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Design And Implementation of An Arduino Microcontroller Based Door Access Control System Using RFID Technology

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Abstract *— All of the door opening system uses traditional ways such as lock and keys, latches, passcode or password locks. It encounters number of limitations that is, access is not time based and ID based facing lot of inconveniencies and drawbacks. In traditional systems there are no limitations on who can enter only manual control (security guards) are available. The focus is on implementation of an arduino based door unlocking system with real time control and implementing security system to avoid illegal and wrong time access. This hardware design and implementation would enable the user to use in real time practical condition. The RFID door lock is a unique lock that will allow the user to easily lock and unlock doors and it is also very simple to install. The door lock will have a RFID reader or writer and a door lock which is magnetic for simple use. When the door is locked, a LED will be turned on. The hardware components required are RFID reader, passive RFID tags, and an Arduino microcontroller. Additionally, there will be a light installed that will automatically switch on when the user unlocks the door and enters. Moreover, this door lock using RFID will be cost-effective and simple upgrade to the average consumer's convenience and security.*

Keywords — *Radio Frequency Identification (RFID), RFID Reader, RFID Tag, Arduino Microcontroller, Access Controller, Solenoid Lock, Relay Module.*

I. INTRODUCTION

RFID is a system of keeping data in a tag and can reading those data from a distance of up to thirty feet. We would like to create our own Door Lock System using RFID Techniques. In this research, the RFID tag will be having the capability to send the signal to unlock the door. The RFID reader will react to the signal and open the door when one of the RFID tags gets closer enough for the antenna to communicate, if only the tag contains the correct information. To create a more convenient way to unlock your door than the traditional key is the only way of the approach. (Gyanendra K et al., 2010) An RFID tag will be used alternate to a key that will unlock the door by proximity. We have planned to create the RFID Door Lock System, for overcoming this matter such as holding lots of key and wasting ample amount of time in search for the correct key. An RFID access control system provides the same purpose as a normal keyed lock, but with using RFID, there are various advantages that go along. From the outside doors are allowed to remain secured and closed yet still be unlocked efficiently and quickly by people with the proper credentials. This eliminates the common practice of propping a door open for convenience, which in turn decreases security (K.Srinivasa Ravi et al., 2013). A log of the system activity is stored in memory and could be accessed in the event of criminal activity or

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emergency. Similar RFID tag could be used to access number of doors, which is not practical with keys or always possible. Less space would be taken by a single RFID tag, and there won't be any need for a keychain full of keys.

II. LITERATURE REVIEW

The literature review will mainly focus on the differences in the currently deployed systems in the market and point out the flaws and demerits of the RFID system. This literature review will justify all the decisions and techniques used.

II.I. Research Reviews

There are various types of technologies that exist for auto identification system. In terms of functionality demands, cost requirement an applications, one or numerous solutions are initiated to fulfil the functionality of auto identification and data collection in the applied systems. With the cost decline in GPS and wireless technology, automatic identification systems can integrate all these high-end technologies with information technology systems to offer not only functionality of identification but also value added information and service in the applied systems. There are different identification technologies such as Auto Identification using Barcode System, Auto Identification using Optical Character Recognition System, Access Control Using Biometric, Access Control using Smart Cards and Access Control using RFID Systems. Door lock security systems are also classified based on technology used as Password based, Biometric based, GSM based, Smart card based, RFID based, Door phone based, Bluetooth based, Social networking sites based, OTP based, Motion detector based, and Combined system. RFID systems are closely similar to the smart cards. Data is stored on an electronic data carrying device. The power supply to the data carrying device and the data exchange are achieved by using electromagnetic and magnetic fields (Sejal Saravankar et al., 2018). A typical RFID system is shown in Fig. 1.

