Microcontroller Based Digital Door Lock Security System Using Keypad

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Abstract **- This research paper presents a microcontroller based digital door lock security system using keypad which will provide complete security solution to lives and properties at homes, schools and offices. The security system contains a 4X4 keypad input unit for entering the Personal Identification Number (PIN) and a display unit in form of Liquid Crystal Display (LCD) for visual display of information. It also contain a servo motor that serves as a switching for locking and unlocking the door and a programmed microcontroller that processes the input information and take appropriate action. When a user enters a PIN into the security system installed at any entrance, the system captures the PIN and compares it with the stored PINs for a match. If the captured PIN matches with any of the stored PINs, access granted is displayed on the LCD and the door opens; otherwise, access denied is displayed on the LCD and the door remains closed. For change of PIN, the user presses # button then the system asks for current PIN and matches it with stored PINs for a match. If a match was found, the user will be asked to enter the new PIN twice, else the user is asked for the current PIN again. The system recorded 100% success rate (SR) access granted to registered users and 100% failure rate (FR) for non-registered users. It is also system is cheap, affordable, small and relatively easy enough to install with just a couple of steps.**

Keywords**— Security, Servo, PIN, Keypad, Access, Microcontroller, LCD**

I. INTRODUCTION

It should be noted that the rapid growth in technology makes the world a global village and has gone a long way in protecting lives and properties. Nevertheless, this growth in technology has brought much development as well as an increasing rate of crime, attacks by thieves, vandals and intruders. This therefore calls for the need of improving the modern security systems in homes, offices and other buildings for the protection of lives and properties [1].

With a critical comparative analysis of the security systems between Iceland and Nigeria, it is noted that Iceland encourages the use of code locks for the security of lives and properties for most offices and homes. As a result, it greatly reduced the rate of crime, thieves and intruders making them safest country (ranks 1st) to live with safety index of (95.3%) while Nigeria ranks 141 with safety index of (34.5%) [2]. The lower rate for the use of code locks in Nigeria explains the reason for the high crime rate compared to other countries like Iceland that has a higher rate in the use of this service. The simplicity in the use and a well structured control unit is of prime importance. Therefore, the idea of implementing this system in buildings in the less developed countries improves the security level.

In this research paper, the design of a simple digital door lock is demonstrated considering all the components and their different functions and importance. Is also analyzes the disadvantages and advantages of using digital door lock. The simplicity of the system on both the hardware and the software makes it easy and preferable for the security of lives and properties in Nigeria.

II. LITERATURE REVIEW

N.H. Ismail et al [3] prototyped an Android-based home door locks application using Bluetooth technology. The system consists of Android App, Bluetooth model, Arduino microcontroller, and an electromagnetic (EM) lock. The author designed an Android Apps called Lock It to allow the user to lock and unlock the door. Once wireless communication between Smartphone Bluetooth and Bluetooth module is established through a pairing process, user's key selections are sent as radio frequency (RF) signal to the main controller board installed at the door. Arduino Uno microcontroller is used to interpret key selections and determines whether to release electromagnetic (EM) lock or not.

The developed system was able to successfully lock and unlock door wirelessly which can help disabled people to lock and lock the door wirelessly using Android Smartphone. A small inconvenience of this new technology is that you have to launch the app every time. It's not as simple as having your phone on your body and merely walking by the card reader [4].

Author Subhankar et al [5] in his paper represents a finger print recognition biometrics system based on real time embedded system which will provides a complete security solution lives and properties. Fingerprint recognition is carried out by a biometric fingerprint scanner that is connected to Arduino microcontroller that validates the authentication. The system stores the finger print of authorized users and access is granted to only users whose fingerprints are stored in the system while access is denied to others not stored in the

system. If the user's fingerprint has a positive match, the door will open otherwise the GSM module gets triggered and the system admin gets a SMS and the buzzer connected will be initiated to alert the security personnel.

