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**COMMUNICATION SYSTEMS  
TC-307**

**COMPLEX ENGINEERING PROBLEM**

**Work By:**

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**RFID Door Lock Access Control System Using Aurdino**

1. **OBJECTIVES:**

The challenge at hand is to conceptualize and implement an intricate RFID door lock access control system utilizing Arduino. The system's overarching goals:

* **User Identification and Authentication:** Forge a robust system for recognizing and authenticating users through the seamless integration of RFID tags.
* **Multi-Door Access Control:** Implement a holistic solution to proficiently manage access across diverse entry points.
* **Audit Log Generation**: Institute a sophisticated mechanism for logging detailed access events, fostering accountability.
* **Scalability and Extensibility:** Architect the system to be adaptive, seamlessly accommodating future expansion.

1. **INTRODUCTION**

The security industry is seeking intricate solutions to ensure robust access control, and the fusion of RFID technology with Arduino offers a remarkable opportunity. This integration aims to engineer an advanced RFID door lock access control system, transcending traditional methods by ensuring foolproof user identification, efficient multi-door access management, and a scalable architecture capable of accommodating future expansions while upholding security integrity.

This system utilizes RFID tags, akin to tiny ID cards, to confirm and manage access through doors while maintaining meticulous records of entries and exits through comprehensive audit logs. The design emphasizes flexibility and adaptability, enabling seamless growth and integration of new technologies.

In modern times, electronic door lock systems have replaced traditional lock-and-key methods, employing various access control systems such as PIN/Password, fingerprint, and RFID-based mechanisms.

The amalgamation of RFID and Arduino technologies marks a significant leap in access control systems. RFID tags serve as digital keys interfacing with Arduino-based systems, revolutionizing conventional security by granting access solely to authorized users. This innovation promises heightened efficiency and reliability in securing entry points, redefining the concept SsS of door access control.

Combining RFID and Arduino technologies, this system offers a smart, efficient, and adaptable solution, redefining door access control with swift user identification and secure area management.

1. **LITERATURE REVIEW**

The integration of Radio Frequency Identification (RFID) technology in door lock access systems has gained considerable attention owing to its efficiency in user authentication and access control. RFID-based access systems have revolutionized traditional security measures due to their convenience and effectiveness. [1][2]

* 1. **RFID Technology in Access Control:**

RFID technology serves as a cornerstone in modern access control systems. It operates through the use of RFID tags that communicate with a reader to authenticate and grant access to authorized individuals. These tags contain unique identification information, facilitating seamless and secure access control.[3][4]

* 1. **Role of Arduino in Access Control:**

Arduino, an open-source microcontroller platform, has gained prominence in developing access control systems due to its versatility, cost-effectiveness, and ease of implementation. Its capability to interface with RFID modules makes it a suitable choice for constructing robust access control mechanism.[5][6]

* 1. **Multi-door Access Control and Scalability:**

Efficient management of multi-door access control systems is crucial in various environments. Implementations challenges in scalability and extensibility, enabling the system to accommodate future expansions without compromising security or performance.[7][8]

* 1. **Security and User Authentication:**

Ensuring robust user identification and authentication remains pivotal. Recent studies have explored advanced authentication mechanisms within RFID-based access control systems, emphasizing the need for enhanced security protocols and encryption techniques.[9][10]

1. **WORKING PRINCIPLE**

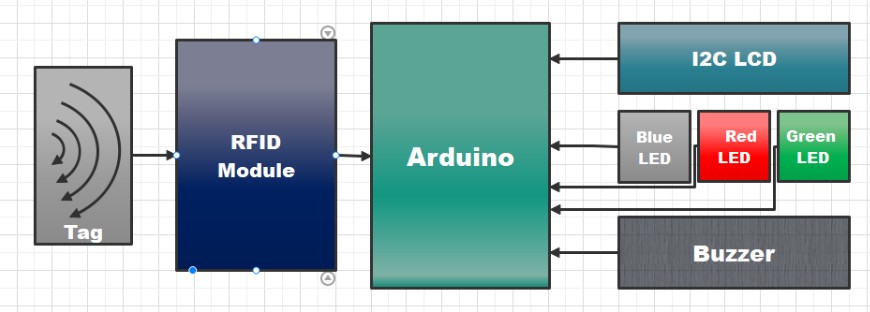
The RFID door lock access control system's foundation rests upon the core principle of RFID technology. When a user presents an RFID tag, the Arduino-based controller engages in the process of reading the unique identifier stored within the tag. This identifier undergoes meticulous comparison with the authorized entries meticulously stored in the system's database. Upon successful verification, the system triggers the corresponding door lock mechanism, enabling access.

