

Construction of Password Based Security Door-Lock System Using Arduino

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Abstract:

A password-based door lock security system was constructed. The work is a prototype of a working model of a security door lock that is password protected built with an Arduino board. It operates by sending control signals through the Arduino that controls the opening and closing of an illustrative door connected to a servo motor. Accessing and changing various information and settings are done through an electronic and embedded system that allows the user to enter secret pass codes through a 4×4 keypad and a 16×2 LCD display. Once the circuit is plugged to the mains supply, LCD displays the different menu functions and waits for input data from the keypad, the door slides open and close when a valid pass code is entered. The work was designed, developed, tested and found to perform according to design objectives. This work stands not to be the best that can be realized as several modifications and improvements can be incorporated into the design, thus, it is recommended that a PC interface should be incorporated to monitor and control the door unit in real time through a logging system and also a motion sensor should be incorporated to automatically sense presence at the door unit and prompt for password.

Keywords:

Password-Based, Door-Lock, Arduino Board, Security, Embedded System

1. Introduction

Security is a serious problem in Nigeria that calls for a proactive measure by all stakeholders and owners of residential buildings. Buildings in Nigeria (residential and organizational) do not have adequate security systems that monitor intruders and prevent access to sensitive files and products [1]. The increasing rate of crime, attacks by thieves, intruders and vandals despite all forms of security gadgets and locks still need the attention of researchers to find a permanent solution to the well-being of lives and properties of individuals [2]. To this end, this work uses the model of a keypad enabled access and seeks to further simplify and solve the problem of security in places where unauthorized access to organization materials and files are to be prevented.

As technology advances, the need for security also is increased considerably. Security has now become one of the most sensitive issues in organizations and the demand for higher security for storing company databases, files (most times on computers) has become higher [3]. An access control for doors forms a vital link in a security chain. This work consists of a code lock system, an alarm system and a driver circuit to open and close a door.

Using physical keys to lock or unlock the door is the most natural way and everyone is acquainted with it. The physical key is a well-tested and well-known technology, but it also has its flaws [4]. Carrying a large number of keys is a burden and increases the chances of keys getting stolen, misplaced or lost. The goal of this work is to design a door-latch opening using a password that is entered through a keypad. This design will enhance security and will eliminate the need of carrying physical keys. The lock system makes use of a pass code to grant access to authorized individuals. The pass code is chosen by the individual who wants to secure the door and it has the advantage that multiple users can access the door each with their unique user I.D. and Pass Code. In other applications, mobile technology can be utilized to control various units of the houses, industries and also provide security system.

This work exhibits low cost home security system which is widely employed in daily life. The system is designed to prevent the opening of the door by unauthorized persons. The system consists of an illustrative door, a matrix keypad interfaced to an Arduino Uno.

2. Literature Review

There were several research works on intelligent lock system which were group into single protocol and multiple protocols depending on the number of security features. In this section, some of the authors along with the Concept and theory of their works will be highlighted. The advantages, disadvantage and possible improvement (research gap) were enumerated [5].

a. Single Protocol System

Hasan, *et al.* [6] designed a microcontroller-based home security system with GSM technology. A mobile phone is interfaced with the microcontroller through a Bluetooth device in order to control the system. A manual keypad is another way to lock or unlock the system. It is a reliable security system because its bi-modal (parallel) nature, but the system lacks code registration mechanism and the microcontroller program lacks auto generated code routine. Modifications can be made in the design by adding auto-generated code device and making the security features work serially, thus making it multiprotocol device.

Alagu *et al.* [7] designed GSM based authorized access with separate user password door lock/unlock control system. SMS application sends data through GSM Modem. Another GSM device connected at the receiving end which is fed to the microcontroller. The microcontroller initiates a mechanism to open the door through a motor driver interface, if the sent data (password entered by the user) matches with the password stored in the microcontroller. This is simple and will give a good value for investment but the program in the microcontroller lacks auto-generated code routine. Improvement can be made by programming the microcontroller to generate codes.

Ushie *et al.* [8] designed and constructed a prototype security door that can be remotely controlled. A GSM phone set acting as the transmitter and another GSM phone set with dual tone multi-frequency (DTMF) connected to the door motor through a DTMF decoder interfaced with microcontroller unit and a stepper motor. It provides an easy way of controlling a lock without physical contact, but the system lacks true user identification system such as biometric and face detection facility. It also lacks notification and alarming system. An improvement can be made by adding another security feature to increase the security reliability.

