Smart Safe Based on IoT

Project Overview

This project, developed as part of my **Bachelor's thesis**, involves the design and implementation of a Smart Safe system based on Internet of Things (IoT) technology. The goal was to create a secure, IoT-enabled safe that provides enhanced protection for valuable items through real-time monitoring, multi-layer authentication, and the ability to send notifications via SMS. The safe system integrates several sensors and communication modules, including a SW-420 vibration sensor, PIR motion sensor, NEO-M8 GPS module, and SIM800L GSM module for communication with the user. The project aimed to combine embedded systems programming, sensor integration, and SMS communication to build a reliable and effective security solution.

This smart safe system allows users to control and monitor their safe remotely, ensuring that their belongings are protected and that they are notified of any suspicious activity or tampering. The system also tracks the safe's location using GPS, providing real-time updates to the user in case of theft or unauthorized access.

Key Features and Functionality

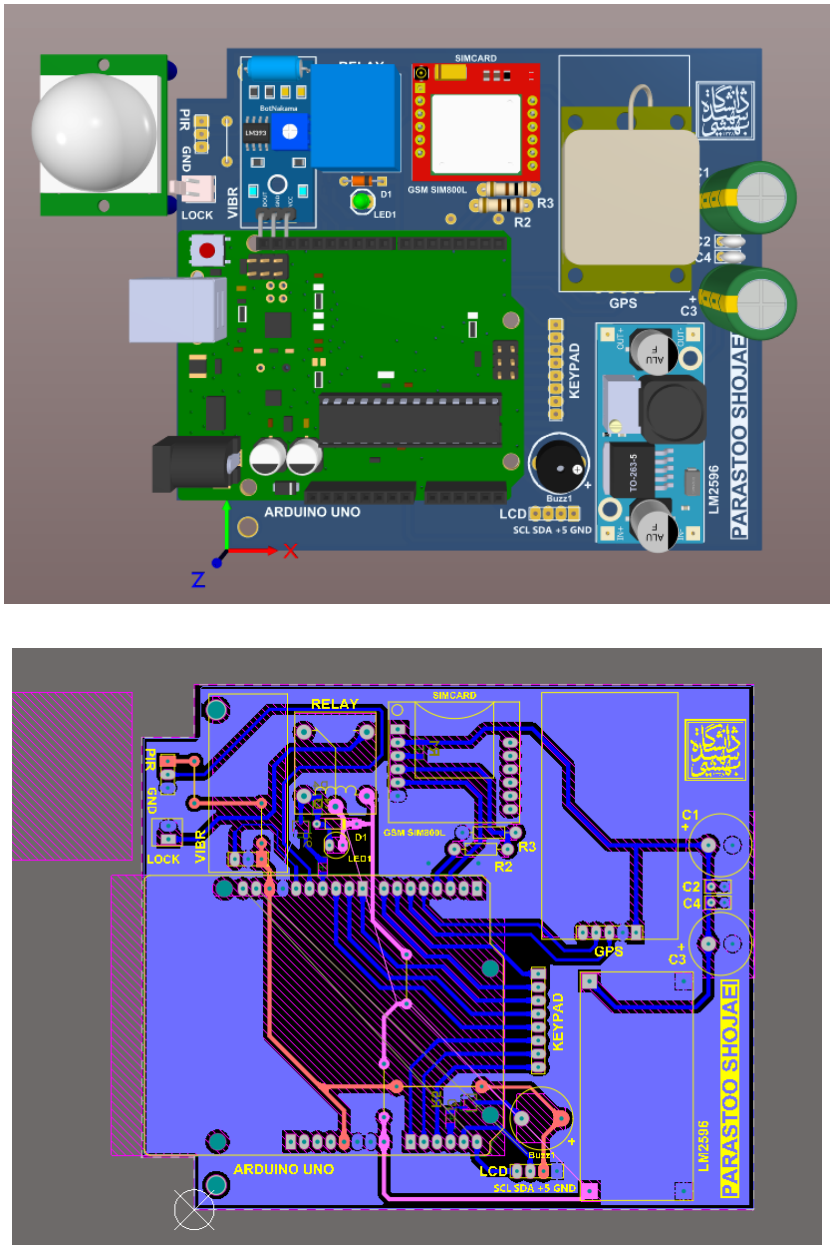
1. **Multi-Layer Authentication**:
    - The safe is secured with a password-based authentication system. After entering the correct password, the system prompts the user for an additional ID verification step via SMS, enhancing the security of the device.
    - Password and OTP Verification: Users must enter a password and a randomly generated ID sent via SMS to unlock the safe, adding an extra layer of security to prevent unauthorized access.
2. **Sensor Integration**:
    - Vibration Detection: The system uses the SW-420 vibration sensor to detect any physical tampering with the safe. When a vibration is detected, the system sends an alert to the user.
    - Motion Detection: The PIR motion sensor detects movement around the safe, providing an additional layer of security. If motion is detected, the system triggers an alert.
3. **Location Tracking**:
    - The NEO-M8 GPS module provides precise location tracking, sending real-time GPS coordinates to the user every 10 minutes, allowing them to track the safe’s location in case of theft.
4. **SMS Communication**:
    - The SIM800L GSM module allows the system to send and receive SMS messages. When suspicious activity is detected (e.g., vibration or motion), the system sends an SMS alert to the user.

