Design and Construction of an Automatic Security System of a Door Using RFID Technology

Syed Mamun R Rasid, Fazlur Rashid, Md. Ali Ahsan Sabri, Md. Rakibul Islam

Abstract— Access control is the process of verifying a user's claimed identity and giving or denying the access. The aim of the proposed system is to construct a secure access control system to control the entry of various items through a door or a passage using RFID technology. Radio Frequency Identification (RFID) systems will become pervasive in our daily lives due to their low cost and easy to use characteristics. At the very simplest level, Radio Frequency Identification (RFID) technologies allow the transmission of a unique serial number wirelessly, using radio waves. The two key parts of the system that are needed to do this are the RFID 'tag' and the 'Reader'. The proposed system is an automatic identification and authentication system which can be deployed at the doors of the building to authenticate authorized people. The proposed system aims to develop a very low cost authentication system based on the low cost components than those which are already available in the market. This approach not only reduces the cost but also enhances the reliability and ease of maintenance of the authentication system. The flexibility of the proposed access control system makes itself suitable for various applications.

Index Terms— RFID reader, RFID tag, Microcontroller, Security System, and Automation.

1 Introduction

The significant problems in the present society are robbery, crime and theft that increasing [1][2]. This raises the access control system issue. Any system that controls the entrance and exit to those who have been authorized may be called an access control system.

The most common method of security which all of us are familiar with is the traditional lock and key arrangement [3]. It is fine for small applications but has a number of pitfalls, especially in application where there is a large number of user or common door. There are several options to replace the traditional method as a security system of a door. Firstly, the magnetic access card may be thought of as an electronic "key". Each access card is uniquely encoded. But it is costly as compared with the economic condition in Bangladesh. Secondly, Access control keypads are devices which may be used in addition to or in place of card readers. The keypad requires that a person desiring to gain access enter a correct numeric code. Where access control keypads are used in place of card readers, only a correct code is required to gain entry. This system is also known as barcode system. But, RFID (Radio Frequency Identification), one of the promising technologies, that has been widely applied into the access control and security systems [4]. RFID is a leading automatic identification technology. RFID is a technology that helps to identify the animate or inanimate through radio waves [5]. A properly selected security system can overcome these problems and can be integrated with other systems to provide a more rounded overall security solution [6].

Numerous technology have been used regarding recurity system by the lot of researchers. The use of RFID have been already used in several applications. For example, In August 2004, V.NagaLakshmi et al. from department of computer science from different institute in India proposed a security mechanism for library management system using low cost RFID tags [7]. The information contained on microchips in the tags affixed to library materials was read using radio frequency technology, regardless of item orientation or alignment. A voice recognition security system [8] is studied by the Xiaowen Lu andShihjia Lee in 2006. The function of this speech recognition security system was to have a system that would only unlock upon recognizing a voice password spoken by the administrator or password holder. Md. Helmi Al Syukran Bin Abdul Malik from Universiti Teknologi Malaysia proposed an automatic door lock system in 2008 [9]. This project was concentrated at the short messaging system (SMS) in order to open the door. The SMS signal coming from the mobile hand phone need to be identified in order to connect with the microcontroller. In December 2010, Muhammad Naveed et al. from Department of Electrical Engineering, University of Engineering and Technology, Peshawar, Pakistan, proposed Reliable and Low Cost RFID Based Authentication System for Large Scale Deployment [10]. The two main tasks of their reader circuit, besides the PC interfacing and database logging, was to create a large amplitude carrier signal which would power up the RFID tags present in proximity of the reader and to receive and interpret the modulated response. In

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August 2010, Gyanendra K Verma et al. from Indian Institute of Information Technology proposed a digital security system with door lock system using RFID technology [11]. They proposed a security system contains door locking system using passive type of RFID tag. M. A. Meor Said et al. constructed a RFID based Wireless Security Car in 2012 [1]. By applies the RFID technology into the security car, it could avoid from being invaded because this technology was very secure because the car engine only could start after tagging the Passive RFID tag on the RFID reader and without tagging, the car engine could not be start. This paper proposed Microcontroller based access control using RFID is a combination of electrical, electronics, and mechanical technology. The purpose of using microcontroller is because it is cheaper and further upgrading is possible without changing the processing of the chip.

The aim of our research is to design and construct the security system of a door using RFID technology. Also, this research aims to measure the performance of the proposed system and compare the cost of the constructed system with the existing security system.