Figure 2 - RFID Pin Configuration

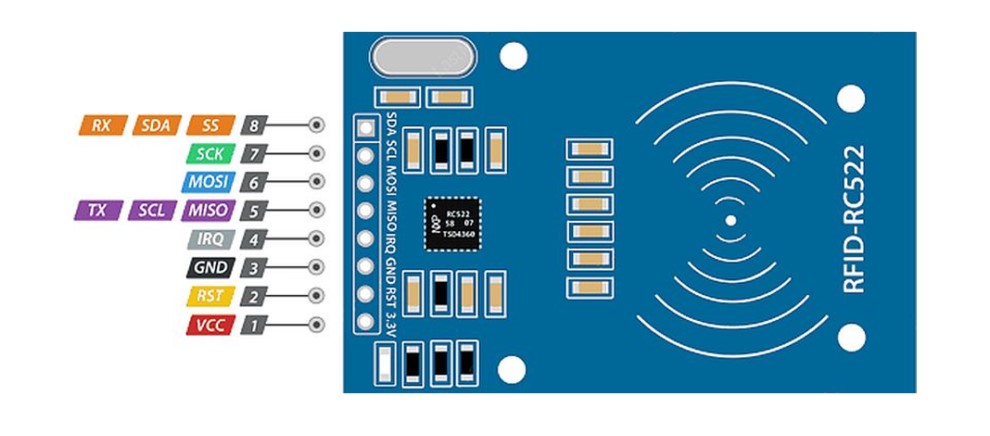
Figure 1 - Block Diagram of RFID Door Lock System using Arduino

The working principle of an RFID door lock system using Arduino involves leveraging Radio Frequency Identification (RFID) technology and Arduino microcontrollers to manage access to doors or entry points. Our project consists of some other components listed above we will be discussing each of their working below:

* 1. **RFID MODULE:**
     1. **RFID Tag Communication**:

Each authorized user possesses an RFID tag, akin to a digital ID card. These RFID tags contain unique identifiers or data that are read wirelessly when brought into proximity with an RFID reader.

* + 1. **RFID Reader**:

The system is equipped with an RFID reader that interacts with the RFID tags. When an RFID tag is brought near the reader, it emits a signal prompting the RFID reader to capture the unique identifier stored within the tag.

* + 1. **Arduino Controller**:

The captured information from the RFID reader is transmitted to an Arduino microcontroller. Arduino processes and interprets this data to determine if the received RFID tag's identifier matches the authorized tags stored within its memory.

* + 1. **Access Control Decision**:

Upon successful verification, where the received tag identifier matches an authorized user's information, the Arduino-controlled system triggers an action. This action can be the unlocking of a door, activating an electric lock, or allowing access to the designated area.

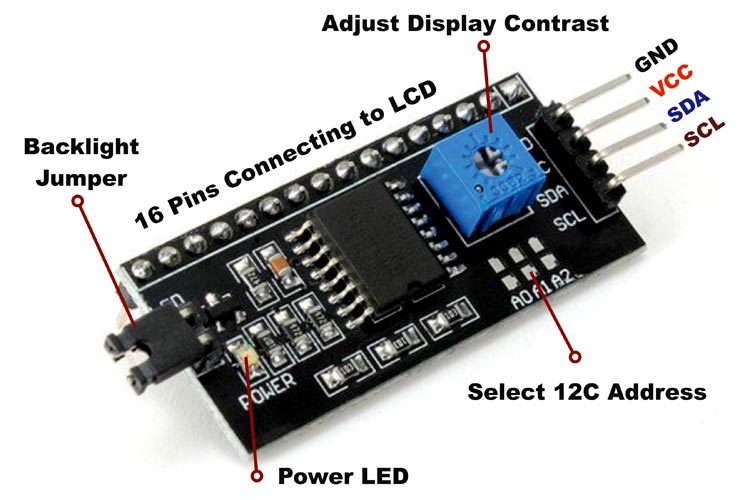
* + 1. **Denial of Access**:

If the RFID tag's identifier does not match any stored authorized user data, access is denied. The system remains locked, preventing entry to unauthorized individuals.

* + 1. **Security and Record Keeping**:

The system may also include additional features such as audit log generation, maintaining records of entry and exit times, adding or removing authorized users, and updating access permissions.

In essence, the working principle revolves around the RFID reader detecting and transmitting the unique identifier from the RFID tag to the Arduino controller, which then processes this data to determine access authorization and triggers the necessary action based on the verification outcome. This method provides a secure, efficient, and automated approach to access control for doors or entry points.

* 1. **Arduino UNO:**

The Arduino Uno is a versatile microcontroller board centered on the ATmega328P microcontroller, which executes user-written code uploaded via the Arduino IDE. It features digital and analog I/O pins for interacting with sensors, actuators, and other components, operating at a clock speed of 16 MHz. Known for its simplicity and versatility, the Uno is widely used for prototyping and diverse electronic projects.

* 1. **Mg945 Servo Motor:**

Figure 3 - I2C module

The MG945 servomotor uses a DC motor, gears, and a control circuit to achieve precise angular positioning based on a **PWM** control signal. A built-in potentiometer provides feedback on the shaft's position, enabling the control circuit to compare it with the desired position. The motor adjusts the shaft until the positions align, then stops, maintaining accuracy. It continuously monitors the input signal for updates, making it ideal for robotics, remote-controlled devices, and motion control systems.