The system proves to be secure and accurate method of door access control system, granting access to users whose fingerprint matched to the one stored in the system. However, the system uses lots of components embedded in it making it very expensive compared to such systems in the market [6].

III. SYSTEM DESIGN

The digital door lock system is made up of two important subsystems, which are the hardware subsystem and the software subsystem. The software subsystem is written in C programming languages using Arduino IDE and uploaded to the microcontroller, which commands the functioning of the hardware subsystem. The hardware subsystem contains microcontroller, which helps to incorporate the information from the code to the various hardware parts of the digital door lock. In this project, the Arduino Uno microcontroller and the 4x4 matrix keypad are the two main hardware components used.

System Block Diagram

Figure 1 depicts our digital door lock security system block diagram; it contains a 4X4 keypad, power supply, Arduino Microcontroller, a buzzer, a servo, and an LCD.

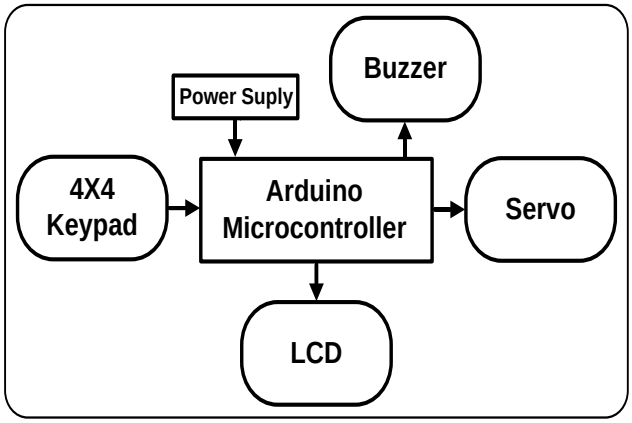

Figure 1: System Block Diagram

Table 1: Hardware Components Description

Item	Mode	Description
Power Supply	Input	Supplies 5V to Arduino Microcontroller which powers all other models
4X4 Keypad	Input	It helps in inputting PIN in the system
Buzzer	Output	Makes audible sound in event of wrong PIN
Servo	Output	Unlock the door or remain locked depending on the PIN entered
LCD	Output	Displays the state of the system and PIN entered.

4x4 Matrix Keypad Overview

The understanding of how the keypad works is simple. The display of figures or letters on the screen of our computers depends on the key of the keypad been pressed. Nevertheless, much understanding is also required from the technical work of switching wires with a supply current (positive +) that is grounded to the other end of the connected wires.

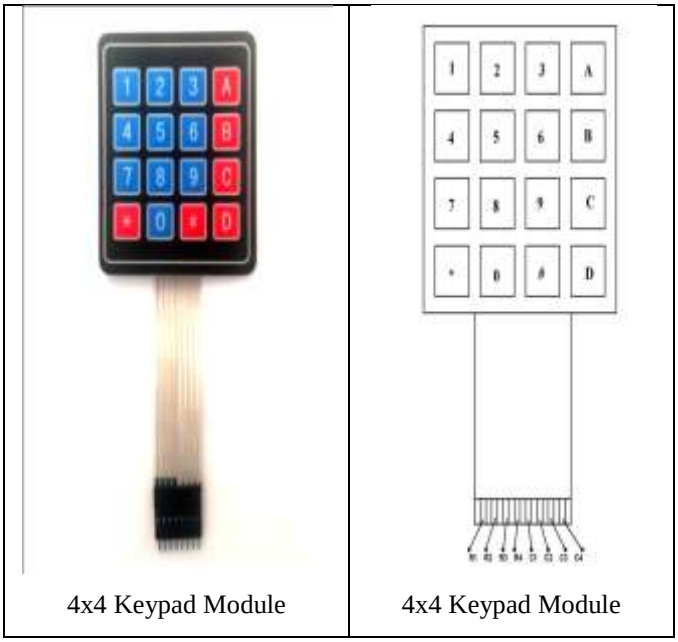

Figure 2: 4x4 Keypad Module

4X4 keypad modules are available in different sizes and shapes. But they all have same principle and pin configuration as shown in **table 2**. It is easy to make 4X4 keypad by arranging 16 buttons in matrix formation as depicted in **figure 2.**

