Enhanced Electric Vehicle (EV) Charging Station Management System

Project synopsis submitted in partial fulfilment

for the Award of

CERTIFICATION OF COMPLETION

In

Embedded Systems Certification Course: Embedded C, 8051, Arduino & Simulation

by

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CHAPTER 1

ENHANCED ELECTRIC VEHICLE (EV) CHARGING STATION MANAGEMENT SYSTEM

OBJECTIVE:

The objective of this project is to design and implement an enhanced EV charging station management system using **Arduino and Tinkercad.** The system will feature smart charging capabilities based on the battery level of connected EVs, in addition to providing real-time status indicators for available charging stations. The objective of the EV charging station management system is to provide an efficient, user friendly, and scalable solution for managing electric vehicle charging infrastructure. This system aims to streamline the operation of charging station by integrating real time monitoring, user management thereby enhancing the overall user experience and operational efficiency.

Key objective includes:

1) Real time monitoring.
2) User management.
3) Reservation and scheduling.
4) Fault detection and maintenance.
5) Data analytics and reporting.
6) Scalability.
7) Sustainable load management.

This system ultimately supports the broader goal of promoting electric mobility by providing a reliable and accessible charging infrastructure.

PROJECT DESCRIPTION

The **EV Charging Station Management System** is a smart and centralized platform designed to streamline the operation, monitoring, and maintenance of electric vehicle (EV) charging stations. With the growing adoption of electric vehicles, there is an increasing need for efficient management systems that ensure optimal usage of charging infrastructure, reduce downtime, and enhance user experience.

As EV adoption grows, the need for robust charging infrastructure and smart management systems becomes critical. This project leverages **IoT integration** (via Arduino and Tinkercad simulation) to offer intelligent management and enhanced accessibility.

System Capabilities:

- **For Operators**:
  - Real-time monitoring of station status
  - Usage analytics and reports
  - Fault detection
  - Remote control of stations
- **For Users**:
  - Slot reservation
  - Live station availability
  - Battery SoC input
  - Online payments
  - Navigation to nearest available station

Benefits:

- Enhances user convenience and accessibility.
- Improves operational efficiency of charging stations.
- Enables data-driven decision making.
- Supports sustainability by promoting EV adoption.

CHAPTER 2

INPUT PARAMETERS

Software Tools:

1) Arduino IDE
2) Tinkercad

Hardware Components (simulated in Tinkercad):

1) Arduino UNO board
2) Seven-segment display
3) LEDs (Green and Red)
4) Pushbutton
5) Breadboard
6) Jumper wires

System Modules:

EV Charging Station Status Indicator:

