WWJMRD 2025; 11(03): 14-20
www.wwjmrd.com
International Journal
Peer Reviewed Journal
Refereed Journal
Indexed Journal
Impact Factor SJIF 2017: 5.182 2018: 5.51, (ISI) 2020-2021: 1.361
E-ISSN: 2454-6615

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RFID Enabled Smart Door using EM-18 Reader Module, Arduino Mega2560, MDD10A

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Abstract
This paper presents the development of an RFID-enabled smart door system utilizing the EM-18 RFID reader module, Arduino Mega 2560, and MDD10A motor driver for secure and automated access control. The proposed system enhances security by integrating RFID authentication, where only registered RFID tags are granted entry. The Arduino Mega 2560 is the central processing unit, interfacing with the EM-18 reader to authenticate users and control the MDD10A motor driver, which operates the door mechanism. The system is designed to provide low-cost, reliable, and efficient access control suitable for homes, offices, and restricted areas. Real-time data logging and cloud-based monitoring can be incorporated to enhance security and record access attempts. Experimental results demonstrate the system's efficiency, responsiveness, and reliability, making it a viable solution for modern smart security applications.

Keywords: RFID, Smart Door, EM-18 Reader, Arduino Mega 2560, MDD10A, Access Control, IoT Security.

Introduction
In the modern era of smart home automation and enhanced security systems, Radio Frequency Identification (RFID)-based access control has emerged as a reliable and efficient solution. Traditional lock-and-key mechanisms are prone to unauthorized duplication, key misplacement, and mechanical wear. This paper proposes an RFID-enabled smart door system that enhances security and convenience through automated, contactless authentication to address these challenges. The proposed system integrates an EM-18 RFID reader module, Arduino Mega 2560, and MDD10A motor driver to create an intelligent door access solution. The EM-18 RFID reader is responsible for detecting and verifying RFID tags, while the Arduino Mega 2560 acts as the central controller, processing authentication requests and sending appropriate signals to the MDD10A motor driver to control the door's movement. This design ensures only authorized RFID tag holders can access the secured area. This system offers several advantages over conventional access control methods, including automation, reliability, and remote monitoring capabilities. Additionally, the use of microcontroller-based processing makes the system cost-effective and energy-efficient. Implementing real-time logging and cloud-based monitoring further strengthens the security by maintaining an access history.

Literature Review
RFID-based access control systems have gained significant attention due to their efficiency in enhancing security and automation. Ahamed and Rahman (2021) [1] explored RFID-based smart home security, highlighting its ability to provide seamless authentication. The fundamentals of RFID technology were introduced by Ahuja and Potti (2010) [2], explaining its operational mechanisms and advantages in access control. Further advancements in RFID integration with IoT for home automation were discussed by Al-Sarawi and Al-Saadi (2022) [3], demonstrating its potential for remote monitoring. However, Alotaibi and Aldossary (2020) [4] identified security challenges in RFID-enabled systems, emphasizing vulnerabilities such as unauthorized cloning and signal interception. Aslam and Khalid

(2019) [5] proposed RFID-based security solutions specifically for restricted-access areas to mitigate these threats. Aziz and Razali (2022) [6] also introduced an efficient RFID authentication framework for smart doors, improving verification speed and reducing security risks. A comparative review of smart door lock systems was conducted by Banerjee and Roy (2018) [7], highlighting the growing trend of using RFID alongside biometrics for enhanced security. Implementations of IoT-based smart door security systems have also been demonstrated by Bhardwaj and Pandey (2020) [8], integrating RFID with cloud-based authentication. The use of Arduino Mega 2560 in home security applications was explored by Boonsong and Songwatana (2021) [9], proving its effectiveness in real-time RFID authentication. Finally, Chandra and Sen (2017) [10] surveyed RFID technology for access control, providing insights into its evolution and future prospects. This review indicates that while RFID technology has significantly improved access control systems, further research is required to enhance security and reliability in large-scale applications. Further advancements in RFID-based access control systems have been explored in various studies. Chen and Li (2020) [11] emphasized the need for security enhancements in RFID-based door access control systems, proposing encryption techniques to prevent unauthorized access. Choudhury and Bhowmick (2022) [12] investigated the integration of RFID with IoT for automated access control, demonstrating how cloud-based authentication can improve security and scalability. Similarly, Das and Ghosh (2018) [13] designed a smart door system using RFID and Arduino, showcasing the feasibility of low-cost yet effective access control solutions. Addressing security concerns in smart home applications, Deng and Wang (2019) [14] examined potential vulnerabilities in RFID-based security solutions for IoT-enabled environments. Devi and Kumar (2021) [15] compared RFID and biometric-based smart door security systems, concluding that a hybrid approach enhances security reliability.