Table 2: 4X4 Keypad Modules Pin Configuration

Row		Column	
Pin #	**Description**	**Pin #**	**Description**
1	Taken out from 1st row	5	Taken out from 1st column
2	Taken out from 2nd row	6	Taken out from 2nd column
3	Taken out from 3rd row	7	Taken out from 3rd column
4	Taken out from 4th row	8	Taken out from 4th column

As given in **table 2**, the 4X4 keypad used this project have eight terminals. In them four are rows of matrix and four are columns of matrix. These 8 pins are driven out from 16 buttons present in the module [7]. Those 16 alphanumeric digits on the module surface are the 16 buttons arranged in matrix formation. The internal structure of 4X4 keypad module is shown in **figure 3.**

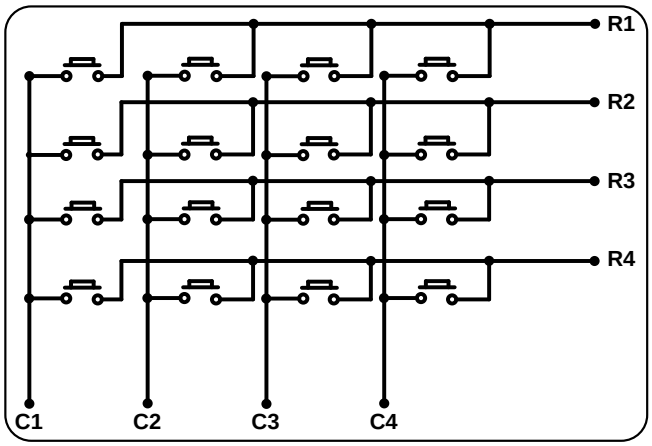

Figure 3: Internal structure of 4X4 keypad module

How the system 4X4 keypad modules works

Understanding how keypad module works is a little complex as 16 keys are connected in matrix formation. The module gives out only 8 pins as a way for the microcontroller to interact with the 16 buttons. How the system microcontroller reads the key pressed after connecting the keypad module to it is illustrated with the following two steps.

Step One

At first, all the keypad module row pins (4 pins) are set to output by the microcontroller at 5V, while module column pins (4 pins) are set to input by the microcontroller to read the high logic. Consider a situation where a button is pressed on the keypad and the button is located in row2 and column3 as illustrated on **figure 4** step one. With the button being pressed, current (*i*) flow from row2 to column3 making 5V to appear at column3 terminal. The microcontroller senses that colomn3 pin is in high state since all column pins ware set as input and low in the initial state. The microcontroller was programmed using the Arduino IDE to remember the change of state (from low to high) of all columns in the keypad module in this case column3.

