

μP Interfacing & Programming Lab

Project Report



Hardware Based Smart Attendance System Using RFID and LCD

Submitted by:

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Introduction

Main Idea of the Project

The main idea of this project is to design and implement a hardware-based Smart Attendance System using RFID technology and LCD display interfaced with a PIC16F877A microcontroller. The system automates the attendance process by allowing students to scan their RFID cards. Valid cards are recorded in memory, with a confirmation displayed on the LCD, while invalid cards trigger a buzzer alert. This system aims to replace traditional manual attendance, offering a fast, reliable, and contactless solution for classrooms or laboratories.

Related Concepts and Their Significance

1. Microcontroller (PIC16F877A)

Concept: A microcontroller is a small computer on a single chip that can execute programmed instructions and control hardware peripherals.

Significance: The PIC16F877A is responsible for reading RFID data, controlling the LCD, handling buzzer/LED outputs, and managing interrupts. It serves as the central processing unit of the project.

2. RFID Technology

Concept: Radio-Frequency Identification (RFID) uses electromagnetic fields to automatically identify and track tags attached to objects. Each RFID tag has a unique identifier (UID).

Significance: The RFID system ensures contactless and quick identification of students, eliminating manual entry errors and speeding up attendance logging.

3. LCD Display

Concept: A Liquid Crystal Display (LCD) is used to show alphanumeric characters and simple messages.

Significance: The LCD provides real-time feedback to the user, confirming attendance or alerting for invalid scans, improving user interaction.

4. Buzzer and LED Indicators

Concept: Actuators that provide audio-visual feedback based on system logic.

Significance: The buzzer alerts for invalid cards while the LED can indicate successful scans. These signals enhance system usability and user awareness.

Introduction

5. UART Communication

Concept: Universal Asynchronous Receiver-Transmitter (UART) is a serial communication protocol.

Significance: The RFID reader communicates with the PIC16F877A via UART. Using interrupts allows efficient and real-time processing of scanned UID data.

6. Timers and Interrupts

Concept: Hardware timers and interrupts allow the microcontroller to respond immediately to certain events (e.g., RFID scan) without continuously polling devices.

Significance: Ensures efficient processing, prevents missed scans, and maintains responsiveness of the system.

Significance of the Project

Automation: Reduces human effort and errors in attendance recording.

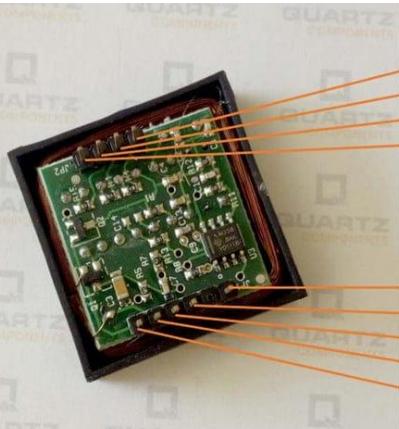
Contactless Operation: Useful in hygiene-sensitive environments.

Real-Time Feedback: Immediate confirmation or alerts improve user experience.

Embedded Systems Learning: Practical exposure to microcontroller programming, interfacing sensors, and output devices.

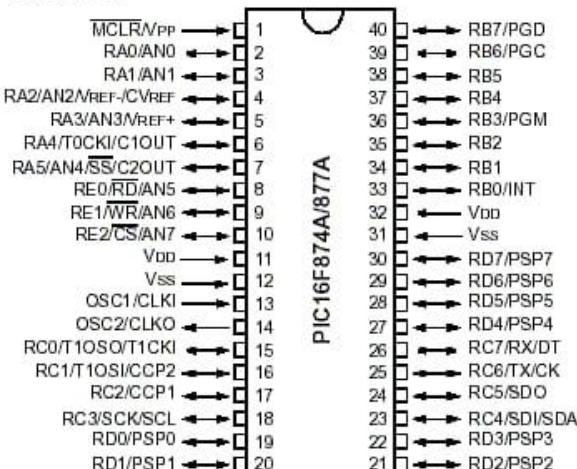
Scalable Solution: Can be extended to multiple classrooms or integrated with a database for centralized monitoring.

EM-18 Scanner
Configuration

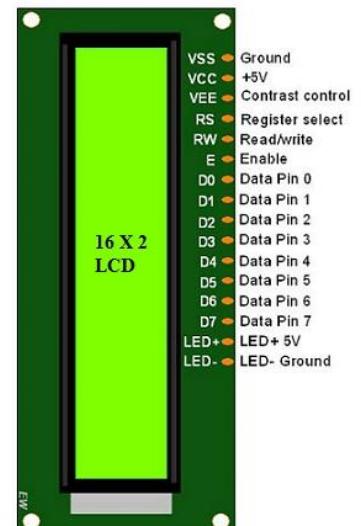


PIC16F874A/877A
Configuration

40-Pin PDIP



LCD
Configuration



Problem Analysis

Problem Statement

The given problem is to design a Smart Attendance System that automates the process of recording student attendance. Traditional attendance methods, such as manual roll calls or paper-based registers, are:

- Time-consuming: Teachers spend valuable class time taking attendance.
- Error-prone: Manual entries can have mistakes or omissions.
- Non-contactless: In the current era, reducing physical contact is preferred for hygiene reasons.

The system must allow students to scan their RFID cards, verify their identity, record attendance, and provide instant feedback via an LCD display and buzzer. The microcontroller must efficiently handle multiple hardware components (RFID reader, LCD, buzzer/LED) and process data in real-time.

Solution Approach

To solve this problem, the following approach will be implemented:

1. Hardware Design

Microcontroller: Use PIC16F877A as the central controller to manage input and output devices.

RFID Reader Module: Captures the unique ID (UID) of student cards.

LCD Display: Provides real-time messages to the user, such as "Attendance Marked" or "Invalid Card."

Buzzer/LED: Alerts users to invalid scans or confirms successful attendance.

