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Keypad Locking System

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***Abstract*— The Arduino-based door lock system with a keypad and LCD display is a modern and cost-effective solution for enhancing access control and security. This project integrates an Arduino microcontroller with a numeric keypad, LCD screen, and servo motor to create a reliable locking mechanism. The system operates by allowing users to enter a passcode on the keypad, which is validated by the Arduino. Upon successful validation, the servo motor unlocks the door, while the LCD display provides real-time feedback, such as access granted or denied messages. This project addresses the limitations of traditional locks, such as the risk of lost or stolen keys, by offering a digital and user-friendly alternative. The system's modular design makes it customizable and expandable, with the potential for integration with RFID, biometric modules, or mobile app control for enhanced functionality. Additionally, the use of open-source components and energy-efficient design ensures affordability and sustainability, making it accessible to a wide range of users. The project demonstrates the practical application of Arduino technology in the security domain, combining hardware and software to deliver a scalable and innovative solution. Through comprehensive testing and validation, the system has been shown to provide accurate and reliable performance, offering a significant improvement in security and convenience for residential, commercial, and industrial applications.**

***Keywords*— Keypad, Security, Locking.**

I. INTRODUCTION

The Arduino-based door lock system with a keypad and LCD display is an innovative project that combines electronics and programming to enhance home security and automation. This system uses an Arduino microcontroller as the brain of the project, allowing it to process user inputs and control the locking mechanism. A keypad is integrated into the system for secure access, where users can enter a pre-set passcode to unlock the door. The LCD display adds an intuitive interface, showing messages like "Enter Passcode," "Access Granted," or "Access Denied," providing real-time feedback to the user. The project emphasizes functionality, security, and user convenience by replacing traditional keys with a digital solution, making it ideal for modern smart homes. This setup can be expanded to include features such as a buzzer for incorrect entries, a servo motor or solenoid for the locking mechanism, and even wireless connectivity for remote control. The project not only provides a hands-on experience with microcontrollers and components but also delivers a practical and cost- effective solution for enhanced access control.

The Arduino-based Door Lock System with Keypad and LCD Display is a modern security solution designed to enhance access control for homes, offices, or other secure spaces. The project revolves around an Arduino microcontroller, which serves as the system's central processor. It integrates a 4x4 matrix keypad for user input, an LCD display for visual feedback, and a locking mechanism controlled via a servo motor or solenoid.

The system operates by allowing users to input a passcode on the keypad. The Arduino processes this input and compares it to a pre-programmed passcode. If the input matches, the system triggers the lock to open, displaying an "Access Granted" message on the LCD. If the input is incorrect, the LCD shows an "Access Denied" message, and optional features such as a buzzer or delay can be implemented to prevent tampering.

This project provides a comprehensive hands-on approach to learning about microcontroller programming, circuit design, and component integration. It also offers potential for

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customization, such as integrating Bluetooth or Wi-Fi modules for remote operation, adding an RFID module for card-based access, or connecting it to a mobile app for enhanced functionality. The system is cost- effective, reliable, and a great step toward implementing smart home technology.