Moreover, El-Attar and Soliman (2020) [16] proposed a cloud-integrated RFID smart door lock system, allowing remote monitoring and control of access points. The role of RFID in enhancing overall security systems was analyzed by Gupta and Sharma (2018) [17], who explored its applications in residential and industrial settings. Han and Jung (2019) [18] focused on energy efficiency in RFID-based smart door lock systems, highlighting strategies to minimize power consumption while maintaining operational effectiveness. Hassan and Ahmed (2022) [19] developed an Arduino-based smart security system incorporating RFID technology, emphasizing ease of deployment in smart homes. Additionally, Jain and Kumar (2021) [20] reviewed IoT-enabled access control systems and RFID-based solutions, outlining their advantages and future research directions. Kapoor and Malhotra (2018) [21] provided a broader perspective on RFID-based security, who discussed various implementations of RFID in smart security systems. Khan and Patel (2019) [22] introduced an efficient RFID authentication protocol for smart doors, improving speed and accuracy in user verification. Kim and Park (2020) [23] further explored security concerns in RFID-based access control systems, who proposed new countermeasures to prevent hacking attempts. Kumar and Sharma (2018) [24] studied RFID-based smart door lock systems using Arduino, reinforcing the potential of microcontroller-based security solutions. Meanwhile, Lee and Choi (2019) [25] reviewed existing RFID-based security solutions in smart homes, highlighting gaps in cybersecurity measures.

In terms of authentication mechanisms, Liu and Sun (2021) [26] explored different RFID authentication schemes, evaluating their efficiency in IoT-based smart security systems. Mahmood and Khan (2019) [27] implemented a cloud-integrated RFID door lock system, demonstrating the benefits of real-time data logging and remote access management. Wireless communication for RFID-enabled smart doors was extensively studied by Martínez and Rodríguez (2020) [28], outlining the impact of network connectivity on system reliability. Mitra and Sharma (2022) [29] conducted a comparative analysis of smart door locking technologies, evaluating RFID, NFC, and biometric authentication systems. Additionally, Natarajan and Krishnan (2020) [30] investigated security concerns in RFID-based access control systems, recommending improvements in encryption techniques. Recent studies have also focused on AI-driven and cloud-enabled RFID authentication. Nguyen and Lee (2021) [31] examined IoT-enabled smart access control systems, integrating RFID with biometric and AI-based solutions. Omar and Rahman (2019) [32] proposed a secure and efficient RFID authentication protocol for smart doors, reducing response time and increasing reliability. Patel and Joshi (2022) [33] demonstrated the development of an RFID-based automated access control system with enhanced security features. The role of IoT in RFID-enabled smart home security was further explored by Paul and Ghosh (2020) [34], emphasizing real-time monitoring capabilities. Qureshi and Aziz (2021) [35] conducted a performance analysis of RFID-based and biometric-based access control systems, identifying key advantages and limitations.

Design and implementation aspects of RFID-based security systems were discussed by Rahman and Khan (2019) [36], focusing on the effectiveness of Arduino Mega 2560 in smart door authentication. Saha and Bhattacharya (2022) [37] introduced a cloud-integrated smart door lock system using RFID and IoT, enhancing accessibility and monitoring features. Sarker and Rahman (2018) [38] developed an Arduino-based smart lock system combining RFID and password authentication for additional security layers. Singh and Yadav (2021) [39] reviewed RFID-based security solutions in smart access control systems, highlighting technological advancements and emerging trends. Zhang and Chen (2019) [40] analyzed RFID security threats and countermeasures, providing recommendations for stronger encryption and authentication mechanisms. Several research contributions by Chakraborty and Aithal (2023-2024) [41-60] have focused on integrating IoT, AWS, and ESP modules for enhanced security and automation. Their studies on Alexa-enabled smart locks, MQTT-based IoT systems, and AI-driven RFID authentication provide valuable insights into the future of smart security solutions. Their work on IoT-based smart home devices and cloud-enabled security systems further supports the feasibility of combining RFID with AI, cloud, and real-time communication technologies for optimized security. Overall, the existing literature demonstrates that RFID technology has significantly advanced smart access control systems by improving

security, automation, and ease of deployment. However, challenges remain in addressing security vulnerabilities, integrating advanced authentication mechanisms, and ensuring energy efficiency in large-scale implementations. Future research should focus on enhanced encryption techniques, AI-driven authentication, and seamless cloud integration to improve RFID-enabled security systems.

