual indication of the authentication status. A Green LED indicates successful authentication, whereas a Red LED indicates unauthorized access. The completed hardware prototype successfully demonstrates secure RFID-based access control suitable for residential, office, and laboratory security applications.

3.3 Software Implementation

The firmware for the STM32 microcontroller was developed using Embedded C in the Keil uVision IDE. During initialization, the GPIO pins, SPI interface, LCD display, and timer peripherals are configured. The program then enters an infinite loop where it continuously waits for an RFID card. Whenever an RFID card is detected, the RFID reader transfers the card's unique identification number to the STM32 microcontroller.

The controller compares the received UID with the authorized IDs stored in memory. If authentication is successful, the servo motor rotates to unlock the door, the LCD displays "ACCESS GRANTED", and the Green LED is turned ON. After a short delay, the servo motor returns to its initial position and locks the door automatically. If the scanned RFID card is unauthorized, the controller immediately displays "ACCESS DENIED" on the LCD, turns ON the Red LED, and keeps the servo motor in the locked position. The controller then returns to the card-scanning mode and repeats the authentication process continuously.

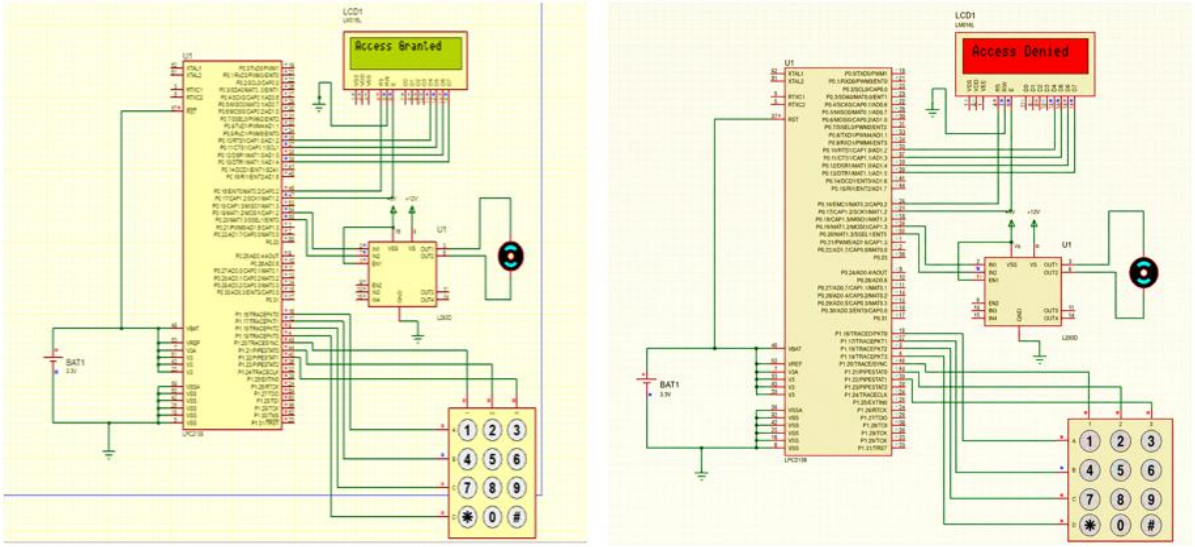

Fig -2: Software Output of Access Granted and Access Denied by RFID-Based Smart Door Lock System

4. RESULTS AND DISCUSSION

The RFID Based Smart Door Lock System was successfully simulated and implemented to verify its functionality under different authentication conditions. The system was evaluated through both software simulation using Proteus and hardware implementation using the STM32F103C8 microcontroller. Experimental testing confirmed that the proposed system accurately authenticates authorized users while preventing unauthorized access. The LCD display, servo motor, and LED indicators responded correctly to all authentication events, demonstrating reliable system performance. The obtained results validate the effectiveness of the proposed access control mechanism for residential and commercial security applications. Table 1 summarizes the experimental results obtained from these test cases.

4.1 Software Results

The authentication algorithm was initially verified in the Proteus simulation environment using the LPC2138 ARM7 microcontroller. Since the RFID-RC522 reader is not supported in Proteus, a 4×3 keypad was used to simulate the authentication process. The keypad allowed users to enter predefined passwords corresponding to authorized credentials. When the correct password was entered, the LPC2138 controller verified the input and activated the motor to simulate door unlocking. The LCD displayed the message "ACCESS GRANTED", confirming successful authentication. If an incorrect password was entered, the controller denied access, kept the door in the locked state, and displayed "ACCESS DENIED" on the LCD.

The Proteus simulation successfully validated the authentication logic and demonstrated that the software responded accurately to both valid and invalid user inputs. Fig. 2 illustrates the Proteus simulation of the keypad-based smart door lock system.

4.2 Hardware Results

After successful software verification, the hardware prototype was implemented using the STM32F103C8 microcontroller, RFID-RC522 reader, 16×2 LCD display, servo motor, and LED indicators. During testing, several authorized and unauthorized RFID cards were scanned to evaluate the system performance. When an authorized RFID card was placed near the RFID reader, the STM32

microcontroller successfully read the card's UID and compared it with the stored authorized credentials. Upon successful authentication, the servo motor rotated to unlock the door, the Green LED turned ON, and the LCD displayed "ACCESS GRANTED". After a predefined delay, the servo motor automatically returned to its initial position, securely locking the door again.

