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Design and Implementation of a Radio Frequency Identification (RFID)- Based Door Lock System

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ABSTRACT

This paper presents the Design and Implementation of a Radio Frequency Identification (RFID) -Based Door Lock System. It is a consequence of the desire to provide a better secured, cheap, flexible and keyless door system. The components used comprises both hardware and software parts. The hardware consists of the ESP8266 Wi-Fi module, an MFRC 522 RFID Reader, a set of RFID Tags, an Electric door lock, an EEPROM, a Fabricated Iron door, a 5.0V regulated power supply unit and connecting leads. The software parts consist of appropriate drivers for the boards, the necessary libraries for the MFRC 522, EEPROM, and the Arduino Software to provide the Integrated Development Environment (IDE) for programming and uploading codes. The tags are activated by writing special codes on them, the codes are retrieved from the tags by the RIFD reader and stored in the EEPROM. When these activated tags are brought close to the door, the RFID reader reads the codes and compare with codes stored in the EEPROM. If there is a match, access is granted to the user otherwise access is denied. With the Wi-Fi capability built onto the module, a cell phone or any Wi-Fi -enabled device such as a tablet or laptop can be used to add or remove a tag from the EEPROM database. The system was tested with several registered and non- registered tags. Only authorized access was granted to those with registered tags. It operates perfectly as envisaged and can be adequately deployed in houses, classrooms, offices, banks, hotels etc.

1. INTRODUCTION

The need for RFID control of keyless doors, both in homes and offices is the main focus of this design. As technology is rapidly evolving and security is a primary concern in today's busy and global world, better and efficient ways to provide security for homes and offices becomes imperative. Security in general is important in our day-to-day life; everyone wants to be as much secured as possible. Knowing your homes or offices are protected provides peace of mind both when you are away and when you are at home. Security is important even if you have outstanding public safety agencies in your area. This need has been so necessary in order to reduce stress and other inconveniences associated with manual locking and unlocking of doors in our homes and offices. The commonly used form of security system is the mechanical door lock system that requires a lock and set of keys. This type of security has many drawbacks, as keys can easily be misplaced, damaged or stolen, even duplicated [1]. Therefore, there is a dire need for a change from the commonly used mechanical door lock system to a better guaranteed security system [2]. Doors are not only been made of wood but also of metals. In order to enhance security, some influential people in our society are making use of bullet proof doors to add additional level of security to their lives, family and properties. While adding to existing security mechanism, we have designed and produced an RFID- based door lock system, which only requires that the user be with an authorized card or tag to have access to the electronic lock. Our system uses an ESP8266 Wi-Fi Node MCU which provides the possibility of using any Wi-Fi enabled device such as cellphones or laptops for registration and de-registration of RFID tags. This system offers powerful means for helping and supporting the special needs of people with disabilities and in particular the elderly persons and senior citizens in the community. It also provides guaranteed security for homes, offices, hotels and other related applications. It will also be beneficial to schools as it can be made to restrict unauthorized access to class rooms and even into the examination halls.

1.1 RELATED WORK

1.1.1 Arduino **RFID Simple Access Control System**

In [3][4][5], an RFID-based control door system is presented. In this work a microcontroller-based control system featuring ATmega328P microchip, an MFRC522 RFID module is used. It uses a 28BJY-48 stepper motor to control the door lock. The stepper motor is driven using ULN2003 high voltage, high current Darlington array Integrated circuit. A 16x2 LCD display is used as output component to show different conditions of the system. Similarly an electric buzzer or a Piezo transducer is used to generate system sounds and alarm in different situations. Several LEDs are used as indicators for different situations.

1.1.2 BLUETOOTH Based Home Door Lock System

[6] Presents a Bluetooth-based home door lock system. In this design, Bluetooth devices are used to connect to interfaces controlling magnetic relays connected to door lock mechanism. The design depends on a stand -alone Arduino Uno and Bluetooth board.