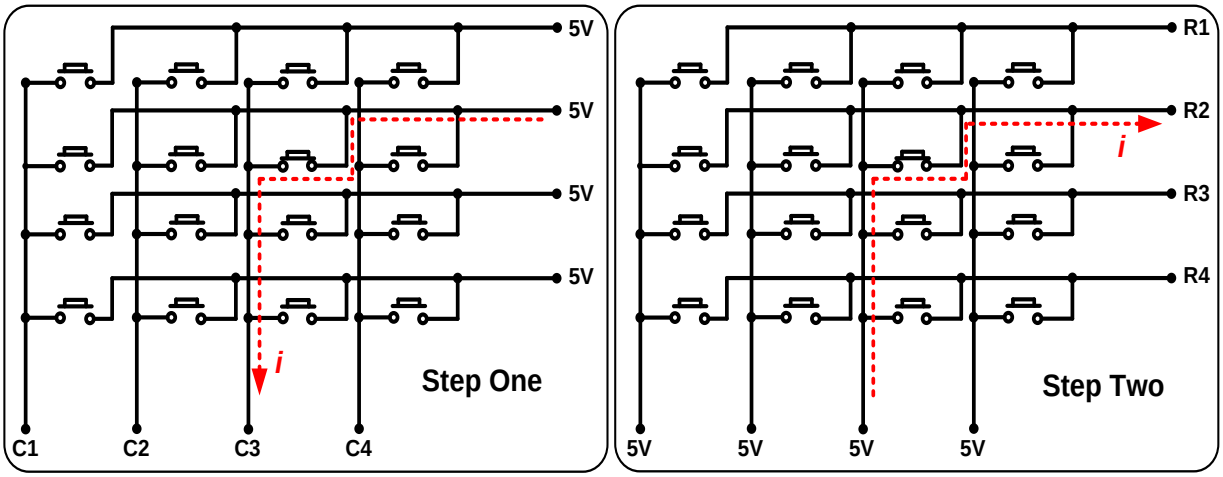

Figure 4: 4X4 keypad module button determination steps

Step Two

In the second step, all the keypad module column pins (4 pins) are set to output by the microcontroller at 5V, while all the row pins (4 pins) are set to input by the microcontroller to read the high logic. This time, current (*i*) flow from column3 to row2 making 5V to appear at row2 terminal since the button pressed is at column3 and row3 as shown in **figure 4** step two. Also the microcontroller senses that row2 pin is in high state since all row pins were set as input and all in low state. Like in step one; the microcontroller was programmed as well to remember the change of state (from low to high) of all rows in the keypad module in this case row2.

Table 3: 4X4 keypad rows and columns change of state unique combinations

Button Pressed	Change of State		Button Pressed	Change of State	
	Row Number	Column Number		Row Number	Column Number
1	1	1	9	3	3
2	1	2	0	4	2
3	1	3	A	1	4
4	2	1	B	2	4
5	2	2	C	3	4
6	2	3	D	4	4
7	3	1	*	4	1
8	3	2	#	4	3

It is known that a button in column3 from step one and row2 from step two was pressed. With that, the microcontroller was able to determine the exact button pressed on the 4x4 keypad module as button 6. With the 4X4 keypad rows and columns change of state unique combinations illustrated in **table 3**, the microcontroller can determine the exact buttons pressed on the module.

Table 4: 4X4 keypad Binary Output

Button Pressed	Binary Output Row				Column				Button Pressed	Binary Output Row				Column			
1	0	0	0	1	0	0	0	1	9	0	1	0	0	0	1	0	0
2	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0	1	0
3	0	0	0	1	0	1	0	0	A	0	0	0	1	1	0	0	0
4	0	0	1	0	0	0	0	1	B	0	0	1	0	1	0	0	0
5	0	0	1	0	0	0	1	0	C	0	1	0	0	1	0	0	0
6	0	0	1	0	0	1	0	0	D	1	0	0	0	1	0	0	0
7	0	1	0	0	0	0	0	1	*	1	0	0	0	0	0	0	1
8	0	1	0	0	0	0	1	0	#	1	0	0	0	0	1	0	0

Table 4 shows the 4x4 keypad output in the form of binary digits [8]. When a button is pressed in the keypad two pins becomes high (one row and one column). With the row and column combination the microcontroller will know the exact button pressed because each combination is unique.

System Flow Chart

The programming of the lock can be illustrated by the simplified flowchart in **figure 5**.