When an unauthorized RFID card was scanned, the controller rejected the authentication request. The servo motor remained in the locked position, the Red LED turned ON, and the LCD displayed "ACCESS DENIED". This confirmed that the system effectively prevented unauthorized access. The hardware prototype operated reliably throughout repeated testing, with consistent authentication accuracy and minimal response delay. The experimental results demonstrate that the proposed RFID-Based Smart Door Lock System performs secure authentication with high reliability and fast response.

Table -1: Performance Evaluation of the Smart Door Lock System

Test Condition	Authentication Result	LCD Display	Servo Motor	LED Status
Authorized RFID Card	Successful	ACCESS GRANTED	Unlocks Door	Green LED ON
Unauthorized RFID Card	Failed	ACCESS DENIED	Door Remains Locked	Red LED ON
Correct Password (Simulation)	Successful	ACCESS GRANTED	Unlocks Door	Green LED ON
Incorrect Password (Simulation)	Failed	ACCESS DENIED	Door Remains Locked	Red LED ON

The software simulation successfully verified the authentication algorithm before hardware implementation, while the hardware prototype confirmed the practical operation of the system using RFID technology. The integration of the STM32 microcontroller, RFID reader, LCD display, servo motor, and LED indicators provides an efficient access control mechanism suitable for homes, offices, laboratories, and restricted areas. Although the Proteus environment does not support direct simulation of the RFID-RC522 module, the keypad-based simulation accurately represented the authentication process and validated the control logic. The successful hardware implementation further confirms the feasibility of deploying the proposed system in real-world security applications.

5. CONCLUSION

The RFID Based Smart Door Lock System Using ARM Controller was successfully designed, simulated, and implemented as a secure and reliable access control solution. The proposed system integrates the STM32F103C8 ARM Cortex-M3 microcontroller, RFID-RC522 reader, 16×2 LCD display, servo motor, and LED indicators to provide automated authentication and door control. The RFID reader accurately identifies authorized users by reading the unique identification number of RFID cards, while the STM32 microcontroller processes the received information and controls the door locking mechanism accordingly. The software simulation performed using the LPC2138 ARM7 microcontroller and keypad successfully verified the authentication algorithm despite the absence of RFID support in the Proteus environment. The hardware implementation further demonstrated the practical operation of the proposed system, where authorized RFID cards successfully unlocked the door and unauthorized cards were denied access.

The LCD provided clear status messages, and the LED indicators offered immediate visual feedback regarding the authentication status. Experimental testing confirmed that the developed system operates with high reliability, fast response time, and accurate authentication while maintaining a simple and cost-effective hardware design. The project successfully achieved all its objectives, including secure RFID-based authentication, automatic door locking and unlocking,

real-time user notification, and reliable access control. The proposed system is suitable for deployment in homes, offices, laboratories, educational institutions, and other restricted areas where enhanced security is required.

Overall, the developed RFID-Based Smart Door Lock System demonstrates the effectiveness of ARM-based embedded systems in modern security applications and provides a scalable platform for future enhancements such as IoT connectivity, cloud-based monitoring, biometric authentication, and mobile application integration.

REFERENCES

[1] R. S. Divya and M. Mathew, "Survey on Various Door-Lock Access Control Mechanisms," Proceedings of the International Conference on Circuit, Power and Computing Technologies (ICCPCT), Kollam, India, Apr. 2017.

[2] F. Gao, F. Meng, and J. Dai, "The Design of Electronic Door Lock Based on RFID," Proceedings of the International Conference on Intelligent Information Processing, Big Data and Applications (IIICEC), 2019, doi:10.25236/IIICEC.2019.077.

[3] A. W. Isah, K. Q. Jimah, and M. L. Audu, "Design and Implementation of a Radio Frequency Identification (RFID)-Based Door Lock System," Greener Journal of Science, Engineering and Technological Research, vol. 9, no. 2, pp. 12–18, 2019.

[4] K. Khabarlak and L. Koriashkina, "Mobile Access Control System Based on RFID Tags and Facial Information," arXiv preprint arXiv:2103.06767, 2021.

[5] G. Bianco, C. Occhiuzzi, M. Panunzio, and G. Marrocco, "RFID Technology and Applications: A Review," 2021.

[6] M. Sai Divya and M. Nagabhushana Rao, "Centralized Authentication Smart Locking System Using RFID, Fingerprint, Password and GSM," International Journal of Engineering and Technology, vol. 7, no. 3, 2018.

[7] K. Tshomo, K. Tshering, D. Gyeltshen, and J. Yeshi, "Dual Door Lock System Using Radio-Frequency Identification and Fingerprint Recognition," Proceedings of the IEEE 5th International Conference for Convergence in Technology (I2CT), 2019.

[8] R. S. Divya and M. Mathew, "Super Secure Door Lock System for Critical Zones," Proceedings of the International Conference on Networks and Advances in Computational Technologies (NetACT), 2017.

[9] R. G. Pratama, "Rancangan Sistem Pengunci Rumah Berbasis Arduino Uno R3 dengan Radio Frequency Identification (RFID) dan Selenoid Door Lock," Ubiquitous: Computers and its Applications Journal, vol. 2, no. 1, pp. 45–50, 2019.

[10] "Design and Implementation of the Intelligent Door Lock System Based on STM32," Frontiers in Science and Engineering, vol. 6, no. 2, 2026.