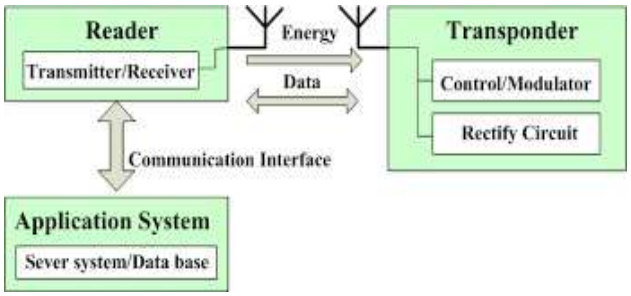


Fig. 1. A typical RFID system (Source: Researchgate.net)

II.II. Comparison Table

A comparison of different identification technologies is shown in Table 1. to demonstrate their parameter characteristics (Academiaedu, 2019) & (R. Weinstein, 2005) and the impact of influence factors against the data reading.

Table 1. Comparison of Automatic Identification Systems

Parameters	Barcode	OCR	Biometric	Smart Card	RFID
Typical Data Capacity	1~100	1~100	-	16~64 k	16~64k
Data Density	Low	Low	High	Very High	Very High
Readability by People	Limited	Simple	Difficult	Impossible	Impossible
Reading Speed	Low	Low	Very Low	Low	Fast
Reading Distance	0~50 cm	< 1 cm	0~2 m*	Contact	0~30 m
Cost of readers	Very Low	Medium	Very High	Low	Medium
Unauthorized Editing	Slight	Slight	Impossible**	Difficult	Difficult
Dirt / Damp	Very High	Very High	--	Possible	No Influence
Covering	Totally Fail	Totally Fail	Possible	--	Very Low
Direction and Position	Low	Low	--	Unidirectional	Very Low

Moreover, the comparison in terms of automation level and cost and is presented. (Pradnya R et al., 2016). RFID technology, the system can adopt the tags from active, semi-active to passive ones. RFID technology is gradually being implemented in a variety is device products and applications.

III. METHODOLOGY

The main objective of the RFID access control system is to open and close the door automatically by the authorized person. The system includes door lock controller & passive reader.

III.I. Functional Requirements:

III.I.I. User: Door should unlock once the user touched the RFID reader, Green light should be on when the user has valid ID, Red light should be on when the user does not have a valid ID, Bulb should turn on once the user unlocks the door.

III.I.II. Administrator: Can add or delete users, View profile and view the number of times they enter and exit.

III.II. Non-functional Requirements: System security, System availability and System design.

III.III. Hardware requirements: Arduino UNO, Relay, RFID Reader, LCD, Magnetic Door Lock, RFID Tag, Bulb, PC, and Related Electronic Components (K.Srinivasa Ravi et al., 2013)

III.IV. Software requirements: Windows, Compiler for C Programming (Embedded). (Circuitdigestcom, 2019).

III.V. Hardware Overview

RFID reader reads the data from tag and sends the card UID number to Arduino microcontroller for comparison, if the card is valid then Arduino microcontroller display access as granted else, access denied on the LCD display. If the access is granted then the door will open. (Electronicsforucom, 2017)

Fig. 2. Am Arduino Based RFID Door Lock Design (Source: Howtomechatronics.com)

III.V.I. Arduino Uno Board

It is basically a microcontroller board based on the ATmega328. Arduino Uno consists of a total of 14 digital output/input pins, (of which 6 can be used as analogue inputs, 6 pins for pulse width modulation outputs), a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP (in-circuit serial programming) header, and a reset button. It contains everything needed to support the microcontroller (A.O. Oke et al., 2009); simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started. The Arduino UNO board (Dhrubajyoti Adak et al., 2017) in Fig. 3. can be toyed without been concerned about doing something wrong with the board, worst case scenario the chip can be replaced with a new and cheap one and start over again.