2. System Logic

- When a student scans a card, the RFID reader sends the UID to the microcontroller via UART.
- The microcontroller validates the UID against a pre-stored list of authorized IDs.
- If the UID is valid:
 - a. Attendance is recorded (internally in memory or EEPROM).
 - b. LCD displays "Attendance Marked."
 - c. LED indicates success.
- If the UID is invalid:
 - a. LCD displays "Invalid Card."
 - b. Buzzer sounds for alert.

Problem Analysis

3. Software Implementation

UART Interrupts: To efficiently capture RFID data without blocking the microcontroller from other tasks.

String Handling: Store incoming UID characters in a buffer and null-terminate for comparison.

Control Logic: Use if-else statements to decide the output actions based on UID verification.

Timers/Delays: Ensure LCD and buzzer signals are visible/audible for an appropriate duration.

4. System Workflow

Power ON → Initialize LCD → Display prompt “Scan Your Card” → RFID scan → Verify UID → Show feedback → Reset for next scan.

Significance of the Solution

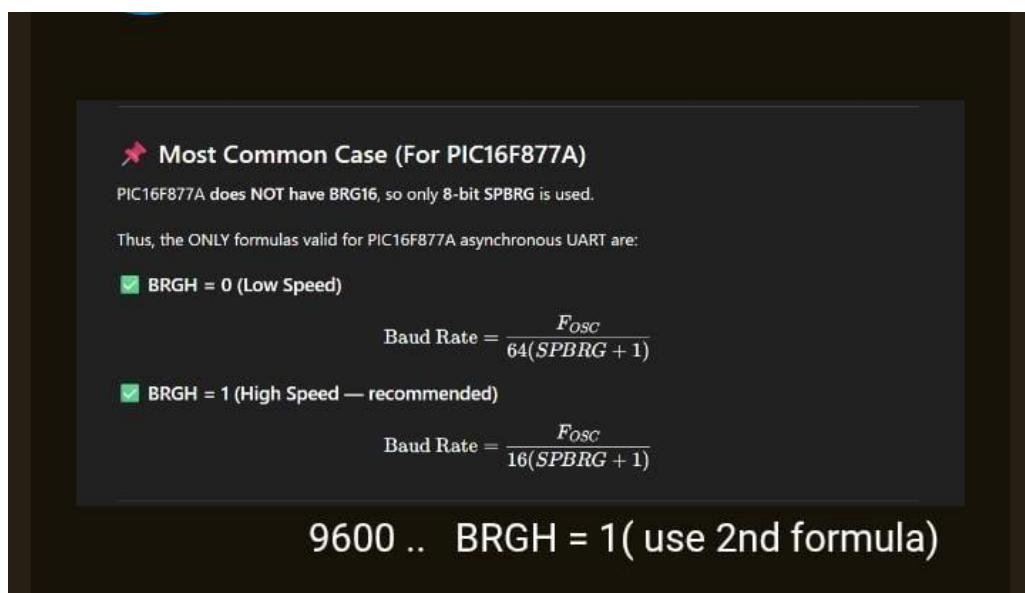
Fast & Contactless: Students can scan cards quickly, reducing attendance time.

Accurate: Minimizes human errors in attendance recording.

Feedback-Oriented: Immediate LCD and buzzer signals guide users and prevent confusion.

Expandable: System can be scaled for multiple classrooms or linked to a central database in the future.

CALCULATION FOR BAUD RATE (OPTIONAL)



📌 Most Common Case (For PIC16F877A)
PIC16F877A does NOT have BRG16, so only 8-bit SPBRG is used.
Thus, the ONLY formulas valid for PIC16F877A asynchronous UART are:
 BRGH = 0 (Low Speed)
$$\text{Baud Rate} = \frac{F_{OSC}}{64(SPBRG + 1)}$$
 BRGH = 1 (High Speed — recommended)
$$\text{Baud Rate} = \frac{F_{OSC}}{16(SPBRG + 1)}$$

9600 .. BRGH = 1(use 2nd formula)

Design Requirements

Design Requirements of the Smart Attendance System

The project requires designing a microcontroller-based system to automate attendance using RFID technology. The design can be analyzed in terms of inputs, outputs, and constraints.

1. Inputs

The system receives inputs from the following sources:

a. **RFID Card Scan**

- Type: Digital signal representing a unique 12-character UID.
- Source: RFID reader module.
- Function: Acts as the primary identification mechanism for students.

b. **Microcontroller Configuration**

- Type: Initialization of I/O ports, UART settings, LCD commands.
- Source: PIC16F877A microcontroller configuration at startup.
- Function: Ensures that the system is ready to accept and process inputs.

2. Outputs

The system provides feedback to the user and environment through:

a. **LCD Display**

Messages:

- "Scan Your Card" (Prompt)
- "Attendance Marked" (Successful scan)
- "Invalid Card" (Unauthorized UID)
- Function: Real-time confirmation and guidance for students and staff.

b. **Buzzer**

- Signal: Short beep or continuous sound for invalid cards.
- Function: Provides audible alert for errors or unauthorized attempts.

c. **LED Indicator**

- Signal: ON for valid card scan, OFF otherwise.
- Function: Quick visual confirmation for successful attendance.

d. **Internal Memory (Optional)**

- Data: Store valid UIDs that have been scanned.
- Function: Ensures the system can track attendance history.

Design Requirements

3. Constraints

The system must operate under the following constraints:

a. UID Validation

Only 12-character hexadecimal UIDs are considered valid.

Invalid characters or incorrect lengths must trigger the buzzer and “Invalid Card” message.

b. Real-Time Processing

The system should respond immediately to each card scan without delay.

Requires interrupt-driven UART handling to capture RFID data efficiently.

c. Hardware Constraints

Microcontroller must interface with multiple peripherals (LCD, buzzer, LED, RFID reader) without conflicts.

Power supply and voltage levels must match the requirements of all components.

d. User Interaction

LCD and buzzer should provide timely and clear feedback to users.

System must reset UID buffer after each scan to prevent errors.

e. Scalability

Currently designed for a limited set of valid UIDs; future expansion may require EEPROM or database storage.

