EC6020 – EMBEDDED SYSTEMS AND DESIGN

AUTOMATIC ROOM LIGHTING SYSTEM

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CONTENTS

INTRODUCTION

In many homes and workplaces, lights are often left on even when no one is present, leading to unnecessary energy consumption and increased electricity bills. The manual operation of lights can be inconvenient and prone to human error, such as forgetting to turn off the lights when leaving a room. This not only results in wastage of energy but also contributes to higher utility costs.

To address this issue, we propose an **Automatic Room Lighting System** using an Arduino Uno microcontroller. This system integrates **infrared (IR) sensors** and a **bidirectional visitor counter** to efficiently manage room lighting based on occupancy.

- IR Sensors
  - Two IR sensors are employed to detect human movement at the entrance and exit of the room. These sensors help in determining when a person enters or leaves the room.
- Bidirectional Visitor Counter
  - This feature tracks the number of people in the room. The system turns the lights on when the first person enters and keeps them on as long as there are people present. When the last person leaves, the system ensures that the lights are turned off.
- Arduino Uno
  - The central microcontroller processes input from the IR sensors and controls the lighting based on the visitor count.

BENEFITS

- Energy Efficiency
  - By ensuring that lights are only on when needed, the system reduces unnecessary energy consumption and lowers electricity bills.
- Convenience
  - The automation provided by the system eliminates the need for manual operation, reducing the likelihood of forgetting to turn off the lights.

This Automatic Room Lighting System not only enhances energy efficiency but also improves user convenience by adapting to the real-time occupancy of the room. It represents a practical solution to managing lighting in both residential and commercial settings, making it a valuable addition to modern automation solutions.

