

Construction of a Contactless Key Card Access Control System Using a Radio Frequency Identification (RFID) Scanner and Arduino

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Abstract - Security is needed more and becoming more important today. Physical security and physical access control are only sometimes the best solution, especially in instances with large crowds or systems that require round-the-clock security. For this reason, an Arduino-based access control system using RFID (Radio Frequency Identification Technology) was created to provide security and access control to buildings and physical spaces, eliminating the need for physical security at all times. The device makes use of RFID technology and Arduino to complete its work. RFID (Radio Frequency Identification) is a communication technology commonly known as electronic tags. Radio transmissions can identify targets and transfer data without direct communication. Advancements in radio frequency recognition technology have led to its widespread usage in identity documents, defence, and industrial control. When the RFID scanner recognizes a tag, it checks its UID to the stored database to ensure accuracy. Access is granted if the captured user's UID matches a previously saved UID; otherwise, access is denied.

Keywords - Access Control, Arduino, RFID, RFID card, Card UID

1. INTRODUCTION

Access control determines who, when, and why access should be provided to a space and is essential for safeguarding structures and services. Access control systems protect essential infrastructure, spaces, properties, and assets which in turn preserves the privacy, reliability, and accessibility of resources.[21] Implementing a contactless key card access control system aims not only to limit physical access to physical infrastructures and spaces but is also a means to digitally increase safety. It will track who enters specific spaces and when. [3]. This leads to the implementation and utilization of digital access control systems with secure authentication and authorization capabilities in buildings to meet security demands. The utilization of a contactless key card for entry and exit (access) authorization has eliminated the challenge of physical security involving padlocks or physical security personnel. For this reason, many modern organizations employ smart doors with access card scanners, primarily using RFID cards.[10]

The Arduino microcontroller is the storage device in this security system which stores all identification, authorization and authentication information about all users to be granted access to the controlled system and the RFID scanner or reader scans the card that will be granted or rejected access. Arduino boards

can receive inputs such as button presses, login credentials, and other data and convert them into outputs such as motion activation, and LED changing. [3] Both the RFID sensor and the Arduino microcontroller are significantly key components in digital contactless key card access control systems as they are responsible for storing user information, retrieving user information, comparing user information, granting or restricting access to hardware components and other security measures needed to be taken. Both the RFID scanner and the Arduino microcontroller control the whole access security system.

The main process is checking card UID. If the card UID is registered in the database and is allowed access after checking, the security system is unlocked and the user is permitted access. If the card UID is not registered in the database, the security system remains locked and the user is not permitted access.[19] The successful development of this access control security system will enable infrastructures to have a reliable unmanned security system and will enable easy, efficient and reliable identification and authorization for users who are trying to access the infrastructure.

2. RFID

Radio Frequency Identification (RFID) is a common

form of contactless or wireless technology, and several industries around the world employ this technology for various purposes. These include tollgate systems, book-tracking systems in libraries, supply chain management, and access control systems.[15]

The Radio Frequency Identification (RFID) system is a technology that can be utilised to create a security system. RFID systems are commonly used for doors that require clearance to enter or for safes. It works by reading specific key cards that have been prearranged to be recognized by the system, commonly known as a Unique Identifier (UID) – it is a key card that doesn't make contact with the RFID system. Since owners of the UID already have their information in the database of the system, the RFID will give the person access – the lock on the door or safe will open. In a situation where that is not the case, access will be denied and the RFID system turns on a form of alarm system to alert security personnel.[25][17]

RFID Components

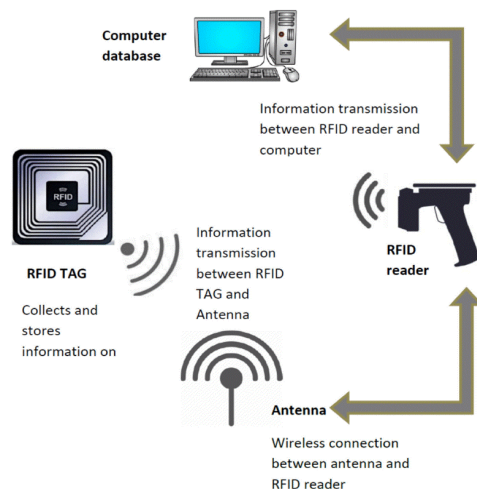


Figure 1: RFID Components

1. *RFID tag or card:* An RFID tag contains a microprocessor or silicon chip, which functions as its memory and stores a unique code that works as an identification system, including a singular identification that is referred to as the tag ID or UID [1]. The microchip has an embedded circuit within it. And, the microchip can provide a unique identification based on a numbering technique [5].
2. *RFID antenna:* The RFID antenna is the

technological component of the system that functions as the middleman between the RFID tag and RFID reader; it provides energy to tags (that is, mostly the passive tags). Furthermore, the antennas collect data and transmit them between the reader and tags.[16]