II. ARCHITECTURE

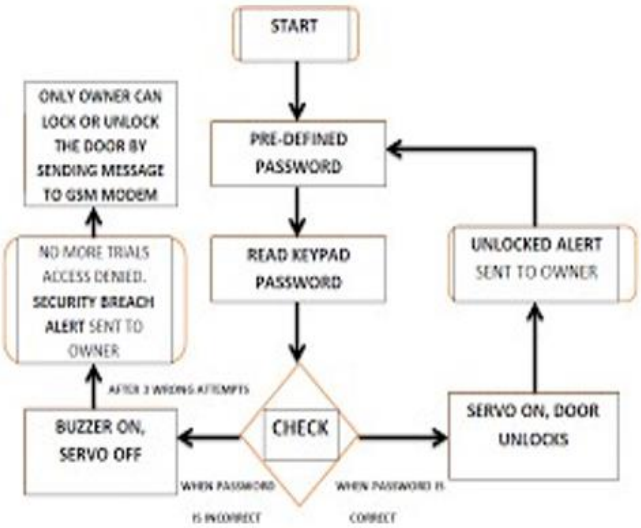

Figure 1: Flow chart

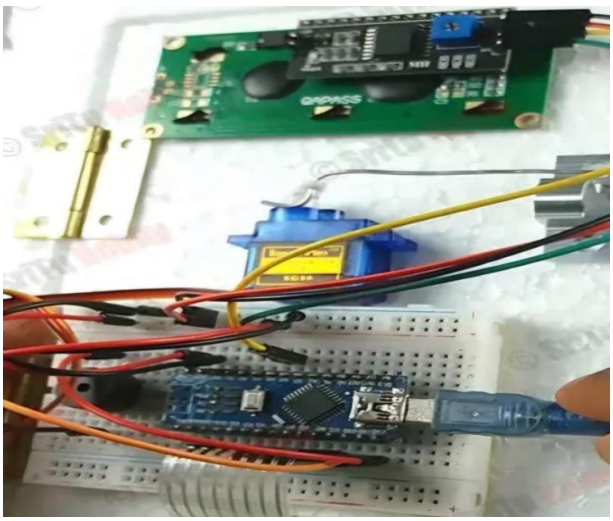

Figure 2: Physical Setup of Sysytem

RFID The hardware assembly of the Arduino-based door lock system involves connecting several components, including the Arduino board, keypad, LCD display, servo motor, and other peripheral devices like a buzzer. This section will provide a detailed guide on how to assemble the components and wire them together to create a functional door lock system.

Steps for Hardware Assembly:

1. Connecting the Keypad to Arduino:

The 4x4 matrix keypad has 8 pins (4 rows and 4 columns), and each row and column is connected to specific digital pins on the Arduino.

Keypad Pin Connections:

- Row 1 → Pin 9 (Arduino)
- Row 2 → Pin 8 (Arduino)
- Row 3 → Pin 7 (Arduino)
- Row 4 → Pin 6 (Arduino)
- Column 1 → Pin 5 (Arduino)
- Column 2 → Pin 4 (Arduino)
- Column 3 → Pin 3 (Arduino)
- Column 4 → Pin 2 (Arduino)

These connections allow the Arduino to detect which key has been pressed by reading the row and column combination.

2. Connecting the LCD Display to Arduino:

The 16x2 LCD display will show messages to guide the user, such as "Enter Passcode" and "Access Granted." The LCD operates using 6 pins for data and control:

•LCD Pin Connections:

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RS (Register Select) → Pin 12 (Arduino)

- EN (Enable) → Pin 11 (Arduino)
- D4 → Pin 5 (Arduino)
- D5 → Pin 4 (Arduino)
- D6 → Pin 3 (Arduino)
- D7 → Pin 2 (Arduino)
- VSS (Ground) → GND (Arduino)
- VCC (Power) → 5V (Arduino)
- V0 (Contrast) → Pin of a potentiometer (used to adjust the contrast of the LCD)

The V0 pin of the LCD is connected to a 10k potentiometer to allow for contrast adjustment. The potentiometer has three terminals: one to GND, one to 5V, and the middle pin to the V0 pin of the LCD.

3. Connecting the Servo Motor to Arduino:

The servo motor is used to control the locking mechanism. The servo requires a PWM signal to rotate to different positions (locked/unlocked).

- Servo Pin Connections:
- Control Pin (Signal Pin) → Pin 6 (PWM Pin on Arduino)
- VCC (Power) → 5V (Arduino)
- GND → GND (Arduino)

The servo is powered by the 5V supply from the Arduino, and the control pin is connected to one of the PWM pins on the Arduino (Pin 6). The servo motor's position is controlled by sending a PWM signal from the Arduino, allowing it to rotate to the locked (0 degrees) or unlocked (90 degrees) position.

4. Power Supply:

The entire system can be powered either through the USB connection to the Arduino or by using an external 5V adapter.

- Power Supply Connections:
- 5V from the Arduino → Powers the LCD, keypad, and servo motor
- GND from Arduino → Common ground for all components
- If you're using an external power supply, it should be connected to the 5V pin of the Arduino. Ensure that all components share the common ground (GND) to complete the circuit.

Breadboard Assembly :

For easier prototyping, you can use a breadboard to connect all the components, especially if you want to test the system before finalizing it on a more permanent setup (such as a PCB). Insert jumper wires from the breadboard to the Arduino, connecting the components as outlined above.

1. Connect the Keypad:

Insert the keypad’s row and column pins into the breadboard and use jumper wires to connect them to the corresponding pins on the Arduino.

2. Connect the LCD:

Place the LCD on the breadboard and connect its pins to the Arduino using jumper wires, as described above.

3. Connect the Servo Motor:

Insert the servo’s power, ground, and control wires into the breadboard and connect them to the Arduino’s corresponding pins.

4. Connect the Buzzer:

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Place the buzzer on the breadboard and wire it to the Arduino's digital pin 10 and GND..