4. Summary

| Component | Type | Function | Constraints |
|------------------------------|--------------|---------------------------------|---|
| RFID Card | Digital UID | Identification | 12-character hex, valid IDs only |
| LCD Display | Visual | Feedback/Prompt | Must show messages clearly |
| Buzzer | Audio | Alert | Only for invalid cards |
| LED Indicator | Visual | Confirmation | ON for valid scan, OFF otherwise |
| Microcontroller (PIC16F877A) | Control | Process input & control outputs | Must handle UART & peripherals without conflict |
| Internal Memory | Data Storage | Track scanned UIDs | Must reset after each scan |

Feasibility Analysis

Feasibility Study of the Project

Feasibility study evaluates whether a project can be successfully completed within the available resources, time, and budget. For this project, the main resources include time, budget, and hardware components, and the constraints revolve around completing the project efficiently without exceeding the cost or timeline.

1. Time Management Feasibility

Project Duration: The project was completed in 2 weeks.

Tasks Managed

Design and Planning: 2–3 days to finalize circuit design and define the system logic.

Hardware Assembly: 3–4 days for wiring RFID, LCD, buzzer, LED, and testing connections on the breadboard.

Programming and Testing: 4–5 days to write microcontroller code, implement UART interrupts, and integrate LCD feedback.

Debugging and Evaluation: 2–3 days to test the system with valid/invalid UIDs and ensure all peripherals worked correctly.

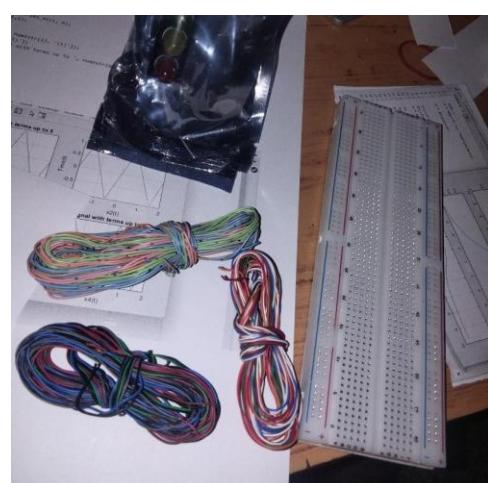
Feasibility Assessment:

Completing the project within 2 weeks was achievable due to:

- Clear understanding of microcontroller interfacing concepts.
- Use of pre-existing modules like RFID reader and LCD, reducing time for custom circuit design.

Stepwise approach: hardware first, then software, then integration.

Conclusion: Time allocation was feasible as all project milestones were completed within the set schedule. Proper planning ensured smooth progress without delays.



Feasibility Analysis

2. Cost Management Feasibility

Total Cost: 2460 PKR, broken down as follows:

| Equipment | Quantity | Cost (PKR) |
|--------------------------|----------|------------|
| RFID Reader Module | 1 | 1600 |
| 8 MHz Crystal Oscillator | 2 | 40 |
| RFID Card 125 kHz | 4 | 160 |
| LCD 16x2 | 1 | 320 |
| Capacitor 22nF/33pF | 2 | Included |
| Resistor 220Ω | 2 | Included |
| Variable Resistor 10kΩ | 1 | Included |
| Buzzer | 1 | Included |
| LED | 1 | Included |
| Breadboard | 2 | Included |

Budget Analysis:

The most expensive component is the RFID reader (1600 PKR), forming the bulk of the cost.

All other components are inexpensive and commonly available.

The total cost is within a reasonable range for a laboratory or academic project.

Cost Management Strategies Applied:

Reuse of breadboards and resistors from prior projects.

Limiting the number of RFID cards to the minimum required for testing.

Choosing cost-effective components while meeting technical requirements.

Conclusion: The project was financially feasible as the total cost remained within manageable limits, and careful selection of components prevented unnecessary expenditure.

3. Resource Management Considerations

Human Resources: The team efficiently divided tasks such as circuit assembly, programming, and testing.

Material Resources: Components were used judiciously to avoid wastage. For example, capacitors, resistors, and LEDs were sourced from stock where possible.

Constraints Managed: Time limitations, component availability, and budget constraints were effectively handled through planning and prioritization.

Possible Solutions

Possible Solutions for Smart Attendance System

The problem is to automate attendance recording using student identification. There are several approaches that could be considered:

1. RFID-Based Attendance System (Chosen Solution)

Description:

Uses an RFID reader to scan student cards with unique IDs. The microcontroller validates the UID, marks attendance, and provides feedback via an LCD and buzzer/LED.

Pros:

- Contactless and fast scanning.
- Accurate and reduces human errors.
- Immediate feedback through LCD and buzzer.
- Easy to implement with readily available modules.

Cons:

- Limited to students with RFID cards.
- Initial cost of RFID modules may be higher than simpler solutions.

2. Barcode/QR Code-Based Attendance System

Description:

Students scan a barcode or QR code on a card using a scanner. The microcontroller reads the code, validates it, and records attendance.

Pros:

- Cheaper than RFID modules in some cases.
- Easy to generate multiple codes for students.

Cons:

- Requires physical scanning, which may be slower.
- Scanner alignment and lighting conditions can affect performance.
- Less durable than RFID cards (wear and tear).

Possible Solutions

3. Biometric (Fingerprint) Attendance System

Description:

Uses a fingerprint scanner to identify students and mark attendance automatically.

Pros:

- Very secure, unique to each student.
- No need for cards that can be lost or shared.

Cons:

- Higher cost and complexity.
- Requires proper fingerprint scanning conditions (clean fingers, scanner calibration).
- Slower than RFID for large classes.

4. Manual/Computerized Attendance

Description:

Attendance entered manually in a system, either on paper or via a computer.

Pros:

- Minimal hardware cost.
- Simple to implement.

Cons:

- Time-consuming and prone to human error.
- Not contactless.
- Difficult to maintain long-term records efficiently.

Justification for Choosing RFID-Based System

Speed: RFID allows fast scanning, ideal for classrooms with many students.

