Princess Sumaya University for Technology

Embedded Systems

Final Project Report

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Smart Home System

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Abstract

This project implements a smart home system design using a PIC microcontroller. The system includes a password-protected door using a keypad, automatic lighting based on ultrasonic distance measurements and gets switched ON or OFF, a temperature-controlled fan using a KY-026 flame sensor, and finally an LCD display that gives the user real-time feedback on the system's operation. The system integrates multiple sensors, actuators, and peripherals to provide an efficient and automated smart home solution.

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Introduction

Smart home systems have become increasingly popular due to their ability to improve convenience, security, and energy efficiency. This project is designed to demonstrate a functional smart home prototype that automates basic home functionalities:

- Door access control using a servo motor and keypad.
- Light control using an ultrasonic sensor to detect objects and motion.
- Fan speed control using H-bridge based on room temperature measured by a KY-026 sensor.

This embedded system demonstrates how microcontroller-based designs can integrate various sensors and actuators to achieve a robust and efficient solution.

Objectives

1. Develop a password-protected door system using a keypad and a servo motor.
2. Implement automatic lighting based on objects using an ultrasonic sensor.
3. Control the speed of a fan using H-bridge based on ambient temperature using an LM35 sensor.
4. Utilize an LCD for user interaction and system feedback.
5. Ensure the system operates efficiently and meets the design requirements.

Components

1. Microcontroller → **PIC16F877A**: Manages the entire system, processing input from sensors and controlling outputs.

2. Input Devices → **4x4 Keypad**: Enables user input for door password.
KY-026 Flame Sensor: Measures ambient temperature.
Ultrasonic Sensor (HC-SR04): Measures distance to control lighting.

3. Output Devices → **Servo Motor**: Controls the door movement.
Fan Motor (H-bridge): Adjusts speed based on temperature.
Buzzer: Alerts the user of incorrect password input.
LCD: Displays user feedback and system status.
LED or Light: Turns on/off based on light and proximity.

4. Power Supply → **Voltage Regulator**: Provides regulated power to the microcontroller and peripherals.

Hardware Design

- Circuit Schematic

- The schematic integrates all components, showing connections between the microcontroller, sensors, actuators, and power supply.
- Key connections include:
    - **Keypad**: Connected to PORTD for password input.
    - **LCD**: Connected to PORTB for system feedback.
    - **Ultrasonic Sensor**: Trigger and Echo connected to PORTC pins, Trigger connected to RC4 while Echo to RC5.
    - **Servo Motor and H-bridge**: Connected to PORTC for door lock and fan control, Servo connected to RC3 while H-bridge IN3 to RC0, IN4 to RC1, ENB to RC2.
    - **Buzzer**: Connected to RC6 to alert that the input password is wrong.
    - **LED**: Connected to RC7 to show the feedback of the ultrasonic sensor.