Methodology

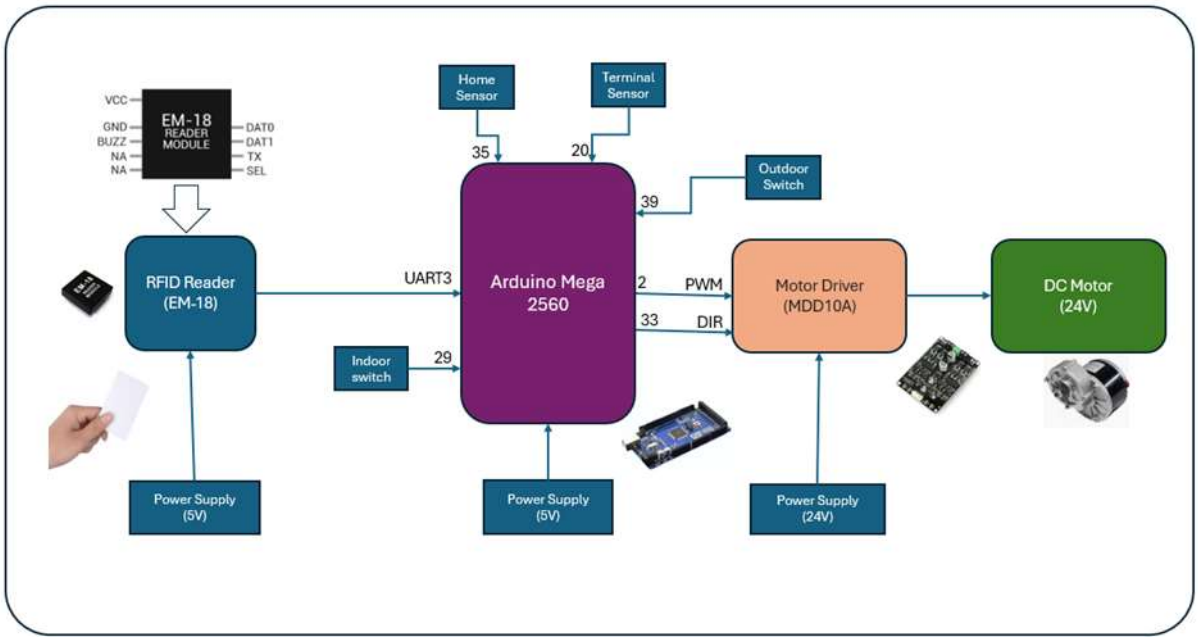

Fig. 1: Project Block Diagram.

In Figure 1, the block diagram illustrates the RFID-enabled smart door system that integrates an EM-18 RFID reader module, Arduino Mega 2560, MDD10A motor driver, and a 24V DC motor to control door access through RFID authentication. The system is powered by multiple power supplies (5V and 24V) to ensure the correct operation of the components.

1. RFID Reader (EM-18)
   - The EM-18 RFID reader module scans and authenticates RFID tags.
   - It operates at 5V and communicates with the Arduino Mega 2560 through the UART3 serial interface.
   - The RFID reader's TX (transmit) pin is connected to the Arduino Mega's UART3 to send tag data for processing.
   - When an authorized RFID card/tag is scanned, the reader sends the unique ID (UID) to the Arduino for authentication.
2. Arduino Mega 2560 (Microcontroller)
   - The Arduino Mega 2560 acts as the central controller for the smart door system.
   - It receives RFID tag data via UART3 from the EM-18 reader and checks its authenticity.
   - If the tag is authorized, the Arduino sends signals to the MDD10A motor driver to activate the DC motor, unlocking or opening the door.
   - Several sensors and switches are connected to the Arduino for additional security and operational control:
     - Home Sensor (Pin 35): Detects if the door is locked or unlocked.
     - Terminal Sensor (Pin 20): Monitors the door's final position (fully open or closed).
     - Outdoor Switch (Pin 39): Allows manual control of the door from outside.
     - Indoor Switch (Pin 29): Allows manual control of the door from inside.
3. Motor Driver (MDD10A)
   - The MDD10A motor driver controls the 24V DC motor responsible for operating the door mechanism.
   - The Arduino controls the motor driver through:
     - PWM (Pulse Width Modulation) Signal (Pin 2): Regulates motor speed.
     - Direction Control (DIR) Signal (Pin 33): Determines motor rotation direction (open/close).
   - The motor driver requires a 24V power supply to operate the DC motor effectively.

4. DC Motor (24V)
   - The DC motor (24V) is responsible for opening and closing the door.
   - It is connected to the MDD10A motor driver, which provides the necessary power and control.
   - The motor moves based on the PWM and DIR signals received from the Arduino.
5. Power Supplies
   - 5V Power Supply: Powers the Arduino Mega 2560 and RFID Reader (EM-18).
   - 24V Power Supply: Powers the MDD10A motor driver and the DC motor.