1.1.3 IOT Based Home Door Lock Automation System

In [7], IOT based home door lock automation system is presented. It uses a NODEMCU ESP866 Wi-Fi module which hosts a webserver. By connecting to the webserver through mobiles, tablets or PCs, the door can be locked or unlocked controlled through sets of relay boards.

2 MATERIALS and METHODS

The proposed system comprises two main parts, namely; hardware and software. The hardware segment consists of the ESP8266 Wi-Fi Node MCU, an MFRC 522 RFID Reader, a set of RFID Tags, an Electric door lock, an EEPROM, a Fabricated Iron door, a 5.0V regulated power supply unit and connecting leads. The software parts consist of appropriate drivers for the boards, the necessary libraries for the MFRC 522, EEPROM, and the Arduino Software to provide the Integrated Development Environment (IDE) for programming and uploading codes. The tags are first activated by writing special codes on them. The codes are retrieved from the tags by the RFID reader and stored in the EEPROM. When these activated tags are brought close to the door, the RFID reader reads the codes and compares with codes stored in the EEPROM. If there is a match, access is granted to the user otherwise access is denied. The **ESP8266 (ESP-12E) Wi-Fi Board** is an all-in-one microcontroller + Wi-Fi capability incorporated. It contains all the necessary components necessary to program and upload code. It has a built-in USB to serial chip converter onboard for communication between the computer system and the device. It features a 3.3V, LM 1117 voltage regulator and a 4MB flash memory. The block diagram of the RFID enabled door system is shown in figure 1.

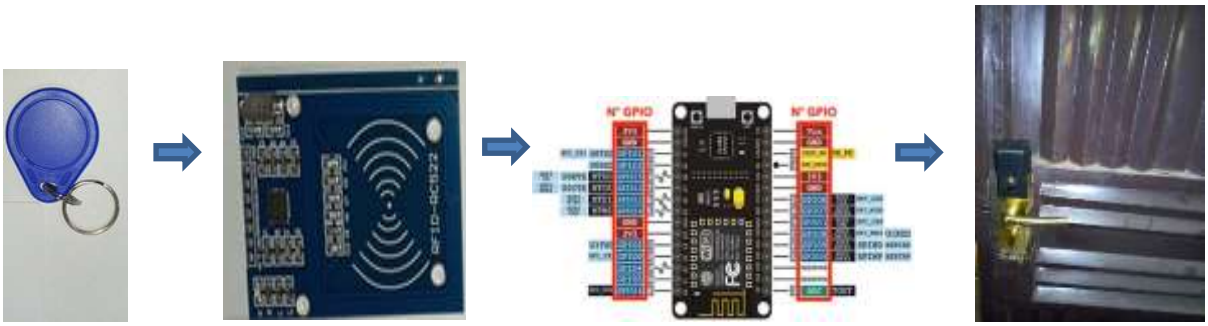


Figure 1. Proposed diagram of the RFID-based door system [1].

2.1 NODE MCU ESP8266 Wi-Fi MODULE

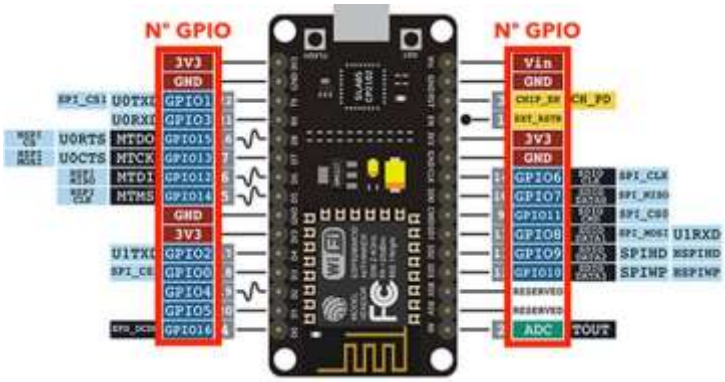


Figure 2. Pin description of Node MCU ESP8266 Wi-Fi module [11]