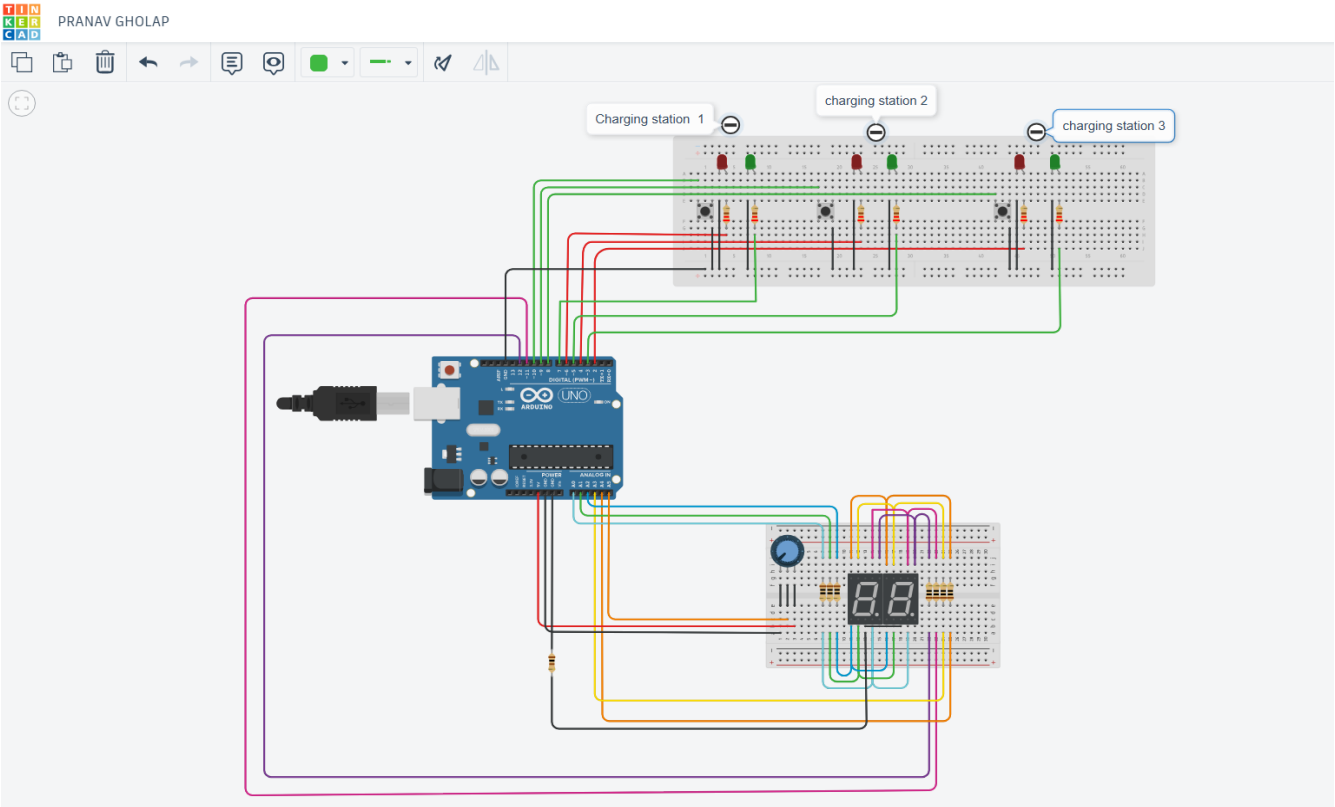
- **LEDs** display status:
  - **Green LED**: Charging station is available.
  - **Red LED**: EV is currently charging.

Smart Charging Module:

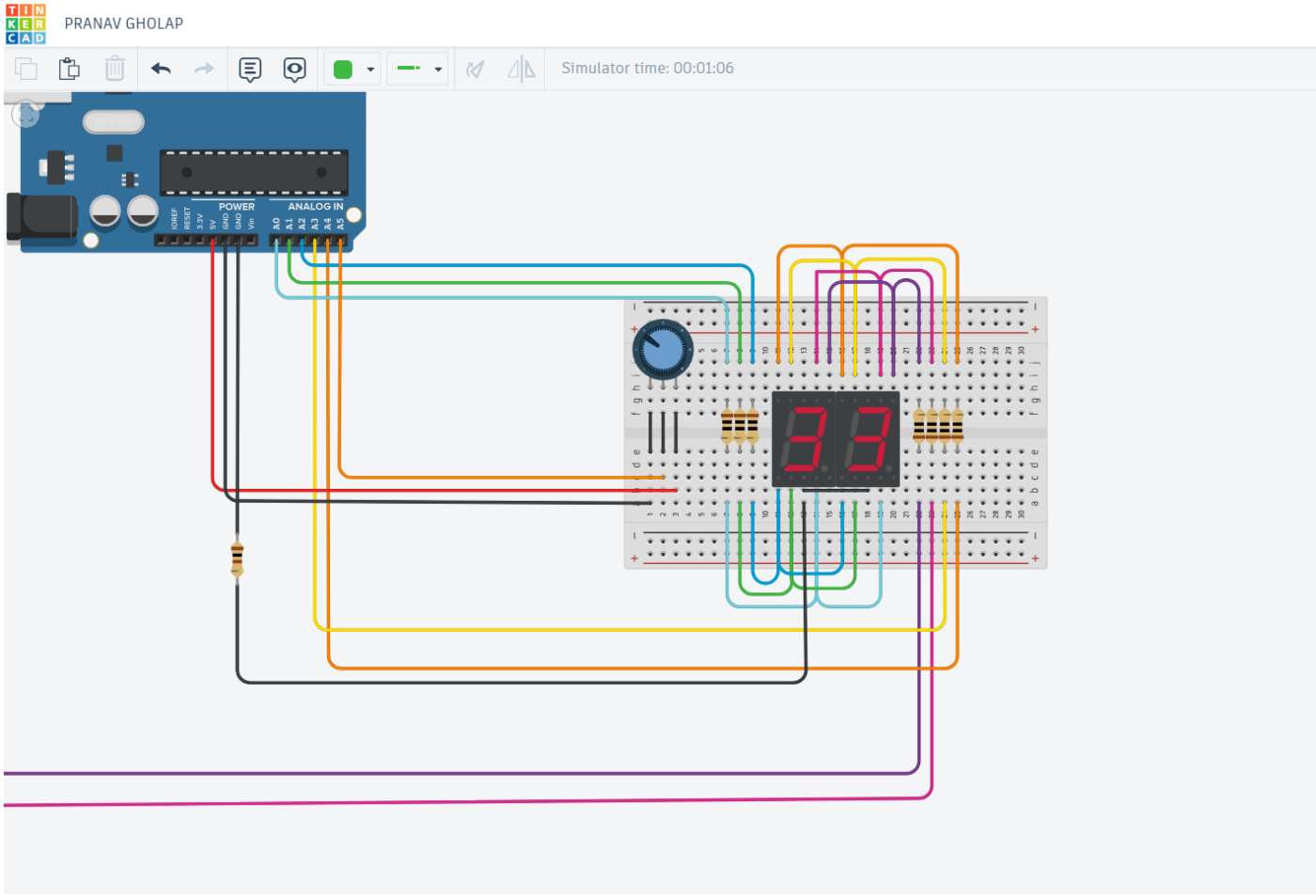
- **Seven-Segment Display**: User inputs current battery level (%)
- **Arduino Logic**: Prioritizes charging based on input SoC