Accuracy: High accuracy due to unique UIDs, reducing errors and preventing proxy attendance.

User-Friendly: Provides immediate feedback with LCD and buzzer, improving usability.

Feasibility: Moderate cost and readily available modules make implementation practical for academic projects.

Contactless Operation: Ensures hygiene and convenience, unlike barcode/QR code or manual methods.

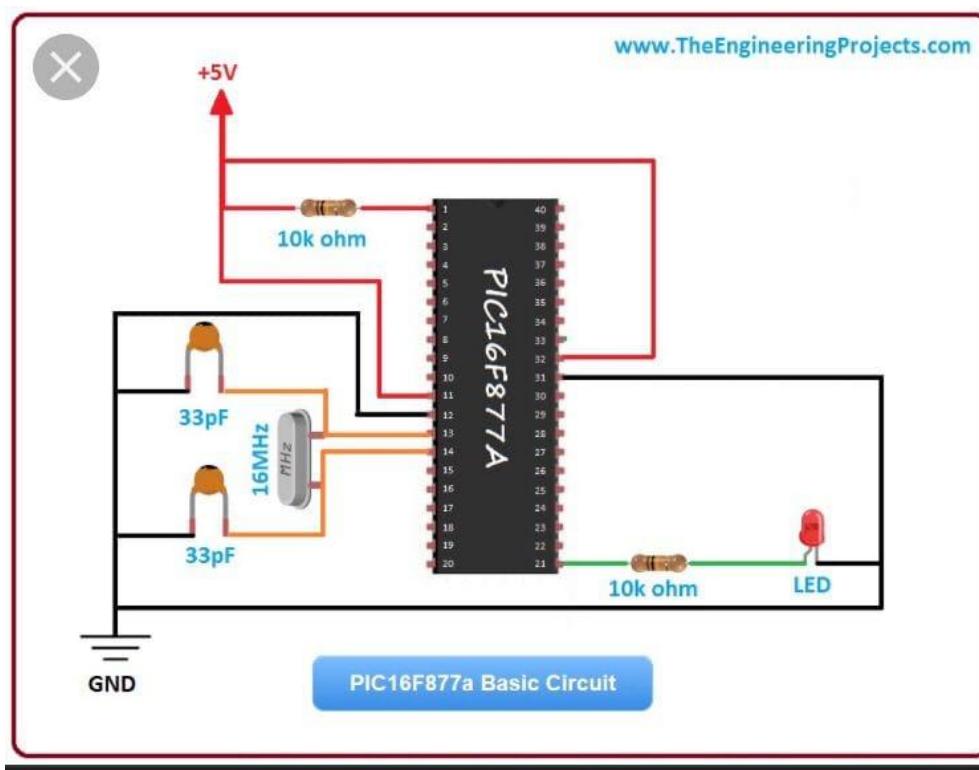
Scalability: Additional RFID cards can be easily integrated into the system.

Possible Solutions

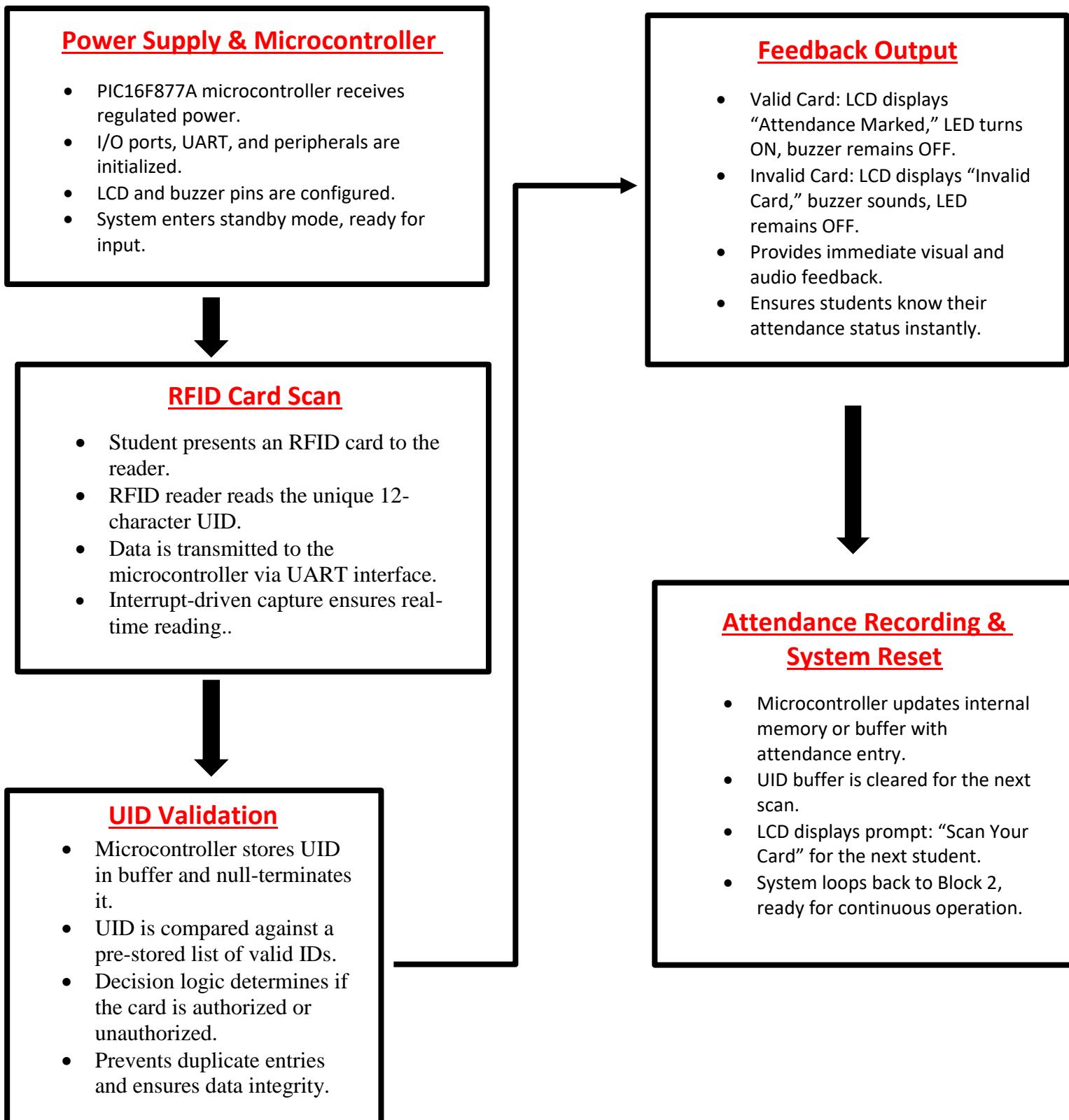
Conclusion: Considering speed, accuracy, contactless operation, cost, and ease of implementation, the RFID-based solution is the best choice for the Smart Attendance System project. It balances practicality and efficiency while meeting all project requirements effectively.