* 1. **Liquid Crystal Display (16X2):**

The 16x2 LCD displays characters and symbols by manipulating liquid crystal cells in a grid using electrical signals to control light passage. A built-in controller interprets data from external devices, like microcontrollers, to activate specific cells, forming characters in a 16-character-per-line, 2-line format. Many models include an LED backlight for enhanced readability, making the 16x2 LCD a versatile display module for electronic devices.

* 1. **I2c(Inter-Integrated) Module:**

The I2C (Inter-Integrated Circuit) module is a communication protocol that enables multiple devices, like sensors and microcontrollers, to share a single bus using two lines: Serial Data (SDA) and Serial Clock (SCL). Operating on a master-slave architecture, the master initiates communication, selects devices via unique addresses, and exchanges data bit by bit in a synchronized manner. Known for its simplicity, efficiency, and versatility, I2C supports high-speed communication and multi-master setups, making it a popular standard for embedded systems.

1. **MODULATION TECHNIQUES**

In an Arduino-based RFID door lock system, data transmission between RFID tags and the reader is typically achieved using Amplitude Shift Keying (ASK) modulation within high-frequency (HF) or ultra-high-frequency (UHF) bands.

* 1. **Amplitude Shift Keying (ASK):**

ASK modulation is commonly employed in RFID systems due to its simplicity and efficiency in low-power applications. It involves altering the amplitude of the radio frequency carrier wave to encode digital information. In the context of an RFID door lock system, ASK modulation allows the transmission of data between the RFID tags and the reader. When an RFID tag is brought into the reader's proximity, the modulation technique enables the reader to detect the changes in amplitude, representing the encoded information in the tag. The Arduino, acting as the control unit, interprets this data to authenticate the user and decide access permissions.

* 1. **Frequency Shift Keying (FSK) and Phase Shift Keying (PSK):**

In Arduino-based RFID systems, Frequency Shift Keying (FSK) and Phase Shift Keying (PSK) are less common alternatives to Amplitude Shift Keying (ASK). FSK encodes data by varying frequency and PSK by modifying phase, offering better noise resilience and spectral efficiency but requiring more complex implementation. ASK remains the preferred choice due to its simplicity.

* 1. **Application-Specific Considerations**:

The choice of modulation in RFID systems depends on the frequency band. HF RFID systems (around 13.56 MHz) typically use ASK modulation, while UHF systems (860-960 MHz) may use ASK variations or other schemes better suited for higher frequencies.

1. **MATHEMATICAL ANALYSIS**

The mathematical analysis of the expression for the modulated waveform. Amplitude Shift Keying is a digital modulation technique where the amplitude of a carrier signal varies according to the binary data being transmitted.

Let be the message signal or ‘UID’ in this case. This message signal is in the binary form.

Now, let carrier signal be:

The ASK modulated signal can be expressed as:

For binary ‘1’,

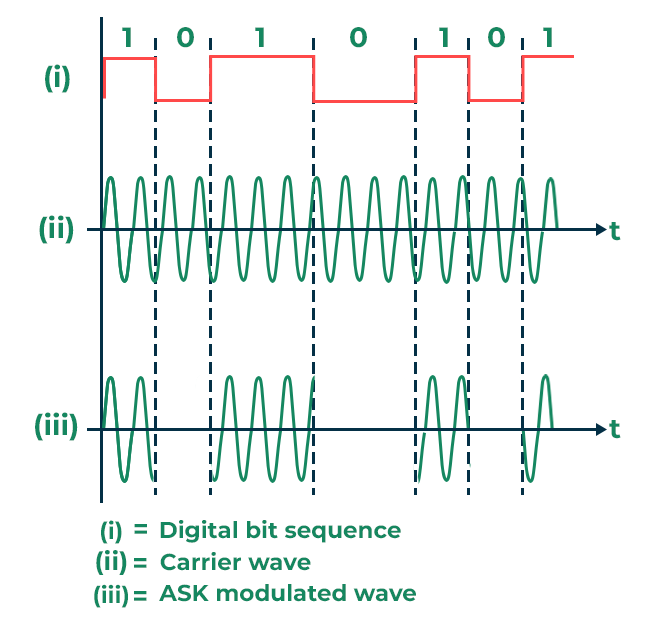
For binary ‘0’,

Figure 4 - ASK modulation

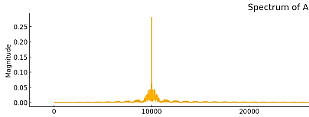
Suppose, the frequency of message signal is 1 kHz and the the frequency of carrier signal is 10 kHz. Then the frequency spectrum of the modulated ASK signal will be as shown below:

Figure 5 - Frequency Spectrum

1. **CODE**

#include <SPI.h>

#include <MFRC522.h>

#include <LiquidCrystal\_I2C.h>

#include <Servo.h>

#define RST\_PIN 9

#define SS\_PIN 10

MFRC522 mfrc522(SS\_PIN, RST\_PIN); // RFID instance

String MasterTag = "95 86 11 7B"; // Set your MasterTag UID here

String UIDCard = "";

LiquidCrystal\_I2C lcd(0x3F, 16, 2);

Servo servo;

#define BlueLED 2

#define GreenLED 3

#define RedLED 4

#define Buzzer 5

void setup() {

Serial.begin(9600);

SPI.begin();

mfrc522.PCD\_Init();

lcd.init();

lcd.backlight();

lcd.clear();

servo.attach(6);

servo.write(0); // Initial servo position

pinMode(GreenLED, OUTPUT);

pinMode(BlueLED, OUTPUT);

pinMode(RedLED, OUTPUT);

pinMode(Buzzer, OUTPUT);

digitalWrite(BlueLED, HIGH);

lcd.clear();

lcd.print(" Access Control ");

lcd.setCursor(0, 1);

lcd.print("Scan Your Card>>");

}

void loop() {

// Default state: LEDs and servo in idle position

digitalWrite(BlueLED, HIGH);

digitalWrite(RedLED, LOW);

digitalWrite(GreenLED, LOW);

noTone(Buzzer);

servo.write(10);

// Check for a scanned card

if (getUID()) {

Serial.print("UID: ");

Serial.println(UIDCard);

lcd.clear();

lcd.setCursor(2, 0);

lcd.print("Permission:");

lcd.setCursor(0, 1);

if (UIDCard == MasterTag) {

// Access granted

lcd.print(" Access Granted!");

digitalWrite(GreenLED, HIGH);

digitalWrite(BlueLED, LOW);

digitalWrite(RedLED, LOW);

servo.write(180); // Open servo

for (int i = 0; i < 2; i++) {

tone(Buzzer, 2000);

delay(250);

noTone(Buzzer);

delay(250);

}

delay(2000); // Keep door open for 2 seconds

servo.write(0); // Close servo

} else {

// Access denied

lcd.print(" Access Denied!");

digitalWrite(BlueLED, LOW);

digitalWrite(GreenLED, LOW);

tone(Buzzer, 2000);

for (int i = 0; i < 10; i++) {

digitalWrite(RedLED, HIGH);

delay(250);

digitalWrite(RedLED, LOW);

delay(250);

}

noTone(Buzzer);

}

delay(2000);

// Reset LCD for next scan

lcd.clear();

lcd.print(" Access Control ");

lcd.setCursor(0, 1);

lcd.print("Scan Your Card>>");

}

}

boolean getUID() {

// Check for a new card

if (!mfrc522.PICC\_IsNewCardPresent()) {

return false;

}

// Try reading the card's UID

if (!mfrc522.PICC\_ReadCardSerial()) {

return false;

}

// Convert the UID to a string

UIDCard = "";

for (byte i = 0; i < mfrc522.uid.size; i++) {

UIDCard.concat(String(mfrc522.uid.uidByte[i] < 0x10 ? "0" : ""));

UIDCard.concat(String(mfrc522.uid.uidByte[i], HEX));