CHAPTER 3

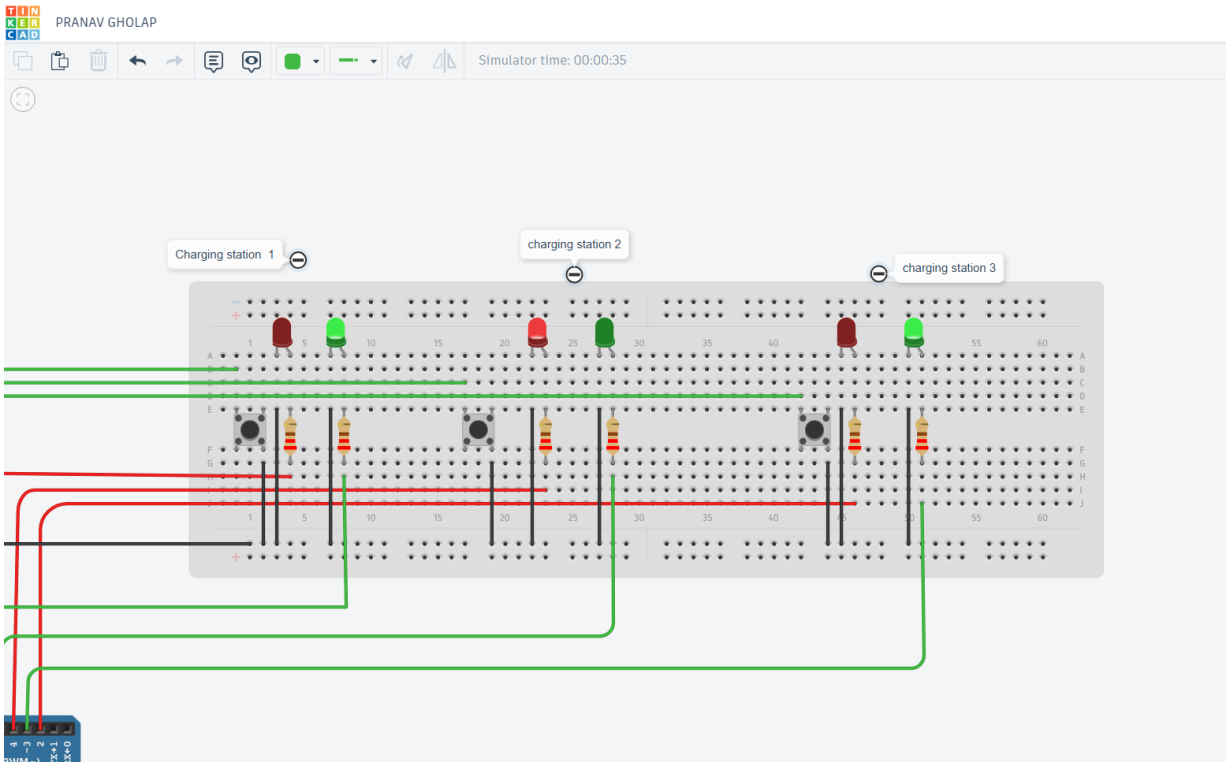
CIRCUIT DESIGN IN TINKERCAD



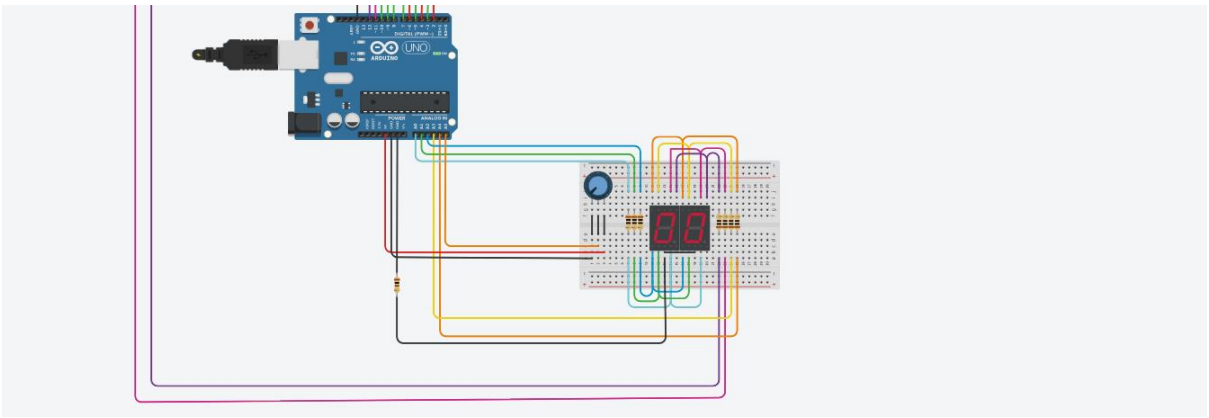
- Digital pins connected to LED indicators.
- Pushbuttons connected via pull-down resistors.
- Seven-segment display configured using multiplexed segments.



EV Charging Station Circuit Design



Connection between Arduino and charging station circuit



Connection between Arduino and 7 segment display (Battery state)

- Display shows battery level input.
- Enables prioritization logic within Arduino sketch.