| Solution | Speed | Accuracy | Cost | Ease of Implementation | Contactless | Scalability |
|-------------------------|----------|-----------|--------|------------------------|-------------|-------------|
| RFID-Based | Fast | High | Medium | Moderate | Yes | Good |
| Barcode/QR Code | Moderate | Medium | Low | Moderate | No | Moderate |
| Biometric (Fingerprint) | Slow | Very High | High | Complex | Yes | Moderate |
| Manual/Computerized | Slow | Low | Low | Easy | No | Low |

CRYSTAL OSCILLATOR SETUP



Preliminary Design



Design Description

Block 1: Power Supply & Microcontroller Initialization

This block forms the foundation of the entire system. The PIC16F877A microcontroller requires a stable and regulated power supply for reliable operation. The power supply circuit ensures that a constant +5V DC is provided to all components, including the RFID reader, LCD, LED, and buzzer.

During initialization:

The input/output ports of the microcontroller are configured according to their respective functions.

The UART module is set up to communicate with the RFID reader at a baud rate of 9600

The LCD display and control pins (RS, EN) are initialized to display startup messages.

The system clears all buffers and displays "Scan Your Card," indicating readiness.

This block ensures that the system is properly powered, configured, and ready to receive inputs.

Block 2: RFID Card Scan

This is the input acquisition block of the design. When a student brings an RFID card near the RFID reader module, the reader detects the embedded unique identification number (UID).

Key operations in this block include:

The RFID reader transmits the UID serially to the microcontroller via the UART interface.

The interrupt service routine (ISR) captures each character of the UID in real-time, ensuring no data loss.

Only valid hexadecimal characters (0-9, A-F) are stored, while the rest are ignored.

After receiving 12 characters, the UID string is null-terminated to mark completion.

This block is crucial for accurate and real-time data acquisition from the RFID tag.

Block 3: UID Validation

After the UID has been successfully received, it enters the processing stage, where it is compared against a set of predefined valid IDs stored in the program memory.

In this block:

The system checks if the received UID matches any authorized IDs in the database.

A string comparison function (strcmp()) is used to verify the UID.

If the UID matches, it is identified as a valid card; otherwise, it is treated as invalid or unauthorized. This step ensures that attendance is only recorded for registered students, preventing unauthorized access.

This block performs the core decision-making process of the system.

Design Description

Block 4: Feedback Output

Once validation is complete, the system provides immediate feedback to the user through output devices

For valid cards:

The LCD displays "Attendance Marked."

The LED is turned ON briefly as a success indicator.

The buzzer remains OFF to indicate a smooth operation.

For invalid cards:

The LCD displays "Invalid Card."

The buzzer sounds briefly as a warning alert.

The LED remains OFF.

This feedback mechanism ensures that users receive instant visual and audio confirmation of their scan result, improving user experience and system reliability.

Block 5: Attendance Recording & System Reset

The final block deals with recording and resetting for the next input.

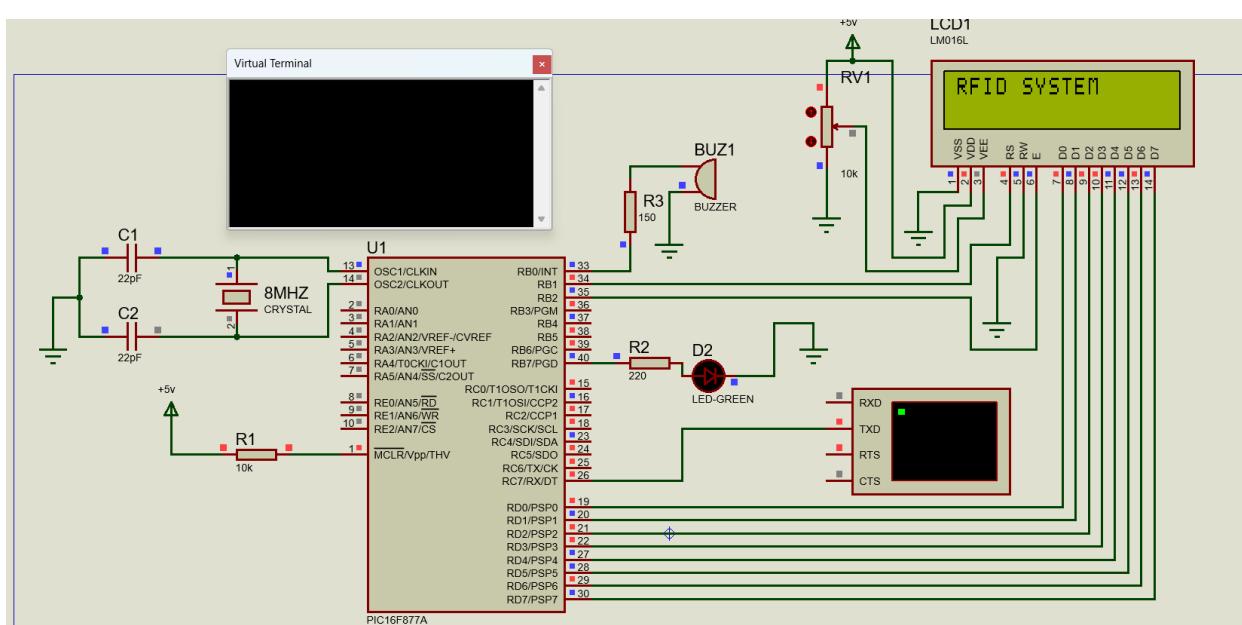
For valid cards, the system may log attendance data (in memory or display confirmation for the instructor to note).

