**RFID & RF Based E-Voting System**

*A Report submitted in partial fulfillment of the requirements to complete Term Work of Project Based Learning (PBL) in the department of*

# Electronics & Telecommunication Engineering

*As prescribed by*

# Savitribai Phule Pune University

*By*

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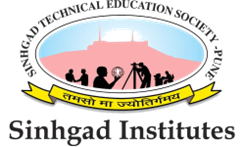
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**Abstract**

• In today's digital era, the need for secure and transparent election processes has become critical due to the limitations of traditional paper-based voting systems, which are prone to human error, duplication, and manipulation.

• This project proposes a smart, IoT-enabled **RFID & RF Based E-Voting System** using the **ESP32 microcontroller**, designed specifically for **small-scale elections** in institutions and organizations.

• The system uses **RFID technology (RC522)** to uniquely identify each voter through a card or tag, ensuring only authorized users can vote, thereby preventing fake or duplicate entries.

• Upon successful card scan, the voter is guided through a **10-second timed voting window** where they can cast their vote using **one of four physical buttons**, each mapped to a political party: **BJP, INC, AAP, and NOTA**.

• Feedback is provided through **LED indicators**, a **buzzer**, and a **16x2 LCD display** which shows dynamic messages such as voter greeting, countdown timer, confirmation of vote, and system status.

• The **ESP32**, leveraging its built-in **WiFi capability**, logs each vote in **real-time to a Google Sheet** using HTTP requests, including the voter's name, UID, selected party, and status (Casted, Invalid, Already Voted).

• A special **master/admin RFID card** is implemented to conclude the voting session, which displays the **result summary and winner** on the LCD and sends a formatted summary to the Google Sheet — handling conditions like **tie** or **no votes cast**.

• The system incorporates edge-case handling for **invalid cards**, **duplicate scans**, and **voting timeouts**, making it **fail-safe and robust**.

• This project serves as a **proof-of-concept** for a smart, eco-friendly, and tamper-proof voting system — enhancing reliability, usability, and transparency in organizational elections while showcasing practical applications of **RFID**, **WiFi IoT**, and **embedded systems**.

**🔑 Keywords – List of Keywords**

* RFID
* RC522
* ESP32
* E-Voting System
* Google Sheets Integration
* Master Card
* Real-Time Data Logging
* 16x2 LCD Display
* IoT
* WiFi Connectivity
* Buzzer
* Voting Buttons
* LED Indicators
* UID Authentication
* Voting Timeout
* Arduino IDE
* Cloud-based Voting
* Secure Vote Casting
* Embedded Systems
* Project Based Learning (PBL)

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| **Chapter 1**  **Introduction** |

**Chapter 1**

**Introduction**

**1.1 Background**

• In today’s fast-paced digital era, the traditional voting system is increasingly seen as outdated due to its reliance on manual processes such as paper ballots, physical verification, and hand counting.  
• These traditional methods are **time-consuming, prone to human error, and vulnerable to fraud** such as multiple voting or identity manipulation.  
• To address these challenges, **technological solutions using RFID and IoT** have emerged as promising alternatives for secure, fast, and reliable voting systems.  
• This project presents a **smart RFID & RF Based E-Voting System** using **ESP32**, which provides **real-time vote logging** and **transparent result monitoring** via **Google Sheets** using WiFi connectivity.

**1.1.1 Problem Statement**

• The major problems in conventional voting systems include:

* Manual registration and validation.
* Risk of **duplicate or fake votes**.
* Delays in vote counting and result declaration.
* Lack of transparency and security.  
  • There is a need for a system that enables **secure authentication**, **one-person-one-vote logic**, **tamper-proof logging**, and **quick result access** — especially in small-scale elections like colleges, clubs, or organizations.

**1.1.2 Significance of the Project**

• This project demonstrates how **RFID and embedded systems** can be used to automate and secure the voting process, eliminating manual errors.  
• It ensures **only authorized users can vote once**, and all data is stored on the **cloud (Google Sheets)** in real time, providing **transparency and traceability**.  
• The system also introduces features such as **admin summary view**, **10-second voting timeout**, and **user feedback** via **LCD, buzzer, and LEDs** — simulating a **real-world EVM** setup on a compact prototype scale.

**1.2 Project Objectives**

• The primary objectives of this project are:

* To design a secure and portable RFID-based voting prototype.
* To ensure real-time vote logging using **WiFi + Google Sheets integration**.
* To implement a **Master Card feature** to display and send final results.
* To eliminate the chances of **duplicate voting or invalid card entries**.
* To improve usability with **LCD guidance**, **LED/buzzer feedback**, and **vote timeout logic**.

**1.3 Organization of Report**

• This report is organized into the following chapters:

* **Chapter 1** provides the background, problem statement, and objectives of the project.
* **Chapter 2** presents a literature review of existing RFID-based and IoT-enabled voting systems.
* **Chapter 3** explains the system design, hardware/software architecture, and implementation details.
* **Chapter 4** shows the results with circuit diagrams, output snapshots, and discussion.
* **Chapter 5** concludes the project with a summary of findings, limitations, and future work.

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| **Chapter 2**  **Literature Survey** |

**Chapter 2**

**Literature Survey**

**2.1 Related Work**

• Various smart voting systems have been proposed in recent years to replace manual ballot-based elections.  
• Most of these projects focus on RFID authentication, real-time data logging, and secure vote counting.  
• Below is a summary of some significant prior works:

**2.1.1 Existing Solutions and Technologies**

| **S.N.** | **Year** | **Title** | **Methodology** |
| --- | --- | --- | --- |
| 1 | 2017 | RFID-Based Electronic Voting Machine | Used RFID cards to authenticate voters and restrict duplicate voting. |
| 2 | 2019 | IoT-Enabled E-Voting with ESP32 and Cloud | ESP32 used to log vote data to Google Sheets for transparency. |
| 3 | 2020 | Multi-Level Authentication Using RFID & Biometrics | Combined RFID with fingerprint scanning for higher security. |
| 4 | 2021 | Blockchain-Based Result Storage | Used RFID with blockchain to store vote logs in a tamper-proof ledger. |
| 5 | 2023 | IoT Voting with LCD Feedback and Remote Monitoring | Provided LCD confirmation and stored data in real-time Google Sheets via WiFi. |

**2.2 Theoretical Foundations**

This section covers the core technologies and principles used in the design of our system.