3. *RFID reader or scanner:* The RFID reader is an external equipment that picks up radio signals and transmits those signals to the RFID system or the Arduino microcontroller. [6]

3. ARDUINO MICROCONTROLLER

The Arduino microcontroller is the part of the system that receives the card UID from the RFID reader and checks the database if the UID is registered. It is figuratively the gatekeeper in a digital system. The Arduino microcontroller is made up of two parts;

1. *The Arduino Board:* The Arduino board is a microcontroller board that is built on ATmega328. There are different types of Arduino boards, but the UNO board is used for this construction. For the UNO board, there are 14 digital input/output pins – 6 out of those 14 pins can function as a pulse with modulation (PWM) outputs, 6 analogue inputs, a 16MHz ceramic resonator, an in-circuit serial programming (ICSP) header, a universal serial box (USB) connection, a reset button, a power jack. Everything needed to serve as the support for the controller is contained in the board. The board is connected to the computer using a USB cable. The Arduino board can also be powered using an AC-to-DC battery or adapter.[15]



Figure 2: An Arduino board

2. *The Arduino IDE:* The Arduino Integrated Development Environment (IDE) is a program that runs on computers, allowing the use of a simple language to be used in writing sketches for the Arduino board.[15] Arduino coding language is required for the coding of the Arduino microcontroller and the language is

based on C or C++. Only two functions the setup() and loop() functions are needed to run the basic executable program. The setup() is what initializes pin modes and the function can only be run once. The actual code is written under loop(). The function, loop(), continues to loop until the power of the device goes off.

4. MATERIALS USED

1. *Transformer*: A transformer is an electrical device that transfers energy from one circuit to another. It accomplishes this without adding any additional power or modifying the frequency of the electrical waves. [11] When a current moves through one of the coils of a transformer, it generates a magnetic field, which induces a voltage across the other coils wrapped around the same core. [23].
2. *Diodes*: A diode is an electronic component that has two terminals and typically conducts current in one way. It has low resistance in one direction and high resistance in the other. A diode's main purpose is to enable current to flow in one direction (forward) while blocking it in the opposite direction (reverse). [22]
3. *Capacitor*: A capacitor is a simple electronic component that stores charge in its electric field and returns it to the electrical circuit when needed. The device consists of two plates that conduct electricity separated by an insulating substance or dielectric.[20]
4. *Resistors*: A resistor is a passive electrical component with two terminals that add resistance to the flow of electric current in an electrical circuit. Resistors are commonly used to balance active components like op-amps, microcontrollers, and other integrated circuits. [9]
5. *Arduino Microcontroller*: Arduino is a freely available microcontroller that can be readily programmed, removed and reconfigured at any given moment. Arduino microcontrollers provide input and output capabilities, allowing for data collection and output. The Arduino platform can be divided into two: Hardware and Software.[7]
6. *LEDs*: Light-emitting diodes (LEDs) are semiconductors that produce light when a forward voltage is passed through them. The LED is a solid-state electronic component. Which means it is more similar to an electronic chip than to an actual light bulb. [2].
7. *Wires*: Wires are conductors used to connect electronic components together in a circuit. They come in different sizes, lengths, and colours, and the use of the wire depends on the width and colour of the wire.
8. *Voltage Regulator*: The voltage regulator, as the name implies, maintains a steady voltage in a circuit. The voltage regulator acts as additional protection, ensuring that only the required voltage enters the circuit. The voltage regulator consists of three primary pins and an adjustable output voltage.[18]
9. *Transistors*: A transistor functions as both a switch and an amplifier; it is a semiconductor device that conducts and insulates electrical voltage/current. Transistors are three-terminal devices that regulate the flow of electrical current, allow for quick switching, and are utilized to create a single integrated circuit.[24]
10. *LCD*: A liquid-crystal display (LCD) is an electronically modified optical system that utilizes liquid crystals and polarizers to manipulate light. Liquid crystals produce color or monochrome images by using a backlight or reflector, rather than emitting light directly. LCDs can display either arbitrary graphics (as in a computer display) or fixed images with limited information content (e.g., preset words, numerals, or seven-segment displays in a digital clock). [12] The LCD screen communicates via an I2C interface. The LCD requires only four pins. The pins are VCC, GND, SDA, and SCL. [8]
11. *RFID scanner or reader*: The RFID reader is a device that is used to gather data from the radio RFID system. The RFID system uses radio waves to transfer the data from the RFID tag to the RFID reader. The RFID reader also called the interrogator, is the brain of the RFID system and must be present for any system to function.[14]
12. *RFID tag or card*: The RFID tag and RFID card are digital tags that use radio waves to transmit data to an RFID reader. The antenna and IC are the two main components of almost all RFID tags. The IC is used to process and save information, and the antenna is utilized to receive radio frequency waves. Any information that the user desires can be written on the RFID microchip.[14]
13. *Solenoid locker*: The solenoid lock indicates the lock for electrical locking and opening. It is available for use in locking and keeping within the control on mode sort, as well as opening within the control on mode sort, depending on the situation. While the solenoid is powered on, the control on the opening effectively empowers the opening. [13]
14. *Buzzer*: Buzzers are devices that produce sound throughout a more precise frequency range. An