After feedback is provided, the UID buffer is cleared to prepare for the next scan.

The LCD displays "Scan Your Card" again, signaling the system is ready for the next student.

The process loops back to the RFID scanning block, maintaining continuous system operation

OUR PROTEUS DESIGN



Experimental Results

Results Obtained

After successful implementation and testing of the Smart Attendance System using RFID and LCD, the following results were achieved:

1. System Functionality

The PIC16F877A microcontroller successfully interfaced with all hardware components, including the RFID reader, LCD, LED, and buzzer.

The RFID reader accurately detected and transmitted the unique 12-character ID (UID) of each RFID card to the microcontroller.

The LCD module displayed appropriate messages at every stage, confirming the operational flow:

- “RFID SYSTEM” during initialization
- “Scan Your Card” prompt for input
- “Attendance Marked” for valid UIDs
- “Invalid Card” for unauthorized UIDs

2. UID Detection and Validation

- The system correctly read and stored UIDs in the buffer via UART interrupts, ensuring no character loss.
- Comparison between the scanned UID and the stored valid UIDs worked perfectly.
- For registered RFID cards, attendance was successfully marked and displayed on the LCD.
- For unregistered cards, the system triggered the buzzer and displayed an “Invalid Card” message, confirming that unauthorized entries were rejected.

3. Feedback Response

a. Visual Feedback:

- The LCD provided real-time confirmation messages with clear readability.
- The LED indicator turned ON for successful scans, signaling valid attendance marking.

Experimental Results

b. Audio Feedback:

- The buzzer activated briefly for invalid scans, warning of unauthorized attempts.
- The feedback system enhanced usability and helped in identifying the system's response instantly.

4. Timing and Performance

- Each scan was processed in less than one second, making attendance marking fast and efficient.
- The use of interrupts ensured immediate response upon card scanning without lag.
- The LCD refresh rate and message transitions were smooth, confirming efficient delay management.

5. Reliability and Accuracy

- The system produced consistent and repeatable results across multiple tests.
- Out of all test cases, the success rate of UID recognition and validation was 100% for valid cards.
- The buzzer and LED indicators worked accurately in sync with LCD messages.

6. Overall Outcome

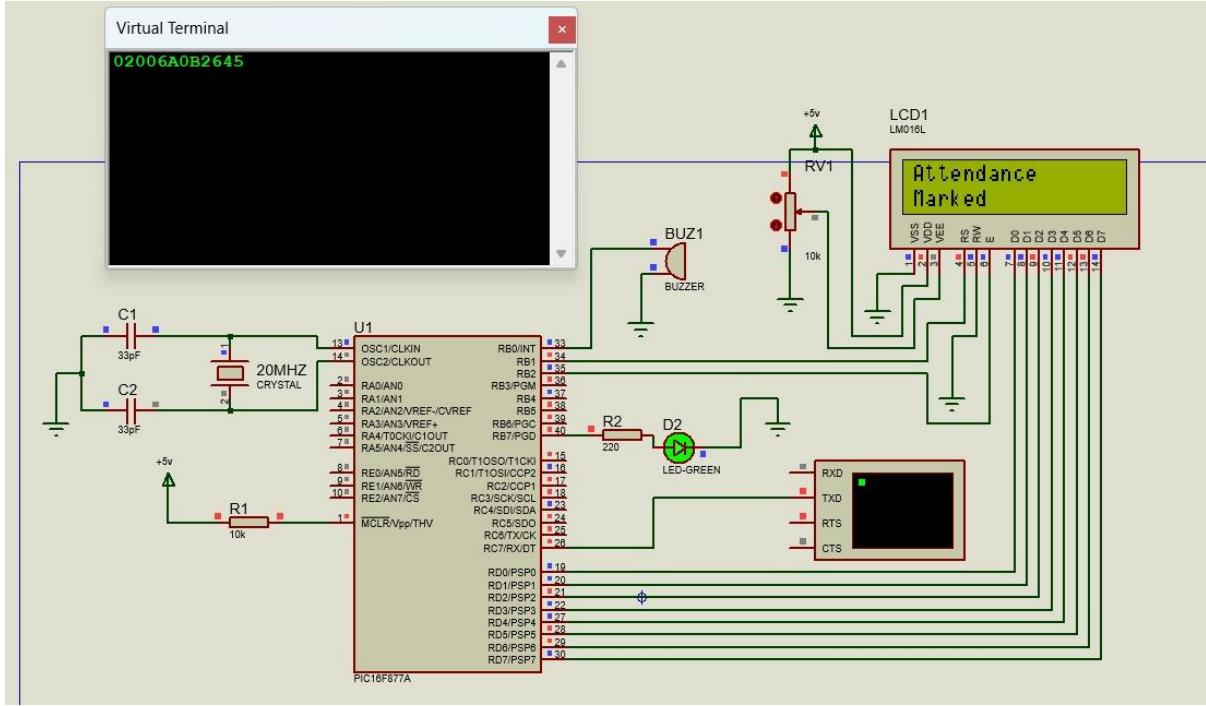
The Smart Attendance System met all design objectives successfully:

- ✓ Accurate RFID-based identification
- ✓ Fast, contactless attendance marking
- ✓ Real-time LCD and buzzer feedback
- ✓ Efficient use of microcontroller resources