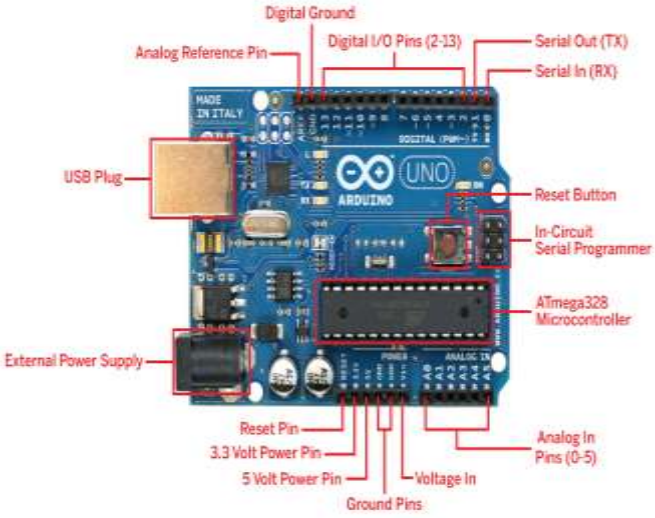


Fig. 3. Arduino Uno (Source: efxkits.co.uk)

III.V.II. Features of Arduino Uno

Table 2. Features of Arduino Uno

MicoController	**ATmega328**
Operating Voltge	5 V
Input Voltage (Recommended)	7-12 V
Input Voltage (Limits)	6-20 V
Digital I/O Pins	14 (of which 6 for PWM Output)
Analog Input Pins	6
DC Current per I/O Pin	40 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32KB (0.5 KB used for Bootloader)
SRAM	2 KB
EPROM	1 KB
Clock Speed	16 MHZ

III.V.III. RFID Tag and Types

An RFID tag is a tag which is read by an RFID reader. The tag is of a size of a credit card and it is very smooth as in Fig. 4. The memory of these tags is 1 kb and it also had microchip that has the ability to do arithmetic operations. 13.56 MHz is their operating frequency and 10 cm is the operating distance but also depends on the antenna geometry. Usually, each tag comes with a unique ID number which is fixed and cannot be changed. Software is used to find out its unique ID. (Yashi Mishra et al., 2015). Tags are differentiated into various types. They are Passive Tags, Active Tags, Read Write Tags, Semi Passive Tags, Read Only Tags and Write Once Read Many Times Tags (Sejal Saravankar et al.,, 2019).

Fig. 4. RFID Tags (Source: Researchgate.net)

III.V.IV. RFID Reader Module

We use MFRC522 RFID reader module shown in Fig. 5. This RFID reader module uses the SPI protocol for communicating with the microcontroller board and connect the VCC if the module to 3.3V and we don't have to worry about the other pins as they are 5V tolerant (Zhang L, 2005).

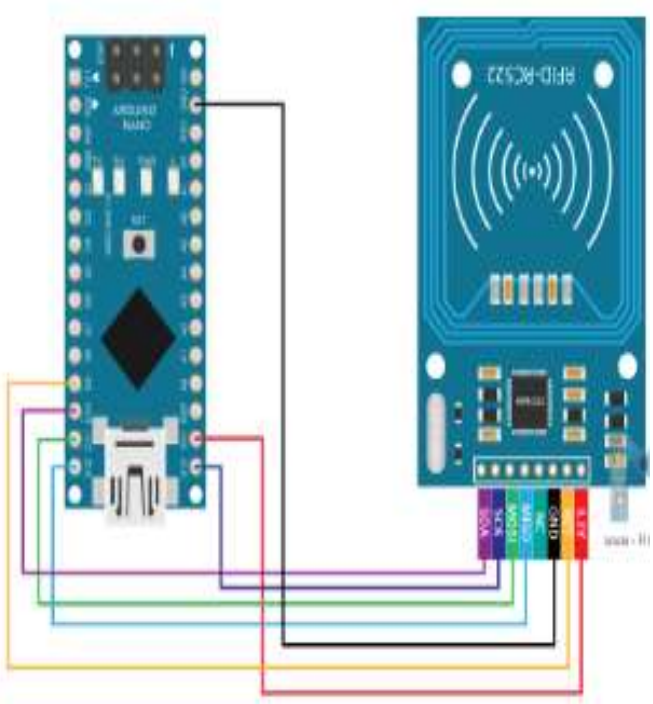


Fig. 5. RFID Reader Module
(source: Howtomechatronics.com)

III.V.V. Schematics of the Work

Fig. 6. Shows the components and the circuit schematics of the work. In addition, for checking whether the door is closed or opened, we will be using a proximity sensor, a character display and a servo motor for the lock mechanism.