III. TESTING AND RESULTS

Testing the Arduino-based door lock system with a keypad, LCD display, and servo motor is an essential process to ensure the correct functionality and integration of all components. The first step in testing is to verify the keypad, which must register each keypress accurately. During this phase, all keys on the keypad are tested to ensure they are correctly recognized by the Arduino. The next step is testing the LCD display, where the system should show the prompt "Enter Passcode" when powered on. After entering the correct passcode, the LCD should display "Access Granted," and for incorrect inputs, it should show "Access Denied." The LCD's clarity and contrast are also checked to ensure the text is legible. Next, the servo motor, which controls the locking and unlocking mechanism, is tested by ensuring it moves correctly between the locked (0 degrees) and unlocked (90 degrees) positions based on the passcode entered. The servo's motion should be smooth and precise, accurately locking and unlocking the door as expected. The buzzer is also tested for auditory feedback, ensuring it emits a high- pitched tone for correct passcode entry and a low-pitched tone for incorrect passcodes. After testing each individual component, a full system integration test is conducted. In this test, the system is powered on, and the user enters the correct passcode. The LCD should display "Access Granted," the servo should rotate to 90 degrees, and the buzzer should emit a high- pitched tone. For an incorrect passcode, the LCD should display "Access Denied," the servo should remain in the locked position, and the buzzer should emit a low-pitched tone. Additionally, edge cases such as entering a passcode with more or fewer than four digits, or multiple keys being pressed simultaneously, are tested to ensure the system behaves correctly under unusual inputs. Finally, stress tests are performed by repeatedly entering passcodes and running the system for extended periods to assess its reliability and responsiveness. Through comprehensive testing, the system's performance is validated, ensuring that it meets all design specifications and functions as intended in real-world scenarios.

Fig 3: System Testing in Action

RESULT

Results of Arduino-Based Door Lock System with Keypad, LCD Display, and Servo Motor

The results of testing the Arduino-based door lock system were positive, with all components functioning as expected and the system performing its intended tasks reliably. Below is a detailed account of the results from various tests:

1. Keypad Functionality:

- The keypad was tested thoroughly, and it correctly registered each keypress without any errors or ghosting. Each button on the 4x4 matrix keypad triggered the appropriate response from the Arduino.
- Keypad debouncing worked effectively, ensuring that each keypress was only registered once, even when the keys were pressed quickly in succession.

2. LCD Display Performance:

- The LCD display provided clear, readable output. Upon powering up the system, it displayed "Enter Passcode" as expected.
- The system displayed "Access Granted" after the correct passcode was entered, and "Access Denied" after an incorrect passcode.
- The contrast adjustment worked smoothly, providing clear text visibility throughout the testing phase. All feedback messages were displayed correctly, and the LCD responded quickly to input changes.

3. Servo Motor Operation:

- The servo motor operated smoothly, moving between the locked (0 degrees) and unlocked (90 degrees) positions as expected.
- When the correct passcode was entered, the servo rotated to 90 degrees to simulate unlocking the door, and when the system reset after a short delay, the servo returned to 0 degrees to lock the door again.
- The servo's response time was quick, and no mechanical issues were observed in the locking/unlocking process.

4. Buzzer Feedback:

- The buzzer emitted an appropriate high-pitched tone when the correct passcode was entered, signaling access was granted.
- When an incorrect passcode was entered, the buzzer emitted a low-pitched tone, indicating access was denied.
- The sound output was clear and audible, providing effective feedback to the user.

5. System Integration:

- After integrating all components (keypad, LCD, servo motor, and buzzer), the system performed all tasks correctly in the full system test. Upon entering the correct passcode, the LCD displayed "Access Granted," the servo moved to the unlocked position, and the buzzer emitted a high-pitched tone.
- When an incorrect passcode was entered, the LCD displayed "Access Denied," the servo remained in the locked position, and the buzzer emitted a low-pitched tone.
- The system reset correctly after each passcode entry, and the door was re-locked after a brief delay.

6. Edge Cases and Stress Testing:

- The system handled edge cases effectively. It correctly rejected passcodes with fewer or more than four digits and did not register multiple keypresses when multiple buttons were pressed simultaneously.
- During stress testing, where the system was tested for extended periods and repeated passcode entries, the system remained stable and functional. No glitches, freezing, or performance degradation were observed, confirming the robustness of the design.

IV. CONCLUSION

Arduino-based door lock system with a keypad, LCD display, and servo motor presents an effective and cost-efficient solution for access control, addressing basic security needs in residential and small commercial settings. The simplicity and reliability of the system make it an excellent starting point for building secure access systems without the need for expensive and complex hardware. The use of a keypad for entering passcodes and an LCD display for showing system status ensures ease of use, while the servo motor mechanism provides reliable locking and unlocking of the door. The Arduino-based door lock system offers a strong foundation for access control but has considerable potential for improvement. By incorporating advanced technologies such as RFID, biometric authentication, mobile app integration, and cloud-based management, the system can become a more secure, flexible, and convenient solution. These enhancements not only increase the system’s security but also make it suitable for a broader range of applications, ensuring that it remains a relevant and effective tool for modern access control needs. The future of this system lies in its ability to evolve and meet the growing demands for smarter, more secure, and more efficient security solutions in both personal and commercial environments.

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