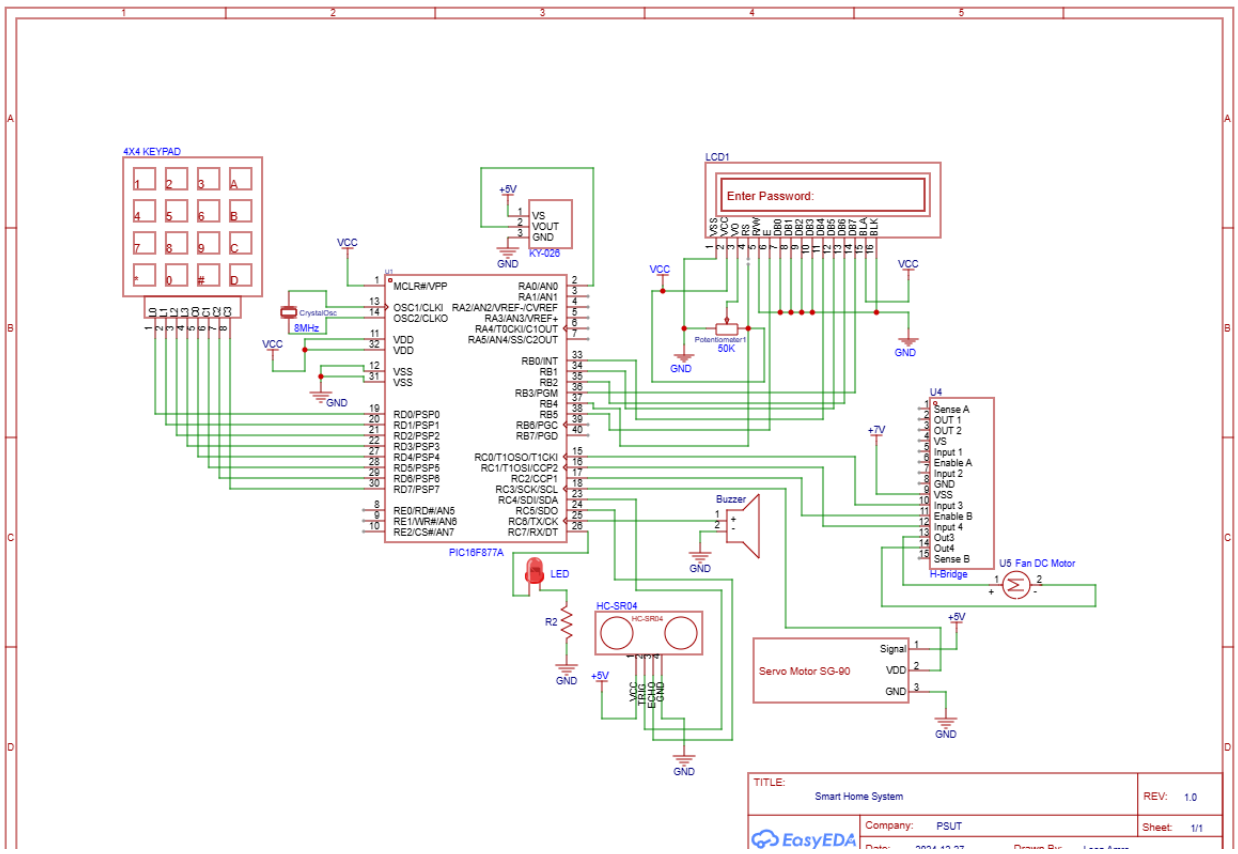

Figure 1: Electric Design

- Prototype

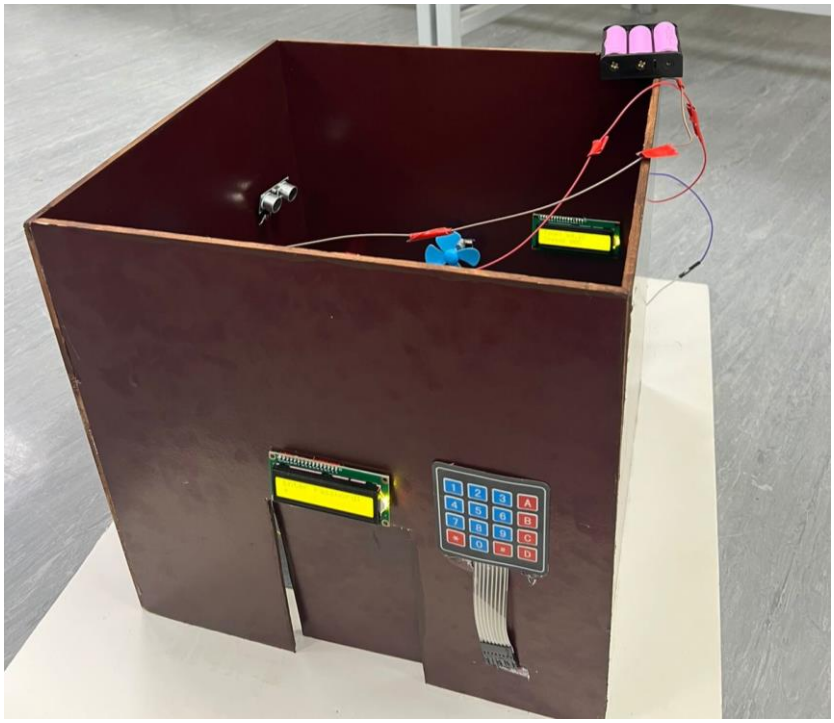

Figure 2: Exterior View

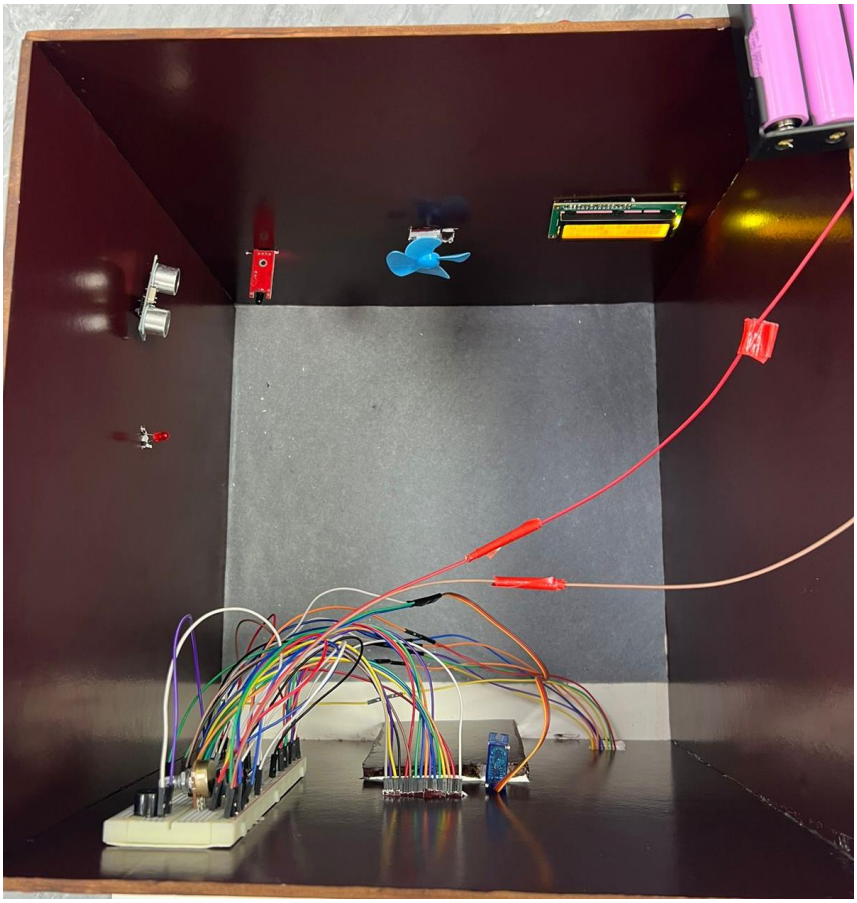

Figure 3: Interior View

Software Design

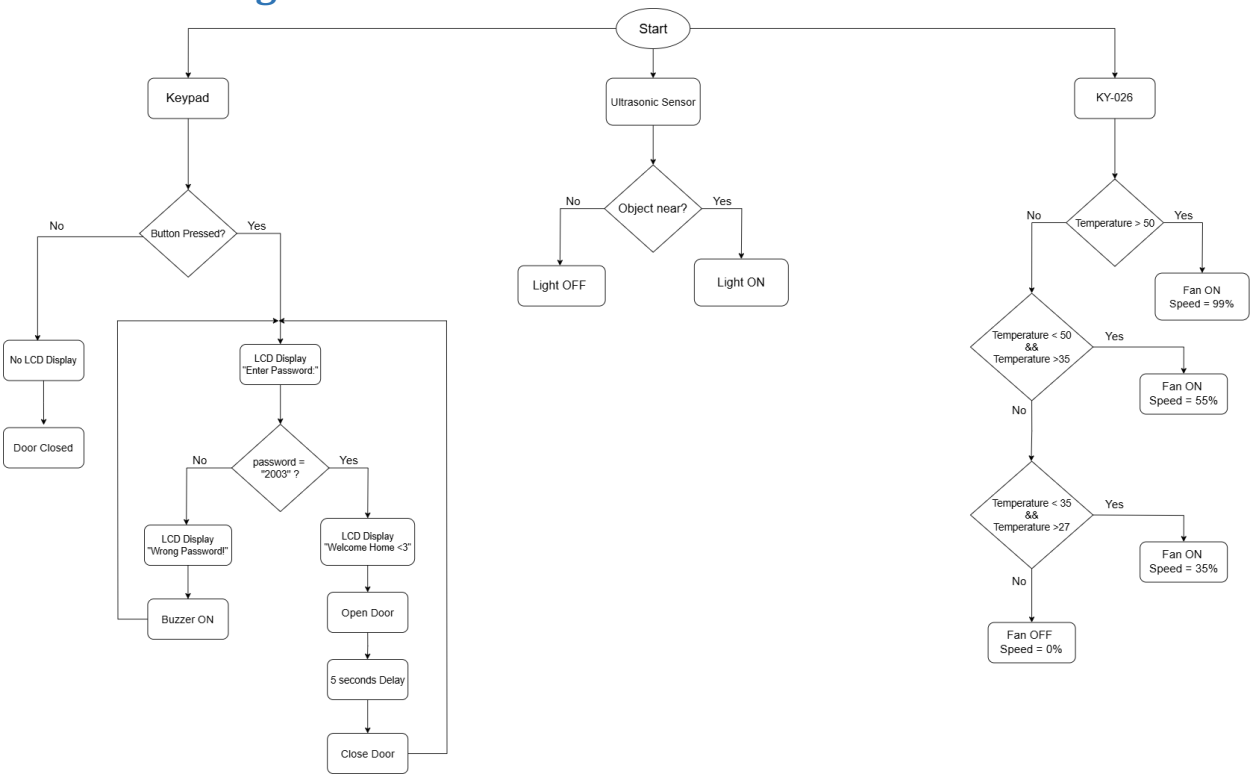

Figure 4: Software Design

The software integrates multiple modules that work to achieve the desired functionalities of the smart home system. Each module is responsible for a specific aspect of the system's operation, ensuring seamless interaction between hardware components.

For **password protection and door access**, the software employs a 4x4 matrix keypad for input. The keypad is scanned to detect key presses, allowing the user to input a 4-digit password. The entered password is then compared to a predefined password stored in the system. If the entered password matches the stored password, the servo motor is activated to unlock the door. After a delay, the motor automatically relocks the door to ensure security. If the password is incorrect, a buzzer is triggered to alert the user.