PROJECT DESIGN AND IMPLEMENTATION

I. HARDWARE DESIGN

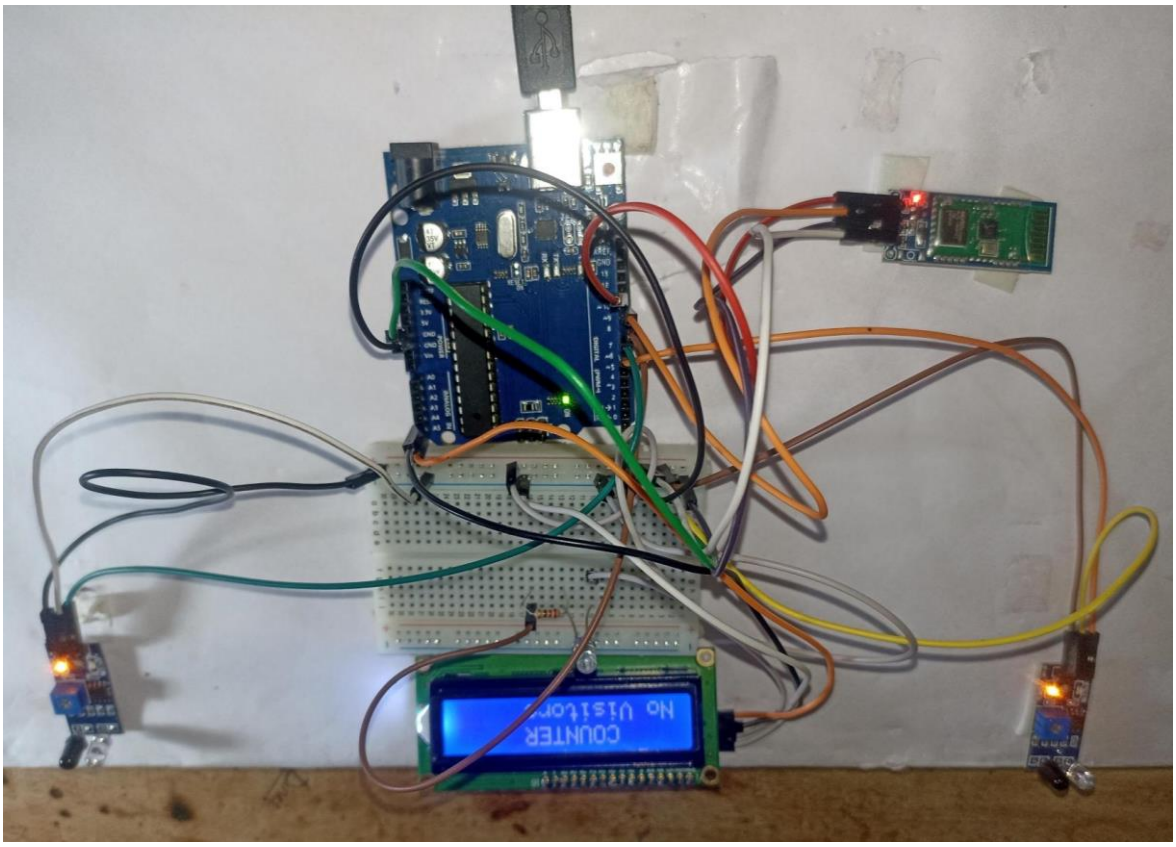


Figure 1

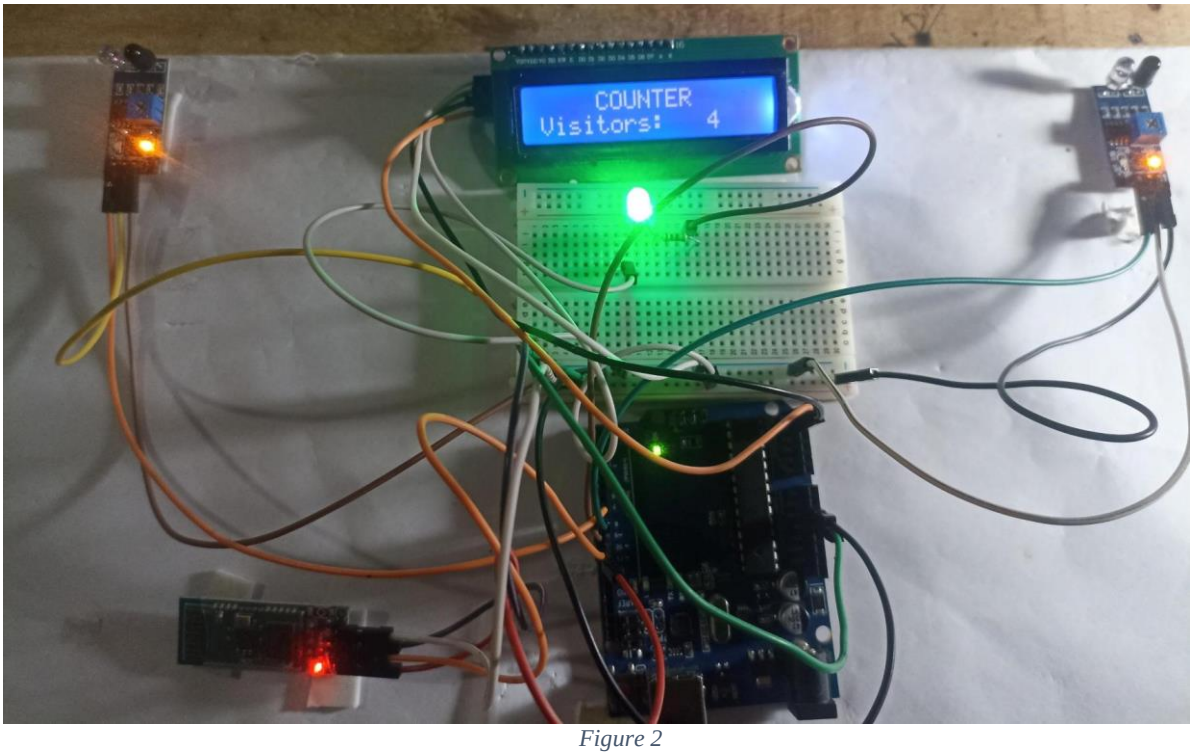


Figure 2

II. INTERFACING

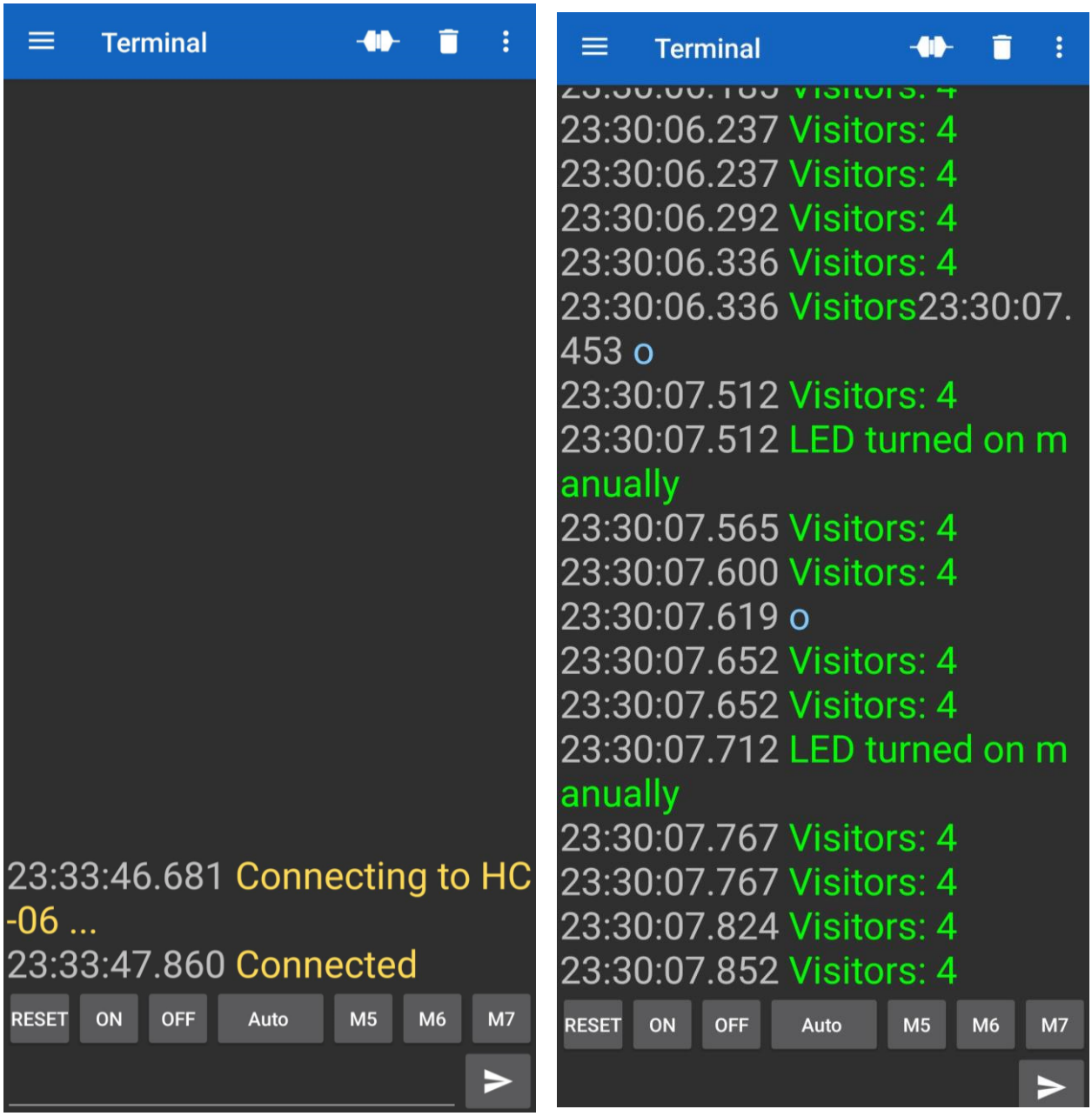


Figure 3

III. SOFTWARE DESIGN

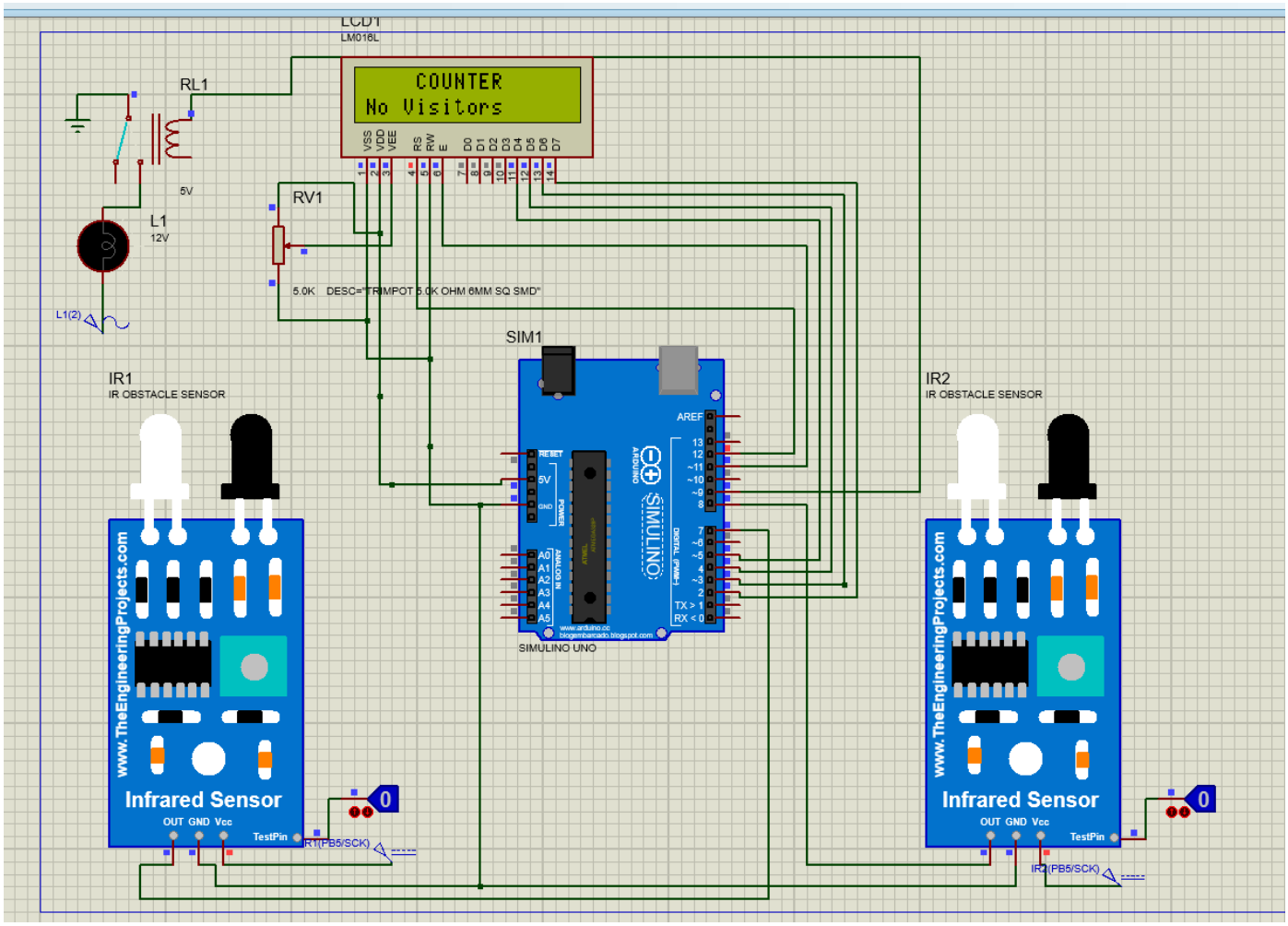


Figure 4

IV. IMPLEMENTATION

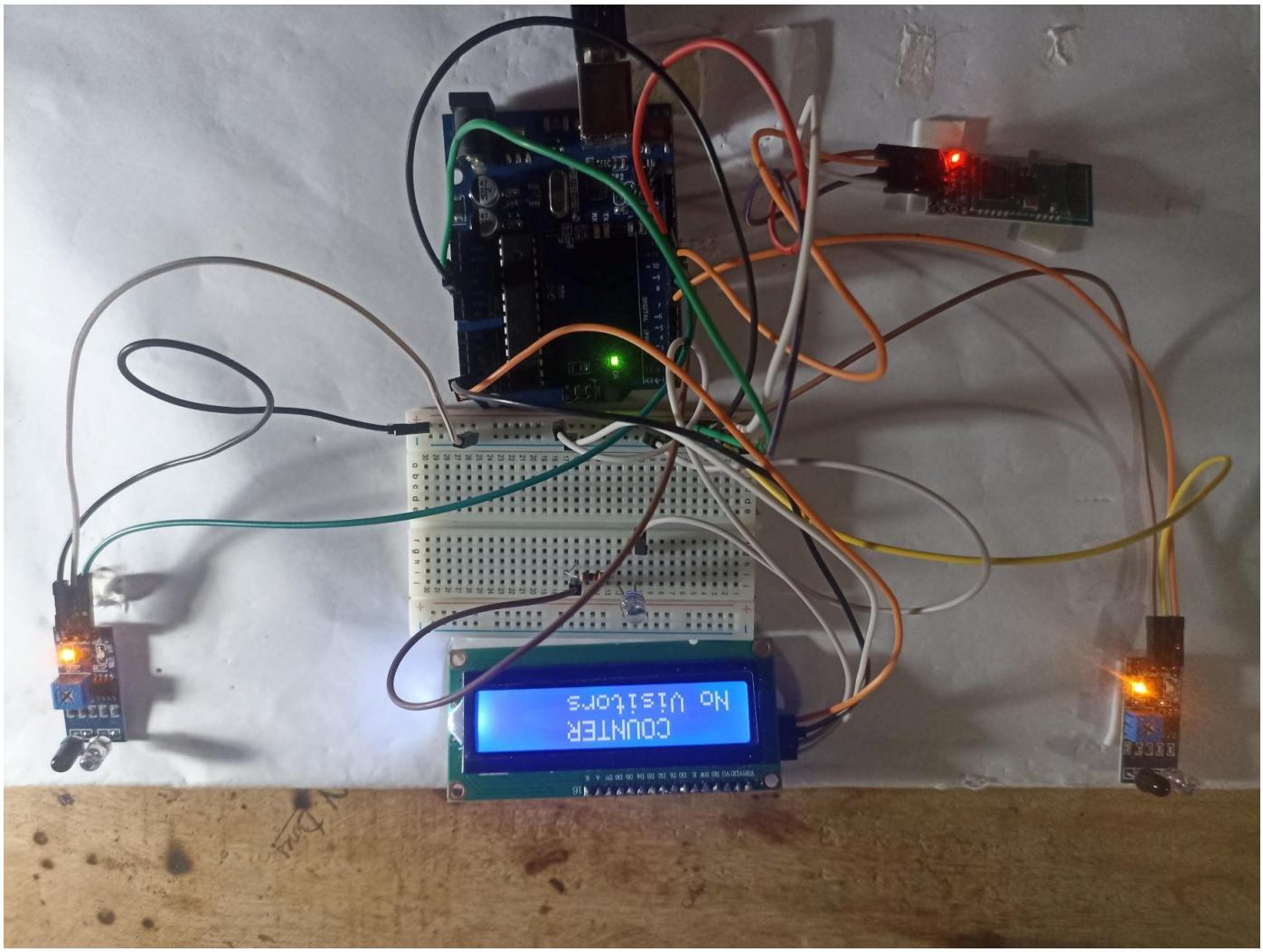


Figure 5

CHALLENGES AND SOLUTIONS

1. Switching from 8051 Microcontroller to Arduino Uno

The initial plan was to use the 8051 microcontroller, but due to availability issues, the project was switched to Arduino Uno. This transition required adapting the project design to work with the new microcontroller and ensuring compatibility with existing components.

Solutions

- We updated the circuit design and code to be compatible with Arduino Uno. This involved reconfiguring the pin assignments and modifying the code to use Arduino's libraries and functions. Despite the switch, the core functionality of the project remained intact, leveraging Arduino Uno's ease of use and extensive community support.

2. Handling Multiple People Exiting Simultaneously

A challenge arose in accurately counting the number of people exiting the room when multiple individuals left at the same time. This could lead to inaccuracies in the visitor count if the system fails to register all exits correctly.

Solutions

- To address this issue, we integrated a **Bluetooth module** for remote control of the lighting system. The Bluetooth module allows for manual intervention and control, which can help in scenarios where the automated counting might encounter issues. Additionally, the system can be monitored and adjusted in real-time to ensure that the lighting control remains accurate even during high traffic.

3. IR Sensor Range for Long Door Distances

IR sensors have a limited range, which can be problematic if the door distance is too long. This could result in incomplete or inaccurate detection of people entering or exiting the room.