    - The system also allows the user to remotely control features like vibration and motion sensors by sending specific SMS commands such as "Motion_on" or "Vibr_on."
5. **User Interface**:
    - The user interface is displayed on a 16x2 LCD. It shows prompts for password entry, status updates, and alerts for the user. The keypad is used for password input and for entering commands.
    - The LCD displays various system statuses, such as "Enter Password", "Enter ID", and "Unlock" based on the current step in the authentication process.
6. **EEPROM Storage**:
    - The system stores the user's password and phone number in EEPROM memory to retain them even after the device is powered off. This ensures that the system can retrieve the stored data when required.
7. **Security Features**:
    - If multiple incorrect attempts are made for either password or ID entry, the system locks for 15 minutes as a safety measure, preventing brute-force attacks.
    - The buzzer emits a sound as an alert whenever there is an incorrect password attempt or other security events.

Technical Details and Hardware Components

The project relies heavily on Arduino as the main microcontroller, which manages the sensors, LCD, keypad, and communication modules. Below is a summary of the key hardware components used:

- **Arduino Uno**: The main controller that orchestrates all components, handles the logic for authentication, and interfaces with the sensors and modules.
- **SW-420 Vibration Sensor**: Detects vibrations that could indicate tampering with the safe.
- **PIR Motion Sensor**: Detects human motion around the safe for enhanced security.
- **NEO-M8 GPS Module**: Provides accurate location information of the safe using GNSS signals.
- **SIM800L GSM Module**: Facilitates communication via SMS, allowing the safe to send alerts and receive commands from the user.
- **16x2 LCD Display**: Displays system prompts and information to the user.
- **Keypad**: Used by the user to enter the password and other commands.
- **EEPROM**: Stores the user’s password and phone number persistently.



PCB layout designed for the Smart Safe system

Challenges and Solutions

1. **Handling Multiple Sensors**:
    - Managing the multiple sensors (vibration, motion, and GPS) simultaneously was a challenge. This was overcome by using timers to handle each sensor's data collection and alerting in parallel, ensuring that the system remained responsive and efficient.

2. **SMS Communication Reliability**:
    - One of the difficulties was ensuring reliable SMS communication through the SIM800L module. By carefully managing the timing of AT commands and checking the module's response, I was able to ensure consistent performance.
3. **GPS Accuracy**:
    - Initially, the GPS module provided some inaccurate readings. This was mitigated by ensuring that the GPS module had a clear view of the sky, and by implementing a check to only send location data once the GPS signal was valid.

Conclusion

The Smart Safe based on IoT project successfully integrates embedded systems, sensor technology, and SMS communication to create a secure, reliable, and user-friendly solution for protecting valuables. The project not only demonstrates the capabilities of Arduino and IoT systems but also highlights the importance of multi-layered security features in protecting sensitive items.