2 MAJOR COMPONENTS USED IN THE PROPOSED SYSTEM

The major components of the proposed security system using RFID technology are RFID reader, RFID tag, microcontroller, DC gear motor, LCD display etc. The brief description and some special features are described in the following:

2.1 RFID Reader

An RFID reader is a device that is used to interrogate an RFID tag. RFID readers communicate with tags through an RF channel to obtain identifying information [1]. RF module acts as both a transmitter and receiver of radio frequency signals. The reader has an antenna that emits radio waves; the tag responds by sending back its signals. The reader is a handheld or fixed unit that can interrogate nearby RFID tags and obtain their ID numbers using radio frequency (RF) communication (i.e. the process does not require contact). When a passive tag is within range of a reader, the tag's antenna absorbs the energy being emitted from the reader, directs the energy to 'fire up' the integrated circuit on the tag, which then uses the energy to beam back the ID number and any other associated information.

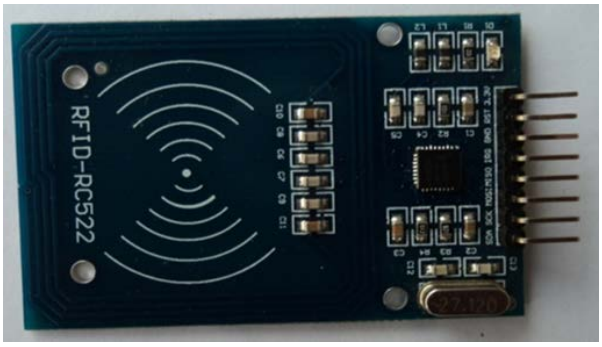

Fig. 1 RFID Reader Module RC522

RFID module has some special features which are given in the following:

- Typical operating distance in Read/Write mode up to 50 mm depending on the antenna size and tuning.
- FIFO buffer handles 64 byte send and receive.
- Flexible interrupt modes.
- Hard reset with low power function.
- Power-down by software mode.
- Programmable timer.
- Internal oscillator for connection to 27.12 MHz quartz crystal.
- 2.5 V to 3.3 V power supply
- CRC coprocessor
- Programmable I/O pins

2.2 RFID tag

A radio-frequency identification system uses tags, or labels attached to the objects to be identified. The RFID tag includes a small RF transmitter and receiver. An RFID reader transmits an encoded radio signal to interrogate the tag. The tag receives the message and responds with its identification information. There are two main components present in the RFID tag. Firstly, a small silicon chip or integrated circuit which contains a unique identification number (ID). Secondly, an antenna that can send and receive radio waves. These two components can be tiny: the antenna consists of a flat, metallic conductive coil rather than a protruding FM-style aerial, and the chip is potentially less than half a millimeter. There are two main types of tags: passive and active. Passive tags are currently the most widely deployed as they are the cheapest to produce. Passive tags is used in this project which is available in our country.

Fig. 2 RFID tag

2.3 Microcontroller

The microcontroller is the main controlling element which controls the operation of this security access control system. Microcontroller is a device which includes a microprocessor, memory and IO lines on a single chip [12]. The microcontroller reads the unique identification number inside the tag. The assembly language programs written in the microcontroller receives input signal, manipulates it, and provides necessary control signals to actuator.

Fig. 3 ATmega48 microcontroller

ATmega48 microcontroller is used in this project, since it contain reasonable amount of ROM and RAM. There is no need of adding further memory for our system. Also it has provision for adding extra memory for further expansion. The main features of ATmega48 are mentioned below.

- 4 Kbytes of in system reprogrammable memory.
- 256 bytes EEPROM
- 512 Kbytes internal SRAM
- Two 8-bit timer/counters with separate prescaler and compare mode
- 23 programmable I/O lines
- Operating voltage: 2.7V - 5.5V
- Speed grade: 0 - 10MHz @ 2.7V - 5.5V

2.4 DC Gear Motor

In this project, DC gear motor is used as actuator in the proposed security system. A door along with locking system is driven by DC Gear motor. DC Gear motor acts as actuator, which is able to open and close the door in real-time. The RFID reader detects tag in real-time and open door automatically and closes it again after a specific time interval. DC Gear motors from Precision Microdrives not only offer the variable speed and torque control required in each of these applications. Some key features of the DC motor we used are mentioned below.