Solutions

For longer distances,

- Use High-Performance IR Sensors
    - Upgrade to sensors with a longer range or more powerful IR emitters. Some sensors are specifically designed for extended ranges and can cover greater distances effectively.
    - Reflective IR sensors with adjustable sensitivity settings can be tuned to cover longer distances.
- Positioning and Alignment
    - Ensure that the IR sensors are accurately aligned to maximize their effective range. Misalignment can significantly reduce the detection area.
    - Positioning the sensors at appropriate heights can improve detection accuracy, especially in environments with varying heights of people.
- Use Multiple Sensor Pairs:
    - Deploy additional pairs of IR sensors along the entrance or exit path to ensure complete coverage. Each pair can be staggered to cover different sections of the doorway.
    -

4. Effective Use of Bluetooth Module

Integrating the Bluetooth module requires managing communication between the Arduino and remote devices effectively. Ensuring reliable and responsive control can be challenging.

Solutions

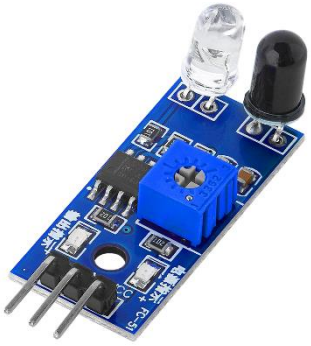
- Bluetooth Module Configuration: Use a well-documented Bluetooth module (e.g., HC-05 or HC-06) and ensure proper pairing with the remote-control device.
- Command Handling: Implement a robust protocol for handling commands sent via Bluetooth, including error-checking and confirmation responses to ensure reliable operation.
- Testing: Conduct thorough testing to validate Bluetooth communication under different conditions and distances to ensure consistent performance.

TIMELINE

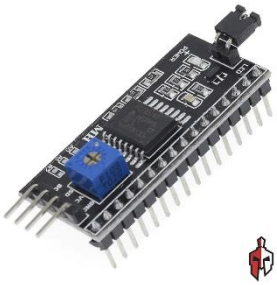
Activity	Week 07	Week 08 & 09	Week 10	Week 11	Week 12	Week 13	Week 14
Title Selection and Project Proposal							
Understanding The Project Deeply							
Working On the Programming Part of The Project							
Collecting And Assembling the Hardware Components							
Software Implementation to The Microcontroller and Testing the Final Prototype							
Demonstration And Evaluation of The Prototype							

COMPONENTS AND COST

The Arduino Uno is a popular microcontroller board based on the ATmega328P. It has 14 digital input/output pins, 6 analog inputs, and is used for building and prototyping electronic projects with ease.



IR sensors produce infrared waves and consist of an IR transmitter (an IR LED) and an IR receiver (a photodiode). The module has three pins: GND, VCC (+5V), and SIG, with the SIG pin providing a TTL value based on the reference voltage. A potentiometer allows adjustment of the reference voltage, varying the sensor's range and accuracy. These sensors, popular in electronic devices, function similarly to human vision and are commonly used to detect obstacles in real-time applications.

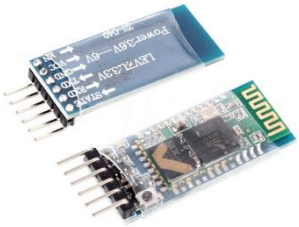


I2C (Inter-Integrated Circuit) is a communication protocol used to connect and exchange data between microcontrollers and peripheral devices over two wires: a data line (SDA) and a clock line (SCL).

A relay module allows a microcontroller to control high-voltage devices by using low-voltage signals. It consists of one or more relays that can switch electrical circuits on and off.

A liquid-crystal display (LCD) is a flat-panel display that uses the light-modulating properties of liquid crystals. A 2x16 LCD has 2 rows and 16 columns, allowing it to display up to 32 characters. Each character is shown in a 5x7 pixel matrix.

A Bluetooth module enables wireless communication between devices using Bluetooth technology. It allows for short-range data transfer and can be used for various wireless applications.



NAME	QTY	PRICE
Arduino Uno	1	2490.00
16/2 LCD Display	1	340.00
IR Sensors (2)	1	190.00
Relay module	1	480.00
Breadboard	1	125.00
Arduino Uno Data Cable	1	90.00
9V Battery	1	150.00
9V Battery Connector	1	50.00
Male-to-Male Jumper Wires	10	150.00
Female to Male Jumper Wires	10	150.00
Light Bulb	1	800.00
Light Bulb Socket	1	150.00
I2C	1	200.00
Bluetooth Module	1	520.00
Miscellaneous	-	615.00
TOTAL	6500/=	

REFLECTION

The project provided hands-on experience with Arduino and various sensors, enhancing our understanding of microcontroller-based automation systems. Switching from the 8051 microcontroller to Arduino Uno required quick adaptation and problem-solving to ensure project continuity. Effective communication and collaboration were crucial in overcoming challenges such as sensor range issues and integrating new components like the Bluetooth module.

