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Development of Remote Controlled Light Dimmer Based on Microcontroller

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Abstract

Light dimming has been possible for many decades by using adjustable power resistors and adjustable transformers. However, these conventional methods which have been used in movie theatres, stages and other public places, suffer from significant imperfections. They are big, expensive, have poor efficiency and they are hard to control from remote location. These also involve a lot of human labor, energy and time wastage. This paper presents the design and implementation of an intelligent microcontroller-based remote controlled light dimmer that make the entire system smarter and easier to operate. A remote control is designed to control the light intensity as well as switch on and off the light. The system works by varying the duty cycle (On/Off time) of the full AC voltage that is applied to the light being controlled. A Triode for Alternating Current (TRIAC) and Diode for Alternating Current (DIAC) were used to control the power of the lamp. The system is found operational and effective within the range of 0.01m to 5.00m in accordance with the design specifications.

Keywords: Microcontroller, Remote Control, Light Intensity, Light Dimmer, Opt Coupler, Infrared.

INTRODUCTION

Lamps are necessary products for everyone's home. Sometimes, the lamp is kind of far away from where we are and it is not convenient to walk towards the lamp and then come back [7]. Manual control of domestic appliances posed difficulty to physically challenged young and elderly people. Therefore, it is useful to have a remote control which can help save energy and make human's daily life more convenient as well. A remote control light dimmer is an electronic device used to regulate the brightness of lighting fixtures wirelessly. Users can change the lighting's intensity without walking or touching the light switch or the light source directly. An IR remote control, an RF remote, a Wi-Fi-based control, or even smartphone apps can all be used to start the dimming process. Remote control facilitates variety of operations around the home or offices from a distance such as fan regulators and mains power supply [1].

Lighting control has changed substantially over the time as a result of technological advancement leading to more sophisticated and efficient methods of regulating illuminations levels. Conventional lighting control techniques such as manual switches or simple dimmer switches have done a good job of serving their purpose. However, they often fall short in meeting the demands of modern lighting systems, which include seamless integration, improved user experience, and energy efficiency.

In recent years, microcontroller-based solutions have emerged as a promising approach to addressing the shortcomings of traditional light control methods. The integration of microcontrollers into lighting systems offers a myriad of possibilities, such as remote control, automation, and intelligent dimming capabilities. These advancements not only improve the user's convenience but also contribute to significant energy savings, aligning with the global push for sustainable and environmentally friendly technologies. Dimmers are devices that are used to reduce a light's brightness. It is possible to reduce the brightness of the light output by altering the voltage waveform applied to the bulb. Although there are many uses for variable-voltage devices, the term "dimmer" is typically only applied to those that are meant to adjust the output of light from resistive incandescent, halogen, etc. The first remote control, called "lazy bones" was developed in 1950 by Zenith Electronics Corporation (then known as Zenith Radio Corporation). The device was developed quickly, and it was called "Zenith Space Command", the remote went into

production in the fall of 1956, becoming the first practical wireless remote control device [9].

The research done in [10] is very much like the Microcontroller based remote controlled voltage but for the fact that, it was purely based on discrete components and has options to load being attached. Joshua [11] designed and developed a variable voltage Regulator. Its method of control is not done via remote control, but rather, on a keypad attached to the receiver terminal. The project did not provide the user with the luxury of being able to vary a voltage from a far. [1] presented a design and implementation of a microcontroller-based infrared (IR) remote control signal decoder for home applications, enabling the control of a fan regulator and mains power switch from a distance of about 10 meters; however, drawbacks include potential harmonic distortion with the triac-based load driver, limitations of the line-of-sight IR communication, sensitivity to ambient light, accuracy concerns with on-chip RC oscillator timing, and a single point of failure with the microcontroller. In [2], a home appliance control system using the PSoC CY8C38KIT for lamp brightness and fan speed control was presented. While the concept is promising, the design should address safety measures, load capacity limitations, and power factor correction to ensure reliable and efficient operation. Li, X (2017), showcased a remote LED dimmer using NRF24L01 radios and PIC32 microcontrollers, controlling light intensity through pulse-width modulation. It offers energy-efficient home lighting with a 15-meter communication range and potential voice control. This work challenges include single point vulnerabilities, setup complexity, technical competence, power consumption, and LED compatibility. [12] Described a microcontroller-based automated lighting control system for Workplaces that uses natural and artificial illumination, controlled by an MCU, LDR, relays, and energy-efficient dimmable LED lamps. The system maintains proper illumination levels in accordance with Energy Efficiency Division standards and Occupational Safety and Health Standard regulations, but its application is limited to workplaces alone. A smart remote controller using the ESP8266 microcontroller and a mobile app for controlling home devices via the Internet was developed in [4]. It aims to eliminate the need for multiple remote controls and incorporates a self-learning feature to copy other remote control codes. The literature review highlights related works but lacks a comparative analysis and detailed discussion of the self-learning feature. The work is not friendly to most people due to the technicality involves in the operation of the system.