Figure 2 shows the pin arrangement of the ESP8266 Wi-Fi Module. The ESP8266 Wi-Fi module can operate in two modes: running and flashing modes. To operate it in the flashing mode, the jumper pin J1 is connected to ground pin 18 (GPIO0). To operate it in the running mode, J1 is left open so that pin 18 (GPIO0) is pulled up through a 1K resistor to the 3.3V supply rail. Pin 22 and Pin 21 are the TX and RX pins which provides means of transferring codes in to the ESP8266. The pin 4, 5, 6, 7,17, 18, 19, 20 which are GPIO16, GPIO14, GPIO12, GPIO13, GPIO2, GPIO0, GPIO4, GPIO5 respectively are programmable pins and thus can be used for interfacing with other devices as shown in figure 1.0. In this design, the GPIO16 GPIO14 are interfaced to the door control motor which is configured to lock and unlock the door. The Pin SDA and SCL are the i2C interface used to communicate with the EEPROM 24C256. The GPIO 12 pin is connected to the buzzer.

2.2 MFRC522 RFID READER MODULE

Figure 3. MFRC522 RFID Reader Module and tags.

Figure 3 shows the MFRC522 RFID Reader Module and tags. To use the RFID reader, it must be properly powered through the 5V pin on the ESP8266 Wi-Fi Module. The TX (pin 2) of the RDID reader is connected to the RX pin of the ESP8266 module and the RX (pin 1) of the RFID Reader is connected to the TX pin of the ESP8266 Module. After adding the requisite libraries, the pins are defined for MFRC522 RFID module's RST and SS pins. A byte array is defined to hold the UID of the RFID card. An integer is defined for determining the reading process when it is done. Then an MFRC522 instance including the pins variables are created. Then the SPI connection between the MFRC522 RFID module and ESP8266 is initiated.

When an RFID card or tags is brought near the antenna, the chip inside is powered up and it transmits the integrated voltage signature to the RFID reader.

2.3 DOOR CONTROL UNIT

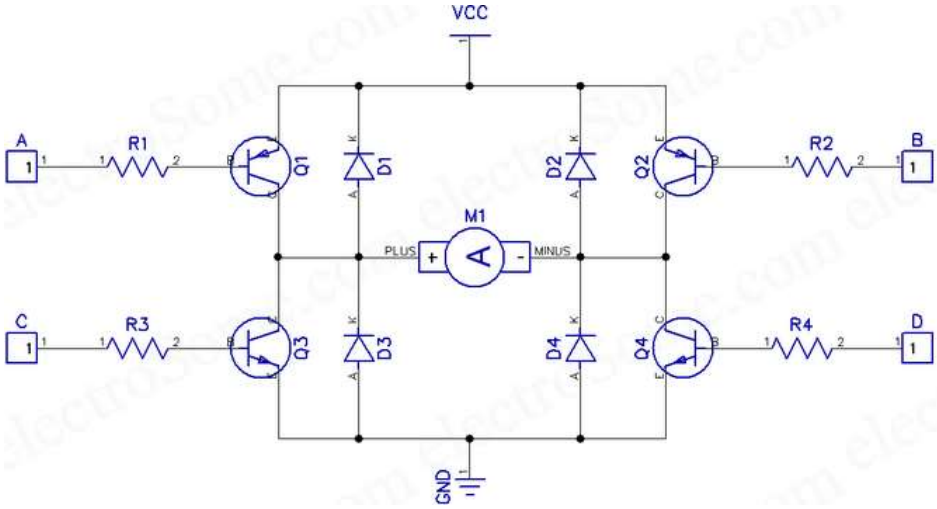


Figure 4. Door Motor driver circuit [10]

Figure 4 shows the door motor driving circuitry. It controls the locking and unlocking of the electronic lock by driving the motor. The motor requires a current of between 0.5A to 0.7A and this is obtained from the ESP8266 Wi-Fi module. In order to facilitate effective control of the motor, an H-bridge network circuitry is provided as shown in figure 4.

