

Smart Embedded Home System Project

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# Abstract

The project aims to enhance life convenience by using the PIC16F877A microcontroller to develop a smart home system that has several functionalities like light automation, fire alarm, climate control, door automation, and garage parking assistance. This project introduces a base ground for modern homes, and it does this by creating a simple miniature house model that contains all the technologies used in the project. Every component is mentioned and described, and the design is illustrated and explained by its mechanical, electrical, and software aspects. Recommendations and the problems that faced us was clarified for future work.

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# Introduction

## Background

In the modern era, the advancement of technology affected the lifestyle of people; it changed how people live their lives. With this idea in mind, it can be noticed that home technology is also advancing in terms of automation, control, and security. This enhances the convenience of living and makes many tasks easy to accomplish. The use of microcontrollers is very important in digitally converting to a smart home model, it can be programmed to manage a variety of interconnected devices, allowing seamless interaction between sensors, actuator, etc. In this report, a modern smart home system will be introduced and explained in detail.

## Objectives

The core of the work is to design a miniature house model that illustrates a smart home system that makes use of PIC16F877A microcontroller to accomplish several objectives related to home technology. The objectives include:-

1. Door automation using servo motor and IR: When a person is detected near the door, the door automatically opens by a servo motor and closes after the person moves away. An LCD panel displays messages to people entering the home.
2. Automation of lights using IR: once a person is detected, a light outside the house automatically turns on.
3. Distance monitoring using Ultrasonic sensor and a buzzer: once a car is detected in the garage, the sensor is responsible for changing the LED lights when the car is approaching so that it informs the driver of the distance between the car and the garage’s internal wall so the car don’t hit it.
4. Climate control: LM35 temperature sensor is used to control the speed of a DC motor fan to control the climate.
5. Fire alarm using KY-026 sensor: if high temperatures are detected, a buzzer is turned on to alarm the residents of a fire presence.

# Design

## Requirements

To make the design model, some hardware and software components are needed, the hardware components are mentioned in section 2.2. In terms of software components, mikroC pro for PIC software was used to write the code in C language and to build and program the instructions to the used PIC to control the hardware components. The required drivers were installed on the computer and a USB cable that was connected between the computer and the EasyPIC also powered it. One of the requirements include activating the light within 1 second of door opening, another is adjusting the temperature and fire sensors to work with the specific dimensions of the room that they are operating in. Switches and reset buttons will be used generally to turn the system ON or OFF and to reset it.

## Components and their Description

### 3.7 V Batteries

Three lithium-Ion batteries are used to supply power to the system.

### EasyPIC

EasyPIC is a development board designed for experimenting and testing microcontrollers. It has many built-in functionalities like LEDs, switches, push buttons, etc. It makes the process of building microcontroller-based projects easy. It’s compatible with microC pro for PIC software and has a built-in programmer/debugger to make coding easy. We used it to test and build the project and connect the components and programming them, in addition to powering them; all in a single development tool.

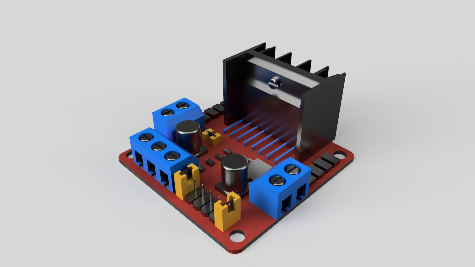
### PIC16F877A

PIC16F877A is a microcontroller that is widely used in embedded systems and educational projects. It uses Reduced Instruction Set Computer (RISC) and it operates on up to 20 MHz frequency. We used it as the central device that controls the other components, and we used the C language.

### DC Motor

DC motor is an electromechanical device that converts electrical energy from direct current to rotational motion. Its speed can be controlled by varying the voltage or current applied to it. We used it as a fan with different speeds to control the climate of the house based on temperature.

### H-Bridge

H-bridge is a bidirectional control that enables a motor to rotate in both directions, and it can also control the speed of the motor with PWM. We used it to connect the DC motor to it and to power the circuit through 5V pin.

### Servo Motor

Servo motor is an actuator designed for the control of angular position. The CCP module of the PIC microcontroller is utilized to generate the PWM control signal is sent to the servo motor to change its angle accurately. It’s widely used in automation applications. We used it to control the door state such that when a person is detected, the servo motor will open the door, and if no person is detected the servo motor will close the door.

### IR Sensor

Infrared sensor is a device that detects infrared radiation from objects in its field of view. It’s widely used in detecting objects to do a specific task based on the detection. It’s composed of an IR emitter that emits infrared radiation and an IR detector that detects the reflected IR radiation. We used it to detect if a person is near the door to open it or if he is far to close it; and we also used it to detect if there’s a person entering the room to light it up or if he’s exiting the room to light it down.

### Ultrasonic Sensor

Ultrasonic sensor is a device that uses sound waves to measure the distance between itself and an object or to detect the presence of an object. It operates on the principles of ultrasound; it works by emitting ultrasonic sound waves from a transmitter and detecting the reflected sound waves by a receiver after bouncing off an object. We used it to measure the distance of the car in the garage and changing the LED light colors based on the distance of the car, so it doesn’t hit the wall.

A red circuit board with a blue screen

Description automatically generated

### KY-026 Sensor

The KY-026 flame sensor is an IR module designed to detect flames or light sources, it’s highly sensitive and capable of detecting small flames. We used it as part of the fire alarm system to detect the presence of fire so that a buzzer alarms the residents of an existing fire.

### Sound Actuator (Buzzer)

A sound actuator is a device that generates sound waves in response to electrical signals. We used it as a sound alarm when fire presence is detected by the KY-026 sensor.

### Liquid Crystal Display (LCD) Panel

An LCD is a module that uses liquid crystals and a backlight to present alphanumeric characters and simple graphics. In our project PIC16F877A drives the LCD in 4-bit mode. We mounted the LCD on the external door of our miniature house model. It displays real-time status messages for anyone approaching the door, enhancing user interaction by visually indicating the door’s current state.

### Other components

We used several other components that include a breadboard to connect the whole system, a switch to power ON/OFF the system, a push button to reset the PIC, an LED that were used in different parts of the design like lighting inside and outside the home and in the garage as a guide to the driver, and we also used resistors.

## Mechanical Design

## Electrical Design

A diagram of a circuit board

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## Software and Flowchart

# Problems and Recommendations

There were some problems that faced us during the project, one of them is using a used breadboard and counterfeit components, and that resulted in some hardship in debugging any errors that could happen because of dead pins in the breadboard or the components being faulty. It’s recommended to use a new breadboard and original components to avoid this. Also, testing the components each one by itself was easy, but merging them to work together was somehow logically difficult in terms of coding but we succeeded in the end, so it’s recommended to carefully trace the code and the hardware components to avoid this. Connecting the LCD with the system made everything go wrong, we didn’t know how to do it despite trying many different ways to fix the problems related to it, we advise using a good LCD component and dive deeper into how to use it. Other problems were minor, like integrating the DC motor with the H-bridge and using PWM, it took us some time to determine the right connections and building the code, so it’s recommended to have datasheets and software references to make this easier.

# Conclusion

The project lays a foundational groundwork for using microcontrollers to convert to a digitally smart home and building a system that is able to make home life more convenient. The use of PIC16F877A achieved the outlined objectives in automating some everyday tasks and increasing the physical security of houses. All of that in a cost-effective manner that most people can afford. The design concept that was introduced in its mechanical, electrical, and software forms worked as it intended to, and it proved that making such innovative systems is expected in the future.