After observing the various methodologies employed and analyzing their various limitations, this demanded the development of a microcontroller-based embedded system for home automation. The choice of using a microcontroller for its implementation is to reduce system complexity and provide a faster mode of operation of the project system. Inclusion of a remote control means of varying voltage tends to provide the operator of the project system with luxury since the manual voltage selection involves a lot of human labor, energy and time wastage.

The infrared remote control dimmer solution implements long-distance beam dimming of lumens lamps. A high performance PIC16F84A is used in this project as the core processor of both the transmitter and receiver for flexible and effective control. Through infrared signal transmission, the infrared Remote control dimming solution features long-distance and high-speed capabilities, reduced power consumption and easy operation. This complete low-cost solution consists of several parts and is detailed in the subsequent section of this research.

MATERIALS AND METHOD

SYSTEM DESCRIPTION

This chapter made an attempt to give a detailed design of the project using remote control system's sub-units. The relationship between the various units is expressed as an aid to the understanding of the system's operation. The system is divided into two sections; the transmitter section and the receiver section.

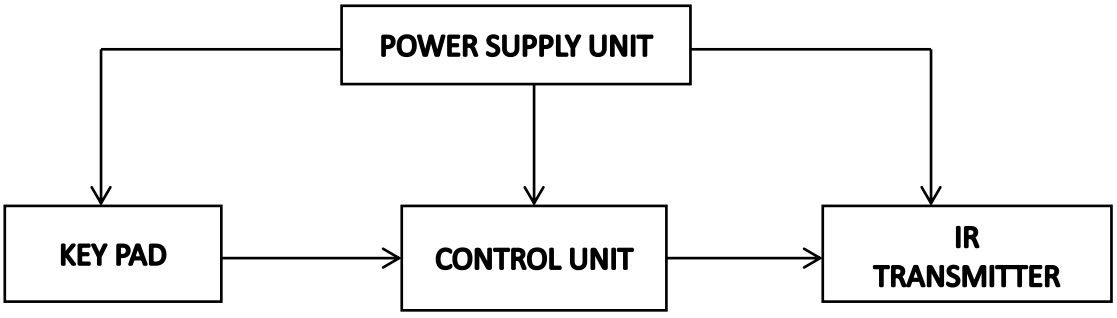


Figure 1.0 (a): Block diagram of a remote control (Transmitter)

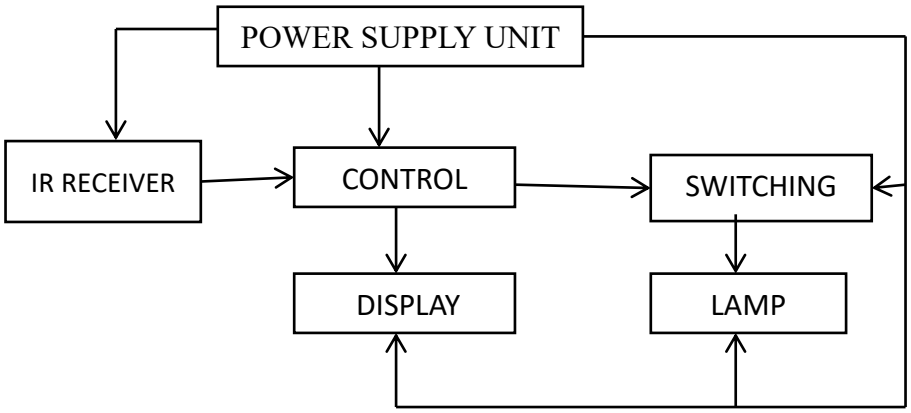


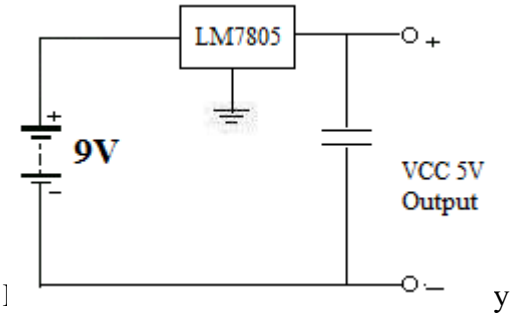
Figure 1.0 (b): Block diagram of microcontroller-based light dimmer receiver unit