**2.2.1 Core Concepts**

• **RFID (Radio Frequency Identification)**

* A wireless system that uses tags and readers to identify objects via unique UIDs.
* Enables secure and contactless identification in voting systems.

• **ESP32 Microcontroller**

* A powerful dual-core WiFi-enabled chip used for edge computing and IoT solutions.
* Handles all voting logic, data transmission, LCD, RFID, and I/O operations.

• **Google Apps Script**

* A scripting language used to connect ESP32 with Google Sheets via HTTP requests.
* Allows real-time logging of vote data and results on the cloud.

**2.2.2 Underlying Principles**

• **One-Person-One-Vote Logic**

* Ensures each card (UID) can only be used once, avoiding multiple voting.

• **Event-Driven Embedded Programming**

* Code execution based on actions (like card scan or button press) using interrupts and conditions.

• **Cloud-Based Logging**

* Votes are sent via URLs (HTTP GET) to a Google Sheet, making data transparent and easily accessible.

• **User Feedback Loop**

* LCD shows instructions and messages, while LEDs and buzzer confirm actions or errors.

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| **Chapter 3**  **System Design** |

**Chapter 3**

**System Design**

**3.1 Design and Development**

**3.1.1 System Architecture**

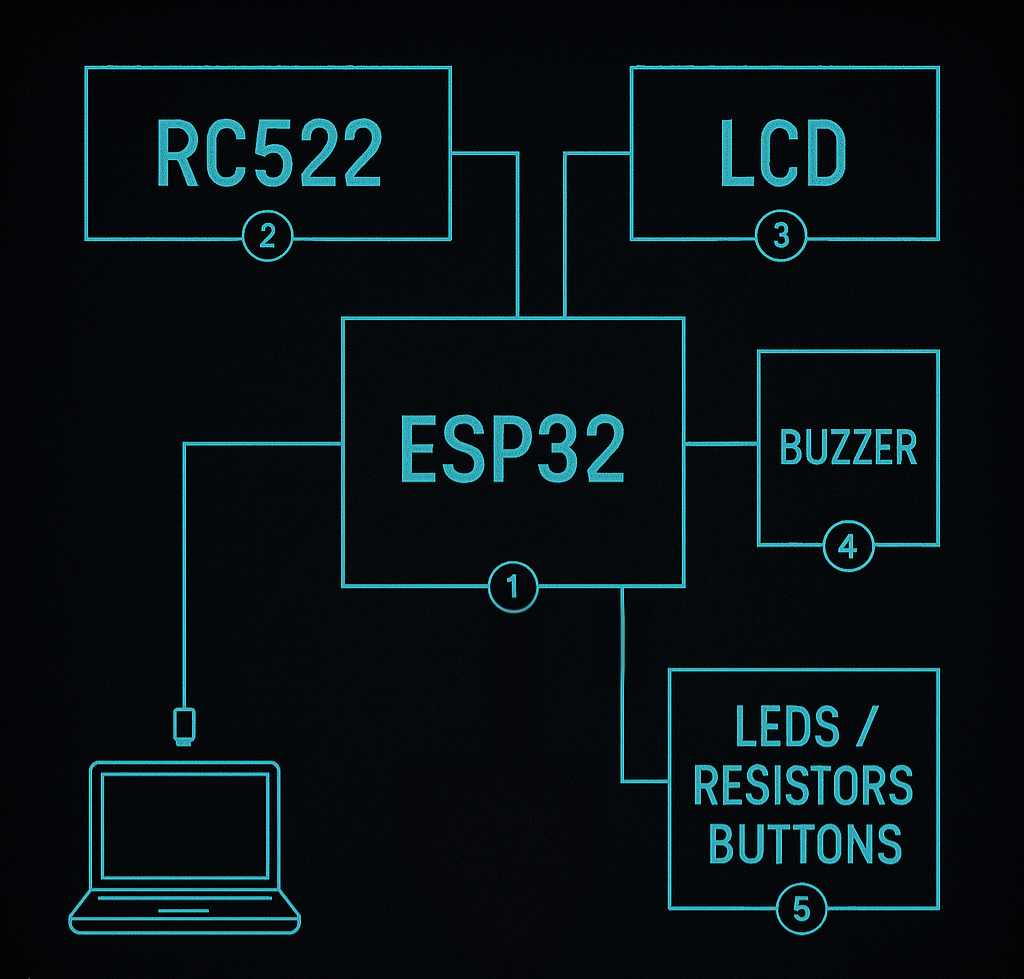
• The proposed RFID-based voting system is built on a **modular architecture** combining hardware and software elements to ensure secure vote casting and transparent result logging.

• The **ESP32** acts as the brain of the system, handling:

* RFID tag scanning
* Button-based voting input
* Real-time Google Sheet communication
* LCD display for instructions
* LED and buzzer feedback

• The entire process is **event-driven** — activated by card scans and button presses.

**✅ Block Diagram Overview**



**Figure 1.1 – Block Diagram of RFID & RF Based E-Voting System**

🧱 **Main blocks**:

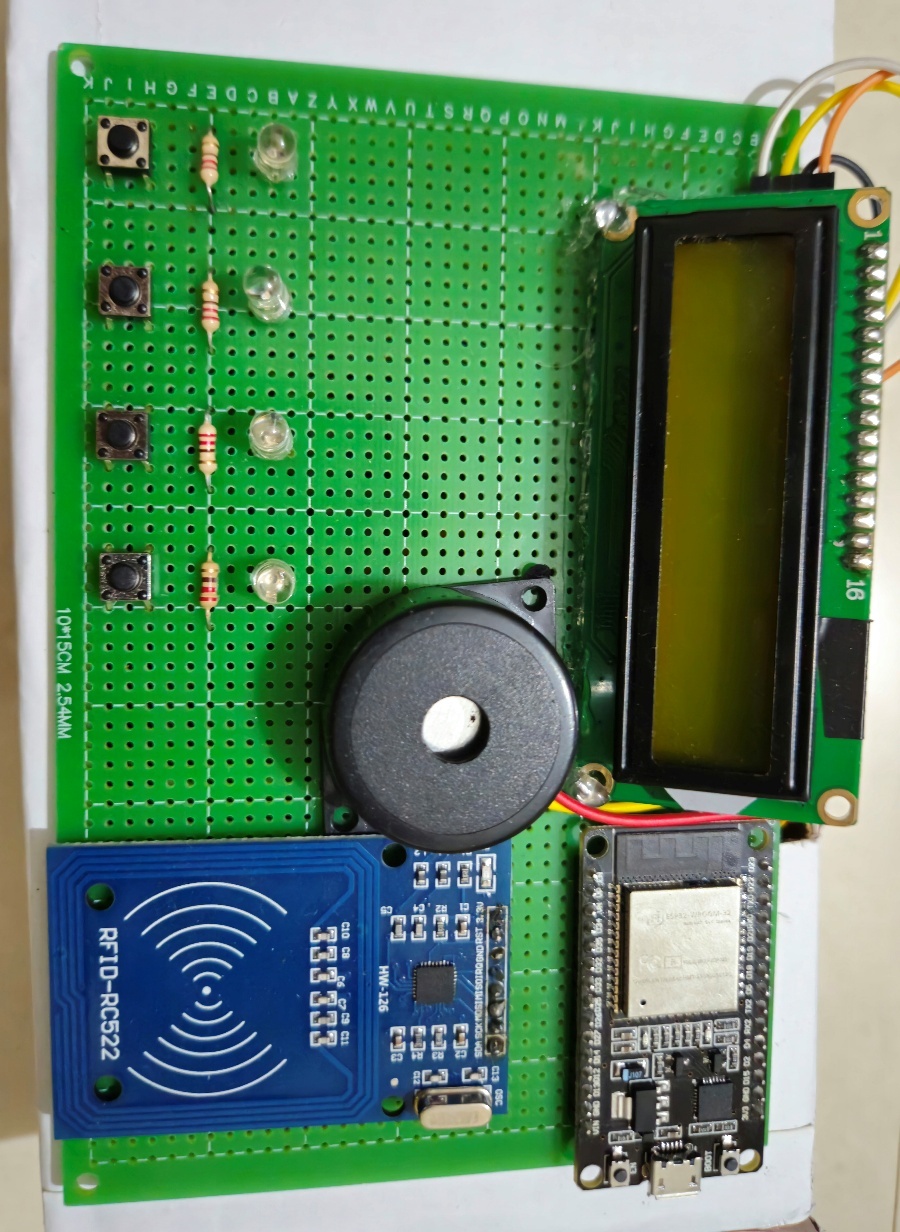
* ESP32 Microcontroller
* RC522 RFID Reader
* Push Buttons (BJP, INC, AAP, NOTA)
* 16x2 LCD with I2C
* 4 LEDs + Buzzer
* Google Sheet Integration (via Apps Script)

**3.1.2 Hardware Design**

• The hardware is built on a **breadboard prototype** powered by USB. All components are interfaced with the ESP32 using jumper wires.

**💡 Key Modules Connected:**

* RFID Reader → SPI Communication
* LCD → I2C Communication
* Buttons & LEDs → GPIO Inputs/Outputs
* Buzzer → GPIO Output
* Power Source → USB (5V)

****

**Figure 1.2 – Actual Hardware Setup of the Voting System**

**🧰 Technology Stack Used**

| **Layer** | **Technology / Component** | **Purpose** |
| --- | --- | --- |
| **Microcontroller** | ESP32 Wroom-32 | Core controller handling all input/output and WiFi |
| **RFID Module** | RC522 | Scans and identifies RFID cards |
| **Display Interface** | 16x2 LCD with I2C | Shows user instructions, status, and results |
| **User Input** | Push Buttons (x4) | Used for party-wise vote selection (BJP, INC, etc.) |
| **Feedback Output** | LEDs + Buzzer | Indicates vote status (casted, invalid, etc.) |
| **Software Platform** | Arduino IDE | Code development and uploading to ESP32 |
| **Data Logging** | Google Sheets + Apps Script | Stores real-time votes and results in the cloud |
| **Communication** | HTTP GET Requests via WiFi | Sends data from ESP32 to Google Sheet |
| **Programming Language** | C / C++ | For Arduino coding logic |

**3.1.3 Software Development**

• The system is programmed using the **Arduino IDE** with libraries:

* WiFi.h, Wire.h, SPI.h, MFRC522.h, HTTPClient.h, LiquidCrystal\_I2C.h

• The logic includes:

* **RFID card UID checking**
* **Vote tracking using arrays**
* **10-second voting countdown**
* **Google Sheet logging using URL encoding**
* **Admin UID triggers vote summary and winner display**