CHAPTER 4

ARDUINO PROGRAMMING

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```
// Pin Assignments
int redLEDs[3] = {2, 4, 6};
int greenLEDs[3] = {3, 5, 7};
int stationButtons[3] = {8, 9, 10};
int batteryLevel = 0;
int segmentPins[7] = {11, 12, A0, A1, A2, A3, A4}; // A-G for 7-seg

// 7-segment patterns (0-9)
byte digitPatterns[10][7] = {
  {1,1,1,1,1,1,0}, // 0
  {0,1,1,0,0,0,0}, // 1
  {1,1,0,1,1,0,1}, // 2
  {1,1,1,1,0,0,1}, // 3
  {0,1,1,0,0,1,1}, // 4
  {1,0,1,1,0,1,1}, // 5
  {1,0,1,1,1,1,1}, // 6
  {1,1,1,0,0,0,0}, // 7
  {1,1,1,1,1,1,1}, // 8
  {1,1,1,1,0,1,1}  // 9
};

void setup() {
  for (int i = 0; i < 3; i++) {
    pinMode(redLEDs[i], OUTPUT);
    pinMode(greenLEDs[i], OUTPUT);
    pinMode(stationButtons[i], INPUT_PULLUP);
  }
  for (int i = 0; i < 7; i++) {
```

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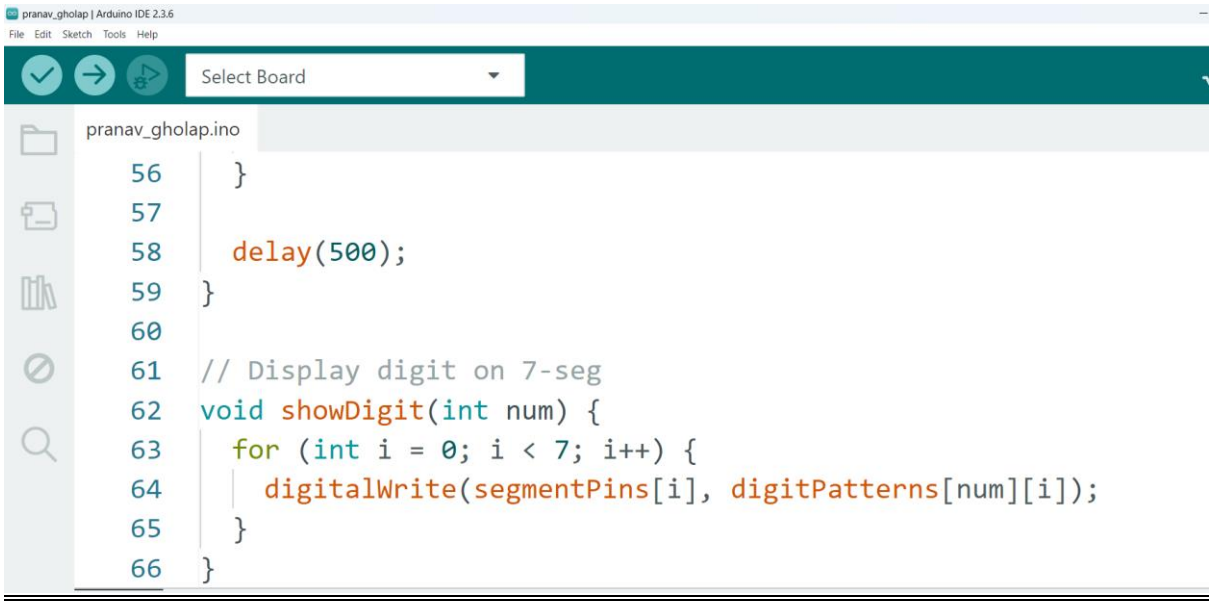
```
    pinMode(segmentPins[i], OUTPUT);
  }
  Serial.begin(9600);
}

void loop() {
  for (int i = 0; i < 3; i++) {
    if (digitalRead(stationButtons[i]) == LOW) {
      digitalWrite(redLEDs[i], HIGH);
      digitalWrite(greenLEDs[i], LOW);
    } else {
      digitalWrite(redLEDs[i], LOW);
      digitalWrite(greenLEDs[i], HIGH);
    }
  }

  // Simulate battery level input (for example, 3)
  batteryLevel = analogRead(A5) / 100; // Map potentiometer input
  if (batteryLevel > 9) batteryLevel = 9;

  showDigit(batteryLevel);