- Body Diameter: 12 mm
- Body Length: 25 mm
- Gear Ratio: 29.5:1
- Gearhead Type: Spur
- Typical N/L Current: 23 mA
- Typical PowerConsumption: 925 mW
- Rated Voltage: 12 V
- Rated Torque: 5 mNm
- Min. Rated Speed: 470 rpm

Fig. 4 DC gear motor

2.5 LCD Display

Definition of LCD come from the name "Liquid Crystal" itself. It is actually a combination of two states of matter – the solid and the liquid. They have both the properties of solids and liquids and maintain their respective states with respect to another. Solids usually maintain their state unlike liquids who change their orientation and move everywhere in the particular liquid. The liquid-crystal display has the distinct advantage of having low power consumption than the LED. It is typically of the order of microwatts for the display in comparison to the some order of milli watts for LEDs. Low power consumption requirement has made it compatible with MOS integrated logic circuit. Its other advantages are its low cost, and good

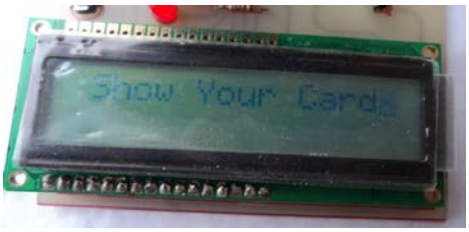

Fig. 5 LCD Display

contrast. The main drawbacks of LCDs are additional requirement of light source, a limited temperature range of operation (between 0 and 60° C), low reliability, short operating life, and poor visibility in low ambient lighting, slow speed and the need for an ac drive.

3 Working Principle of the Proposed System

The Schematic diagram of the working principle of the proposed system shown in Fig. 6. Firstly, RFID reader emits radio waves to obtain identifying information from the tag. The RFID reader retrieve the information contains by tag as it come in the range of 50 millimeters from reader. Secondly, the tag responds by sending back its signals to the reader which is now acting as receiver. Then, RFID Reader converts radio waves returned from the RFID tag into a form that can be passed on to microcontrollers, which can make use of it. Microcontroller then verifies the tag information with the information that was programmed in it. Finally, once the tag information verified, the system generates a control signal through parallel port which controls the opening and closing of door by means of actuator (DC Gear motor). The time gap between the opening and automatically closing the gate is four seconds.

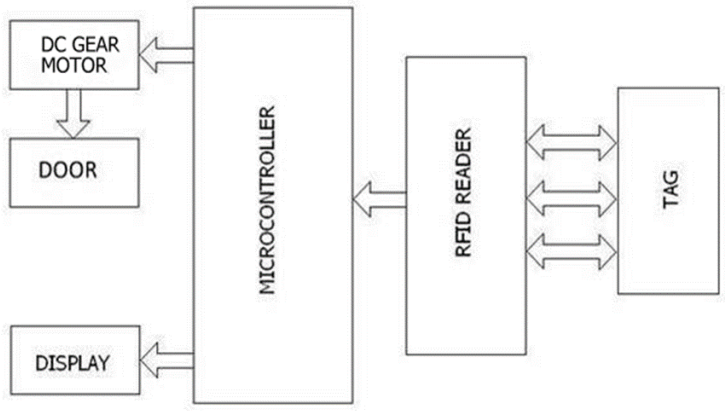

Fig. 6 Block diagram of the automatic security system of door

4 Design of the proposed Security system

4.1 RFID Circuit Diagram

Figure 7 shows the circuit diagram for RFID module circuit board. The circuit contains power source connection to deliver power to microcontroller chip. The circuit also contains RFID reader port connection and pin combination for motor driver circuit board. The circuit has LEDs, push button connection, resistors, capacitors, LCD display board connection with microcontroller chip etc.