The two charts has a different tasks; **figure 5(A)** is responsible for locking and unlocking the door while **figure 5(B)** show the system PIN reset function

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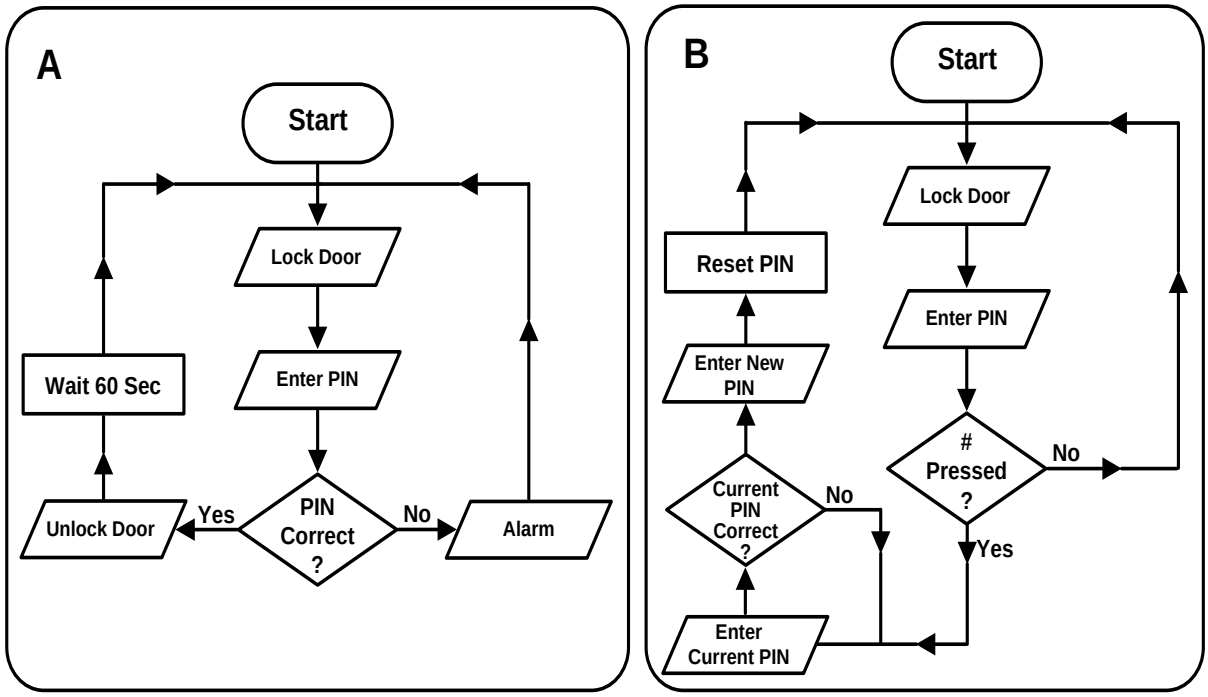

Figure 5: (A) System locking and unlocking flow chart (B) System PIN reset flow chart

System Locking and Unlocking Algorithm Figure 5: (A)

1. Initially, the system is on Lock state.
2. Ask user to enter PIN.
3. The system reads user four digit input from 4X4 keypad.
4. Compare the entered PIN with the stored PIN.
5. If the PIN is correct, the door is unlocked and waits for 60 Sec and lock again.
6. Else, Alarm in triggered and system still remain in lock state.
7. All action of the system in displayed on the LCD.

System PIN Reset Algorithm Figure 5: (B)

1. Initially, the system is on Lock state.
2. Ask user to enter PIN.
3. Checks if # key was pressed, if so.
4. Ask user to enter current PIN and checks if it correct with current PIN.
5. If current PIN is correct, prompt user to enter new PIN.
6. Else, prompt user to correct current PIN again.
7. The system PIN is reset after new PIN is set.

IV. RESULT

In **figure 6**, the user enters four digits PIN through the 4X4 keypad module; the entered PIN will be displayed on the LCD. The system checks if the PIN entered is correct then displays correct PIN and the door will be open else, it will display wrong PIN and the door remains closed. After opening the door, the system waits for 60 seconds before it closes it. Also, changing of the system's PIN can be triggered when # button is presses then old PIN is requested in other to set new PIN.

