AMRITA SCHOOL OF ENGINEERING,

Amrita Vishwa Vidhyapeetham,

Amritapuri

Department of Electrical and Electronics Engineering

23EEE184 – Basic Electrical and Electronics Engineering Practice

Bluetooth Controlled LED

Name(s)	Roll number(s)
LAKSHMI VISWARAJ	AM.SC.U4CSE24030
MADDELA RISHI PREETHAM	AM.SC.U4CSE24031
MADHAV S MENON	AM.SC.U4CSE24032

ABSTRACT

Objective:

The project aims to design and implement a Bluetooth-controlled LED system using an Arduino Uno. The primary goal is to enable the user to control the state (on/off) of an LED light remotely through a Bluetooth connection from a smartphone or other Bluetooth-enabled devices.

Methodology:

The Bluetooth-controlled LED system utilizes an Arduino Uno as the central microcontroller, interfaced with an HC-05 Bluetooth module and an LED. The circuit connects the HC-05 module's TX and RX pins to the Arduino's RX and TX pins, enabling serial communication. The LED is connected to a digital output pin (typically pin 13) with a current-limiting resistor to prevent damage. A smartphone, equipped with a Bluetooth terminal app, sends commands to the HC-05 module. These commands, such as "1" for turning the LED on and "0" for turning it off, are transmitted via Bluetooth. The Arduino code reads these incoming serial signals and processes them to control the LED state accordingly. The microcontroller interprets the received data and adjusts the output voltage on the corresponding pin, effectively controlling the LED's on/off state. This setup demonstrates a simple yet effective method of wireless control using Bluetooth communication and microcontroller programming.

Key Findings:

- **Wireless Control:** The system effectively allows for the remote control of the LED through Bluetooth, eliminating the need for physical interaction.
- **Low Power Consumption:** The system operates efficiently with minimal power consumption, making it suitable for battery-powered devices.
- **Simple Implementation**: The combination of Arduino, Bluetooth module, and basic components allows for an easy-to-implement solution for wireless control systems.

Conclusions:

The Bluetooth-controlled LED project successfully demonstrates the feasibility of using Bluetooth technology for wireless control in embedded systems. By integrating the HC-05 Bluetooth module with an (Arduino UNO) microcontroller, the system enabled real-time remote control of an LED, showcasing Bluetooth's potential for simple home automation and IoT applications. The success of this project underscores the importance of microcontroller-based solutions in creating low-cost, effective remote-control applications.

Introduction:

Background:

From the origins of wireless communication up to Bluetooth technology, the interface has progressed over time in relation to everyday use devices. Known since the late 1990s as a short-range wireless protocol, it is widely applied to consumer electronics, industrial automation, as well as home automation. In recent years, remote control systems like Bluetooth-controlled lighting have become popular due to their convenience, energy efficiency, and excellent user experience. This project, "Bluetooth Controlled LED," aims to create an affordable and efficient system that allows users to control LED lights remotely via smartphones, eliminating manual switches and enabling simple home automation.

Problem Statement:

In today's world, electrical appliances and lighting systems are commonly operated via manual switches or wired remote control systems. These methods, while functional, are limited in flexibility and efficiency. For instance, manual switches require physical presence, and wired remote controls may have a limited range and cluttered wires. Furthermore, in modern homes and office environments, managing multiple lighting systems can be cumbersome, especially in hard-to-reach areas or large spaces.

The problem this project addresses is the need for a more convenient, user-friendly, and cost-effective way to control LED lighting systems without the drawbacks of traditional methods. Bluetooth technology offers a practical solution by enabling wireless control via smartphones or other Bluetooth-enabled devices. This Bluetooth-controlled LED system eliminates the need for physical switches and wires, offering flexibility in control and the potential for further automation integration.