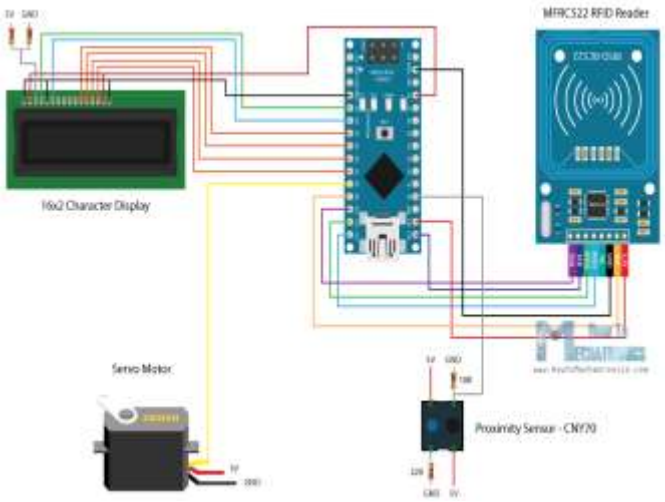


Fig. 6. Schematics of the Work
(source: Howtomechatronics.com)

III.VI. Software Overview

To program the Arduino Microcontroller Arduino Coding Language was used. The Arduino language is based on C and the most basic executable program only needs two functions as shown in Figure: 7, a setup() and a loop(), to run. In the setup() function variables, pin modes, serial communication, etc are initialized. This function only runs once. The loop() function is where one write the actual code. As the name implies, the loop() function loops continuously until the device is powered off. Simple as it may sound; (Circuitdigestcom, 2019) it is possible to write complex programs using the above described structure.

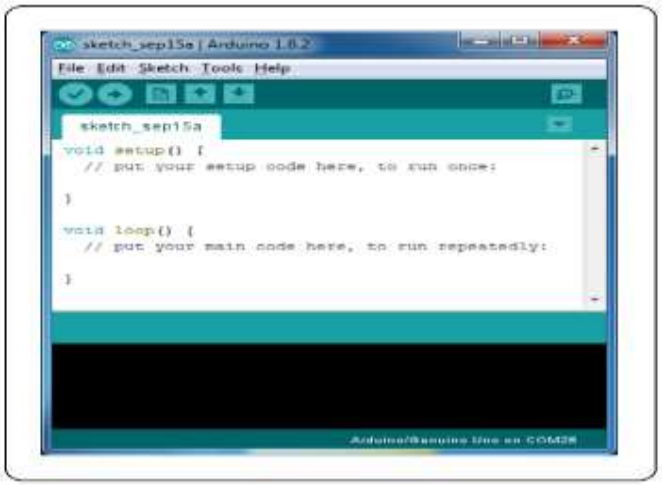


Fig. 7. Arduino Microcontroller Arduino Coding Language

III.VII. Working of the System

III.VII.I. Block Diagram

The access control system block diagram using Arduino and RFID as shown in Figure: 8. The system has three separate parts, an RFID reader, a microcontroller, and an access controller. The RFID reader reads the RFID tags and the microcontroller accept the data from the reader process it and use the result to either grant or deny access to the user using access controller (Researchgatenet, 2019). The work can be enhanced by connecting an LCD display to display if access is granted or denied instead of serial monitor .