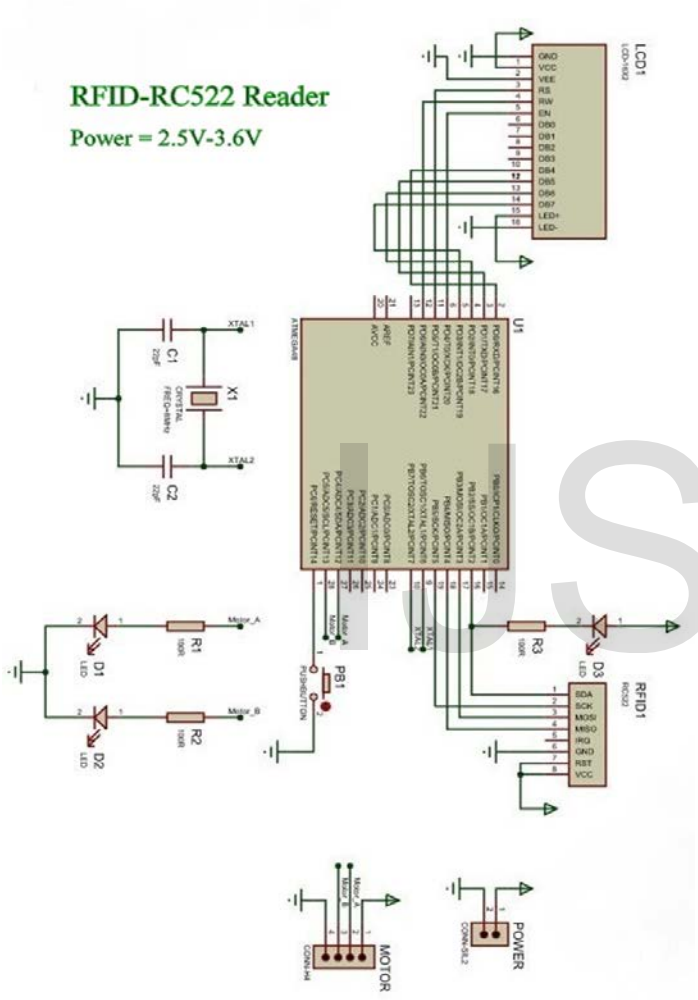

Fig. 7 Circuit diagram for RFID module.

4.2 Motor Driver Circuit Diagram

The motor driver circuit diagram shown in Fig. 8 which has power source connection, dc motor is connected directly to motor driver circuit, the diagram also has capacitors, resistors, pin combination for RFID circuit etc. Also, Fig. 9 shows the combined circuit which contains all of the components of the circuit combination.