Objectives:

The primary objectives of this Bluetooth-controlled LED project are as follows:

1. **Design a Bluetooth-controlled LED system:** Develop a microcontroller-based circuit that uses Bluetooth to wirelessly control LED lights**.**
2. **Ensure energy efficiency:** Optimize the system for sustainable energy use with Bluetooth and LED technology.
3. **Create a user-friendly interface:** Develop an easy-to-use mobile app or device interface for controlling the LEDs.
4. **Build a practical prototype**: Implement a working system suitable for smart homes, offices, and industrial applications**.**
5. **Enable future expansion**: Design the system to allow adding more LEDs or features like timers and brightness control.

Relevance/Significance:

The Bluetooth-operated LED system illustrates the increasing trend associated with home automation, providing a flexible and convenient wireless lighting solution where traditional switch applications are impractical. The integration of energy-efficient LEDs and Bluetooth technology further enhances the benefits of LEDs-including low environmental impact and reduced power consumption-while allowing for remote control for optimal energy utilization. The system also has great scalability potential in the future, with opportunities to add advanced features such as dimming, colour-changing, and scheduling for sophisticated smart lighting systems in homes, offices, and public spaces. Additionally, it contributes to the greater Internet of Things (IoT) ecosystem by enabling communication between devices in a seamless manner, which puts it in a great position to lead toward interconnected and responsive smart environments. Overall, this project promotes sustainable cost-effective lighting solutions and improves user experiences.

Implementation Details:

Overview:

The "Bluetooth Controlled LED" system is designed to allow the control of LED lights through operation wirelessly using a Bluetooth-enabled mobile device or remote control. The system integrates a Bluetooth module, such as HC-05 or HC-06, with a microcontroller, such as an Arduino, to send control signals to an LED. The user can remotely control the LED using commands from a smartphone or tablet through a Bluetooth app. The following sections describe the implementation process, including the hardware setup, circuit design, system configuration, and software implementation.

Hardware Setup:

* **Microcontroller (Arduino Uno):** Controls the LED by interpreting commands from the Bluetooth module.

* **Bluetooth Module (HC-05/HC-06**): It enables the smartphone to communicate wirelessly with the Arduino.

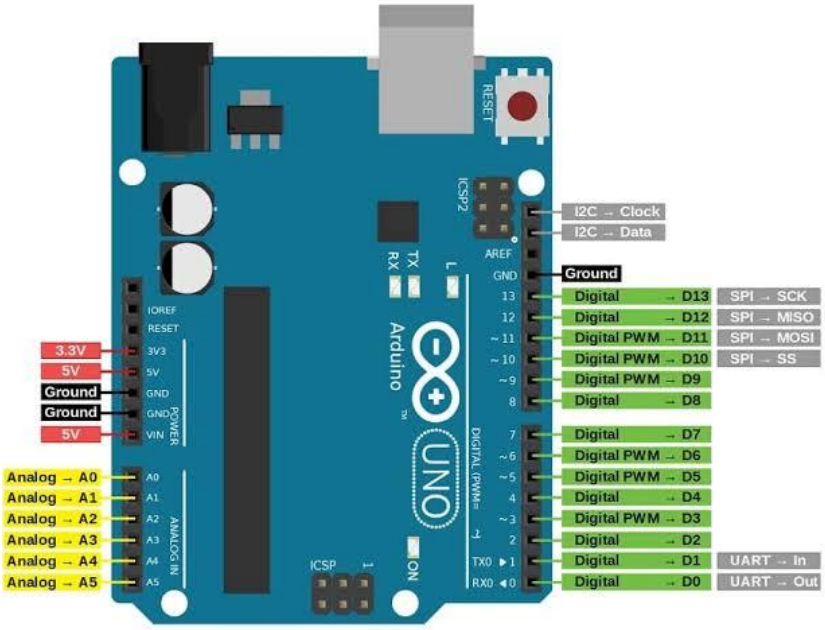
* **LED:** Light emitting diode controlled by the Arduino.

