Department of Computer Engineering

MCU-based Motion and Proximity-Triggered Lighting Control System

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Department of Computer Engineering

Executive Summary

Rationale

In today's modern world, energy consumption continues to increase due to a rise of electronic devices and lighting systems. A significant portion of this electricity is wasted through lights that remain on even when not need. This occurs in shared spaces like hallways, staircases, and outdoor areas. According to the International Energy Agency (IEA) the operations of buildings account for 30% of global final energy consumption and 26% of global energy-related emissions [1].

People often forget to switch off their lights when they leave an area, which of course leads to both increased utility costs and environmental impact. Automated lighting systems have emerged as a practical solution to this issue, where it offers convenience, efficiency, and sustainability [2]. They can reduce power consumption by ensuring that lights only operate when necessary.

This project proposes a motion and proximity-triggered lighting control system utilizing a microcontroller unit. The system detects motion at a fixed distance and automatically turns the light on or off based on movement. The microcontroller allows the system to adjust based on the sensor data and program logic of the system. This project promotes energy-efficient alternatives to lighting systems we have today.

Problem

How to save electricity consumption caused by lighting devices?

Goals and Objectives

The goal of this project is to develop a MCU -based proximity-triggered lighting control system capable of measuring distance and detecting motion to turn the lights on or off. Furthermore, the following objectives are to be met:

- Study existing motion-sensing and distance-measuring technologies applicable to our lighting system;
- Integrate an ultrasonic sensor and passive infrared sensor with the use of a microcontroller unit;
- Design and develop the circuit required for sensor interfacing and lighting control;
- To create embedded software that processes sensor data and controls the lighting response in real time.

Scope & Limitation

The project scope involves only the construction of the motion and distance detection system using appropriate sensors, the design and implementation of the circuit required to interface the sensors with the MCU, and the development of the embedded software running on the MCU to control the lighting based on motion and proximity detection.

The proposed design has the following limitations:

- distance and motion detection is limited to the sensors capability

- light will not turn on if there is no motion detected
- environmental interference may affect the sensors reading and data output
- system operates on a pre-programmed logic
- data is not logged in a memory system
- only a bulb will be used as the light device

Conceptual Framework

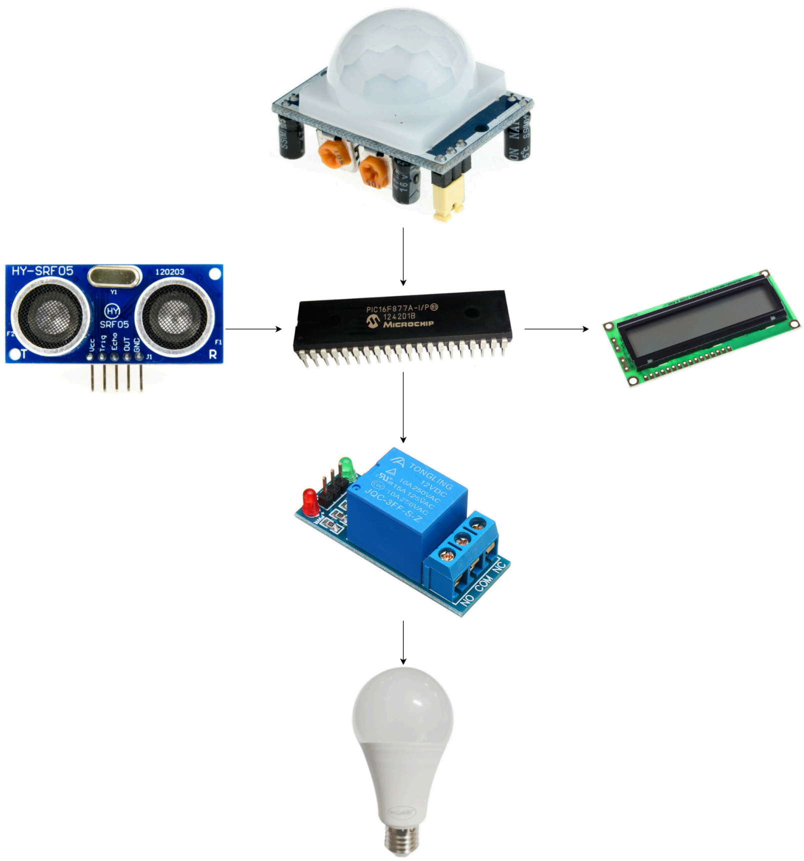
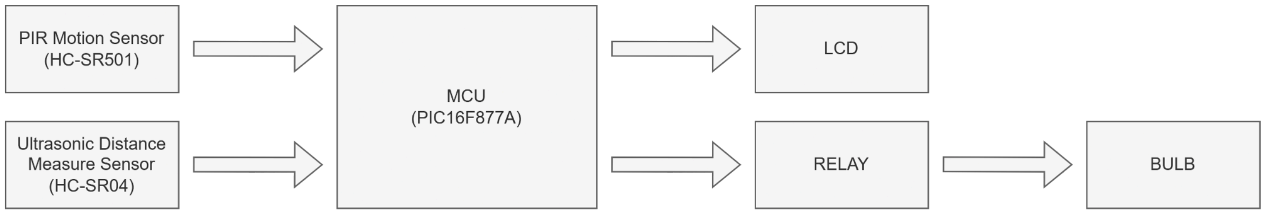


