IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Smart AC Fan Speed Control Via Bluetooth Using Custom Optocoupler

A Custom LED-LDR Optocoupler Approach for AC Load Regulation in Smart Home Environments

[1] Mr. H. S. Sayyed, [2] Dr. G. B. Bhagat , [3] Ms. K. S. Salunke, [4] Ms. C. D. Kale, [5] Ms. P. S. Lodha

[1,2,3,4,5] Assistant Professor

[1,2,3,4,5] Department of Electronic Science,

[1]New Arts, Commerce and Science College, Ahilyanagar, Maharashtra, India

[2, 3, 4,5] S.S.G.M College, Kopargaon, Ahilyanagar, Maharashtra, India

Abstract: In this project, we present a simple yet innovative way to control the speed of an AC fan using a mobile phone via Bluetooth. The main focus is on the development of a custom-built sensor that acts like a variable resistor but is controlled by light instead of touch. This sensor is made by placing an LED and an LDR (light-dependent resistor) face to face inside a small, enclosed cylindrical structure. When a PWM (pulse width modulation) signal is sent from an Arduino to the LED, the brightness of the LED changes based on the signal strength. This change in brightness affects the resistance of the LDR. As the LED gets brighter, the LDR's resistance drops, and when the LED dims, the resistance increases. By replacing the traditional potentiometer in a TRIAC-based dimmer circuit with this LDR, we are able to change the fan's speed based on the PWM signal, without any physical contact. The PWM signal is controlled through a mobile application connected to the Arduino via an HC-05 Bluetooth module. This setup allows users to wirelessly adjust fan speed with high precision. The key advantage of this approach is the use of an optically isolated and non-contact method for controlling AC appliances, which increases safety and offers a new way to build smart home devices. Our method introduces a new type of sensor that reacts to electrical input using light and can be used in many other electronic control systems.

Index Terms - PWM (pulse width modulation, Arduino, Triac, Diac, Bluetooth Module, LDR (Light Dependent Resistor)

I. Introduction

The demand for smart and energy-efficient home automation systems has grown rapidly in recent years. Among various applications, controlling the speed of household fans has traditionally been done manually using rotary dimmers or mechanical regulators. While these methods are functional, they often lack precision, are not remotely accessible, and can suffer from wear over time. To overcome these limitations, this project explores a new approach that combines mobile technology, wireless communication, and a novel custom-built sensor to provide a simple yet effective solution for remote AC fan speed control.

The heart of this project is a unique optocoupler-based sensor constructed using an LED and an LDR (Light Dependent Resistor) housed inside a light-tight cylindrical enclosure. Instead of relying on physical touch or mechanical adjustment, this sensor changes its electrical resistance based on the intensity of light emitted by the LED, which is controlled by a PWM (Pulse Width Modulation) signal from an Arduino. This resistance variation is then used to regulate the fan speed in a TRIAC-based dimmer circuit by replacing the traditional potentiometer.

The PWM signal is adjusted through a mobile application connected to the Arduino via an HC-05 Bluetooth module. This enables users to control the fan speed wirelessly and with greater convenience. Beyond ease of use, the system offers enhanced safety by ensuring complete electrical isolation between the control circuit and the high-voltage AC line, thanks to the optical nature of the sensor.

In addition to safety and remote access, the design also emphasizes cost-effectiveness and simplicity. Traditional commercial optocouplers are designed primarily for digital switching applications and do not offer analog variability suitable for dimming control. By creating a custom analog optocoupler using discrete components, this project introduces a low-cost and flexible alternative that can be tailored for a wide range of analog control tasks, including but not limited to fan speed regulation.