Throughout the project, we gained proficiency in interfacing sensors, configuring Bluetooth modules, and implementing bidirectional counting logic. Additionally, we implemented creative solutions for sensor range issues and optimized the placement of IR sensors for accurate counting. This experience highlighted the practical applications of energy conservation in homes and workplaces, emphasizing the importance of iterative testing and continuous improvement to achieve reliable and accurate results.

Looking forward, we identified potential enhancements for the project, such as integrating additional sensors or expanding the system for larger buildings. The project underscored the importance of continuous improvement and innovation in developing effective automation systems. We recognize the potential for future development and are eager to explore new possibilities for enhancing the system's capabilities.

CONCLUSION

In conclusion, the Automatic Room Lighting System using Arduino Uno with a bidirectional visitor counter and Bluetooth module has shown great potential in reducing energy consumption and enhancing convenience. By employing infrared sensors for occupancy detection and enabling manual control via Bluetooth, the system offers an effective solution for automated lighting control. The switch from the 8051 microcontrollers to Arduino Uno provided flexibility and ease of implementation, while iterative testing ensured system reliability and accuracy.

Despite challenges like sensor range limitations and initial microcontroller unavailability, the project demonstrated adaptability and innovation. While there are drawbacks such as sensor accuracy and scalability issues, the system effectively addresses unnecessary energy consumption by ensuring lights are only on when a room is occupied. This project has been a valuable learning experience, emphasizing the importance of sustainable technology solutions and paving the way for future enhancements, such as integrating additional sensors and expanding the system for larger buildings.

REFERENCES

- *Automatic Room Light Controller with Bidirectional Visitor Counter: Arduino Project with Circuit Diagram & Code (circuitdigest.com)*
- *https://www.electronicshub.org/automatic-room-lighting-system-using-microcontroller/*
- *https://www.researchtrend.net/ijet/pdf/44-S-837.pdf*
- *https://www.irjet.net/archives/V8/i4/PIT/ICIETET-100.pdf*
- *https://circuitdigest.com/microcontroller-projects/automatic-room-light-controller-with-bidirectional-visitor-counter-using-arduino*

APPENDIX

I. CODE

```
#include <Wire.h>
#include <LiquidCrystal_I2C.h>
#include <SoftwareSerial.h>

// Initialize the LCD with the I2C address
LiquidCrystal_I2C lcd(0x27, 16, 2);

// Bluetooth module connections
SoftwareSerial bluetooth(10, 11); // RX, TX

#define sensorPin1 7
#define sensorPin2 8
#define ledPin 9

int sensorState1 = 0;
int sensorState2 = 0;
int count = 0;
bool ledManualControl = false;

void setup() {
  pinMode(sensorPin1, INPUT_PULLUP);
  pinMode(sensorPin2, INPUT_PULLUP);
  pinMode(ledPin, OUTPUT);

  lcd.init();
  lcd.backlight();
  lcd.setCursor(4, 0);
  lcd.print("COUNTER");
  lcd.setCursor(0, 1);
  lcd.print("No Visitors     ");
  delay(2000);

  // Initialize Bluetooth
  bluetooth.begin(9600);
}

void loop() {
  sensorState1 = digitalRead(sensorPin1);
  sensorState2 = digitalRead(sensorPin2);
```

```
if (sensorState1 == LOW) {
  count++;
  while (digitalRead(sensorPin1) == LOW);
  delay(500); // Debounce delay
}

if (sensorState2 == LOW) {
  count--;
  while (digitalRead(sensorPin2) == LOW);
  delay(500); // Debounce delay
}

if (count <= 0) {
  count = 0;
  lcd.setCursor(0, 1);
  lcd.print("No Visitors     ");
  bluetooth.println("No Visitors");

  if (!ledManualControl) {
    digitalWrite(ledPin, LOW);
  }
} else if (count > 0 && count < 10) {
  lcd.setCursor(0, 1);
  lcd.print("Visitors:   ");
  lcd.setCursor(12, 1);
  lcd.print(count);
  lcd.print(" ");
  bluetooth.print("Visitors: ");
  bluetooth.println(count);

  if (!ledManualControl) {
    digitalWrite(ledPin, HIGH);
  }
} else {
  lcd.setCursor(0, 1);
  lcd.print("Visitors:   ");
  lcd.setCursor(12, 1);
  lcd.print(count);
  bluetooth.print("Visitors: ");
  bluetooth.println(count);

  if (!ledManualControl) {
    digitalWrite(ledPin, HIGH);
  }
}
```

```
  // Check for incoming Bluetooth commands
  if (bluetooth.available()) {
    char command = bluetooth.read();
    if (command == 'r') { // Reset command
      count = 0;
      lcd.setCursor(0, 1);
      lcd.print("No Visitors     ");
      bluetooth.println("Counter reset");
    } else if (command == 'o') { // Turn LED on manually
      digitalWrite(ledPin, LOW);
      ledManualControl = true; // Enable manual control
      bluetooth.println("LED turned on manually");
    } else if (command == 'f') { // Turn LED off manually
      digitalWrite(ledPin, HIGH);
      ledManualControl = true; // Enable manual control
      bluetooth.println("LED turned off manually");
    } else if (command == 'a') { // Auto control
      ledManualControl = false; // Disable manual control
      bluetooth.println("LED auto control enabled");
    }
  }
}
```