Figure 1. Conceptual Framework of the Motion and Proximity-Triggered Lighting Control System

As shown in Figure 1, the motion and proximity sensors are interfaced to the PIC16F877A which are mainly responsible for the lighting control. PIC16F877A processes the inputs and determines the appropriate output for the lighting control system. The Passive Infrared Sensor (PIR) detects movement within its area. Simultaneously, the ultrasonic sensor measures the proximity or distance of the person. When the person is coming towards or away the sensors, this triggers for the relay to either open or close. The LCD provides real-time information if there is a person detected.

System Block Diagram



Hardware Design

The hardware of the MCU-based Motion and Proximity-Triggered Lighting Control System is composed of sensors, a microcontroller, a relay module, an LCD display, and a lighting load. These components work together to detect motion and proximity, then control the light accordingly. The following subsections detail the purpose and interaction of each hardware component in the system.

Microcontroller (PIC16F877A)

It receives input signals from both the ultrasonic sensor and the passive infrared (PIR) sensor, processes the data using programmed logic, and controls the output devices (LCD and relay). The microcontroller also provides the necessary decision-making to determine whether to turn the light ON or OFF.

PIR Motion Sensor (HC-SRS501)

The PIR sensor detects motion by sensing infrared radiation emitted by humans. When a moving object enters its detection range, it outputs a HIGH signal to the microcontroller. This sensor is responsible for determining if there is movement within its field of view.

Ultrasonic Sensor (HC-SR04)

The ultrasonic sensor measures the distance between the system and an approaching object. It works by sending out ultrasonic pulses and measuring the time taken for the echo to return. If the distance is within a preset range, and motion is detected, the light is turned ON.

