

Development of a Universal RFID-Based Smart ID Card Integrated with IoT for Academic Institutions.

Shivam Karvire¹, Sohan Kumbhar², Bhushan Kamble³, Adarsh Managave⁴, Mr. Swapnil Sajane⁵

¹Department of Mechatronics Engineering, Sharad Institute of Technology, College of Engineering, Yadrav. Maharashtra, India.

²Department of Mechatronics Engineering, Sharad Institute of Technology, College of Engineering, Yadrav. Maharashtra, India.

³Department of Mechatronics Engineering, Sharad Institute of Technology, College of Engineering, Yadrav. Maharashtra, India.

⁴Department of Mechatronics Engineering, Sharad Institute of Technology, College of Engineering, Yadrav. Maharashtra, India.

⁵Professor, Department of Mechatronics Engineering, Sharad Institute of Technology, College of Engineering, Yadrav. Maharashtra, India.

Abstract - This paper presents the design and development of a **Universal Smart ID Card System** based on **ESP32 microcontroller and RFID technology** for efficient and automated attendance management in academic institutions. The proposed system replaces traditional paper-based attendance with a **wireless, IoT-enabled solution** that improves accuracy and reduces manual workload. Each student is assigned an RFID-based unique identification card, which is authenticated by an ESP32 module integrated with a 1.3-inch OLED display for real-time verification. Student details are displayed locally and synchronized with a cloud-connected database through Wi-Fi. A dedicated web portal allows faculty members to manage sessions, add or remove students, and review attendance statistics by date and class. A secondary RFID scanner assists in new student registration by fetching unique UIDs directly into the backend database. The hardware is implemented on a **custom-designed PCB**, ensuring compactness and power efficiency. Experimental results confirm reliable identification, fast response time, and seamless data transfer between the device and the web portal. The proposed model can be extended to support **other institutional operations** such as library management, canteen payment, bus pass verification, and fee payment, achieving a unified **Universal Smart ID** platform.

Key Words: IoT, ESP32, RFID, Smart ID, Attendance System, Web Portal, Universal Card, Campus Automation

1. INTRODUCTION

The digital transformation of academic institutions has created a demand for smart and automated solutions to manage student information and campus activities. Attendance tracking, in particular, remains one of the most time-consuming administrative processes. Manual attendance leads to errors, proxy issues, and data handling inefficiency.

To address these challenges, this work introduces an IoT-based Universal Smart ID Card System using ESP32 and

RFID. The system not only automates attendance but also forms the foundation for future integration of all institutional functions—fees, library, canteen, and transport—into a single identity framework.

1.1 Motivation

Existing attendance systems rely on biometric or manual entry, which require high maintenance or physical contact. RFID technology provides a **contactless and cost-effective** alternative, while the ESP32 microcontroller offers integrated Wi-Fi connectivity for seamless communication with cloud databases.

1.2 Objectives

The primary objective of this project is to design and implement a **wireless RFID-based attendance system** using the ESP32 microcontroller and a 1.3-inch OLED display to ensure contactless, reliable, and efficient student identification. A dedicated **web portal** has been developed for faculty members to manage class sessions, visualize attendance data in real time, and perform administrative operations such as adding or removing students. The hardware design incorporates a **custom PCB** to achieve compactness, improved reliability, and suitability for real-world field deployment. Furthermore, the system is designed as a **scalable framework** that can be expanded into a universal identification platform capable of integrating multiple institutional services such as fee payment, library management, canteen access, and transport verification under a single smart ID card.

2. SYSTEM DESIGN AND ARCHITECTURE

2.1 Hardware Components

The core hardware consists of:

- **ESP32 microcontroller** with dual-core processor and in-built Wi-Fi.
- **RFID reader (RC522)** for scanning unique ID cards.
- **1.3-inch OLED display (I²C)** for displaying student verification details.
- **Custom PCB** integrating ESP32, power supply, and connectors for RFID and OLED.
- **Secondary RFID scanner** for UID registration.

2.2 Software Framework

The ESP32 microcontroller is programmed using the Arduino IDE, where the embedded firmware manages **RFID card scanning, OLED display control, Wi-Fi connectivity, and data communication** with the cloud database through HTTP requests. The backend of the system is developed using **Node.js** and **MySQL**, providing a robust and scalable environment for data storage and API handling. The frontend web portal, designed using **HTML, CSS, and JavaScript**, offers an intuitive interface for faculty users. Through this portal, faculty members can **add, remove, or update student records, create lecture or practical sessions, submit attendance data** received from the ESP32-based scanner, and **generate detailed reports and analytics** categorized by date, subject, or class. The combination of Node.js and MySQL ensures fast processing, asynchronous data handling, and efficient real-time synchronization between the web portal and the IoT hardware.