UIDCard.concat(" "); // Add space between bytes

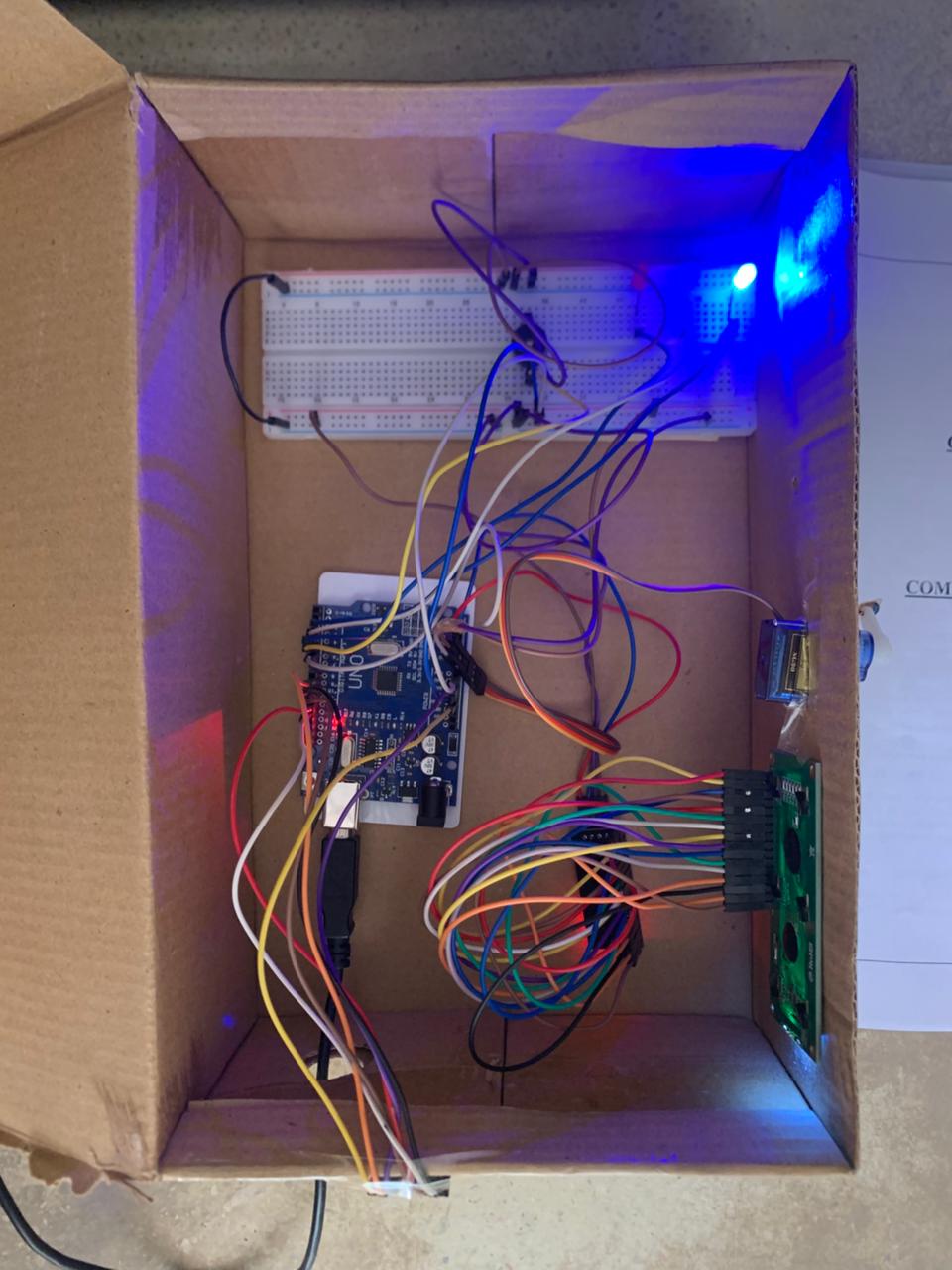
}

UIDCard.toUpperCase();

UIDCard.trim(); // Remove trailing space

mfrc522.PICC\_HaltA(); // Halt the card

return true;

1. **RESULTS**
   1. **Hardware**

The Idle state of the system means that the system is not performing any action and