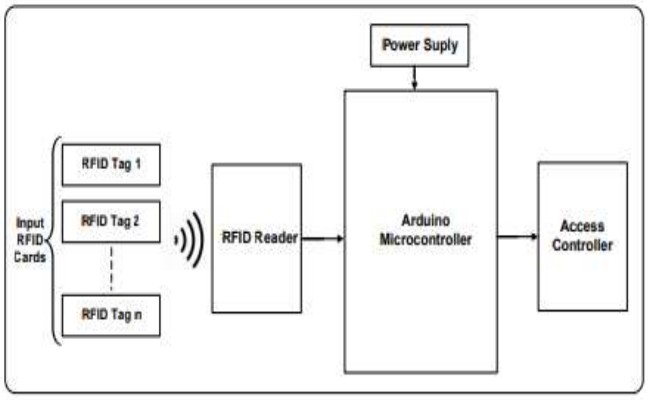


Fig. 8. RFID Block Diagram
(source: howtomechatronics.com)

III.VII.II. Work Flow

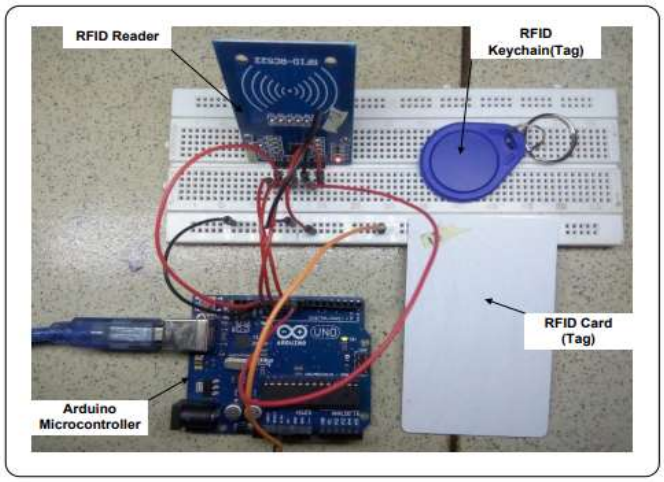


Fig. 9. RFID Prototype

The RFID tag is placed close to the RFID reader, access is granted or denied. The right tag stored on the microcontroller grants access to the secure environment (Fig. 12.) while the wrong tag not stored on the microcontroller will deny access to the card holder (Fig. 11.) (Makerpro, 2018).

Table 3. Connection of the RFID Reader with Arduino Microcontroller

RFID Module	Arduino
SDA	Digital Pin 10
SCK	Digital Pin 13
MOSI	Digital Pin 11
MISO	Digital Pin 12
IRQ	No Connection
GND	GND
RST	Digital Pin 9
3.3V	3.3V

III.VII.III. Simulation Results

Fig.10. Shows how the LCD will display before touching the RFID tag to the RFID reader.

Fig. 10. LCD Display

Fig. 11. Shows what the LCD will be displayed if the code does not match with the stored code.

Fig. 11. Access Denied

Fig. 12. Shows what the LCD will be displayed if the code matches with the stored code.

Fig. 12. Access Granted

IV. IMPLEMENTATION

IV.I. Circuit Diagram Design

IV.I.I. RFID Module to Arduino Mega 2560

The first step is to connect the RC522 RFID reader module to the Arduino. Table: 3 below shows what pin from RFID is to be connected to the accurate pin in Arduino Mega 2560, (Electronicsforucom, 2017) & (Circuitdigestcom, 2019) so that the RFID module doesn't get destroyed and Fig. 13. shows how the RFID and Arduino Mega 2560 are connected·

Table 4. RFID module to Arduino connections

RFID Module	Arduino Mega 2560
3.3V	3.3V Pin
RST	Pin
GND	GND
NC	NC
MISO	Pin 50
MOSI	Pin 51
SCK	Pin 52
SDA	Pin 53