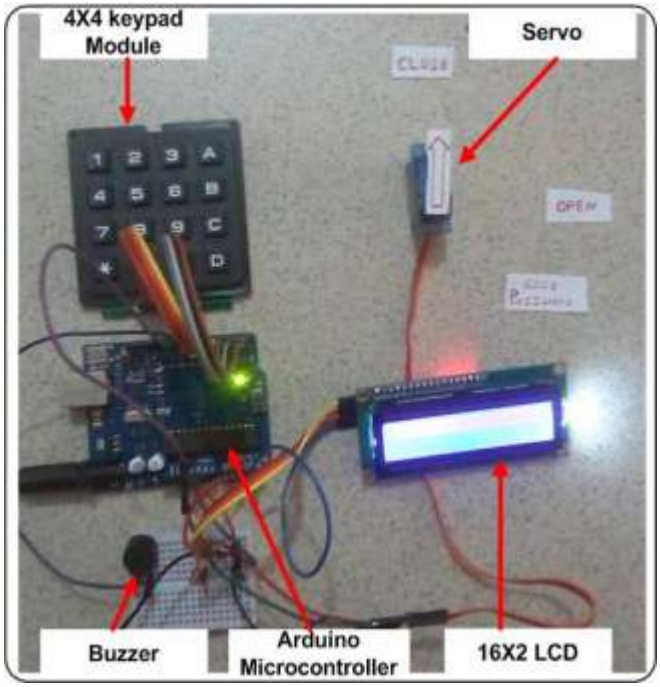

Figure 6: Microcontroller Based Digital Door Lock Security System Using Keypad

Table 5 shows our system's test results where eight tests were conducted, four registered users and four non-registered users with varying number of trials. All four registered users PIN were accepted and access granted while the four users PIN that were not registered failed to gain access in our system.

Table 5: System test Results

Test	PIN	Registered	No of Trial	Successful	Failed
1	6558	Yes	2	2	0
2	9704	Yes	3	3	0
3	4809	Yes	4	4	0
4	8852	Yes	5	5	0
5	7335	No	1	0	1
6	3547	No	2	0	2
7	6970	No	3	0	3
8	6507	No	4	0	4

The system success rate (SR) and failure rate (FR) is calculated using equation **(1)** and **(2)** respectively to determine how much success and failure our system recorded against registered and non-registered users.

$$SR = \frac{S_{Avg}}{ST_{Avg}} \times 100 \qquad \textbf{(1)}$$

Where: S_{Avg} and ST_{Avg} is system successful average and system successful trial average respectively for registered users. It has 100% successful access once current PIN is entered.

$$FR = \frac{F_{Avg}}{FT_{Avg}} \times 100 \qquad \textbf{(2)}$$

Where: F_{Avg} and FT_{Avg} is system failure average and system failure trial average respectively for non-registered users. Access will be 100% denied once unregistered PIN is entered.

Advantages of using digital door lock [9]

Pick proof: Because there is no place for a key with these locks, this prevents break-ins because burglars are unable to pick or 'bump' the lock.

No more keys: You won't have to carry around a large set of keys and they will be less likely to be lost or stolen. Also, if you are a landlord, you don't have to give residents keys or replace them if they lose them.

Disadvantages of using digital door lock [9]

Forgetful: You may be the type that forgets your keys every now and then, and it can also be easy to forget your PIN code for the lock and when you are in a rush to get into the room or building it will be difficult to again access.

Power Failure: Some digital door locks are powered by electricity, if your house or building has a power failure, then the door lock will not work which restricts you from entering the building. Buying a mechanical or battery powered lock will not affect you if there is a power failure.

V. CONCLUSION

The microcontroller based digital door lock security system using keypad is effective in providing security to lives and properties as long as the PIN is not shared with unauthorized person. The system is cheap, affordable, small and relatively easy enough to install with just a couple of steps. Face detection can be an additional feature to operate the door lock system in order to make the system much secured. However, it is important to take cost into consideration when adding such extra feature to system.

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