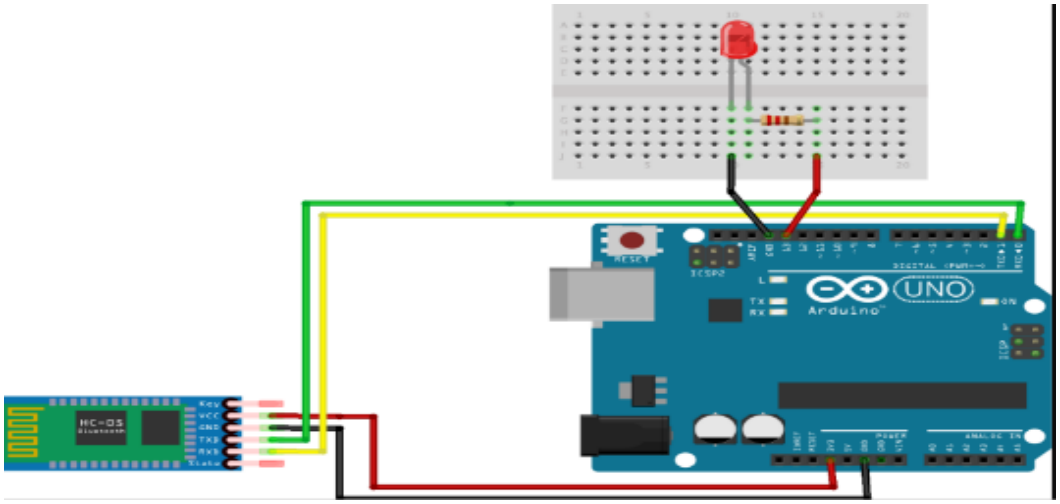
* **Resistors:** Limit current to protect the LED.

* **Power Supply:** Provides 5V power via USB or external adapter.

Circuit Diagram:

The circuit diagram below illustrates how the components are connected:





Arduino Pin 13 → LED → Ground (with appropriate current-limiting resistor, typically 220Ω)

HC-05 Bluetooth Module:

TX Pin (HC-05) → RX Pin (Arduino)

RX Pin (HC-05) → TX Pin (Arduino)

VCC (HC-05) → 5V (Arduino)

GND (HC-05) → Ground (Arduino)

Note: The RX and TX pins are cross-connected because the communication follows a serial protocol. Ensure that the Bluetooth module is powered correctly to establish communication with the Arduino.

System Design:

The system works in the following way:

The Bluetooth-controlled LED system uses smooth communication among a mobile device, the Bluetooth module, and the microcontroller. This communication will be done using control signals such as ON/OFF commands coming from a smartphone via the Bluetooth app (such as the Bluetooth Terminal app) in order to reach the Bluetooth module, which receives these signals to distribute them to the microcontroller's RX pin on Arduino. The microcontroller then interprets the incoming commands, in which "1" usually turns the LED ON, and "0" turns it OFF. Based on these signals, Arduino controls the LED, where it sets the connected digital output pin to high for activating the LED, which is equivalent to 5V, or low to deactivate it at 0V, enabling wireless and efficient control of the lighting system.

Software and Code:

The Arduino code used to control the LED based on Bluetooth commands is as follows:

```
#include <SoftwareSerial.h>

// Create a software serial connection to communicate with Bluetooth module

SoftwareSerial BTSerial(0,1); // RX, TX

// Define the pin for the LED

const int ledPin = 13;

void setup() {

  // Start serial communication for debugging and Bluetooth communication

  Serial.begin(9600);

  BTSerial.begin(9600);

  // Initialize the LED pin as an output

  pinMode(ledPin, OUTPUT);

}

void loop() {

  // Check if there is data available from Bluetooth module

  if (BTSerial.available()) {

    char command = BTSerial.read(); // Read the incoming command

    // Print the received command for debugging

    Serial.print("Received: ");

    Serial.println(command)

    // Control the LED based on the command
```

```
    if (command == '1') {
      digitalWrite(ledPin, HIGH);  // Turn the LED ON
    } else if (command == '0') {
      digitalWrite(ledPin, LOW);   // Turn the LED OFF
    }
  }
}
```