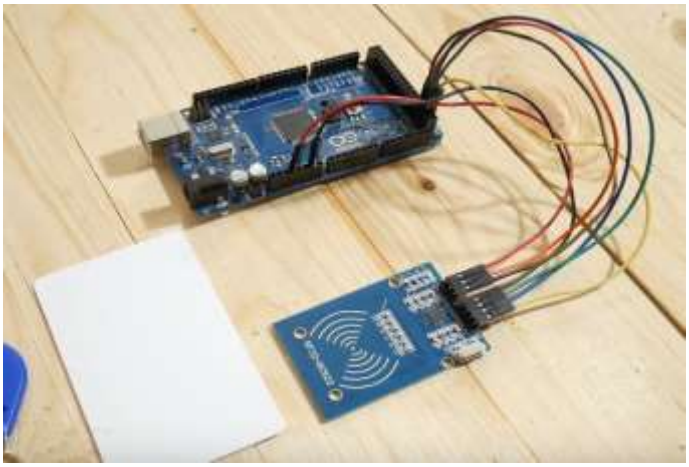


Fig. 13. Connecting RFID module to Arduino

IV.I.II. I2C LCD module to Arduino Mega 2560.

Table: 5 below shows what pin from I2C LCD Module is to be connected to the accurate pin in Arduino Mega 2560, so that the I2C module doesn't get destroyed (Makerpro, 2018)

Table 5. I2C LCD module to Arduino connections

I2C LCD	Arduino Mega 2560
GND	GND
VCC	5V
SDA	Pin 20
SCL	Pin 21

Fig. 14. Shows how the I2C LCD module and Arduino Mega 2560 are connected.

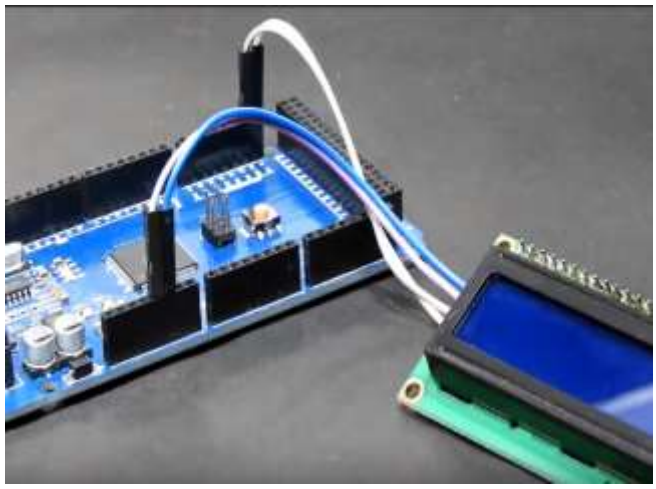


Fig. 14.Connecting I2C LCD module to Arduino

IV.I.III. Relay Module to Arduino Mega 2560.

Table 6. RELAY Module to Arduino Connections

Relay	Arduino Mega 2560
GND	GND
VCC	5 V
IN	Pin 9

Fig. 15. shows how the Relay module and Arduino Mega 2560 are connected

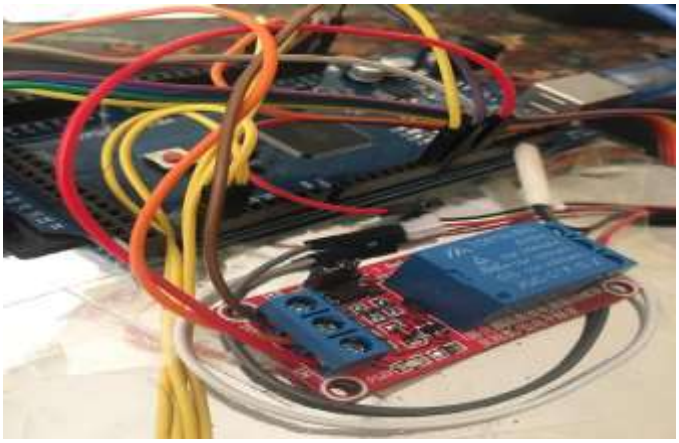


Fig. 15. Connecting RELAY Module to Arduino

IV.I.IV. Door buzzer and LED lights to Arduino Mega 2560.