is ready to use. This means that RFID door unlock system is waiting for a card to be scanned indicated by a blue LED.

Figure 6 – Door lock System (Idle state)

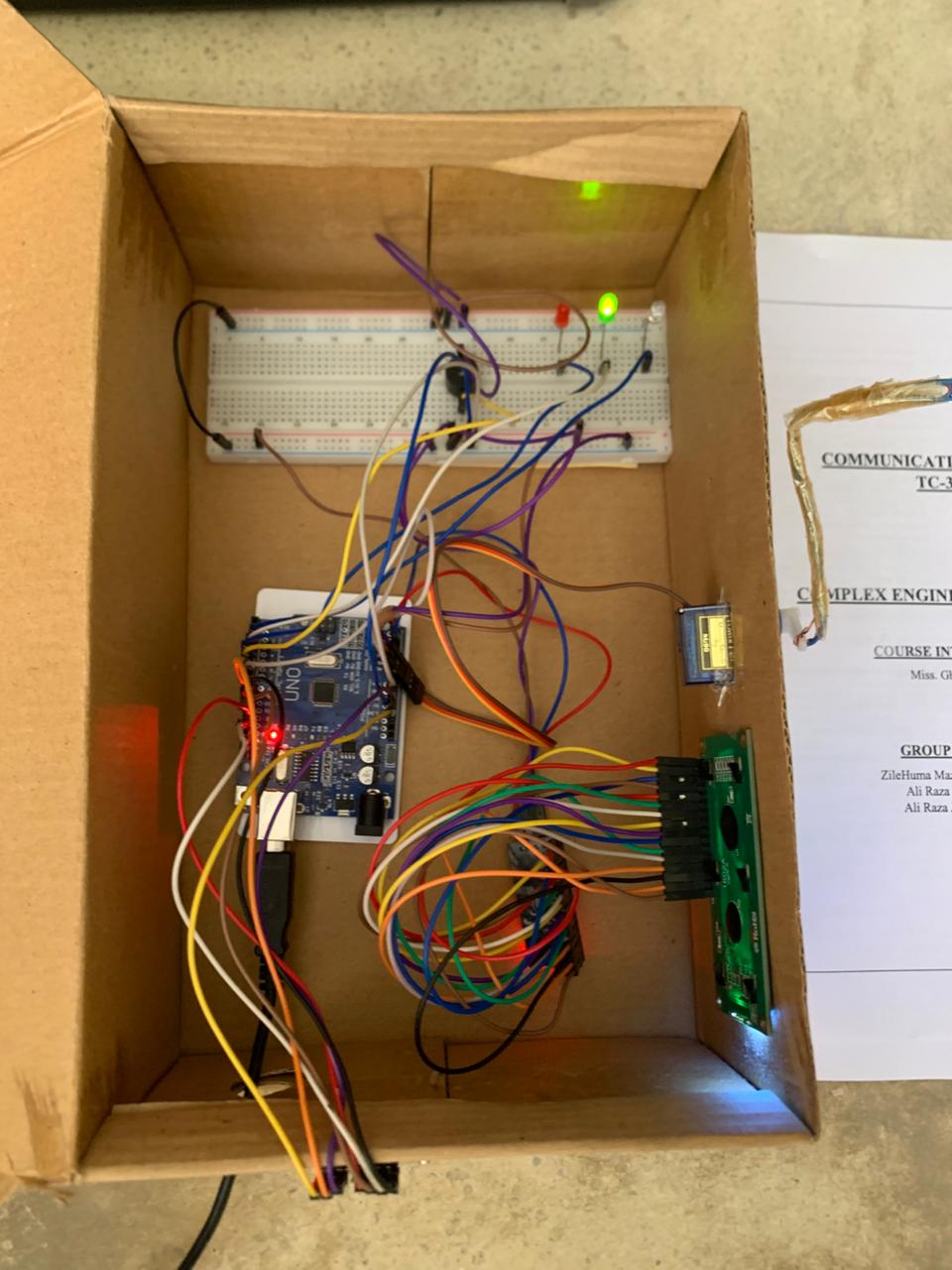
****When the card is scanned and the receiver detects correct **UID** from the tag, the access is granted indicated by a green LED.