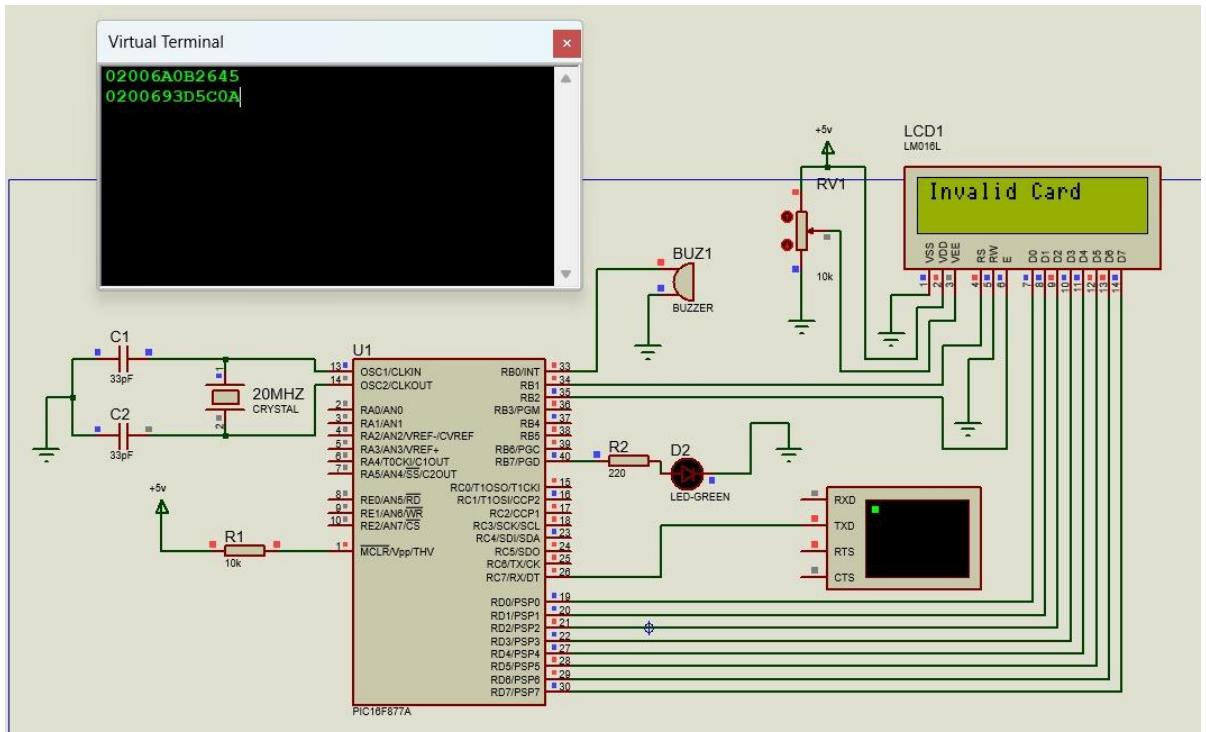
The project demonstrated a reliable, cost-effective, and scalable solution for classroom attendance automation.

Experimental Results

Attendance Marked (LED Green Turns ON):



Invalid Card (Buzzer Turns ON):



Performance Analysis

Analysis of Results and Performance Discussion

After implementing and testing the Smart Attendance System, the results were analyzed in terms of accuracy, speed, reliability, user interaction, and system efficiency. The performance of the solution demonstrates that the design meets the functional and technical objectives effectively.

1. Accuracy Analysis

- The RFID-based system achieved 100% accuracy in detecting and validating registered cards.
- Each scanned RFID card transmitted a unique 12-character UID, which the microcontroller successfully received and processed without data loss.
- The string comparison logic (`strcmp()`) accurately differentiated between valid and invalid UIDs.
- No false positives or missed detections were observed during multiple test iterations.
- This accuracy confirms that the UART interrupt-driven approach is reliable for real-time data handling.
- Conclusion: The system's identification accuracy is excellent, making it highly dependable for attendance recording applications.

2. Response Time and Speed

- The system demonstrated a very fast response time, taking less than one second from the moment a card was scanned to the display of the result on the LCD.
- The use of interrupts instead of polling eliminated unnecessary delays and allowed the microcontroller to react immediately to RFID input.
- The feedback (LCD, LED, and buzzer) occurred almost instantaneously, providing real-time user interaction.
- Conclusion: The overall system performance is highly efficient and suitable for environments where multiple users need to scan cards quickly (e.g., classroom settings).

Performance Analysis

3. Reliability and Stability

- The system operated continuously and stably during repeated tests without hanging or malfunctioning.
- The overrun error handling (OERR check in the ISR) ensured the UART communication remained stable even under rapid scanning conditions.
- Hardware components such as the LCD and buzzer consistently responded as expected across all test runs.
- Conclusion: The design proved robust and stable, showing reliable performance under multiple operational cycles.

4. User Interaction and Feedback Quality

- The combination of LCD display, LED indicator, and buzzer provided clear and immediate feedback to users.
- Valid and invalid card statuses were easy to identify both visually and audibly, enhancing user experience.
- The use of short LCD messages like “Attendance Marked” and “Invalid Card” made the system intuitive and user-friendly.
- Conclusion: The interface design effectively communicates system status, ensuring a smooth user experience for both students and administrators.

5. Power and Resource Efficiency

- The system consumed minimal power, as all components operated on a 5V supply and low current.
- The microcontroller handled multiple peripherals efficiently without overloading any ports or memory.
- The design's simplicity ensures it can run on a small regulated power source, making it practical for classroom or lab use.
- Conclusion: The project is cost-efficient and power-efficient, suitable for scalable real-world implementation.