Table 7. Door Buzzer to Arduino connections

Door Buzzer	Arduino Mega 2560
GND	GND
V in	Pin 8

Table 8. Green LED to Arduino connections

Door Buzzer	Arduino Mega 2560
GND	GND
V in	Pin 7

Table 9. RED LED to Arduino connections

Door Buzzer	Arduino Mega 2560
GND	GND
V in	Pin 6

Fig. 16. Shows how the LEDs and buzzer and Arduino Mega 2560 are connected.

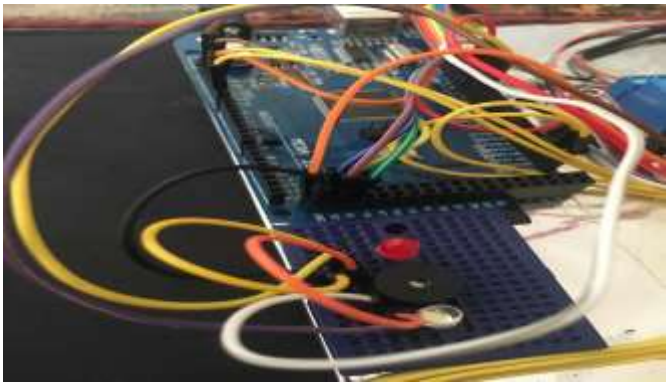


Fig. 16.Connecting LED and BUZZER module to Arduino

IV.I.V. Solenoid Lock RELAY module.

To connect with the Solenoid Lock to relay module, I have used a 12V adapter. Solenoid Lock's GND wire is connected to Adapter's GND wire. Adapter's 5V wire is connected to NO port in Relay module. And solenoid's 5V is connected to COM port of Relay module (Orji EZ et al., 2018)

IV.I.VI. Complete RFID Door Lock System

Fig. 17. Complete RFID Door Lock ystem

IV.II. Coding Part

This part shown the coding implementation of the system.