Nwankwo *et al.* [9] designed security door that opened by pressing the keys of the assigned codes on the mobile phone, or by entering the corresponding code in a computer set interfaced with the system. The door opens automatically when the right code is entered and remains open for 10 seconds before closing back. The security system is affordable but lack auto-generation code and registration mode mechanism. An improvement can be made by adding biometric, auto-generation and registration mode mechanism.

b. Multiple Protocol System

Ramani *et al.* [10] proposed a vehicle tracking and locking system based on GSM and GPS for car security system. These systems constantly watch a moving Vehicle and report the status on demand. When theft is suspected, the responsible person actuates the sending of SMS to the microcontroller, then microcontroller issue the control signals to stop the engine motor. The system will provide a good security system for vehicle, but is not linked to an online mapping system to give the exact location of the vehicle. The system can be improved further by extending the system with Online Web based monitoring system which should be linked to security agencies.

Hussaini *et al.* [11], designed of a GSM-based biometric access control system. The Fingerprint Scanner automatically scans a finger placed on it, and compares it against its template. If a match exists, "Access Granted" is displayed on the LCD and the door is opened, otherwise, "access denied" is displayed. The GSM module is used in the acknowledgement mode to send an Access Request SMS to the Admin Phone (stating the user's unique 3-digit number), waits for the Admin to acknowledge the request. IF the admin acknowledges the request, the microcontroller opens the door and displays "access granted". If due to network errors or the admin refuses to reply for some time (30 seconds), the system automatically takes it as an access denied. Generally biometric system cannot be hacked easily but the system lacks an automated facility in the acknowledgement mode. This system can be enhanced by adding automated security facilities which acknowledge the user instead of admin personnel.

Raghu and Subhramanya [12], designed and implemented a security lock based on RFID, Fingerprint, Password and GSM technology. The RFID reader reads the ID number from the passive tag and sends it to the microcontroller, if the ID number is valid, then it gives access to the fingerprint scanner otherwise it stops the process, if the fingerprint is matched then the microcontroller sends the password to the authenticated person mobile number then the authenticated person enters the passwords in the keyboard which was already given to the user and that received from the microcontroller. If these two passwords are matched, then the locker will be opened otherwise the microcontroller sends a warning message to the authenticated person mobile number and it will be remaining in lock position. The system is highly secured due the its multiple security features but the program in the microcontroller

does not contain auto-code generation routine. An improvement can be made by making the microcontroller generates codes instead of predetermined passwords.

2.1. Materials

The materials that were used for this construction are Arduino Uno board, 16 x 2 LCD (Liquid Crystal Display), 4 x 4 matrix keypad for Arduino, and Servo motor.

2.1.1. Arduino Uno

This microcontroller is based on the ATmega328P. There are total of 20 pins (0-19) out of which 6 are analog inputs, 14 are digital input output pins (6 pins provide PWM voltage) which can also be used as general purpose pins, a ceramic resonator of frequency 16 MHz, an USB connection, a power jack and a reset button. It has an operating voltage of 5V. It contains everything needed to support a microcontroller. Pictorial description of an Arduino Uno board is shown in Figure 1.



Figure 1. Pictorial Description of an Arduino Uno Board [13]

2.1.2. Keypad

A keypad is a set of buttons or keys arranged on a pad that bear digits, symbols, or alphabetical letters, which can be used as an efficient input device. Keypads are a great way to let users interact with their project. They can be used to navigate menus, enter passwords, and control games and robots. In this construction, a 4X4 matrix keypad was used. This 16 button keypad provided user interface component for the Arduino project. This is programmed using the library <Keypad.h>. (Figure 2)



Figure 2. Pictorial Diagram of a 4 x 4 Keypad.

2.1.3. Liquid Crystal Display (LCD)

A liquid crystal display (LCD) is a flat-panel display that uses the light-modulating properties of liquid crystals combined with polarizers to display information on a screen that become visible when electricity is passed it. A 16×2 LCD will be used in this work. This is programmed using the library <LiquidCrystal.h>. (Figure 3)



Figure 3. Pictorial Diagram of a 16 ×2 LCD.

2.1.4. Servo Motor

A servo motor is a type of motor that can rotate with great precision. It is a rotary actuator or linear actuator that allows for precise control of angular or linear position, velocity and acceleration. The servo motor used in the project is SG90 Micro Servo weighing about 9g. This is programmed using the library <Servo.h>. (Figure 4)



Figure 4. Pictorial Diagram of a Servo Motor.

3. Methods

The block diagram for the password door lock system is shown below in Figure 5.