II. Comparison between different types of fan regulators

Feature	Capacitor-based Fan Speed Control	Resistor-based Fan Speed Control	TRIAC-based Fan Speed Control
Principle of Operation	Uses a capacitor in series with the fan motor to limit current, controlling speed by changing the phase angle.	Uses resistors in series with the fan to drop voltage and reduce current, which affects motor speed.	Uses a TRIAC to chop the AC waveform, adjusting the phase angle and controlling the power delivered to the fan motor.
Efficiency	High efficiency compared to resistors. Less energy loss.	Low efficiency due to significant power loss in resistors as heat.	Very efficient as it regulates power with minimal heat loss.
Heat Generation	Low heat generation due to the passive nature of the capacitor.	High heat generation due to the power dissipation in resistors.	Low heat generation as the TRIAC only switches on/off the current.
Control Type	Fixed speed settings with limited adjustability.	Fixed speed settings with limited adjustability.	Precise and variable speed control with a wide range of adjustment.
Cost	Relatively low cost.	Inexpensive, as resistors are cheap components.	Higher cost due to the use of TRIAC and control circuits.
Maintenance	Low maintenance, as capacitors are reliable and have a long lifespan.	Requires maintenance due to heat buildup, which may degrade resistors.	Low maintenance; TRIACs are durable and require minimal care.
Noise	May produce slight humming noise.	May produce more noise due to heat dissipation and electrical losses.	Silent operation due to smooth control of the current waveform.
Compatibility	Suitable for AC motors but can be less effective at very low speeds.	Suitable for simple fans, but not ideal for precision control.	Works well for precise speed control on both AC and DC motors.
Power Factor	Low power factor due to the inductive nature of the fan and capacitor.	Power factor is affected, but less critical than TRIAC-based systems.	High power factor as TRIAC-based control doesn't create reactive power.
Use Cases	Common in low-cost fan speed controllers for household fans.	Typically used in cheaper or older fan designs, less efficient.	Modern fan speed controllers, especially in smart home or energy-efficient systems.

III. System Design

The proposed system is designed to remotely control the speed of an AC fan using a mobile phone. The control signal is sent via Bluetooth to an Arduino, which in turn adjusts the brightness of an LED. This LED is part of a custom-built optocoupler, where an LDR placed opposite to the LED senses the light intensity and changes its resistance accordingly. This varying resistance is then used to control a TRIAC-based dimmer circuit, which ultimately regulates the fan's speed. The entire system consists of five main blocks:

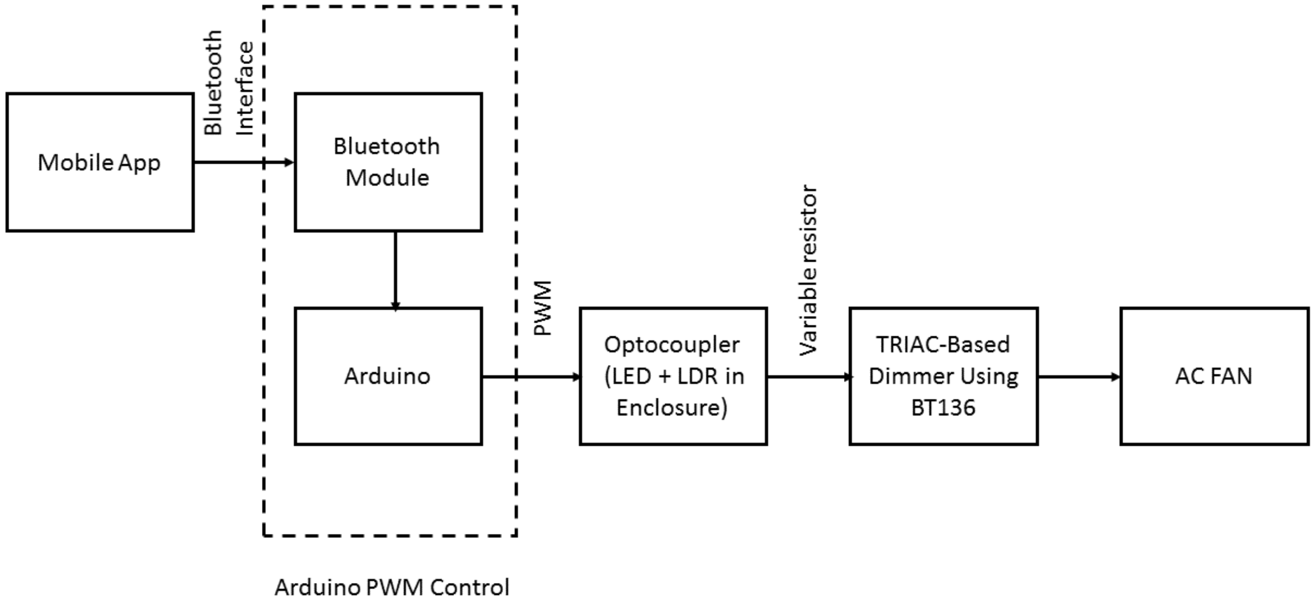


Fig.1 Block Diagram

1. Mobile App (Bluetooth Communication):

A simple mobile application acts as the user interface. It allows users to send PWM values over Bluetooth, which are interpreted as fan speed levels. The app connects to the Arduino using the HC-05 Bluetooth module. Sliders or buttons in the app can increase or decrease the PWM signal, making the fan run faster or slower. This offers a wireless and user-friendly way to control the appliance.

2. Arduino PWM Control:

The Arduino receives the PWM level from the mobile app via the HC-05 Bluetooth module. It then generates a corresponding PWM signal and sends it to the LED in the custom optocoupler. The Arduino plays a central role by bridging communication between the mobile app and the hardware control circuit, ensuring accurate and real-time response to user commands.

3. Custom Optocoupler (LED + LDR in Enclosure):

At the core of this system is a homemade optocoupler. It consists of an LED and an LDR placed at a fixed distance inside a dark cylindrical enclosure, preventing external light interference. As the PWM signal from the Arduino changes, the brightness of the LED also changes. This varying light falls on the LDR, which reacts by altering its resistance. This setup effectively transforms the LED's light intensity (controlled by voltage) into a resistance value, functioning like a digitally controlled potentiometer.

4. TRIAC-Based Dimmer Using BT136:

The varying resistance from the LDR is used in a traditional TRIAC dimmer circuit to control the power delivered to the AC fan. The TRIAC (BT136) acts as a switching device that adjusts the conduction angle of the AC waveform, thereby controlling the voltage supplied to the fan. Replacing the usual potentiometer with the LDR makes the system electronically controllable and safer, as there's no direct contact with high-voltage components.

5. AC Fan:

The final component is the standard AC fan, which responds to the varying output from the dimmer circuit. As the PWM value increases or decreases via mobile input, the LDR's resistance changes, which in turn adjusts the TRIAC output and varies the fan's speed accordingly. The result is a smooth, safe, and wireless fan speed control system.

IV. Working Principle

The core idea behind this project is to control the speed of an AC fan using light-based resistance variation through a custom optocoupler and a TRIAC-based dimmer circuit. This is achieved by converting digital signals from a mobile phone into physical light changes that indirectly control AC voltage, without any mechanical components or direct electrical contact.

The process starts with a mobile phone application, where the user selects a desired fan speed. This speed value is sent to an Arduino using the HC-05 Bluetooth module. Once received, the Arduino generates a PWM

(Pulse Width Modulation) signal. The duty cycle of this PWM signal directly controls the brightness of an LED placed inside a custom-made cylindrical optocoupler.

This optocoupler consists of an LED and an LDR (Light Dependent Resistor) positioned face to face within a sealed, dark enclosure. When the brightness of the LED changes, the amount of light reaching the LDR also changes. Since the resistance of the LDR is dependent on the light intensity it receives, it starts to act like a variable resistor controlled by the PWM signal. Higher PWM duty cycles make the LED brighter, lowering the LDR resistance, while lower PWM duty cycles dim the LED and increase the resistance.