**3.2 Implementation**

**3.2.1 Experimental Setup**

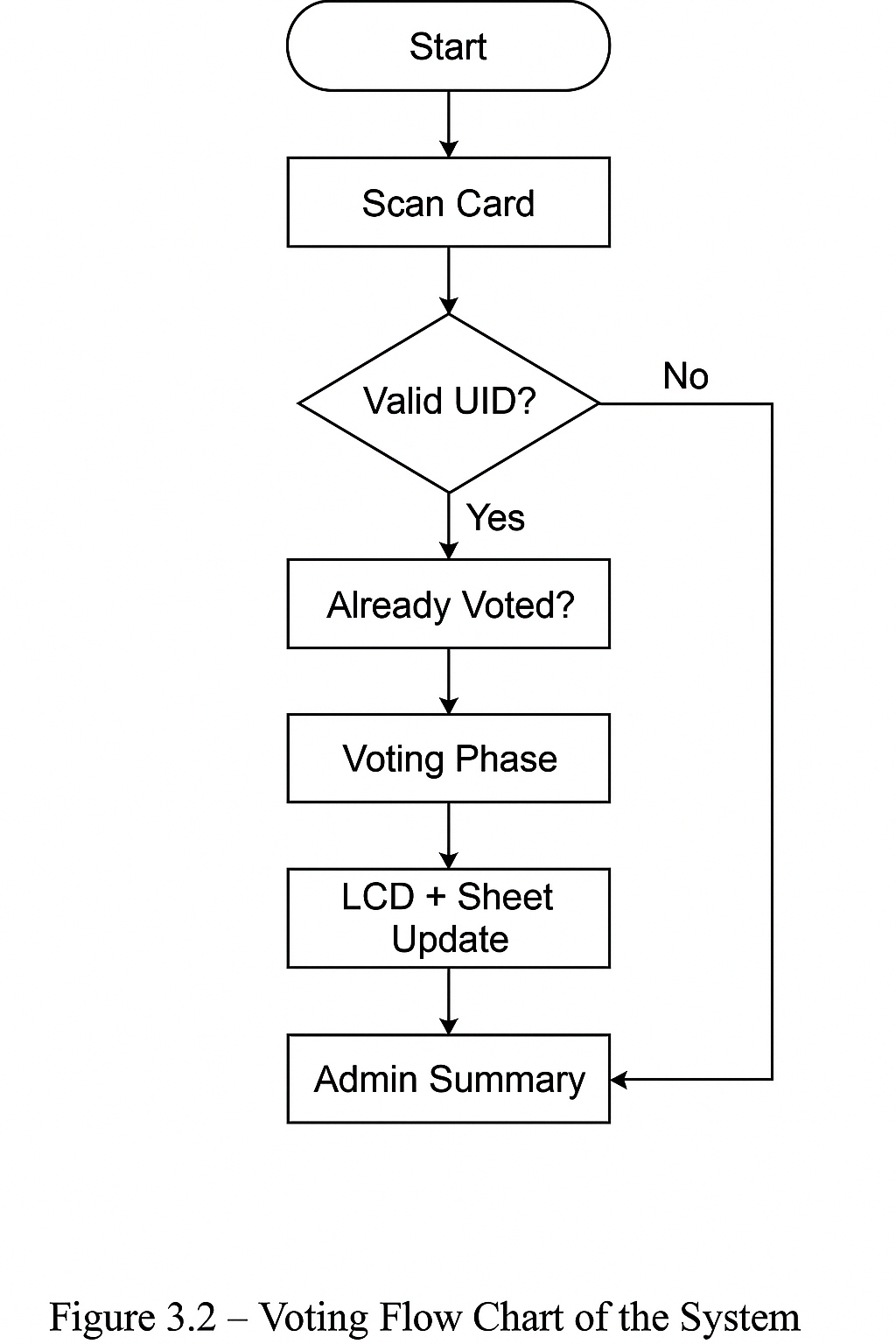
• The system was assembled using:

* **5 registered RFID cards** (each linked to a voter name)
* **1 master RFID card** (for admin)
* **Push buttons** to simulate party selection
* **Google Sheet** and **Apps Script** for backend

✅ All features were tested with real hardware and logs were verified on the sheet.

* + **The GPIO pin connections of the ESP32 to external components are listed in Table 3.2 below:**

| **Component** | **Pin Description** | **ESP32 GPIO Pin** |
| --- | --- | --- |
| RC522 (RFID) | SDA (SS) | GPIO 5 |
|  | SCK | GPIO 18 |
|  | MOSI | GPIO 23 |
|  | MISO | GPIO 19 |
|  | RST | GPIO 27 |
|  | VCC | 3.3V |
|  | GND | GND |
| LCD (I2C 16x2) | SDA | GPIO 21 |
|  | SCL | GPIO 22 |
|  | VCC | 3.3V |
|  | GND | GND |
| Buttons | BJP | GPIO 33 |
|  | INC | GPIO 32 |
|  | AAP | GPIO 25 |
|  | NOTA | GPIO 4 |
| LEDs (All Green) | BJP Indicator | GPIO 12 |
|  | INC Indicator | GPIO 13 |
|  | AAP Indicator | GPIO 14 |
|  | NOTA Indicator | GPIO 15 |
| Buzzer | Output | GPIO 26 |

**3.2.2 Flow Chart**

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| **Chapter 4**  **Results and Discussion** |