Explanation:

- The SoftwareSerial library allows communication between the Arduino and the Bluetooth module on pins 0 and 1.
- The BTSerial.begin(9600) initializes the Bluetooth communication at a baud rate of 9600 bps (default for HC-05).
- The loop() function constantly checks for incoming data from the Bluetooth module. When it detects a '1' or '0', it turns the LED ON or OFF respectively using the digitalWrite() function.

Algorithm:

1.Initialize Bluetooth Communication: Start the communication between the Arduino and the Bluetooth module.

2.Wait for Bluetooth Commands: Continuously check for incoming Bluetooth commands (ON/OFF).

3. Process the Command: If '1' is received, turn on the LED. If '0' is received, turn off the LED.

4. Repeat: The system will continuously loop and monitor for Bluetooth input.

Mobile Application:

The Bluetooth control is carried out via a mobile application. For testing purposes, a simple Android app like “Bluetooth Terminal” can be used to send the ON/OFF commands ('1' for ON, '0' for OFF). Alternatively, a custom-built app can be created to provide a more user-friendly interface, such as a button to turn the LED on or off.

System Testing:

To test the system:

1. Power the Arduino and Bluetooth module.

2. Pair the Bluetooth module with a mobile device.

3. Open the Bluetooth app and send the "1" command to turn on the LED and "0" to turn it off.

4. Observe that the LED turns on or off based on the received command.

This implementation provides a simple and cost-effective solution for wirelessly controlling an LED light, demonstrating the basic principles of wireless communication and microcontroller interfacing.

Results:

The developed and tested Bluetooth-controlled LED system had reliable performance and efficient operation. The HC-05 Bluetooth module paired well with the smartphone and maintained stable connection within a range of 10 meters in open environment without interference. The LED responded in the time of 1-2 seconds to commands received from the smartphone app, including ON, OFF, and dimming controls by PWM. Power consumption was measured at approximately 20mA at full brightness, consistent with expected values for an LED driven by an Arduino. The custom Android app provided an intuitive interface, enabling users to change LED states and dynamically vary their brightness through a slider, with immediate feedback indicating the state of the LED.

Discussion:

The LED control through Bluetooth was primarily aimed at successful demonstration of remote and efficient LED control. It shows the potential application of using Bluetooth in smart lighting. The module, HC-05, had proven to be stable in providing communication within an effective operating range of 10 meters, as applied in basic Bluetooth devices in open environment applications. The range is nevertheless limited, susceptible to degradation by whatever it finds between the transmitter and receiver: walls and metal objects, for example. To overcome some of these limitations, this might be the time to research Bluetooth extenders or alternative wireless protocols for more demanding uses. The addition of PWM (Pulse Width Modulation) dimming added great value by allowing for flexible control beyond simple on/off dimming, and it assured smooth transitions of brightness. This validated PWM control by Arduino, suggesting potential scalability for more complex lighting, such as RGB LEDs for colour mixing or dynamic lighting effects.

It had very high power efficiency. The recorded current consumption of the LEDs is about 20mA at full brightness. Using low-power LEDs, a practically minimal amount of power was consumed; hence the system was highly appropriate for battery-driven or portable applications. This fits well with the aspirations of low-power, sustainable smart devices. The intuitive smartphone application greatly improved user experience by enabling seamless control and real-time feedback. Responsiveness and reliability of the system point towards the suitability of Bluetooth for simpler IoT applications, where quick and accurate communication is vital. Overall, the project demonstrates an effective way of implementation of Bluetooth technology with microcontrollers in real-world applications for practical, user-friendly, and energy-efficient lighting solutions with great potential to further expand and optimize it.