This varying resistance from the LDR is fed into a TRIAC-based dimmer circuit built around a BT136 TRIAC. In a typical dimmer, a potentiometer is used to control the phase angle of the AC waveform, which adjusts the power sent to the fan. In our setup, the LDR replaces the potentiometer, allowing the PWM signal—via the LED—to indirectly adjust the TRIAC's triggering point.

As a result, when the LDR resistance decreases (due to brighter LED), the TRIAC allows more voltage through to the fan, increasing its speed. When the resistance increases (due to dimmer LED), less voltage is passed through, reducing the fan speed. This entire process happens smoothly and safely, without any direct contact with the high-voltage AC part of the circuit, since the LED-LDR pairing provides natural electrical isolation.

V. Hardware Implementation

The hardware setup of this project involves several interconnected modules that work together to achieve wireless fan speed control. Each component is selected and arranged to ensure safety, efficiency, and ease of control.

1. Arduino and HC-05 Bluetooth Module:

At the center of the control system is an Arduino board, which acts as the main controller. It receives fan speed values sent from the mobile app via the HC-05 Bluetooth module. The HC-05 is connected to the Arduino using the SoftwareSerial library, with the module's TX and RX pins connected to two digital pins on the Arduino. Power is supplied to both modules from a regulated 5V supply or directly from the Arduino board.

2. PWM Output to LED:

The Arduino generates a PWM signal on one of its digital pins (e.g., pin 9). This pin is connected in series with a current-limiting resistor and an LED, which forms one half of the custom optocoupler. The PWM duty cycle controls the brightness of this LED.

3. Custom Optocoupler (LED + LDR Enclosure):

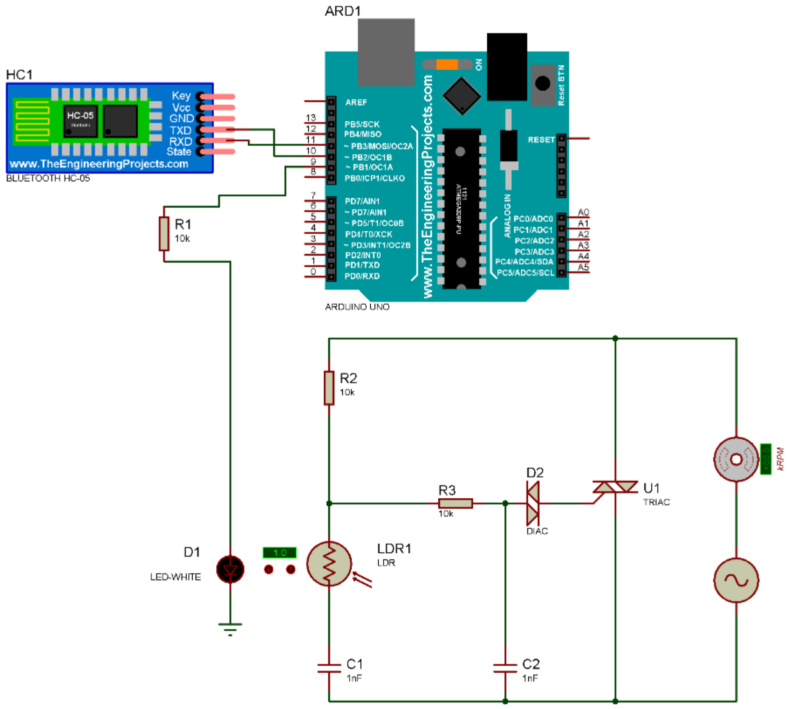
The LED is placed facing an LDR (Light Dependent Resistor) inside a dark cylindrical tube. The tube blocks external light to ensure that the LDR only responds to the LED. This simple setup transforms PWM signals into resistance values: as the LED gets brighter, the LDR's resistance decreases, and vice versa. This varying resistance simulates the behavior of a potentiometer.