**Chapter 4**

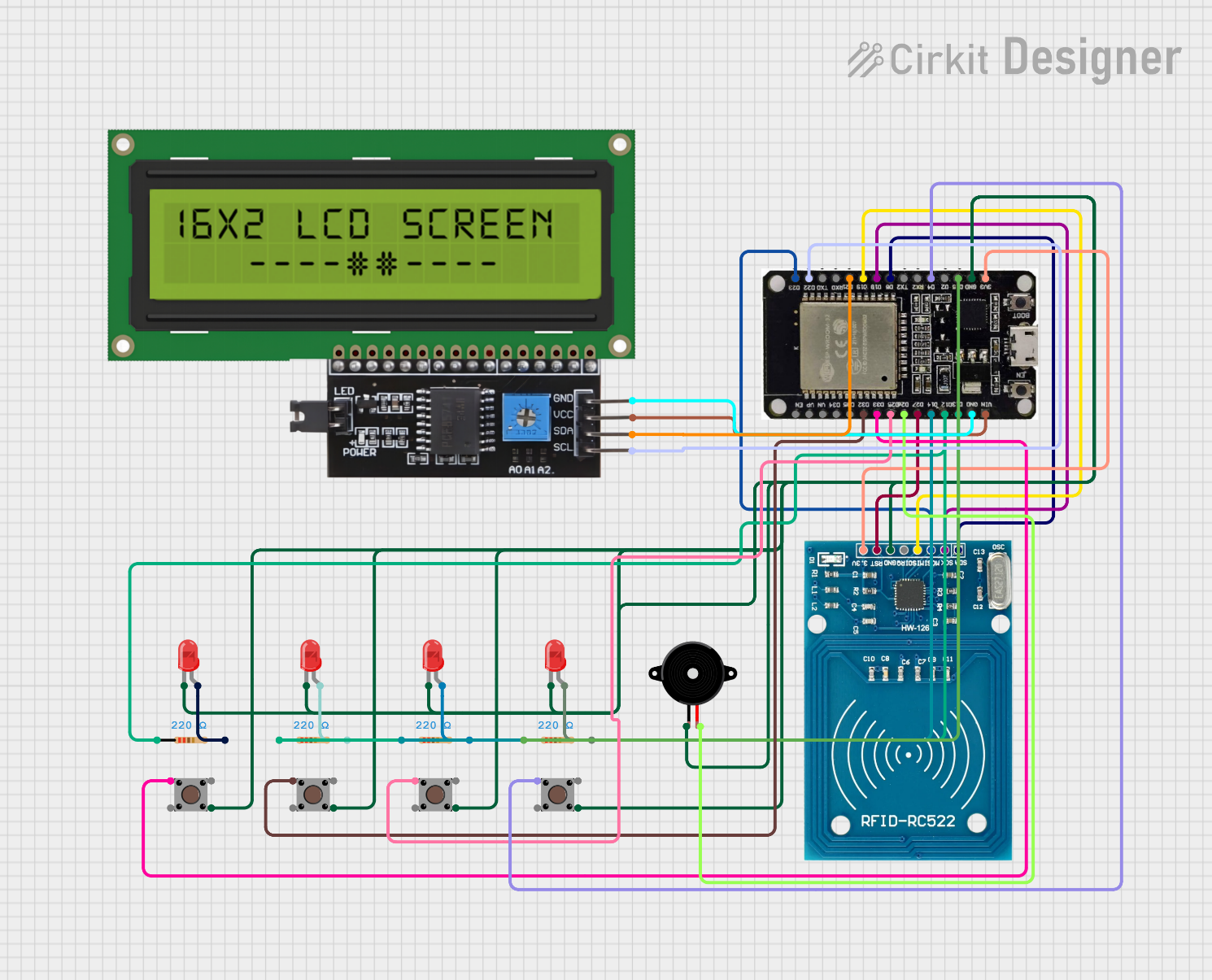
**Results and Discussion**

**4.1 Results**

**4.1.1 Circuit Diagram**

• The circuit diagram represents all physical connections between the ESP32, RFID reader, push buttons, LEDs, buzzer, and LCD display.

• It shows the **SPI connections for the RC522 RFID module**, **I2C interface for the LCD**, and GPIO pins assigned to each party button and corresponding LED.

**Figure 4.1 – Circuit Diagram of the E-Voting System**  


**4.1.2 Circuit Working Description**

• The heart of the system is the **ESP32 microcontroller**, which acts as the central controller managing inputs, outputs, and cloud communication.

• The **RC522 RFID Reader** is connected to the ESP32 using the **SPI interface** (GPIOs: 5, 18, 23, 19, 27). When a card is brought near the reader, it scans the **UID** and sends it to the ESP32 for authentication.

• If the card is valid and hasn’t been used before, the LCD displays a **"Welcome"** message followed by a **10-second countdown** for voting.

• The user can then press one of the **four push buttons**, each representing a political party:

* **BJP → Button on GPIO 33**
* **INC → GPIO 32**
* **AAP → GPIO 25**
* **NOTA → GPIO 4**

• Once a vote is cast, the corresponding **LED (Red, Green, Blue, Yellow)** glows briefly using GPIOs 12 to 15, and a short beep is played via the **buzzer** on GPIO 26 to indicate successful voting.

• Simultaneously, the selected party, voter's name, UID, and status are logged in **real-time to a Google Sheet** via an HTTP request using ESP32's **WiFi capability**.

• If the card has **already been used**, or is **invalid**, the system responds with a proper **error message on LCD** and a **double beep + blink** for feedback.

• Scanning the **Master Card (UID: 33EDA6D)** triggers the **vote summary display**, both on the LCD and on the Google Sheet, including party-wise counts and the declared winner. Tie/no-vote cases are handled smartly in both display and logging.

**4.2 Discussion**

• The system was successfully tested using **5 unique RFID cards** and **1 Master Card**, each assigned to a known voter or function.

• On scanning a valid card, the user was prompted to vote within a **10-second countdown window** using physical push buttons.

• The vote casting process worked flawlessly, with **LED feedback**, **buzzer alert**, and **Google Sheet logging** visible in real-time.

• Special cases were also handled correctly:

* **Already voted cards** triggered an LCD warning and double-beep.
* **Invalid/unregistered cards** were rejected gracefully with a message and blink.
* **Master card** displayed the party-wise summary and winner/tie/no-vote messages on both LCD and Sheet.

**4.2.1 Interpretation of Results**

• The system successfully met all design goals — including **accuracy**, **user guidance**, and **real-time logging**.

• Vote data appeared correctly in the Google Sheet with:

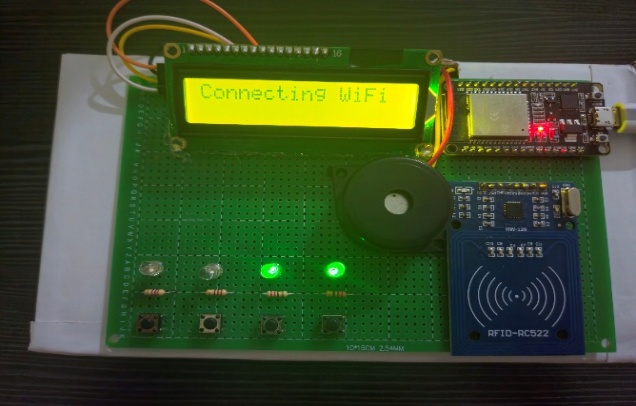
* Voter name
* UID
* Selected party with emoji
* Voting status (✅ Casted, ❌ Already voted, ❌ Invalid)

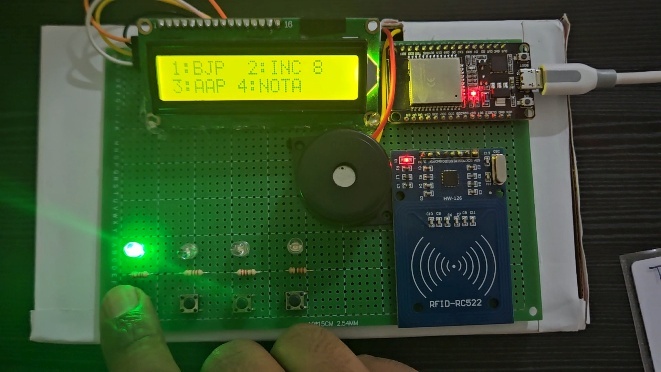
• The **summary row**, generated using the Master Card, included a **multiline party-wise vote count** and the declared **winner** — proving the end-to-end functionality.