Figure 7 - Door Lock System (Access Granted)

And, when the receiver detects incorrect **UID** from the tag, it denies the access which is indicated by a red LED.

Figure 8 - Door Lock system (Access Denied)

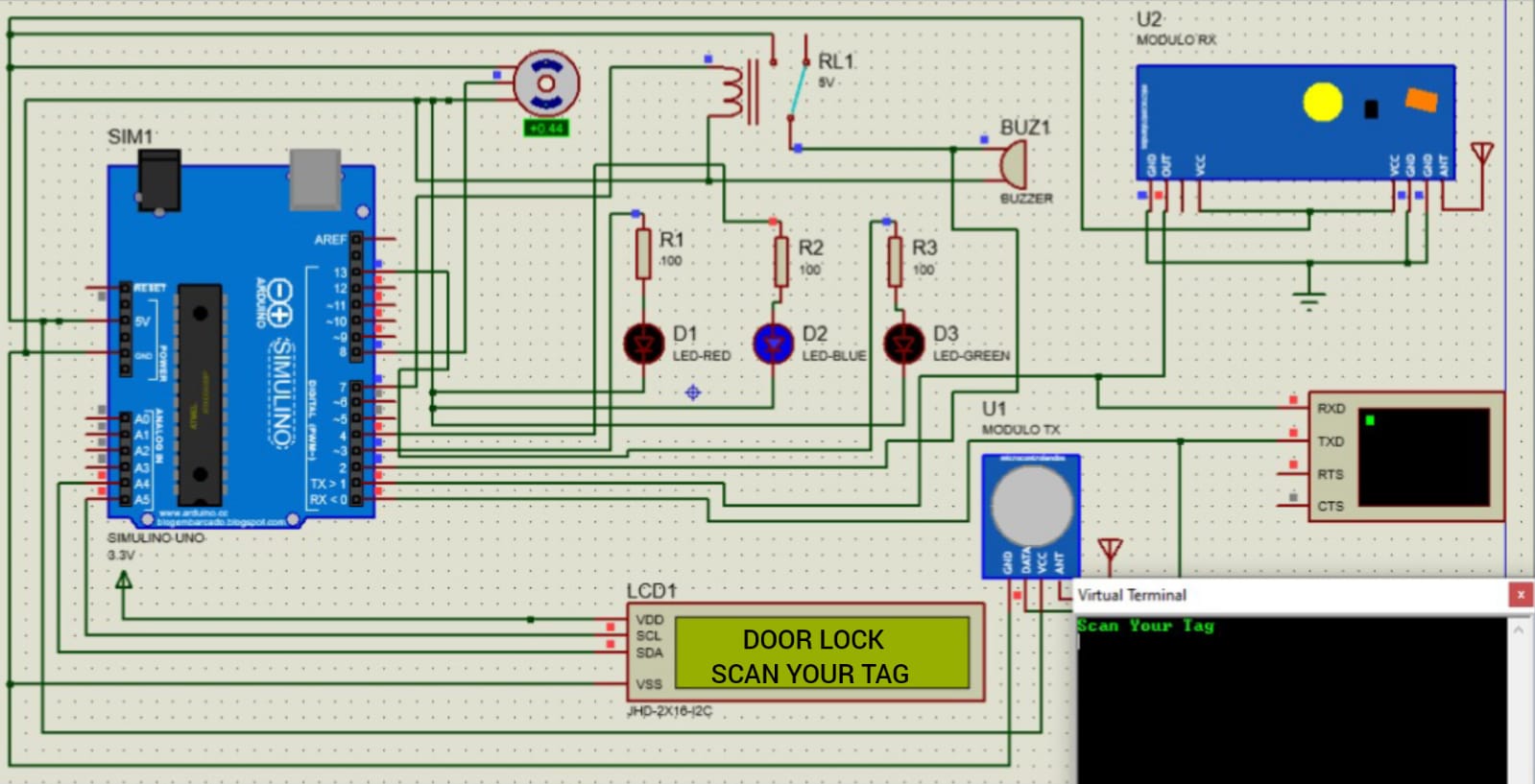
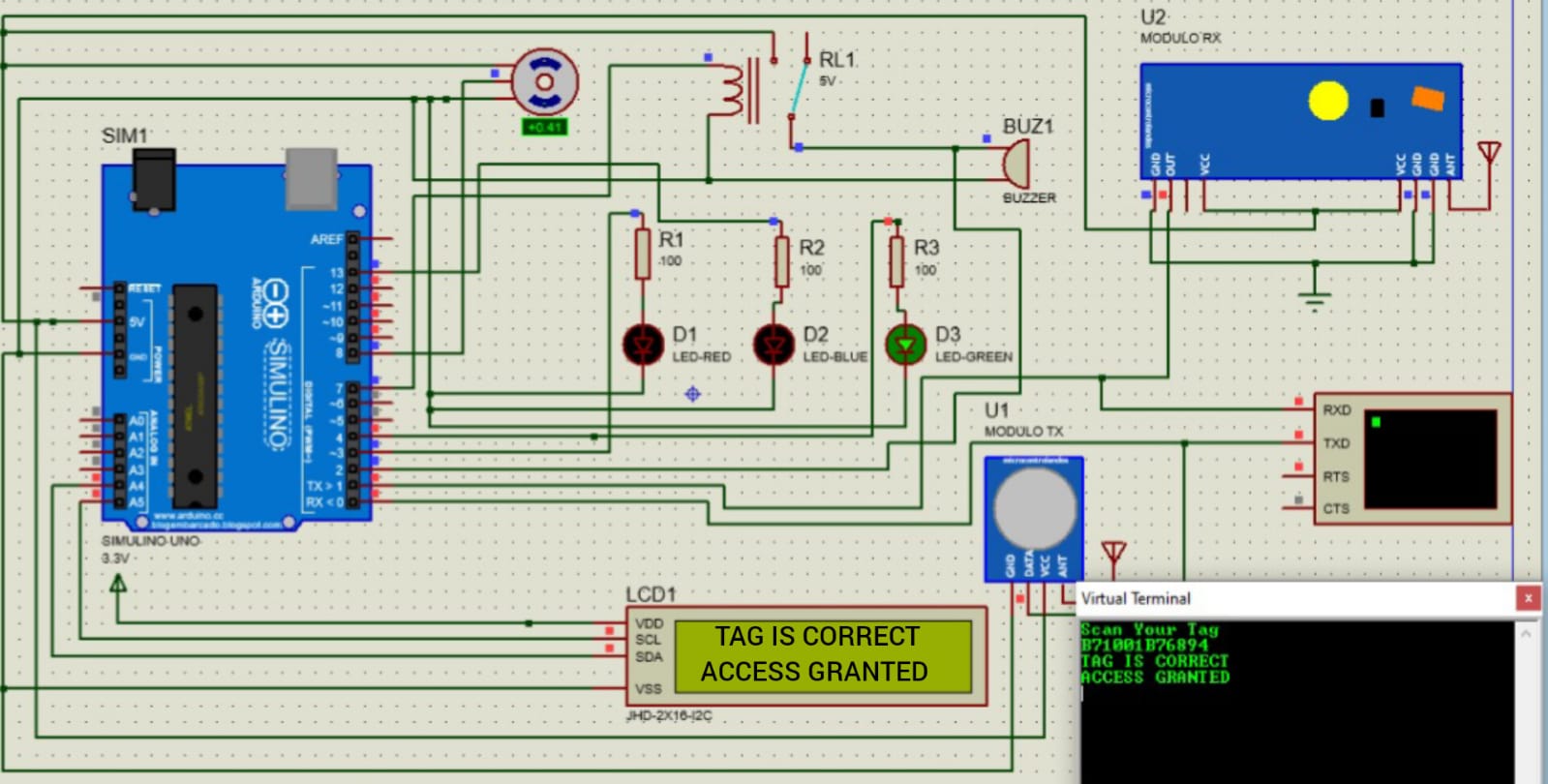
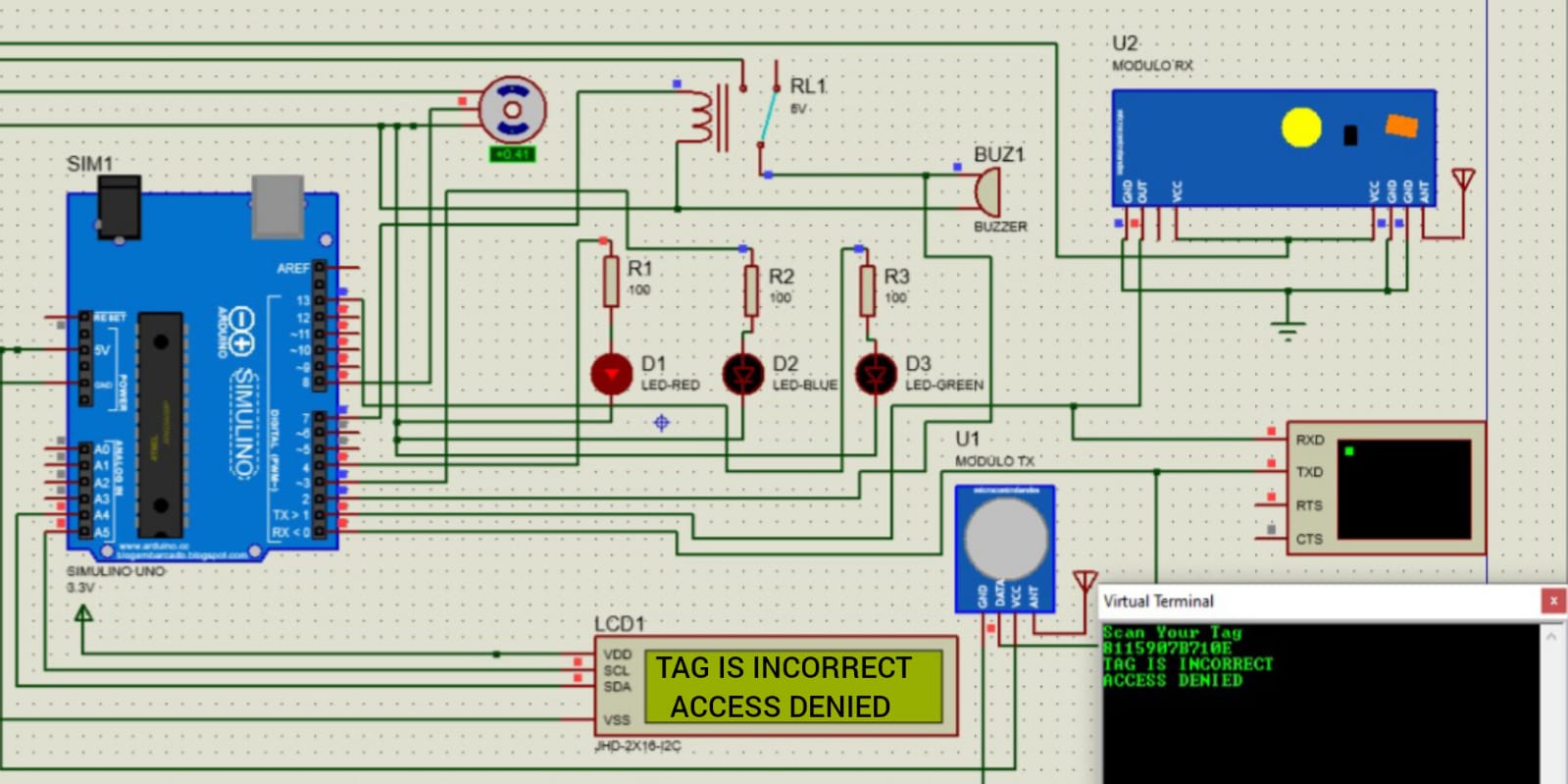
* 1. **Simulation**

Figure 11 - Door Lock System (Access Denied)

Figure 10 - Door Lock System (Access Granted)

Figure 9 - Door Lock System (Idle State)

* 1. **Discussion**

RFID system uses ASK modulation – a digital modulation – to receive the UID from the tag which is then matched with the pre-loaded UID. The UID from the tag is received using ASK modulation and decoded by the receiver after demodulation. If UID matches with the pre-loaded one, it grants access to the door, else it starts buzzing.

1. **CONCLUSION**

In conclusion, the RFID door lock access control system using Arduino demonstrates a significant advancement in security technology by combining the efficiency of RFID and the versatility of Arduino microcontrollers. The system effectively addresses key challenges, including secure user identification, multi-door access management, and scalability for future expansions. By employing modulation techniques like Amplitude Shift Keying (ASK), the design ensures reliable communication between RFID tags and readers.

1. **REFERENCES**

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