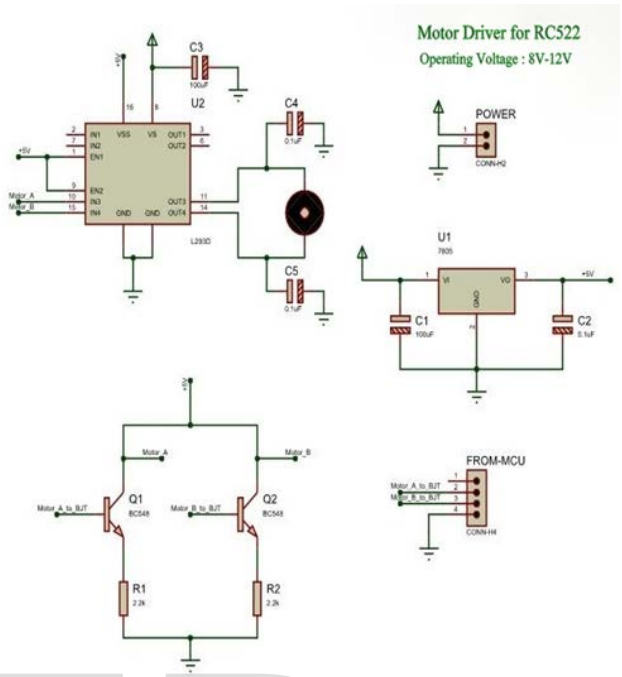

Fig. 8 Motor Driver Circuit Diagram

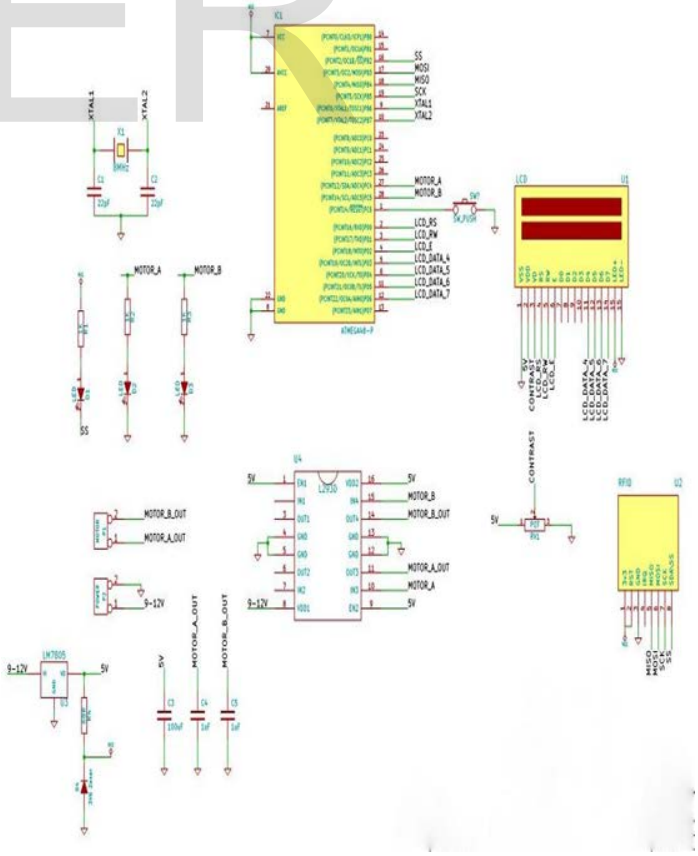

Fig. 9 Combined circuit diagram of the proposed system

5 EXPERIMENT

5.1 Experimental setup

5.1.1 Construction of RC522 PCB (Printed Circuit Board)

Fig. 10 shows the main board of RFID module RC522. The display is placed on the board as shown in this figure. The blue wire from the display is connected with a regulator that regulates the contrast of the LCD display. At the upper left corner there are four pins to connect with the motor driver PCB. The black pin-port at the upper side of the board is the RFID reader port. Here the reader is placed according to the pin combination.

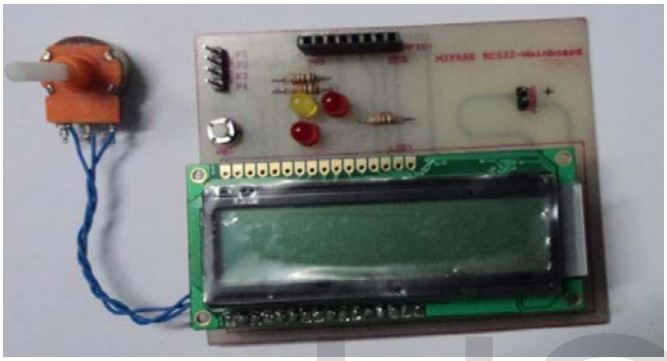

Fig. 10 RC522 Printed Circuit Board

5.1.2 Connection between RFID PCB and Motor Driver PCB

The Fig. 11 shows the connection between the RFID main board and the motor driver circuit board. In the picture at the upper right corner the small black board is the motor driver PCB. There are two connections between the both PCBs. The two pin wire is the power connection and three-pin wire connecting the PCBs makes the data connection for microcontroller. The power source is the battery which is directly connected with motor driver circuit. The gear DC motor is connected also with the motor driver PCB and it is to use as actuator. The microcontroller placed on the RFID circuit sends the signal to run the motor. After receiving signals from microcontroller the motor driver runs to open or close the door.

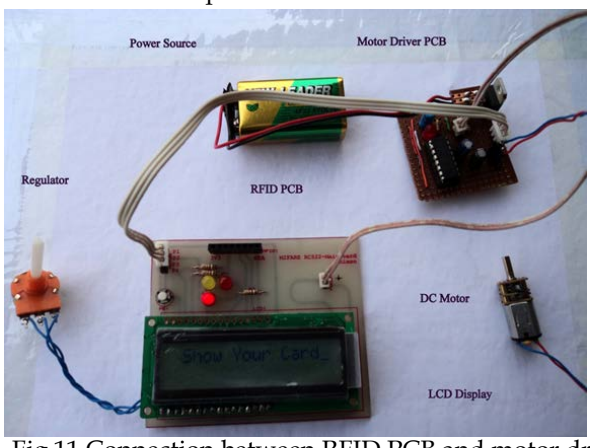

Fig.11 Connection between RFID PCB and motor driver

5.1.3 Construction of Door

The construction of a prototype door has been done as required. The DC motor driver is connected to the door. The mechanism is when the microcontroller receives the correct identification number from the tag it sends the programmed signal to actuator DC motor. Then the DC motor drives to open door and closes automatically after a while. The prototype of a door is shown in Fig. 12.

Fig. 12 Construction of Prototype door

5.1.4 Complete setup of the proposed system

The total arrangement of the proposed system is made by connecting the two PCBs with the door by means of DC motor. The complete arrangement of the components of our proposed system is shown in Fig. 13.