4. TRIAC-Based Dimmer Circuit (BT136):

The LDR is integrated into a TRIAC-based dimmer circuit. The BT136 TRIAC is used to switch and regulate the AC voltage supplied to the fan. The circuit is similar to a conventional light dimmer but uses the LDR in place of a variable resistor. As the resistance changes, it adjusts the firing angle of the TRIAC, controlling how much AC voltage reaches the fan.

5. AC Fan Connection:

The output of the dimmer circuit is connected to a standard AC fan. The fan speed changes based on the voltage it receives. All high-voltage components are safely isolated and enclosed, and care is taken to prevent



user exposure to AC mains.

Fig.2 Circuit Diagram

Circuit Safety Measures:

Because the system deals with both low-voltage DC control and high-voltage AC power, special attention is given to safety. The optocoupler ensures complete electrical isolation between the Arduino and the AC circuit. The enclosure for the TRIAC circuit is insulated, and proper fusing is used to protect against overcurrent.

VI. Software and Control

The software running on the Arduino is responsible for receiving input from the mobile app, processing it, and generating a suitable PWM signal to control the LED inside the optocoupler. The logic is simple but efficient, allowing real-time fan speed adjustments through a clean and wireless interface.

Bluetooth Communication:

The mobile application communicates with the Arduino via the HC-05 Bluetooth module. The app sends a numeric value—typically between 0 and 255—representing the desired fan speed. This value corresponds directly to the PWM duty cycle that will be applied to the LED. For example, a value of 0 means the LED will remain off (resulting in maximum LDR resistance and lowest fan speed), while 255 will turn the LED fully on (minimum LDR resistance, highest fan speed).

The HC-05 module is connected to the Arduino using SoftwareSerial on two digital pins (e.g., pin 10 for RX and pin 11 for TX). When a value is received, the Arduino reads it using the Serial.read() function.

PWM Signal Generation:

Once the Arduino reads the speed value, it maps or directly applies this value to a PWM-capable pin (e.g., pin 9). The analogWrite() function is used to generate a PWM signal with a duty cycle matching the value received from the mobile app. This PWM signal controls the brightness of the LED inside the custom optocoupler.

Arduino Code:

```
#include <SoftwareSerial.h>
SoftwareSerial btSerial(10, 11); // RX, TX
int pwmPin = 9;
int speedValue = 0;
void setup() {
  btSerial.begin(9600);
  pinMode(pwmPin, OUTPUT);
}
void loop() {
```

```
    if (btSerial.available()) {
      speedValue = btSerial.read(); // Receive PWM value (0–255)
      analogWrite(pwmPin, speedValue); // Control LED brightness
    }
  }
```

Flow Chart:

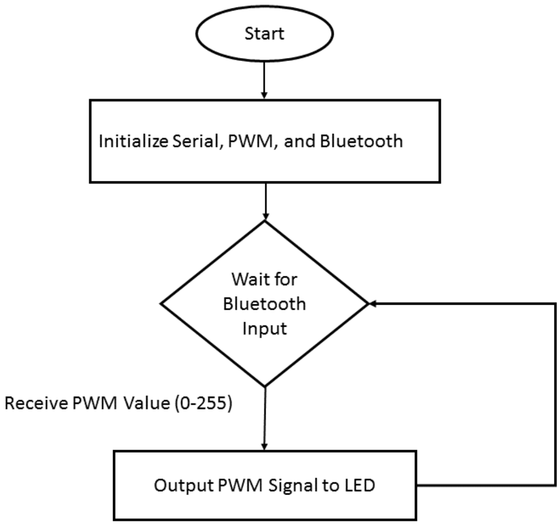


Fig.3 Flowchart

Mobile App Integration:

The mobile app uses Bluetooth communication to pair with the HC-05. A slider or button sends values between 0 and 255 to adjust speed. The simplicity of this user interface makes the system intuitive and accessible even for non-technical users.

This software approach not only provides real-time control but also showcases how even basic microcontroller programming can be combined with a novel hardware setup to create a practical and modern solution for smart home applications.