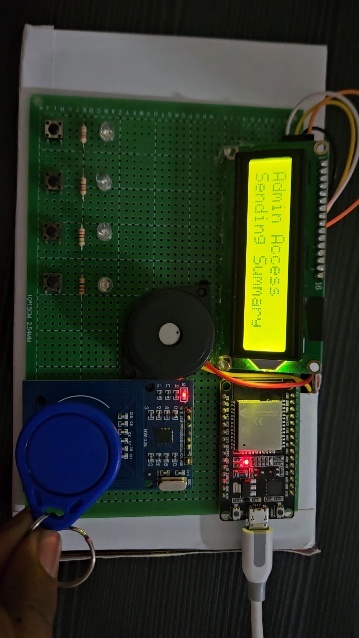
• The system's **user interaction** (LCD messages, timeout, feedback) made the prototype **engaging, error-resistant, and ideal for small-scale voting scenarios**.

**4.3 Working Images of Project Execution**

> The following images showcase the live working of the RFID & RF Based E-Voting System during testing and demonstration :



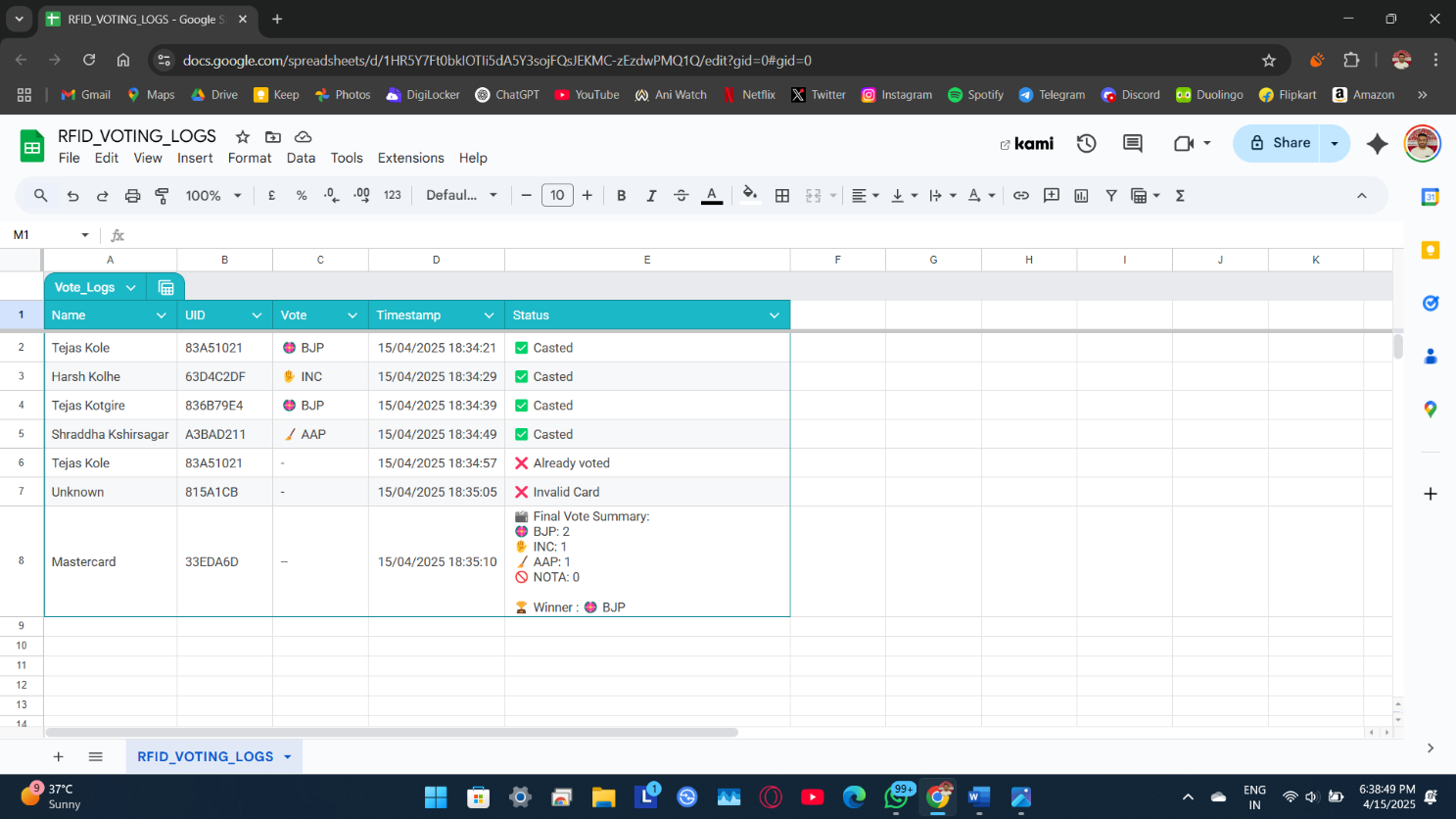








**Real-Time Vote Logging on Google Sheet via ESP32**

**•** The below sheet displays real-time logs of RFID-based votes, including voter name, UID, selected party (with emoji), and voting status sent through WiFi :

• The last row in the sheet represents the admin summary triggered by the Master Card, showing party-wise vote counts and the final winner.

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| **Chapter 5**  **Conclusion** |

**Chapter 5**

**Conclusion**

**5.1 Summary of Findings**

• The RFID & RF Based E-Voting System achieved its goal of providing a **secure, real-time, and tamper-proof voting solution** using RFID authentication and cloud-based logging.

• All core functionalities were successfully implemented:

* Voter authentication through RFID card scanning.
* One-vote-per-person logic to prevent duplication.
* Vote selection using physical push buttons.
* Real-time data logging to a **Google Sheet** with status, UID, and vote info.
* Display of **live feedback** through LCD, LEDs, and buzzer.
* Admin/master card functionality to display **vote summary and winner**.

• The system also included intelligent features like:

* 10-second timeout with reverse countdown.
* Error handling for **invalid** or **duplicate cards**.
* Emoji-based party representation in both **LCD** and **Google Sheets**.
* Proper formatting of results including **tie cases and no-vote conditions**.

**5.2 Limitations and Future Work**

• **Limitations:**

* The system supports only **5 RFID cards** due to static array allocation.
* No encryption is used in the communication between ESP32 and Google Sheets.
* Power supply is dependent on USB; not battery-optimized for portability.

