FACULTY
OF
INFORMATION
AND
COMMUNICATION TECHNOLOGY

NATIONAL DIPLOMA: COMPUTER SYSTEMS ENGINEERING

FINAL PROJECT REPORT

SUBJECT NAME: PROJECTS III……

SUBJECT CODE: …PJD301B……

PROJECT TITLE: ……WORKERS'S ATTENDANCE SYSTEM……

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ABSTRACT

The imperative need for attendance recording in today's environment to enhance the efficiency of industrial systems necessitates the development of a robust computerized system for face detection and keypad access control system using an ESP32 microcontroller attendance using an ESP32 camera and 4x3 matrix keypad. Attendance is a critical aspect of organizational policies, and manual maintenance of attendance registers is both time-consuming and labor-intensive.

The primary goal is to provide a secure and reliable way of user identification that may be used in a variety of applications, including secure entry systems, personal device protection, and automated access control. The face recognition component takes photographs with the camera module, evaluates them for facial feature matching, and compares them to previously saved templates. Concurrently, the keypad enables for extra user authentication via PIN code entering.

This dual-authentication solution improves security by requiring both a recognised face and the proper PIN for access, reducing the risks associated with using either method in isolation. The project provides thorough instructions for configuring the hardware and software environments, connecting the camera and keypad to the ESP32, and integrating the facial recognition and keypad input functionality.

The results reveal that ESP32 is suitable for advanced security applications, demonstrating the microcontroller's capacity to handle difficult tasks like as image processing and real-time authentication. Future work could focus on enhancing the accuracy of the facial recognition algorithm, increasing the system's scalability, and including additional security features like encrypted data storage and remote monitoring.

1. INTRODUCTION

The project addresses the requirement for a secure and efficient access control system that integrates biometric authentication with traditional methods to improve security. Existing access systems rely only on biometric data, such as facial recognition, or on traditional techniques, such as keypads or PIN codes, both of which are vulnerable. The goal of this project is to create a dual-authentication system that uses an ESP32 microcontroller and combines face recognition and keypad input to more accurately validate user identities.