2.4 BUZZER CONTROL UNIT

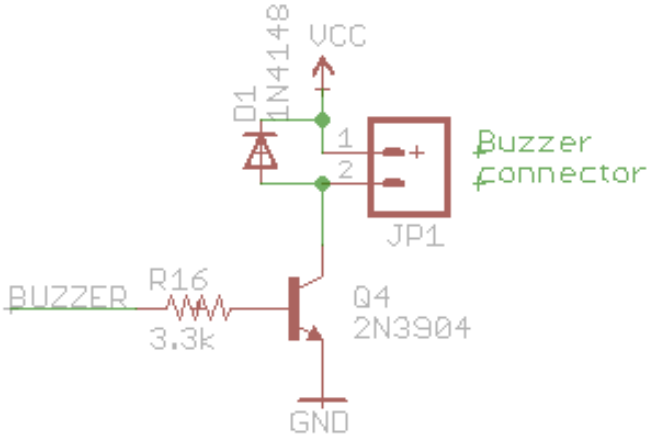
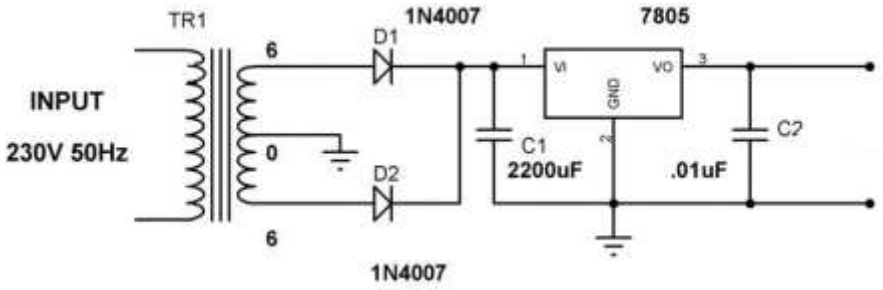


Figure 5. Interfacing a Buzzer with Arduino Uno [9]

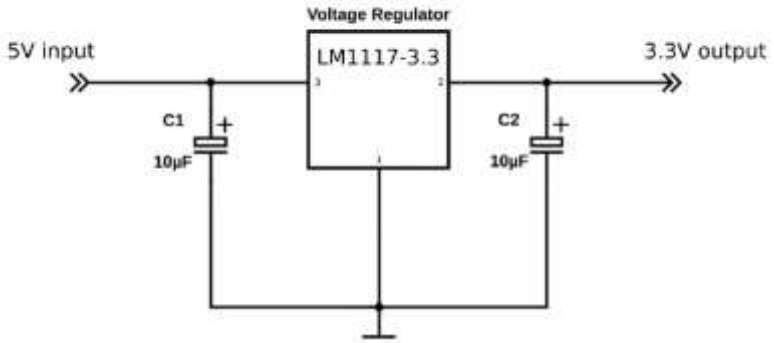
Figure 5 shows the buzzer control unit. The unit consists of a simple NPN transistor driver circuit. A signal from the ESP8266 Wi-Fi module drives the base of the transistor which activates the buzzer. A flywheel diode is connected across the buzzer to protect it against back e.m.f.

2.5 POWER SUPPLY UNIT.

Figure 6 shows the circuit for the voltage regulated power supply unit. The A.C voltage of 220 V is stepped down to 5V and rectified using the full wave rectifier model. The output voltage is smoothened using a 2200uf capacitor. The 5V obtained is supplied to the RFID Reader. The 5V is further passed through a lm1117 regulator to derive the 3.3 volt needed to drive the ESP8266 Wi-Fi Module. Both circuits are shown in figure 6a and b.