• **Future Enhancements:**

* Integration of **biometric verification** along with RFID for dual-layer security.
* Development of a **dashboard or app** to visualize live votes and results.
* Use of **secured HTTPS with encryption** for transmitting sensitive data.
* Expansion to support **multiple voting booths** through a centralized database.

**5.3 Conclusion**

• This project successfully demonstrates the use of **IoT and embedded systems** to create a **modern electronic voting machine** prototype.

• It eliminates common issues in traditional systems such as **manual errors, fake votes, and delayed results**, and offers a **transparent and user-friendly** voting experience.

• With features like **Google Sheet integration**, **RFID-based validation**, and **admin-controlled result generation**, the system is ideal for **internal elections in educational institutes, clubs, or organizations**.

• Overall, this project serves as a **reliable, efficient, and secure e-voting prototype**, showcasing the practical applications of **RFID technology, microcontrollers, and cloud integration** in real-world systems.

|  |
| --- |
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8. **William Stallings, *Wireless Communications and Networks*, Pearson Education.**
9. **Arduino.cc Community Forums – Discussions on RFID integration and real-time cloud logging.**
10. **GitHub Repository: *RFID-RF-Based-E-Voting-System*, TejasK-02.**[**https://github.com/TejasK-02/RFID-RF-Based-E-Voting-System**](https://github.com/TejasK-02/RFID-RF-Based-E-Voting-System)
11. **YouTube Project Demo: *RFID Voting System – Real-Time Demo*.**[**https://youtube.com/shorts/w2tXMks05K4**](https://youtube.com/shorts/w2tXMks05K4)
12. **Project Resource Drive Folder (Code, Images, Working Proof):**[**https://drive.google.com/drive/folders/1dlD695RuSaaR76-CfT7QR9z3M7TtpGgr**](https://drive.google.com/drive/folders/1dlD695RuSaaR76-CfT7QR9z3M7TtpGgr)

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| **Appendix A**  **Cost Sheet** |

**Cost Sheet**

• **Table A.1 :**

| **S.N.** | **Component** | **Specification / Model** | **Quantity** | **Unit Price (₹)** | **Total (₹)** |
| --- | --- | --- | --- | --- | --- |
| 1 | ESP32 Dev Board | Wroom-32 | 1 | 380 | 380 |
| 2 | RFID Module | RC522 | 1 | 80 | 80 |
| 3 | RFID Cards/Tags | UID-based | 6 (5+1 admin) | 10 | 60 |
| 4 | I2C LCD Display | 16x2 with I2C backpack | 1 | 190 | 190 |
| 5 | Push Buttons | Tactile buttons | 4 | 5 | 20 |
| 6 | LEDs | Green | 4 | 2 | 8 |
| 7 | Buzzer | 5V | 1 | 18 | 18 |
| 8 | Resistors | 220Ω | 4 | 5 | 20 |
| 9 | Jumper Wires | Male-to-male | 50 | 2 | 100 |
| 10 | PCB | General purpose | 1 | 120 | 120 |
| 11 | Soldering Wire | Standard 22 SWG (Rosin Core) | 1 Roll | 100 | 100 |
| 12 | Soldering Paste (Flux Wax) | Standard flux (small box) | 1 | 40 | 40 |
| 13 | Glue Stick | Medium size (for glue gun) | 1 | 10 | 10 |
| 14 | Electricity | Power consumption (approx.) | - | 10 | 10 |

| | **Total Estimated Cost** :: **₹1156** | |

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| **Appendix B**  **Code** |

**Code 1: Arduino Code**

The following code is used to implement RFID authentication, voting logic, LCD feedback, and Google Sheet integration using ESP32 :

#include <WiFi.h>

#include <Wire.h>

#include <LiquidCrystal\_I2C.h>

#include <SPI.h>

#include <MFRC522.h>

#include <HTTPClient.h>

#define RST\_PIN 27

#define SS\_PIN 5

#define BUZZER 26

int leds[] = {12, 13, 14, 15};

int buttons[] = {33, 32, 25, 4};

String parties[] = {"BJP", "INC", "AAP", "NOTA"};

int votes[4] = {0, 0, 0, 0};

String masterUID = "33EDA6D";

LiquidCrystal\_I2C lcd(0x27, 16, 2);

MFRC522 mfrc522(SS\_PIN, RST\_PIN);

void setup() {

Serial.begin(115200);

SPI.begin();

mfrc522.PCD\_Init();

lcd.begin();

lcd.backlight();

pinMode(BUZZER, OUTPUT);

for (int i = 0; i < 4; i++) {

pinMode(leds[i], OUTPUT);

pinMode(buttons[i], INPUT\_PULLUP);

}

}

..

…

….

*Note: Complete 425 lines of code is available in soft copy and on the GitHub repository.*  
<https://github.com/TejasK-02/RFID-RF-Based-E-Voting-System>

**Code 2: Serial Interface**

The following is a sample output observed in the Serial Monitor during real-time operation of the RFID & RF Based E-Voting System :

Card UID: 83A51021

Please vote using buttons (BJP/INC/AAP/NOTA)...

🗳 Vote Casted for Candidate BJP

📡 Sending to Google Sheet:

https://script.google.com/macros/s/AKfycbxp1hC\_1\_Kb9F1buncDfLuXfGl2yaUmO\_cj3gbC80ti2uvO\_sBUgnSSMxHilJh-n2VD/exec?name=Tejas%20Kole&uid=83A51021&vote=%F0%9F%AA%B7%20BJP&status=%E2%9C%85%20Casted

Response: <HTML>

<HEAD>

<TITLE>Moved Temporarily</TITLE>

</HEAD>

<BODY BGCOLOR="#FFFFFF" TEXT="#000000">

<!-- GSE Default Error -->

<H1>Moved Temporarily</H1>

The document has moved <A HREF="https://script.googleusercontent.com/macros/echo?user\_content\_key=AehSKLgmiLQKfOWBP1AAZbpE9gFLMEzy5G9mbTQ3buBmO1f\_0z7a6hh8hhuWpTjNnI-Bsik\_qjZCqH2CJVHCFXCVV02OA2YOE8tOchiJmR9Lnv1SCqey-zxBDOduU8MJtZmsW4KKHFneskltAEMRZvOAqW0FjYFhJU7ZdTF0mlcZebSog\_uthrxh\_nJ5r9NaJqqLjZOImUEb56vd2waCXWQ617rB1cGxUaCF7cG6yzuncIQpty0Jz6mSX\_mXIWty9Va2b3VOXP6rI-BtbM4Fe8kW5t\_bM8D9HO2S1UFcCskF2vOt1eZiFSDz6u7DD7ovP\_TiWhz7sl0RS5Y0rtrGngE9ylThaAJqmhN7OomtUV6GBSOBkE1Gy4A3rxBYAgeUm6h9zpbImphj&amp;lib=ME9\_pg7NCfV4qphC\_\_D4MUMWr1zeZllwf">here</A>.