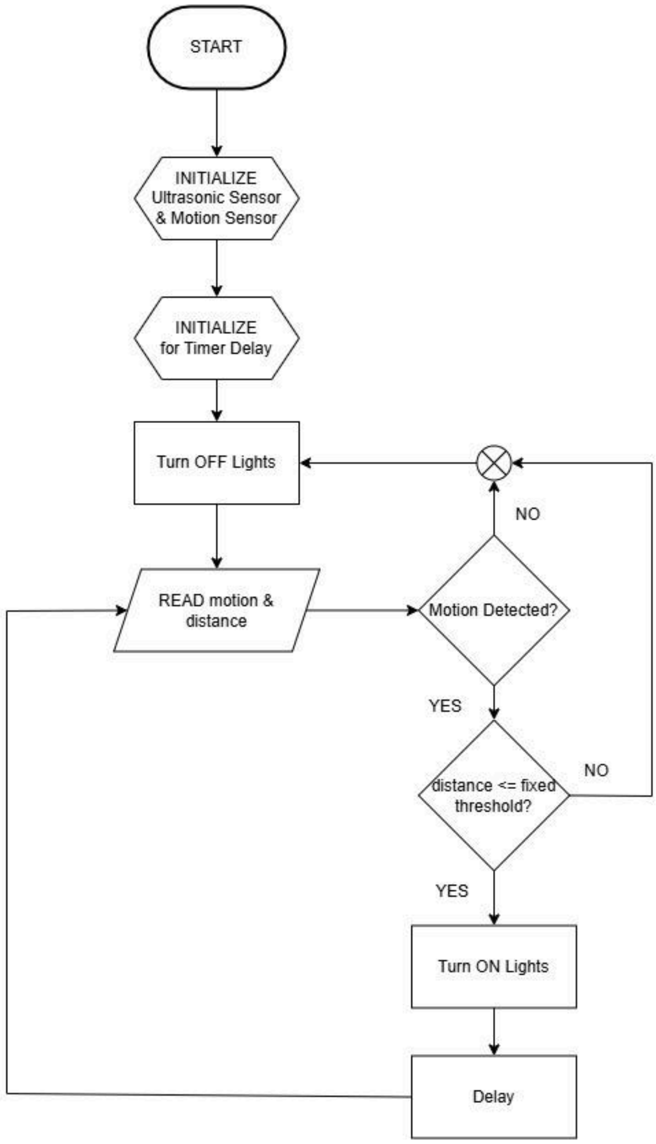
Relay Module

The relay acts as a switch that allows the microcontroller to control an external AC-powered light bulb. When triggered by a HIGH signal from the microcontroller, the relay closes the circuit and powers the bulb.

LCD Display

LCD is used to display real-time information such as "Motion Detected", "Distance: XX cm", or "Light ON/OFF". This provides feedback for debugging and user awareness.

Software Design



The system is designed to automate lighting based on the detection of movement. The system uses an ultrasonic sensor (HC-SR05) to measure the distance of an approaching object and a motion sensor (HC-SR501) to detect movement. The microcontroller processes this data and determines whether to turn the lights on or off based on predefined thresholds. If an object is detected within a certain range and movement is confirmed, the microcontroller activates the lighting system.

Project Management

Team Composition

May Ochia (Team Leader/Hardware Lead) - Is responsible for managing the project and developing the task scheduler. Represents the team to the instructor.

Isaac Jadon Alotaya (Member/Hardware) - Responsible for checking the functionality of the hardware components. Assists the hardware lead in the connection of the components in an organized manner.

Kinshin Sorallo (Member/Software Lead) - Creates the code foundation of the required functionalities of the system. Finalizes and tests the connection of the software and hardware components.

Elisha Tepait (Member/Software) - Assists the Software Lead in developing and refining the system's software components. Works on debugging, optimizing, and ensuring seamless integration between software and hardware.

Task Assignment

Research on motion-sensing and proximity technologies - All Members

1. Sensor Selection and Purchasing - May Ochia & Isaac Jadon Alotaya
2. Circuit design and prototyping - May Ochia & Isaac Jadon Alotaya
3. Software Programming and Sensor Interfacing - Kinshin Sorallo & Elisha Tepait
4. Software-Hardware integration & debugging - All Members
5. Testing of the system functionalities - Kinshin Sorallo & Elisha Tepait
6. Final optimization and documentation - All Members

Development Timeline

Task	April	May				June			
	4th Week	1st Week	2nd Week	3rd Week	4th Week	1st Week	2nd Week	3rd Week	4th Week
Project Propsal Approval									
Research on motion-sensing and proximity technologies									
Sensor Selection and Purchasing									
Circuit design and prototyping									
Software Programming and Sensor Interfacing									

Testing of the system functionalities									
Final optimization and documentation									

References

[1] IEA, "Buildings - Energy System," *IEA*, Jul. 11, 2023. https://www.iea.org/energy-system/buildings

[2] PacLights, "The Science Behind automated lighting and Its Practical Applications," *PacLights*, Feb. 13, 2025. https://www.paclights.com/explore/the-science-behind-automated-lighting-and-its-practical-applications (accessed Apr. 19, 2025).