2.3 System Architecture Diagram

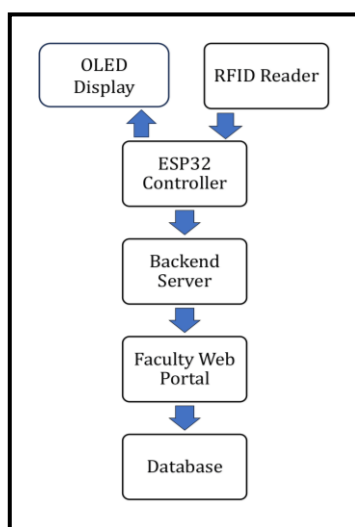


Fig-1: Block Diagram of the Universal Smart ID Card System

3. HARDWARE IMPLEMENTATION

3.1 Custom PCB Design

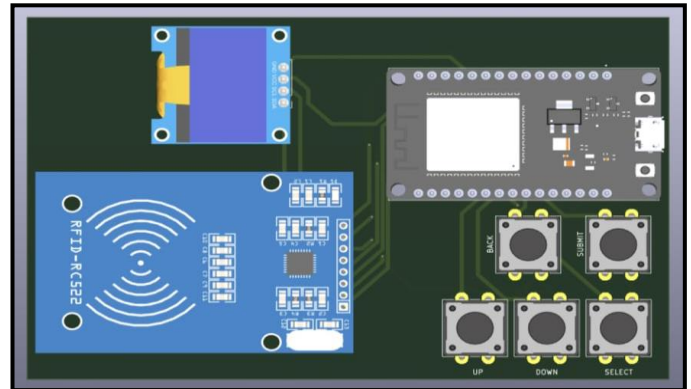


Fig-2: Custom PCB Layout of the Smart ID Device

3.2 Circuit Schematic

The schematic integrates ESP32 GPIO pins with RFID (SPI interface) and OLED (I²C). Separate pins are used for serial debugging and power monitoring.

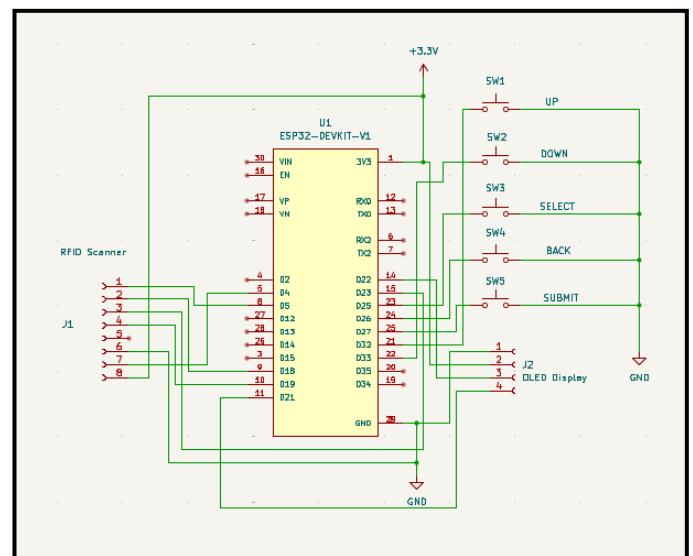


Fig-3: Circuit Schematic of the Universal Smart ID System

3.3 Device Operation

When a student scans their RFID card, the ESP32 retrieves the UID, verifies it with the database, and displays the student's name and status on the OLED. Once all students are marked, the faculty presses the Submit button on the web interface, sending data to the backend for permanent storage.

4. RESULTS AND DISCUSSION

The prototype was tested in a classroom environment with 25 students. The system successfully:

- Verified each RFID tag in under **1 second**.
- Displayed accurate student details on the OLED.
- Synced attendance data with the backend without packet loss.
- Allowed addition/removal of students dynamically via the secondary registration scanner.

The system demonstrated **100% recognition accuracy** within 3 cm reading distance and reliable database synchronization. The modular design supports future IoT expansion such as **cashless canteen, bus pass validation, and library book issue** under the same Universal Smart ID framework.

5. CONCLUSION

This paper presents an innovative **IoT-based Universal Smart ID Card System** using ESP32 and RFID technology. The system successfully automates attendance management, enhances data reliability, and provides a scalable hardware-software platform for institutional applications. With a single ID card, multiple services can be accessed, reducing administrative overhead and promoting a **digitally unified campus environment**.

Future work includes integration with payment gateways and mobile app interfaces for complete **college automation**.

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REFERENCES

[1] J. Smith et al., "RFID Based Smart Attendance System," IEEE Transactions on Education, vol. 65, no. 3, pp. 210-217, 2022.

[2] A. Gupta, R. Sharma, "IoT Enabled Campus Management System Using ESP32," International Journal of Advanced Research in Electronics and Communication Engineering, 2023.

[3] S. Patel et al., "Design of Smart Identification System for Institutional Automation," IRJET, vol. 11, issue 5, 2024.

[4] Datasheet, "ESP32-WROOM-32D Technical Reference Manual," Espressif Systems, 2024.

[5] RC522 RFID Reader Datasheet, NXP Semiconductors.

BIOGRAPHIES



Shivam Karvire, B. Tech Student, Department of Mechatronics Engineering, Sharad Institute of Technology College of Engineering, Yadrav. His interests lie in Web Development and Data Processing.



Sohan Kumbhar, B. Tech Student, Department of Mechatronics Engineering, Sharad Institute of Technology College of Engineering, Yadrav. His interests lie in microcontroller programming, sensor integration.



Bhushan Kamble, B. Tech Student, Department of Mechatronics Engineering, Sharad Institute of Technology College of Engineering, Yadrav. His interests lie in Electrical Wiring and Circuit Wiring.



Adarsh Managave, B. Tech Student, Department of Mechatronics Engineering, Sharad Institute of Technology College of Engineering, Yadrav. His interests lie in CAD and Circuit Designing.