VII. Construction and Testing of Sensor

When a 10kΩ resistor is placed in parallel with an LDR (Light Dependent Resistor), the overall resistance of the combination will depend on the resistance of the LDR and how much light it is exposed to. In this case, as the PWM controls the intensity of the LED, it will affect the LDR resistance, and thus the overall resistance will also change based on the amount of light received by the LDR.

Key Points:

- When the LDR receives more light (higher LED intensity), its resistance decreases.
- The parallel connection of the LDR and the 10kΩ resistor means the total resistance will always be lower than the LDR resistance alone because the total resistance of two parallel components is always less than the smallest resistance.

Formula for Parallel Resistance:

$$\frac{1}{Rtotal} = \frac{1}{RLDR} + \frac{1}{Rresistor}$$

Where:

- RLDR is the resistance of the LDR,
- Rresistor is the resistance of the 10kΩ resistor.

For example:

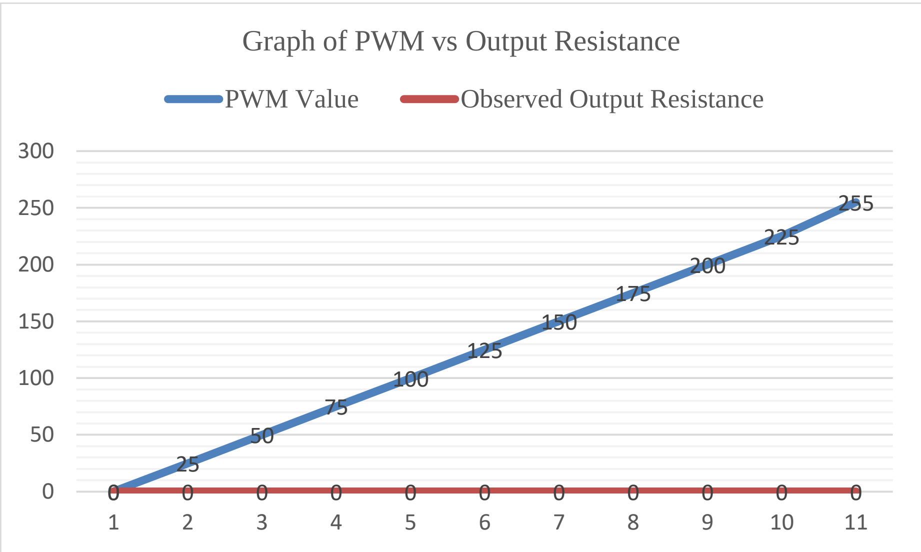
- When RLDR is very high (in dark conditions), the total resistance will be close to 10kΩ.
- As the LDR's resistance decreases with increasing light, the total resistance will drop below 10kΩ.

Example Calculation for Various PWM Values:

Let's assume the following LDR resistances at different PWM values and calculate the total resistance when the LDR is in parallel with a 10kΩ resistor.

Sr. No.	PWM Value	LED Intensity (%)	LDR Resistance (Ohms)	Total Resistance (Parallel LDR + 10kΩ)
1.	0	0%	Very High (~10MΩ)	~10kΩ
2.	25	10%	~9MΩ	~9.1kΩ
3.	50	20%	~8MΩ	~8.2kΩ
4.	75	30%	~7MΩ	~7.4kΩ
5.	100	40%	~6MΩ	~6.6kΩ
6.	125	50%	~5MΩ	~5.8kΩ
7.	150	60%	~4.5MΩ	~5.1kΩ
8.	175	70%	~4MΩ	~4.5kΩ
9.	200	80%	~3MΩ	~3.8kΩ
10.	225	90%	~2MΩ	~3.2kΩ
11.	255	100%	~1MΩ	~2.0kΩ

Table 1: PWM vs output Resistance of Optocoupler



Graph 1: PWM vs output Resistance of Optocoupler

Explanation:

- As the LDR resistance decreases (as the LED intensity increases), the total resistance also decreases but always stays lower than the LDR resistance alone because of the parallel resistor.
- For very low PWM (low LED intensity), the LDR resistance is very high (close to 10MΩ), so the total resistance will be almost equal to 10kΩ.
- As the PWM increases and the LED brightens, the LDR resistance decreases, pulling the total resistance lower.