  // Prioritize if battery level < 3
  if (batteryLevel < 3) {
    Serial.println("Low Battery - Priority Charging Enabled");
  } else {
    Serial.println("Standard Charging");
  }
```



This section includes:

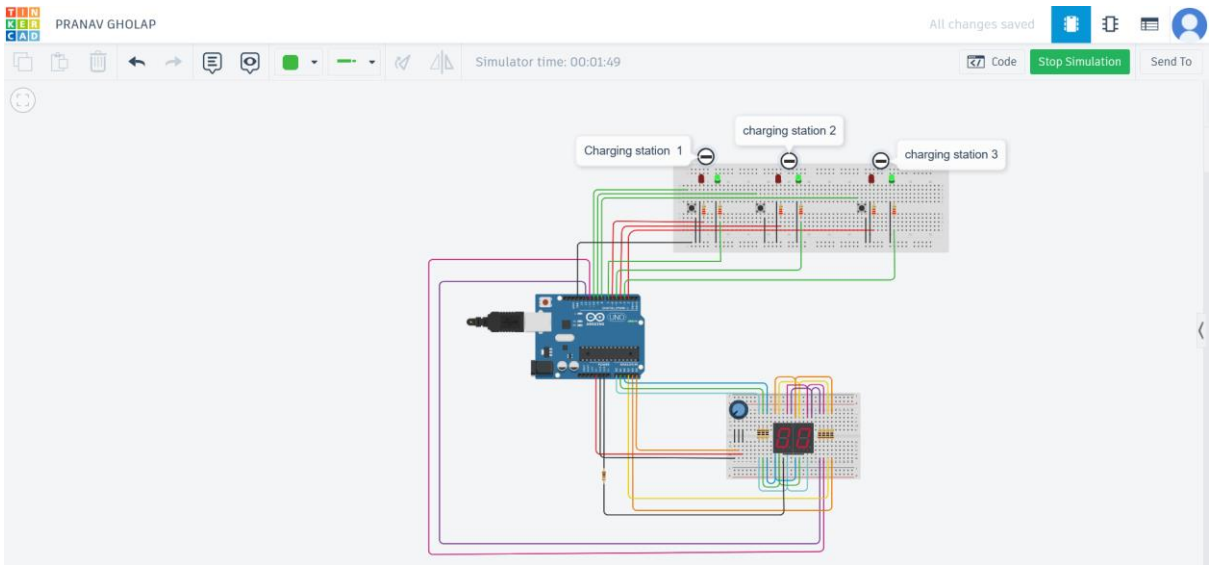
- Code for controlling LED indicators based on input.
- Logic to read battery level from user input.
- Priority decision-making based on SoC.
- Timing and blinking behaviour for indicators.

CHAPTER 5

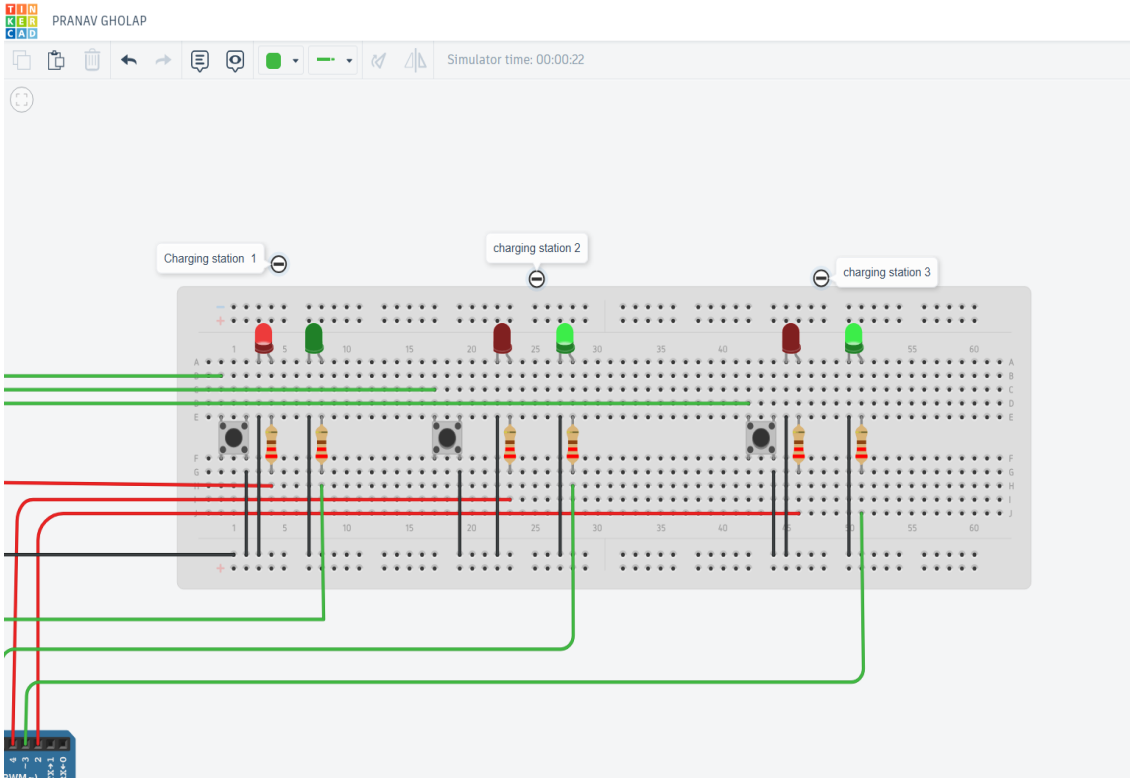
SIMULATION AND TESTING

Testing Outcomes:

These indicators simulate how a real charging station would function in a smart environment, providing users with status feedback and prioritization.



Blinking Green LED: Indicates station is available.



Blinking Red LED: Indicates an EV is actively charging.

Seven-Segment Display: Shows battery level (e.g., 44% SoC).

CHAPTER 6

RESULTS AND CONCLUSION

The simulation and testing of the Enhanced EV Charging Station Management System yielded successful and expected outcomes. The system components worked in synchronization to demonstrate key functionalities as designed.

Observed Results:

- **LED Indicators:**
  1. **Green LED** blinks to indicate an available charging station.
  2. **Red LED** blinks to indicate an ongoing charging session.
- **Seven-Segment Display:**
  1. Accurately displays the **State of Charge (SoC)** of the connected EV battery (e.g., 44%).
  2. Used as an input reference to simulate user-provided battery status for smart prioritization.
- **Arduino-Based Logic:**
  1. Correctly processes inputs from buttons and seven-segment display.
  2. Successfully prioritizes vehicles with lower battery levels.
  3. Controls LED outputs based on charging status and battery level.
- **User Interaction Simulation:**
  1. Pushbuttons effectively emulate vehicle connections.
  2. Charging slots change status in real-time as per system logic.

Conclusion:

The **Enhanced Electric Vehicle (EV) Charging Station Management System** successfully demonstrates how smart technology can be integrated into EV infrastructure to improve usability, efficiency, and scalability. Through the use of Arduino and Tinkercad simulation, the project showcases a working prototype capable of real-time monitoring, charging slot status indication, and smart charging prioritization based on battery levels.

By simulating EV user interaction, battery state input, and live status updates using LEDs and a seven-segment display, the system highlights how automation and user-focused design can optimize the EV charging process. The project not only provides a foundation for a centralized and intelligent charging network, but

also aligns with global efforts toward sustainable transportation and energy management.

Key takeaways from the project include:

- Efficient management of multiple charging stations.
- Enhanced user experience through visual status indicators and input-based charging logic.
- Scalable and adaptable system design for real-world application.

Overall, this project contributes meaningfully to the development of smart EV infrastructure, supporting the transition to cleaner energy solutions and more connected urban mobility systems.