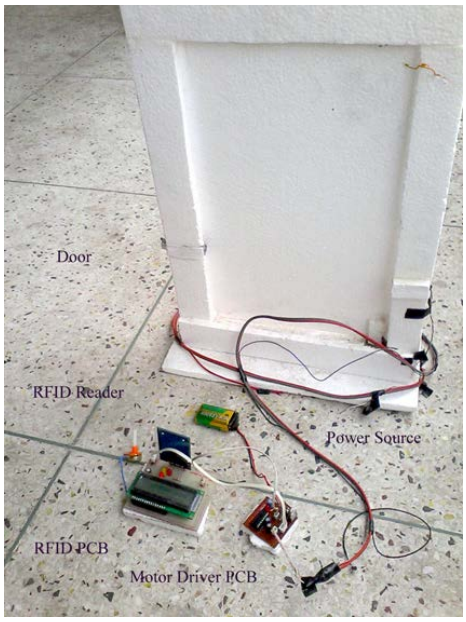

Fig. 13 Complete setup of the propsed system

5.2 Experimental Results

5.2.1 Opening and Closing Door

There are two types of RFID tags used in this project. One is blue tag and the other one is white in color. Blue tags is named them as Blue and White correspondingly and this has been set in the program in microcontroller. When the blue tag is held within 50mm of the RFID reader then the gate has been opened showing in the LCD display "Hello Blue, opening gate" which is shown in Fig. 14 and 16. For the same action of white tag, gate has been opened and LCD display has showed "Hello White, opening gate" which is shown in Fig. 15 and 17.

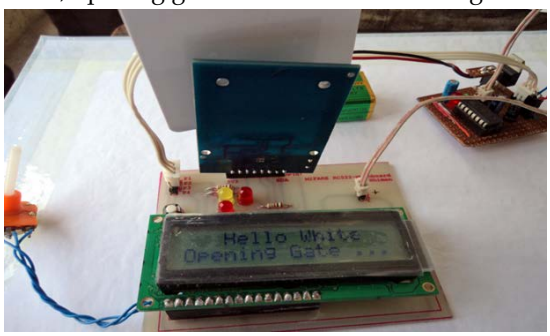

Fig. 14 Diplay messeage for white tag

Fig. 15 Display message for blue tag

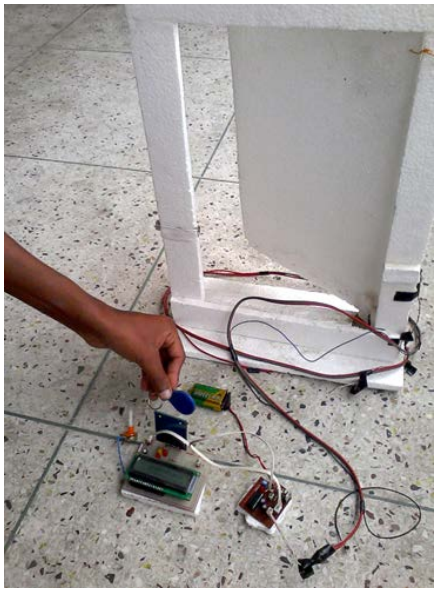

Fig. 16 Door opening on showing RFID tags

The Fig. 16 shows the opening of door for both two tags and after four seconds of opening the door it has been automatically closed. The time gap has been set in program as four seconds so that the command of microcontroller for opening and closing is operated between four seconds.

The status of the proposed system door for different tag distance is examined which is shown in Table 1 and success rate for the door opening under the designed reader range is shown in Table 2.

Table 1. The status of door with various tag distance

Distance between RFID reader and tag	Status of door
7cm	Not opening
6cm	Not opening
5cm	Opening
4cm	Opening

Table 2. Success rate of door opening

Trial	Response from door after showing tag within range(5cm)
1	Yes
2	Yes
3	Yes
4	Yes

6. Conclusions

The design and construction of the propoed security system is successfully implemented using RFID technology. One of the objectives of this project was to compare the cost of the proposed system with the existing access control system. RFID based accesss control system which is constructed costs only about 2000 Tk or about 30$ which is very much cheaper then the existing security system which costs about 100-400$. Therefore proposed security system achieved an impressive range of 5cm using passive RFID tags while keeping the cost of the complete system under 30$.

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