Effect on Fan Speed Control:

This combination of the LDR and 10kΩ resistor would ensure a more stable range of resistance for controlling the fan speed. With the parallel resistor, the system becomes more linear in its response, and the effect of light intensity on the LDR's resistance will be more controlled.

VIII. RESULTS AND DISCUSSION

After assembling the complete system and uploading the control code to the Arduino, the wireless fan speed control was tested under various conditions. The system successfully demonstrated its ability to adjust the speed of a standard AC fan in response to input from a mobile application. The results validated the core idea of using a custom optocoupler-based variable resistance to regulate AC power through a TRIAC dimmer circuit.

1. **Smooth Speed Control:**
   The PWM values sent from the mobile app translated directly into changes in fan speed. As the slider on the app was adjusted from 0 to 255, the fan responded with a noticeable and smooth change in rotation speed. There was no abrupt switching or delay, indicating that the optocoupler and TRIAC were responding effectively to changes in the LDR resistance.
2. **Effective Optical Coupling:**
   The custom-built optocoupler—using a basic LED and LDR inside a cylindrical tube—worked reliably. The enclosure successfully blocked external light, ensuring the LDR's resistance was only influenced by the LED. This demonstrated that even a simple, low-cost optical coupling method could achieve consistent analog control based on digital input.
3. **Responsiveness and Range:**
   The Bluetooth connection via the HC-05 module was stable within a range of approximately 8–10 meters. Commands sent from the mobile phone were received without noticeable delay. The system performed well even with frequent changes in speed values, maintaining consistent communication between the app and the Arduino.

IX. Conclusion

In this paper, we presented a novel approach to controlling the speed of an AC fan using a mobile phone via Bluetooth. The system relies on an innovative custom optocoupler sensor, consisting of an LED and an LDR, to convert digital PWM signals into a varying resistance that adjusts the fan speed via a TRIAC-based dimmer circuit. This method offers several advantages, including enhanced safety through optical isolation, ease of use with wireless control, and the flexibility to adjust fan speeds remotely.

The results confirmed that the system operates reliably, with smooth control and accurate fan speed adjustments in response to changes in the PWM signal. The custom sensor proved to be effective in converting light intensity into resistance, which was then used to control the AC voltage supplied to the fan. The Bluetooth communication was stable, and the fan responded promptly to input from the mobile app.

While the system is functional and provides a safe, non-contact solution for controlling AC appliances, there are opportunities for improvement. Future work could address the non-linearity observed in the fan speed control, implement feedback mechanisms for more precise control, and integrate the system with other smart home platforms for enhanced functionality.

This project demonstrates the potential of using simple, low-cost components to create a functional and safe smart home device, contributing to the growing field of IoT-based home automation systems. The core innovation lies in the custom optocoupler sensor, which could be adapted for other applications requiring variable resistance control, making it a versatile solution for electronic control systems.

References

1. Kumar, R., & Jain, S. (2017). "Design and Development of a Microcontroller-Based Electronic Fan Regulator." International Journal of Emerging Trends in Engineering and Development (IJETED), Vol. 7, Issue 2.
2. Patel, N., & Mehta, A. (2019). "Wireless Fan Speed Control System Using TRIAC and Microcontroller." International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering (IJIREEICE), Vol. 7, Issue 6.
3. Deshmukh, P., & Kale, V. (2020). "Bluetooth-Based Home Automation System Using Android and Arduino." International Journal of Computer Applications (IJCA), Vol. 176, Issue 12.
4. Bose, S., & Raj, R. (2021). "Design and Implementation of Mobile App Controlled Home Automation System Using Bluetooth." International Journal of Engineering Science and Computing (IJESC), Vol. 11, Issue 3.