</BODY>

</HTML>

Card UID: 33EDA6D

📡 Sending Summary to Google Sheet...

https://script.google.com/macros/s/AKfycbxp1hC\_1\_Kb9F1buncDfLuXfGl2yaUmO\_cj3gbC80ti2uvO\_sBUgnSSMxHilJh-n2VD/exec?name=Mastercard&uid=33EDA6D&vote=--&status=%F0%9F%97%B3%EF%B8%8F%20Final%20Vote%20Summary%3A%0A%F0%9F%AA%B7%20BJP%3A%201%0A%E2%9C%8B%20INC%3A%200%0A%F0%9F%A7%B9%20AAP%3A%200%0A%F0%9F%9A%AB%20NOTA%3A%200%0A%0A%F0%9F%8F%86%20Winner%20%3A%20%F0%9F%AA%B7%20BJP

Summary sent to sheet.

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| **Appendix C**  **Data Sheet** |

**Data Sheet for Arduino (ESP32 Dev Board)**

🔸 **The ESP32 Wroom-32 is a dual-core microcontroller with built-in WiFi and Bluetooth, used as the central controller in the project.  
Key specifications are listed below:**

| **Parameter** | **Value** |
| --- | --- |
| Microcontroller | Tensilica Xtensa LX6 (dual core) |
| Clock Speed | Up to 240 MHz |
| Flash Memory | 4MB |
| SRAM | 520 KB |
| WiFi & Bluetooth | Built-in (802.11 b/g/n) |
| Operating Voltage | 3.3V |
| GPIO Pins | 34 |

🔸 **Official Datasheet**: https://www.espressif.com/sites/default/files/documentation/esp32\_datasheet\_en.pdf

**Data Sheet for LED (Green 5mm)**

🔸 **LEDs are used for visual feedback in the voting process. Green 5mm LEDs are used for all four party indicators :**

| **Parameter** | **Value** |
| --- | --- |
| Color | Green |
| Diameter | 5mm |
| Forward Voltage | 2.0V – 2.2V |
| Forward Current | 20mA |
| Viewing Angle | 60° |
| Package Type | Round, Diffused |

🔸 **Typical Datasheet**: https://components101.com/sites/default/files/component\_datasheet/LED-Green.pdf

**Data Sheet for Buzzer (5V Passive Type)**

🔸 **A passive buzzer is used to indicate system actions such as vote cast, invalid attempt, or admin access :**

| **Parameter** | **Value** |
| --- | --- |
| Type | Passive |
| Rated Voltage | 5V DC |
| Operating Voltage | 3V – 7V |
| Sound Output | 85 dB (at 10cm) |
| Resonant Frequency | 2.0 ± 0.5 KHz |
| Pin Type | PCB Mount |

🔸 **Buzzer Datasheet :** https://components101.com/sites/default/files/component\_datasheet/Buzzer-Datasheet.pdf

**Datasheets for Other Components**

**🔸 RC522 RFID Reader Module**

* Manufacturer: NXP Semiconductors
* Datasheet: <https://www.nxp.com/docs/en/data-sheet/MFRC522.pdf>

🔸 **LCD Display (16x2 with I2C)**

* Manufacturer: Hitachi-compatible
* Datasheet: <https://components101.com/sites/default/files/component_datasheet/LCD16x2.pdf>

🔸 **Tactile Push Buttons**

* Standard 6mm button used in breadboard circuits
* Datasheet: <https://components101.com/sites/default/files/component_datasheet/Tactile-Switch-Datasheet.pdf>

**🔸 220Ω Resistor**

* Standard carbon film resistor
* Datasheet: <https://components101.com/sites/default/files/component_datasheet/Resistor-Datasheet.pdf>

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| **Appendix D**  **Technology Readiness Levels** |

**Technology Readiness Levels Summary**

• **Table D.1 :**

| **TRL** | **Description** | **Criterion** | **Evidence** | **Assessment (Y/N)** | **Supporting Evidence** |
| --- | --- | --- | --- | --- | --- |
| 1 | **Basic Principles Observed** | Have the underlying principles of RFID, ESP32, microcontrollers, sensors, etc. been understood? | Literature review on ESP32, RFID, WiFi, buzzer, LCD | Yes | Literature Review Report, Datasheets, Project Proposal |
| 2 | **Technology Concept Formulated** | Has a conceptual design for the project been developed? | Block diagram, flowchart, list of components, working strategy | Yes | System Design Diagram, Flowchart, Project Sketches |
| 3 | **Critical Function and/or Physical Principle Validated** | Have basic modules been tested? | Testing of RFID card detection, button input, buzzer, and LCD | Yes | Breadboard Tests, Code Snippets, Photos |
| 4 | **Component Validation** | Have the components been integrated and tested together? | RFID + ESP32 + LCD + Google Sheet integration | Yes | Circuit Diagram, Pin Mapping Table, Video Demo |
| 5 | **System/Subsystem Validation** | Has the system been tested in a representative environment? | Full test in college lab with cards and buttons, Google Sheet updates | Yes | Serial Monitor Logs, Sheet Screenshots, Lab Notes |
| 6 | **System/Subsystem Demonstration** | Has the system been successfully demonstrated with all features? | Admin summary, error handling (invalid/already voted), vote summary and LCD feedback | Yes | Master Card Response, Summary Table, Google Sheet Logs |

**Technology Readiness Level (TRL) =** **6**