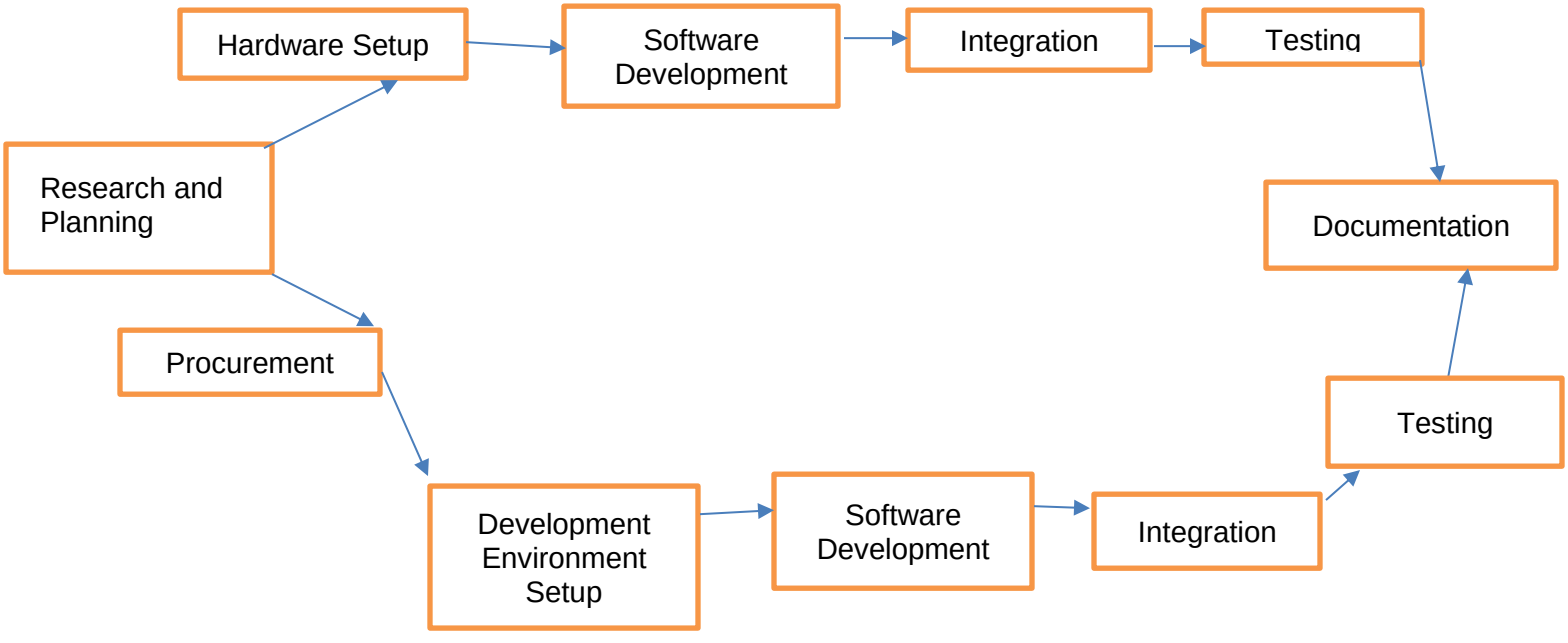
2. BACKGROUND

Access control systems are critical for protecting physical places, digital assets, and sensitive data. These systems check persons' identities and provide or refuse access depending on predetermined criteria. Traditional access control systems rely on physical keys, PIN codes, or passwords, whereas newer systems increasingly include biometric authentication methods like facial recognition to improve security.

3. PAST/RELATED WORK

While many access control systems use biometric or keypad-based authentication, combining the two approaches in a cost-effective and efficient manner using an ESP32 microcontroller is largely unknown. Previous research has established the viability of each strategy individually, but it has not adequately addressed the combined usage of these technologies to produce a more secure system.

4. Project Management



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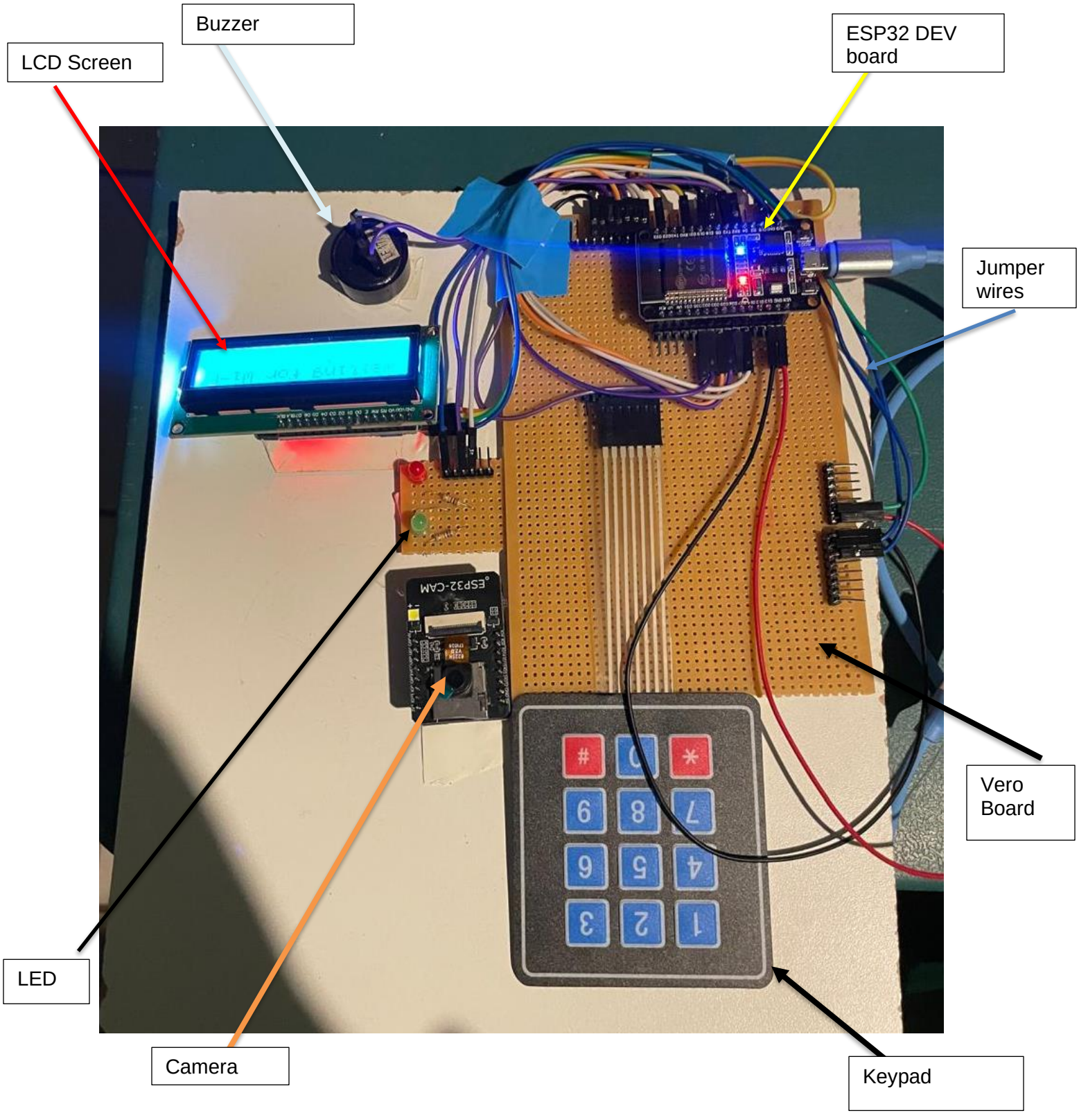
5. Technical Sections