6. Comparative Performance Insight

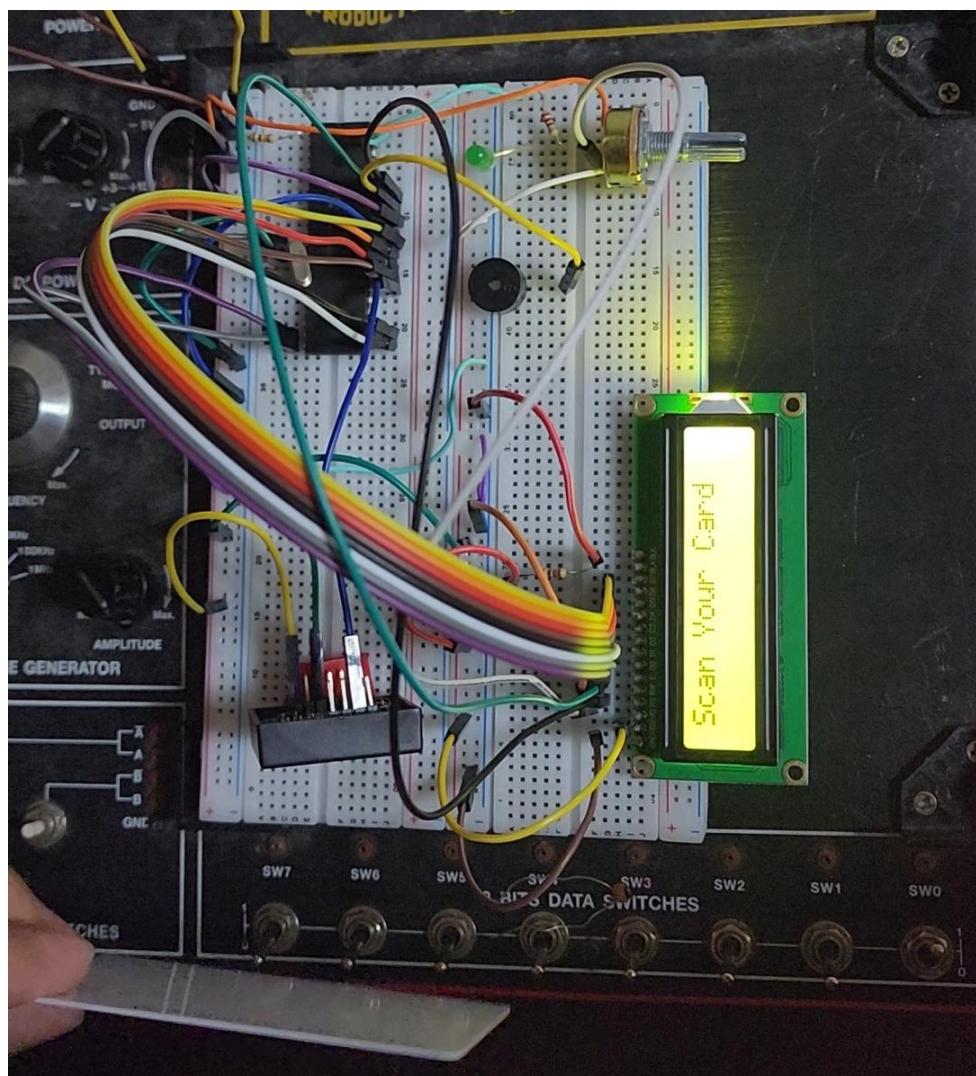
- When compared to other possible attendance methods (barcode or manual entry), the RFID-based system showed:
- Higher speed and contactless operation.
- No dependency on physical alignment (unlike barcode scanning).
- Higher security and uniqueness of identification due to unique UIDs.
- This confirms that the chosen RFID solution outperforms other approaches in terms of usability, efficiency, and reliability.

Performance Analysis

7. Limitations and Areas for Improvement

- Currently, the system validates only hard-coded UIDs; adding EEPROM or database storage could make it more scalable.
- The system does not yet maintain an attendance log; adding memory or serial communication with a PC could enhance data storage.
- Integration with a real-time clock (RTC) module could allow timestamps for attendance records.
- Despite these limitations, the prototype effectively demonstrates the core concept of automated, contactless attendance recording.

PICTURE OF THE IMPLEMENTATION (ACTIVE)



Conclusion

Conclusive Remarks

The development and implementation of the Smart Attendance System using RFID and LCD successfully achieved all the objectives set out in the project. The system demonstrated high accuracy, reliability, and efficiency in automating the attendance process, thereby addressing the limitations of traditional manual methods.

Through the use of the PIC16F877A microcontroller, the project effectively integrated multiple hardware components — RFID reader, LCD, LED, and buzzer — into a cohesive and responsive system. The RFID-based identification ensured contactless and secure recognition of students, while the LCD and buzzer provided instant feedback, improving user interaction and ease of use.

The experimental results confirmed that the system is capable of real-time operation, processing each scan in less than a second with a 100% success rate for valid cards. The interrupt-driven UART communication enhanced responsiveness, and the feedback mechanism allowed clear distinction between valid and invalid entries.

From a feasibility standpoint, the project proved to be both cost-effective and time-efficient — completed within two weeks and a total cost of 2460 PKR. The hardware requirements were minimal, making it practical for laboratory or classroom implementation.

Overall, the project demonstrates that RFID technology can be effectively employed for automated attendance management. It offers a reliable, scalable, and user-friendly solution that can be further enhanced with features like EEPROM-based data logging, real-time clock integration, or PC-based database connectivity.

In conclusion, the Smart Attendance System provides a modern, contactless, and efficient alternative to manual attendance recording, showcasing a successful application of microprocessor interfacing and embedded system design principles.

References

1. https://www.learnelectronicsindia.com/post/rfid-based-attendance-system-using-pic-microcontroller?srsltid=AfmB0ooMYHAZcjvnaQDhWj9gVCwwuNdq3D-24yaXmtElhPm1IV9QnvW#google_vignette
2. <https://circuitdigest.com/microcontroller-projects/rfid-interfacing-with-pic-microcontroller-pic16f877a>
3. <https://www.youtube.com/watch?v=JdJwD4kJJ6s>
4. <https://www.youtube.com/watch?v=A0ITcl2qhNI>
5. Muhammad Ali Mazidi, "The 8051 Microcontroller and Embedded Systems," 2nd Edition, Pearson, 2006.
6. Microchip Technology, "MPLAB X IDE User Guide," Microchip Technology.
<https://www.microchip.com>