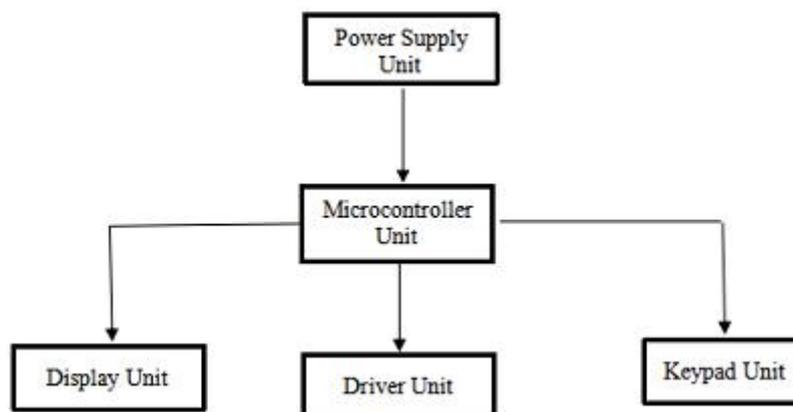


Figure 5. Block Diagram of Password Door-Lock System Using Arduino.

Power Supply Unit

The entire circuit was powered by a standard 5Volts DC power supply since most of the components were digital logic components. Before the power supply unit was designed, the total power requirements of the circuit were analyzed as follows:

- i. The Arduino datasheet specified that the maximum voltage to be 8V and the minimum voltage to be 5Volts.
- ii. The servo motor required 5Volts
- iii. The LCD also required 5Volts to be supplied to its pins

Therefore, the circuit can adequately run on a 5Volts DC supply.

Microcontroller Unit

The Arduino Uno is the central control of the circuit. All other components were interfaced to it. The micro-controller received data and manipulated them according to the code programmed into it. For various results, it outputs from specific pins. The circuit keypad matrix, liquid crystal display (LCD) and motor drive were interfaced to the Arduino Uno board and the pin configuration of the digital input/output was done in the C++ programming language which was then burnt into the micro-controller in the Arduino Uno board.

Driver Unit

In this work, the door was illustrated using a mechanism that will allow a model door to open and close. It involved a servo motor, connected to a mechanism that can be powered to rotate either in a clockwise or anti-clockwise direction.

Keypad Unit

The input keypad allowed the user to enter passwords and act as an interface for the user to communicate with the device. The keypad was matrix arrangement of push-buttons arranged in such a manner that each of the sixteen buttons were enabled any of the external interrupts when depressed. This made the circuit very responsive.

Display Unit

A 16×2 LCD was incorporated to display the message by the Arduino, eight of its pins are data lines (pins 7-14), two are for power and ground (pins 1 and 16), three are used to control the operation of LCD (pins 4-6), and one is used to adjust the LCD screen brightness (pin 3). The remaining two pins (15 and 16) power the backlight.

The flowchart gives a brief idea as to how the project works. Initially the password is known. When the device is turned on, it resets the servo angle to lock the door. Now the user is prompted to enter the password. The user enters the passcode through a keypad which is read by the Arduino. Now the entered password is checked with the known password. If the password matches, then the servo motor deflects and the door unlocks for 10 seconds else the buzzer beeps indicating the invalidity of the password. If the password does not match, after 3 wrong attempts, the system automatically gets locked showing “NO MORE TRIALS ACCESS DENIED”. (Figure 6, Figure 7)