The **automatic lighting control** module uses an ultrasonic sensor to measure the distance to nearby objects. The sensor continuously monitors the environment, and if an object is detected within a specified distance, an LED is turned ON to simulate automatic lighting. Conversely, if no object is detected, the LED is turned OFF. This functionality adds convenience and energy efficiency to the system.

The **temperature-based fan speed control** utilizes the KY-026 flame sensor to measure ambient temperature. The sensor's analog output is read by the microcontroller's ADC module, and the voltage is converted into a temperature value using the equation:

$$\text{Temperature} = \left(\frac{ADC\ Value}{1023}\right) \times 5v\ \div 0.01v/C$$

Based on the calculated temperature, a PWM signal is generated to control the fan's speed via an H-bridge. The PWM duty cycle increases with higher temperatures, resulting in increased fan speed. The software implements a threshold system to define specific fan speeds for different temperature ranges, ensuring optimal performance and energy usage.

The **LCD feedback module** provides real-time interaction and information display. The LCD displays prompts for password entry and indicates whether access is granted or denied. Additionally, it shows real-time temperature readings and the corresponding fan speed, along with system status messages related to lighting control. This user-friendly interface enhances the system's usability by providing clear feedback on its operation.

Conclusion

This project successfully demonstrates a smart home prototype with essential functionalities like secure access control, automated lighting, and temperature-based fan control. It highlights the capabilities of embedded systems in building intelligent, automated environments.