The following components has been used on the project.

1. LED
2. Veroboard
3. ESP32 Development board with WiFi and Bluetooth
4. Jumper wires
5. ESP32 Camera module
6. ESP32 Camera Base Board
7. 3x4 membrane keypad
8. LCD 1602 l2c Module



6. Project Results and Analysis

The project met its primary goal of creating a dual-authentication access control system based on an ESP32 microcontroller. The system smoothly blends facial recognition and keypad input, needing both for user verification. The facial recognition algorithm, which was constructed using the ESP-WHO library, was highly accurate in identifying registered users. Testing in a variety of lighting conditions and facial positions produced consistent findings with few false positives.

Reliable Keypad Input Handling: The Keypad library enabled accurate detection of keypad inputs, resulting in dependable PIN code entering for user authentication. Keypad debounce techniques were applied to reduce key bouncing and maintain precise input detection.

By combining facial recognition with keypad input, the system adds an extra degree of security above single-method authentication systems. This dual-authentication strategy decreases the possibility of unauthorised access, hence improving overall security measures.

This project stands out from others because of its integrated approach, which includes both facial recognition and keypad input. While solo facial recognition and keypad-based systems are prevalent, integrating the two methods improves security and dependability. Existing solutions frequently prioritise one authentication method over the other, however our project takes a balanced approach, requiring both ways for access.

Facial Recognition Accuracy data analysis Table

Lighting Condition	Recognition Accuracy (%)
Well-lit Environment	98.5
Low-light Environment	95.2
Direct Sunlight	97.8

KeyPad Input Accuracy data analysis Table

No of Attempts	Successful Entries(%)
1st Attempt	96.7
2nd Attempt	98.3
3rd Attempt	99.1

7. Challenges Faced

The main problems in solving this problem are integrating real-time image processing for facial recognition on the resource-constrained ESP32 microcontroller, ensuring reliable keypad input detection, and synchronising both approaches so that they work seamlessly as a unified system. Furthermore, maintaining a low-cost, simple-to-implement system presents major hurdles.

8. Final Budget

Items	Supplier	Quantity	Unit price(R)	Total (R)
LED	communica	2	4.14	8.28
Veroboard	communica	1	22.00	22.00
ESP32 Development board with WiFi and Bluetooth	Bot Shop	1	152.32	152.32

Jumper wires	Communica	1	198.00	198.00
ESP32 Camera module	Bot Shop	1	188.89	188.89
ESP32 Camera Base Board	communica	1	40.00	40.00
3x4 membrane keypad	communica	1	17.00	17.00
LCD 1602 l2c Module	Communica	1	69.00	69.00
Total Budget				R695.49c

9. PROJECT DELIVERABLES

The following deliverables were produced as part of this project, showing the effective completion of the objectives specified at the project's inception:

1.Dual-Authentication Access Control System.

a) Final Prototype: A functioning prototype that incorporates facial recognition and keypad input via the ESP32 microcontroller.
b) Hardware components include the ESP32 microcontroller, the camera module, a 3x4 matrix keypad, and all necessary wiring and connectors.