II. POSTER

AUTOMATIC ROOM LIGHTING SYSTEM

LIGHTS ON WHEN WALK IN
LIGHTS OUT WHEN LEAVE

2020E120
2020E122
2020E132

Inefficient lighting use in homes and workplaces leads to unnecessary energy consumption and increased electricity bills.

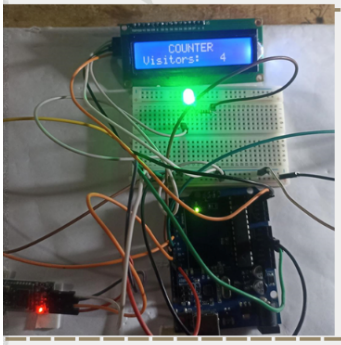
PROBLEMS & SOLUTIONS

An Automatic Room Lighting System using a microcontroller and IR sensors to detect room occupancy, turning lights on when someone enters and off when the room is empty, thereby conserving energy and reducing costs.

KEY FEATURES

- AUTOMATIC ON/OFF LIGHTING CONTROL
- IR SENSOR-BASED OCCUPANCY DETECTION
- BIDIRECTIONAL VISITOR COUNTING
- ARDUINO UNO MICROCONTROLLER INTEGRATION
- CONVENIENT, HANDS-FREE OPERATION
- BLUETOOTH MODULE INTEGRATION FOR SMARTPHONE CONTROL.

7K ★RUPEES★

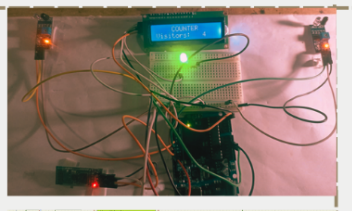


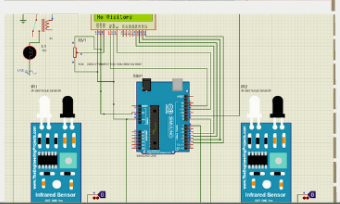
- Reduce energy waste and lower electricity bills
- Enhance convenience with automatic lighting control
- Maintain optimal lighting conditions based on occupancy
- Contribute to a more sustainable and eco-friendly environment
- Prevents potential safety hazards.

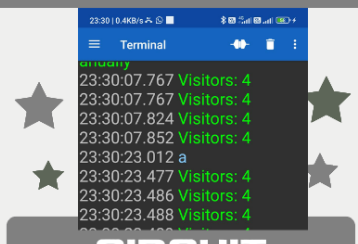
ENJOY THE BENEFITS

TECHNICAL SPECIFICATION

- Microcontroller: Arduino Uno
- Sensors: Two infrared (IR) sensors for bidirectional visitor counting
- Display: 16x2 LCD for real-time visitor count and status display
- Control: 5V relay module for light control, integrated with BC547 transistor
- Connectivity: Bluetooth module for remote control of lighting via a mobile app







CIRCUIT

Components
Arduino Uno, IR Sensor, Bluetooth Module, LCD Display, Relay Module

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