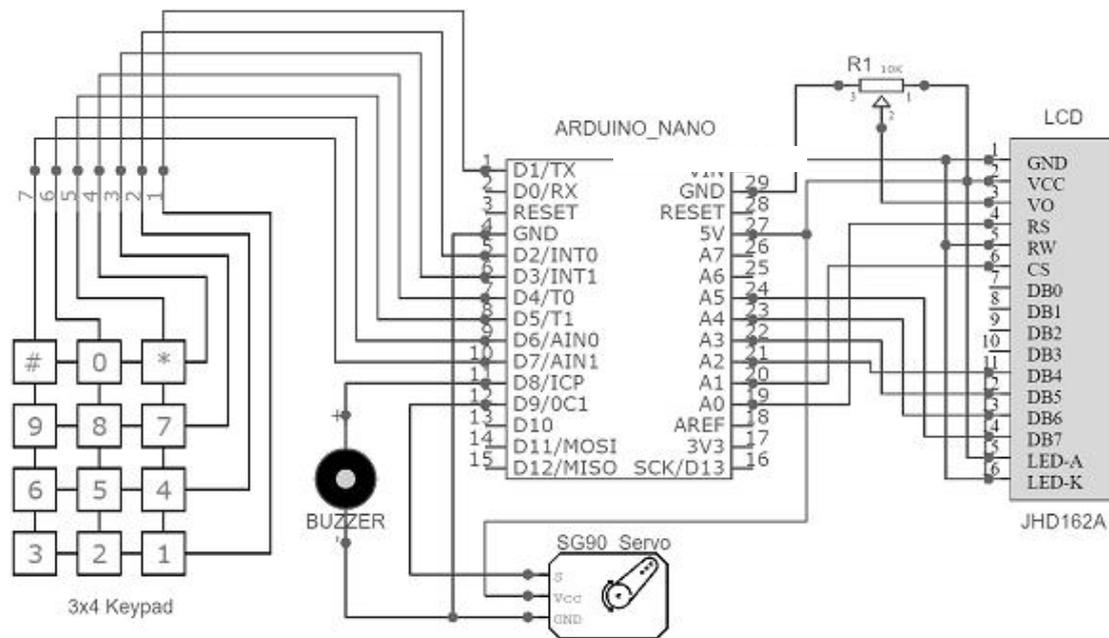


Figure 6. Circuit Diagram of a Password Door-Lock System Using Arduino.

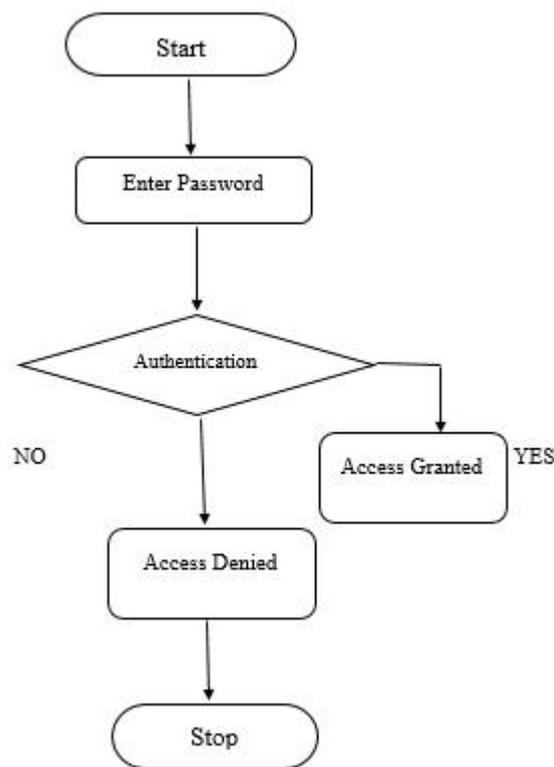


Figure 7. Flowchart of the System.

4. Results

The moment the circuit was powered ON; the name of the system was displayed on the LCD. Then LCD displays the user “ENTER PASSWORD” (Figure 8) as can be shown in the diagram below.



Figure 8. Displaying “Enter Password” for the input of the user.

In the Figure 9 below, the user entered the correct password and the LCD shows “DOOR IS OPEN”, the servo motor deflects thus unlocking the door.

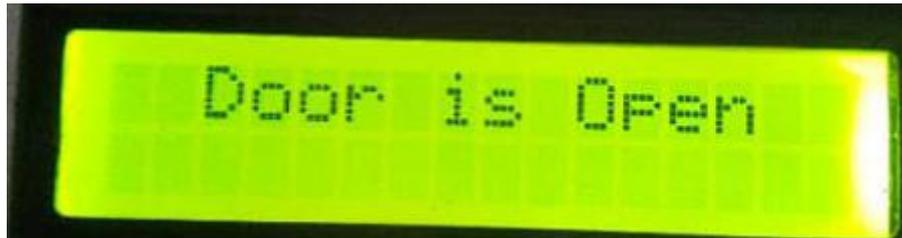


Figure 9. The LCD Response to the Input by the User, thus granting him access.

5. Conclusions

Considering the need for security consciousness, a password based door lock security system was constructed using Arduino. The system serves to mitigate the increasing rate of crime, attacks by thieves and intruders. With this system, the burden of carrying large numbers of keys is eliminated. This work stands not to be the best that can be realized as several modifications and improvements can be incorporated into the design, these include:

- i. Incorporating a PC interface to monitor and control activities at the door unit in real time through a logging system;
- ii. Incorporating a motion sensor to automatically sense presence at the door unit and prompt for password; and
- iii. Provision for rechargeable back-up batteries in case of power failure from the mains supply.
- iv. Adding fingerprint sensor so incase the user forgets the password entry will be allowed for him using fingerprints

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this article.

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