(a) 5v regulated power supply



(b) 3.3 V regulated power supply
Figure 6. Regulated Power supply unit

2.6 INTERFACING EEPROM 24C04 TO ARDUNI UNO

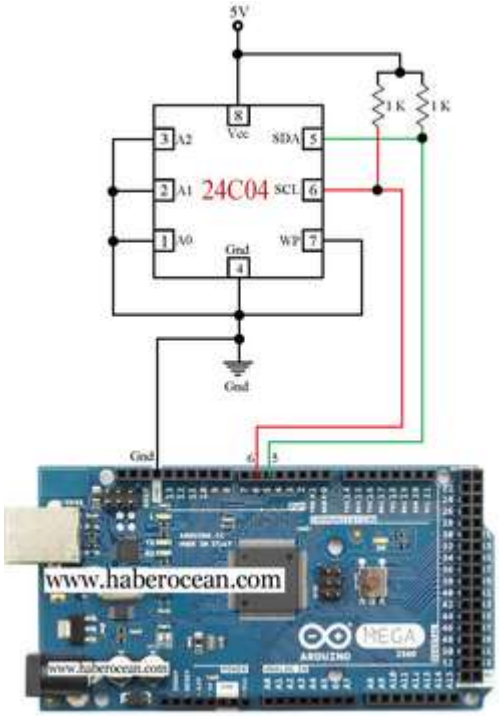


Figure 7. Interfacing EEPROM 24C04 with Arduino [8].

Figure 7 shows the connection of the EEPROM Chip. It clearly describes how the pins should be connected to the power supply and to the ESP8266 Module. The pins on the 24LC256 chip consist of power (pin 8), GND (pin 4), write protect (pin 7), SCL/SDA (pin 6, pin 5), and three address pins (1, 2, 3). In figure 7, pin A0, A1, A3 are tied to ground in order to set the EEPROM address .

to 0 x 50. The SCK (Serial Clock Pin) and SDA (Serial Data Pin) are connected to GPIO0 and GPIO 4 of the Node MCU respectively. This allows the MCU to read and write to the EEPROM at address of 0 x 50. The WP pin stands for write-protected and this allows you to control if data can be written to the EEPROM or not. Connecting it to ground means it can be written on to

3. ARCHITECTURE OF THE SYSTEM

A (RFID tag) B (RFID Reader) C (RFID -Enabled Door)

Figure 8. Architecture of the RFID- based Door lock system.

In this system, the RFID tag contains the user identification code (UID) or authorized codes which are stored on to the EEPROM memory. The UID in the tag is read by the RFID reader when it is brought close to it. The read UID from the tag is compared with that stored in the EEPROM Memory. When there is a match between the read and stored UID in the EEPROM, the ESP8266 NodeMcu sends a signal to the door motor which opens the door. If when compared, there is no match between the read tag's UID and that stored in the EEPROM, access is denied and the door remains locked.

4. RESULTS AND DISCUSSION

The complete system is completed and tested for performance efficiency. The system works by first registering or adding a user tag on to the EEPROM database. Thereafter, the door is powered through a set of four, 1.5V batteries each. When the tag is brought near to the electromagnetic field of the RFID reader mounted inside the key, it reads the UID of the tag and compares it with registered value of the UID in the EEPROM database. When the values match, the ESP8266 Wi-Fi sends a command to drive the motor in the door. When the motor is switched, it turns and the door is opened. If both values of the UID do not match, the motor remains intact and the door remains locked. For an occupant inside the room or office, the door can simply be opened by turning the door handle. Once the door is closed, it cannot be opened from outside without an authorized tag brought close to the reader. The system also permits the addition and removal of RFID tags or cards. Any RFID tag or Card removed cannot open the door.

5. CONCLUSION

In this work, we have designed and implemented an RFID-based door lock system. The door system is protected against access from unauthorized users. Any prospective user is required to be provided with an activated RFID enabled tag or Card for authentication before access is allowed. The door lock system has provision for disabling the lock system and using a key to gain access.

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