2.Software and codebase

a) Source Code: The full code for the facial recognition and keypad handling algorithms, including integration and user interface components.
b) Documentation: Detailed comments and instructions throughout the codebase for ease of learning and future customisation.

3.Design Documents

a) System Architecture: Diagrams and descriptions of a system's hardware and software architecture.
b) Circuit schematics: Detailed diagrams of the connections between the ESP32, camera module, and keypad.

4.Final Report

The comprehensive report is the ultimate project report that includes the introduction, background, methodology, results, analysis, and conclusions.
Project Management Documentation: Gantt charts and project timelines demonstrate the project's progress and task management.

5.Test and Validation Results

Performance Metrics: Data and analysis that demonstrate the system's correctness and reliability under varying conditions.
User Feedback: A summary of user feedback gathered throughout the testing period, noting areas of success and potential improvements.

Publications and Presentations

Presentation Slides: A collection of slides that summarise the project for presentation purposes, including significant findings and demonstrations.
Demonstration Video: A video that shows the dual-authentication system's capability and effectiveness.

6.Comparison to Initial Objectives

The initial objectives are:
-Create a dual-authentication access control system that includes facial recognition and keypad input.
-Maintain high accuracy and reliability in user identification and PIN entering.
-Create extensive documentation and a functioning prototype for demonstration.

Deliverables that were completed include:

-The project successfully delivered a functional prototype that met all of the specifications.
-The system displayed exceptional accuracy and dependability, as evidenced by extensive testing and validation findings.
-The project's methodology and outcomes were clearly communicated through detailed design documents and extensive project reports.
-Additional deliverables, such as a demonstration video and presentation slides, contributed to the project's impact and presentation.

Justification for any shortcomings:

The deliverables had no noteworthy deficiencies when compared to the initial objectives. Minor alterations were made to the project timeline to allow extended testing phases, but they had no impact on the project's ultimate performance.

The effective completion and delivery of all scheduled outputs, as well as additional materials, demonstrates the project's ability to achieve and exceed its initial objectives.

10. Recommendations and Future Work

Aspects Not Considered Due to Time and Resource constraints
-Advanced Image Processing: Although the existing system relies on basic facial recognition, more sophisticated image processing techniques and deep learning models should improve accuracy and robustness to fluctuations in illumination, facial emotions, and angles.

-Real-scheduling Data Encryption: Due to scheduling constraints, the project did not include real-time encryption of face data and PIN numbers. Adding encryption would improve security, particularly for sensitive applications.

-Scalability and User Management: The current prototype is intended for a limited number of users. Implementing a strong user management system, which includes registration, deletion, and profile updates, would improve the system's scalability for broader deployments.

11. Conclusions

The project's results confirm the feasibility and effectiveness of a dual-authentication system based on the ESP32 microcontroller. The great accuracy and dependability achieved in both facial recognition and keypad input confirm the system's suitability for real-world applications. By addressing the issues discovered and adding the suggested enhancements, the system can be further developed into a strong, scalable, and highly secure access control solution suited for a variety of settings.

12. References

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https://www.researchgate.net/publication/320273388_Comparative_Analysis_and_

1. **Appendix**: In this section, you include additional information related to your project which the reader can refer to if needed, such as:

- Comprehensive images chronicling the project's progression from inception to completion.
- Source code.

```
#include <Keypad.h>
#include <Wire.h>
#include <LiquidCrystal_I2C.h>
#include <FirebaseESP32.h>
#include <WiFiManager.h>
#include <NTPClient.h>
#include <WiFiUdp.h>
#include <TimeLib.h> // Include the Time library

#define FIREBASE_HOST "zidane-a422b-default-rtdb.firebaseio.com"
#define FIREBASE_AUTH "AIzaSyAwJ9APZl_GSRrAbtiOF9s3HNbcAeeEylY"

#define ROWS 4
#define COLS 3

char keyMap[ROWS][COLS] = {
  {'1', '2', '3'},
  {'4', '5', '6'},
  {'7', '8', '9'},
  {'*', '0', '#'}
};

uint8_t rowPins[ROWS] = {14, 27, 26, 25};
uint8_t colPins[COLS] = {33, 32, 18};
const int buzzerPin = 5; // Pin for the buzzer

Keypad keypad = Keypad(makeKeymap(keyMap), rowPins, colPins, ROWS, COLS);

LiquidCrystal_I2C lcd(0x27, 16, 2);

FirebaseData firebaseData;

String passcode = "";

WiFiUDP ntpUDP;
NTPClient timeClient(ntpUDP, "pool.ntp.org");

void setup() {
  Serial.begin(115200);
  pinMode(buzzerPin, OUTPUT); // Set the buzzer pin as an output
```

```
  digitalWrite(buzzerPin, LOW); // Turn off the buzzer
  lcd.init();
  lcd.backlight();
  lcd.print("Waiting for Wi-Fi");

  WiFiManager wifiManager;
  wifiManager.autoConnect("AttendanceSystemAP");
  lcd.init();
  lcd.print("Connected");
  delay(3000);
  lcd.clear();
  lcd.print("Enter Passcode");
  Firebase.begin(FIREBASE_HOST, FIREBASE_AUTH);

  timeClient.begin(); // Initialize NTPClient
  setTime(timeClient.getEpochTime()); // Set the system time using NTP
}

void loop() {
  timeClient.update(); // Update NTPClient

  char key = keypad.getKey();
  if (key) {
    if (key == '*') {
      if (passcode.length() > 0) {
        passcode.remove(passcode.length() - 1);
        lcd.setCursor(passcode.length(), 1);
        lcd.print(" ");
      }
    } else if (key == '#') {
      lcd.setCursor(0, 1);
      lcd.print("Processing...");

      int maxUserId = 10; // Adjust this to the maximum user ID in your Firebase
      bool userFound = false;

time_t currentTime = timeClient.getEpochTime();
int timeZoneOffsetInSeconds = 7200; // 2 hours in seconds

// Add daylight saving time (DST) offset if applicable
bool isDst = false; // Set this to true if DST is in effect
if (isDst) {
  timeZoneOffsetInSeconds += 3600; // Add 1 hour for DST
}

currentTime += timeZoneOffsetInSeconds; // Apply the time zone offset
```

```
String currentDateTime = formatTimeDigits(year(currentTime)) + "-" +
                         formatTimeDigits(month(currentTime)) + "-" +
                         formatTimeDigits(day(currentTime)) + " " +
                         formatTimeDigits(hour(currentTime)) + ":" +
                         formatTimeDigits(minute(currentTime)) + ":" +
                         formatTimeDigits(second(currentTime));



    for (int i = 1; i <= maxUserId; i++) {
      Firebase.getString(firebaseData, "/users/user" + String(i) + "/passcode");

      if (firebaseData.dataType() == "string") {
        String storedPasscode = firebaseData.stringData();
         Serial.println("Stored Passcode: " + storedPasscode); // Add this line

        if (storedPasscode == passcode) {
          Firebase.getString(firebaseData, "/users/user" + String(i) + "/name");
          if (firebaseData.dataType() == "string") {
            String userName = firebaseData.stringData();
            Serial.println("User Name: " + userName); // Add this line
            if (!userName.isEmpty()) {
              lcd.clear();
              lcd.print("Welcome " + userName); // Display welcome message
              delay(2000);

              Firebase.setString(firebaseData, "/attendance/" + userName + "/" +
currentDateTime, "present");

              if (firebaseData.httpCode() == 200) {
                lcd.clear();
                lcd.print("Attendance marked");
                delay(2000);
                userFound = true; // Set the flag to indicate a valid user was found
                break; // Exit the loop once a valid user is found and attendance is marked
              } else {
                lcd.clear();
                lcd.print("Failed to mark");
                delay(2000);
              }
            } else {
              lcd.clear();
              lcd.print("User not found");
              delay(2000);
            }
          }
        }
```

```
      }
     }

     if (!userFound) {
      lcd.clear();
      lcd.print("Invalid passcode");
      digitalWrite(buzzerPin, HIGH); // Turn on the buzzer
      delay(500); // Beep for 0.5 seconds
      digitalWrite(buzzerPin, LOW); // Turn off the buzzer
      delay(2000);
     }

     passcode = "";
     lcd.clear();
     lcd.print("Enter passcode:");
    } else {
     passcode += key;
     lcd.setCursor(passcode.length() - 1, 1);
     lcd.print(key);
    }
  }
}


String formatTimeDigits(int value) {
  if (value < 10) {
    return "0" + String(value);
  } else {
    return String(value);
  }
}
```

- Detailed hardware schematics.