endless variety of electrical gadgets, such as fire alarms, medical equipment, alarm clocks, and intruder alarms, use buzzers. [4]

5. SETUP

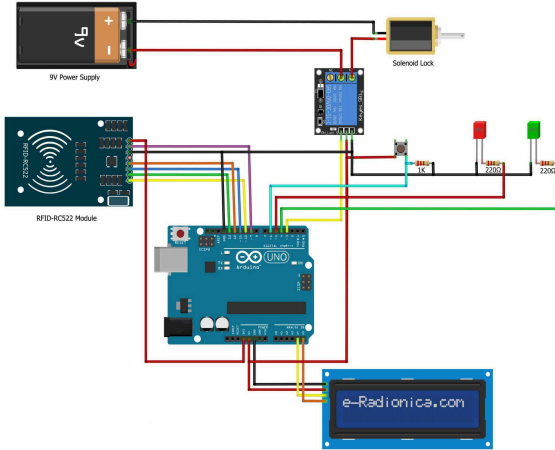


Figure 3: The complete system setup circuit

6. MODE OF OPERATION

All the available Power or AC sources are used as input into the power supply to make sure that as long as there is a supply from any of the AC sources, the system can be turned ON. The setup in Figure 3 above consists of all the materials listed and when activated (plugged into a power source), an LED turns on (to represent power in the system) and the LCD displays the text: “Scan tag to open door”. The RFID reader is connected to the microcontroller and communication happens between them. Other components like the solenoid locker, buzzer, LEDs and LCD are connected to different pins in the microcontroller. When the RFID reader scans a card or tag it gets the UID of the card or tag and sends it to the microcontroller as input. The code in the microcontroller runs and checks if the UID is registered. If it is registered, the microcontroller gives an output to the green LED, the LCD displays the text “Access Granted Successfully”, the buzzer makes a sound and the solenoid locker is unlocked for some seconds. If the UID is not registered, the microcontroller gives an output to the red LED, the LCD displays the text “Invalid card, please try again”, and the buzzer makes a sound. In this case, the solenoid locker remains locked.

7. CONCLUSION

After considering the physical design of the hardware, as well as the installation of the components, the RFID and Arduino-based access control system was successfully developed and constructed. The system was able to grant access to an RFID card with a known and registered UID and rejected access to an RFID tag with an unknown UID.

The construction of an RFID and Arduino-based access control system offers numerous benefits for efficient and effective security and access control management. The developed system is also flexible in a way that each RFID card and RFID tag can be registered and unregistered in the system using the microcontroller code. The system can be widely applied to both personal and industrial systems, and it can easily be modified to include more security measures. With this system, security need not be physical and this can be extremely advantageous, especially with systems and spaces that require security at all times.

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