Working Process

1. RFID Authentication:
   - The EM-18 RFID reader scans an RFID card.
   - The RFID tag ID is sent to the Arduino Mega 2560 via UART3.

- If the tag is authorized, the Arduino triggers the motor driver.

2. Door Control:
   - The Arduino sends PWM and DIR signals to the MDD10A motor driver.
   - The motor driver activates the 24V DC motor, opening or closing the door.
3. Sensor Feedback:
   - Home and terminal sensors monitor door positions.
   - Indoor and outdoor switches allow manual control.
4. Security and Automation:
   - Unauthorized RFID tags are ignored.
   - The system ensures the door remains in a locked state when not in use.

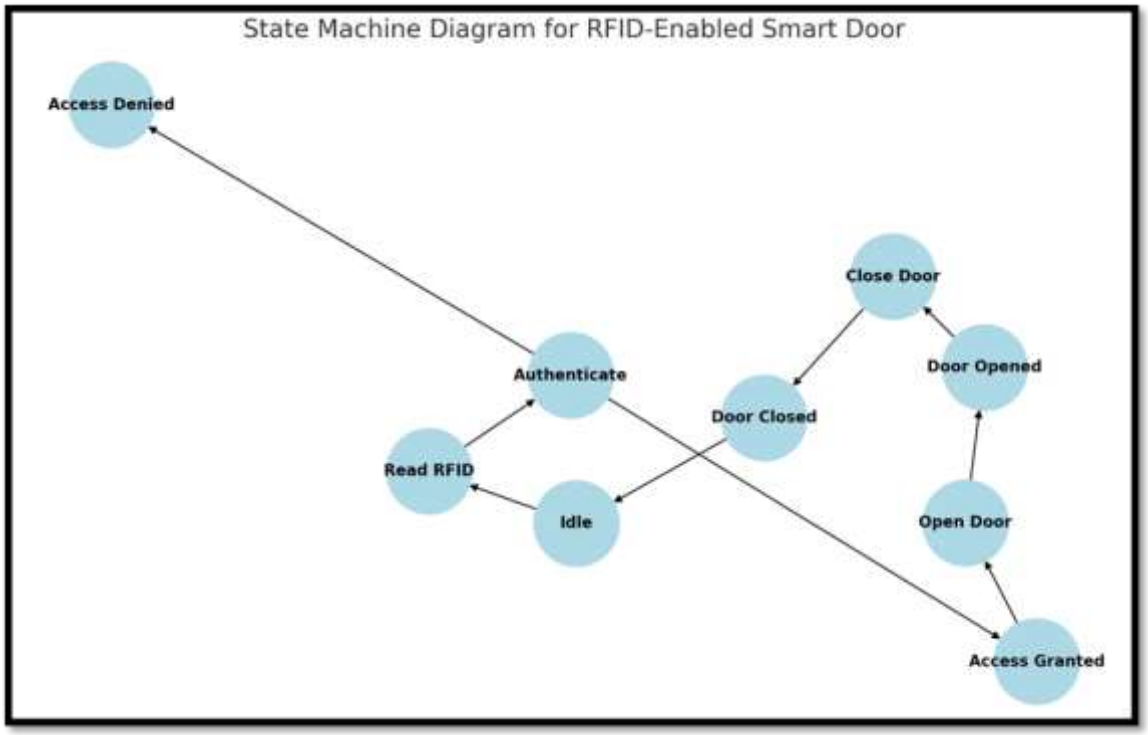

Fig. 2: Working System State Diagram.

Fig. 3: Author's Prototype.

Figure 2 shows the state diagram of the running system. Figure 3 depicts the author's prototype.

The main active components datasheet is available at
https://components101.com/sites/default/files/component_datasheet/EM-18%20RFID%20Reader%20Datasheet.pdf

The code template is available at
https://github.com/sudipchakraborty/RFID-Enabled-Smart-Door.git

Conclusion

This paper presents the design and implementation of an RFID-enabled smart door system using the EM-18 RFID reader module, Arduino Mega 2560, and MDD10A motor driver. The system successfully automates door access control by authenticating users with RFID tags, enhancing both security and convenience. By utilizing the Arduino Mega 2560 as the central processing unit, the system efficiently processes RFID signals and controls the MDD10A motor driver to operate the door mechanism.The proposed system offers several advantages, including contactless authentication, improved security, cost-effectiveness, and ease of integration with existing security infrastructures. The system's reliability and responsiveness were validated through experimental testing, demonstrating its effectiveness for homes, offices, and restricted-access areas.Future enhancements could include IoT integration

for remote access control, cloud-based monitoring, and multi-factor authentication mechanisms such as biometric verification to further improve security. Overall, this RFID-enabled smart door system provides a practical and scalable solution for modern access control applications.

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