(Orji EZ et al., 2018) & (Circuitdigestcom, 2019)

```
#include <LiquidCrystal_I2C.h>
#include <SPI.h>
#include <MFRC522.h>
#include <Wire.h>
constexpr uint8_t RST_PIN = 5;
constexpr uint8_t SS_PIN = 53;
LiquidCrystal_I2C lcd(0x27,20,4);
#define LED_G 7 //define green LED pin
#define LED_R 6 //define red LED
#define beep_pin 8
#define relayPin 9 //relayPin pin
#define ACCESS_DELAY 2000
#define DENIED_DELAY 1000
MFRC522 mfrc522(SS_PIN , RST_PIN);
// Create MFRC522 instance.
void setup()
{
  Serial.begin(9600);   // Initiate a serial communication
  SPI.begin();      // Initiate  SPI bus
  lcd.init();
  mfrc522.PCD_Init();   // Initiate MFRC522
  pinMode(LED_G, OUTPUT);
  pinMode(LED_R, OUTPUT);
  pinMode(relayPin, OUTPUT);
  pinMode(beep_pin,OUTPUT);
  digitalWrite(beep_pin,LOW);
  digitalWrite(relayPin, LOW);
  lcd.backlight();
  lcd.setCursor(0, 0);
  lcd.print("FYP");
  lcd.setCursor(2, 1);
  lcd.print("By Talha");
  delay(4000);
  lcd.clear();
  mfrc522.PCD_Init();   // Initiate MFRC522
  Serial.println("Put your card to the reader.");
  Serial.println();
}
void loop()
```

```
{
  digitalWrite(beep_pin, LOW);
  lcd.setCursor(0, 0);
  lcd.print("RFID Door Lock");
  lcd.setCursor(0, 1);
  lcd.print("Put Your Tag");
  // Look for new cards
  if ( ! mfrc522.PICC_IsNewCardPresent())
  {
    return;
  }
  // Select one of the cards
  if ( ! mfrc522.PICC_ReadCardSerial())
  {
    return;
  }
  //Show UID on serial monitor
  Serial.print("UID tag :");
  String content= "";
  byte letter;
  for (byte i = 0; i < mfrc522.uid.size; i++)
  {
     Serial.print(mfrc522.uid.uidByte[i] < 0x10 ? " 0" : " ");
     Serial.print(mfrc522.uid.uidByte[i], HEX);
     content.concat(String(mfrc522.uid.uidByte[i] < 0x10 ? " 0" : " "));
     content.concat(String(mfrc522.uid.uidByte[i], HEX));
  }
  Serial.println();
  Serial.print("Message : ");
  content.toUpperCase();
  if (content.substring(1) == "3B FE 45 0B")
//change here the UID of the card/cards that you want     to give access
  {
    tone(beep_pin,300);
    digitalWrite(LED_G, HIGH);
    lcd.clear();
    lcd.setCursor(0, 0);
    lcd.print("Authorized access");
    lcd.setCursor(0, 1);
    lcd.print("Door is open");
    noTone(beep_pin);
    digitalWrite(LED_G, LOW);
    digitalWrite(relayPin, HIGH);
    delay(3000);
    delay(ACCESS_DELAY);
    digitalWrite(relayPin, LOW);
    Serial.println("Authorized access");
    Serial.println();
    delay(500);
    lcd.clear();
     }
  else   {
   digitalWrite(LED_R, HIGH);
    tone(beep_pin,200);
    lcd.clear();
    lcd.setCursor(0, 0);
    lcd.print(" Wrong Tag ");
    lcd.setCursor(0, 1);
    lcd.print("Access Denied");
    delay(2000);
```

```
  delay(DENIED_DELAY);
  digitalWrite(LED_R, LOW);
  noTone(beep_pin);
  Serial.println(" Access denied ");
 lcd.clear()
   }}
```

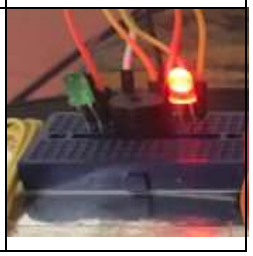
V. TEST RESULTS AND DISCUSSION

V.I. Testing Strategy

As discussed in the previous chapter in the testing section; Testing of the RFID Access Control system was planned prior to the creation of code solutions concentrating on the main areas of input and output results. A test plan was created to include description of the test and actions used. Once the code solution was completed, the test plan was implemented and recorded as a test log. The tests that were carried out are listed as LCD displays Authorization Denied, LCD Display Authorization Access, LCD displays to place the access card, Buzzer beeps, LED lights, Solenoid locks/unlocks

V.II. Test Result

Table 10. Test Results

Test Case	RFID Access Control System	Result expected	Result
1	Authorization Access	LCD Should display Authorization Access.	
2	Authorization Denied	LCD Should display Authorization Denied.	
3	Buzzer beeps	Buzzer should beep when the card is placed.	SUCCESSFUL
4	LED lights	LED lights should light up to indicate if the user is accessed or denied.	

5	Solenoid locks / unlocks	Lock should unlock when the registered access card is placed.	

VI. CONCLUSION

In conclusion, nowadays almost all of the organisations and small to medium enterprises (SMEs) have their own RFID access control system that displays information about the users that enter and exit the organisation. Today's world has gone digital and social. The social integration has made everything very easily accessible to everyone. There the need for an RFID Access Control System is the need of an hour. There are a few recommendations from our point of view. Some of the recommendations might make the system look more professional and complete. Following are the recommendations for the System such as providing more control to the admins over the users to better overlook the activities of the users, adding more features and functions into the system to make it more functional and versatile. Having a backup power supply in case the electricity goes off.

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