DESIGN ANALYSIS OF SYSTEM UNITS

The system model of the project is implemented using the block diagrams as shown in figure 1.0 (a) and (b) above. Hence, the details of the design, specifications and calculations involved in the design of each unit or section of the project's block diagram are discussed below:

(I) POWER SUPPLY UNIT

The power supply unit is the unit that powers all other units of the project using remote control system at a steady voltage. The transmitter unit is a hand held and portable device; hence its power supply unit is designed with a battery or DC cell of 9V which is also regulated to 5V using LM7805 as shown in figure 3.2 below:



On the other hand, the receiver unit power supply powered both AC load and the control circuitry; hence it is a multi-stage power supply unit. The first stage is the direct AC supply from the grid (220 V_{AC}, 50Hz) which is being tapped to the

electromechanical relays through which the Load is being supplied. The second stage is the DC supplied to the electronic control circuitry. Functionally, it converts AC voltage of 220V AC 50 Hz power line to DC voltage. In the design of this unit, 12V and 5V DC voltage levels are required for all the system units. The process for the conversion of AC supply to DC is termed "rectification" which has the following components:

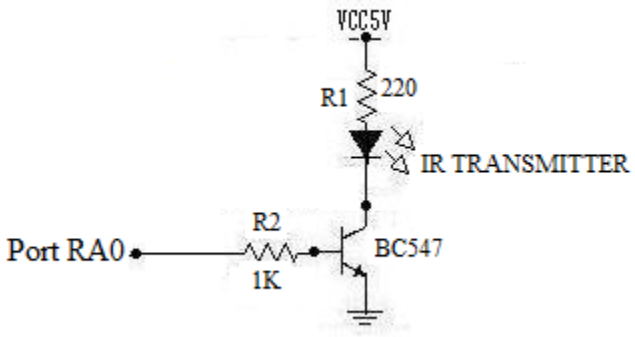
1. Step-down transformer.
2. Rectifier.
3. Filter.
4. Voltage Regulator.

(II) INFRA-RED TRANSMITTER UNIT

The infra-red T232/HO-A was used as transmitter and it has the following specifications:

- Continuous DC forward current, I_f = 100mA
- Frequency spectrum, F = 100THz to 400THz
- Power dissipation = 200mWatt
- View color = invisible
- Forward voltage drop, V_f = 1.7V

The infra-red transmitter circuit is shown in figure 3.5 below:



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Hence, from the above figure 3.5, the equation is given by:

$$V_{CC} - I_f R - V_f = 0 \quad (10)$$

Therefore, the limiting resistor R2 can be calculated as:

$$R_2 = \frac{V_{CC} - V_F}{I_F}$$

$$R_2 = \frac{5 - 1.7}{0.1} \times 1000$$

$$R2 = 100\Omega$$

But a 220Ω resistor was used for complete protection of the infra-red diode

(III) KEYPAD UNIT

A transducer is responsible for the conversion of physical parameters into electrical signals. The transducer used for the purpose of this project is the keypad. The keypad is actually a collection of push-buttons, arranged in triangular form. The key-pad layout is as follows:

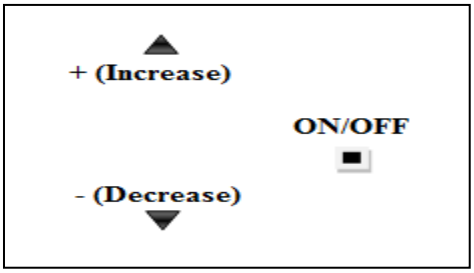


Figure 3.6: Keypad arrangements

(IV) CONTROL UNIT

The control unit is mainly the PIC16F84A microcontroller IC for both the transmitter and receiver unit, and most of its values for the design were gotten from the data sheet except in some few cases.

The programs are responsible for the mode of operation of both control units of the project system. The program flowchart is given below:

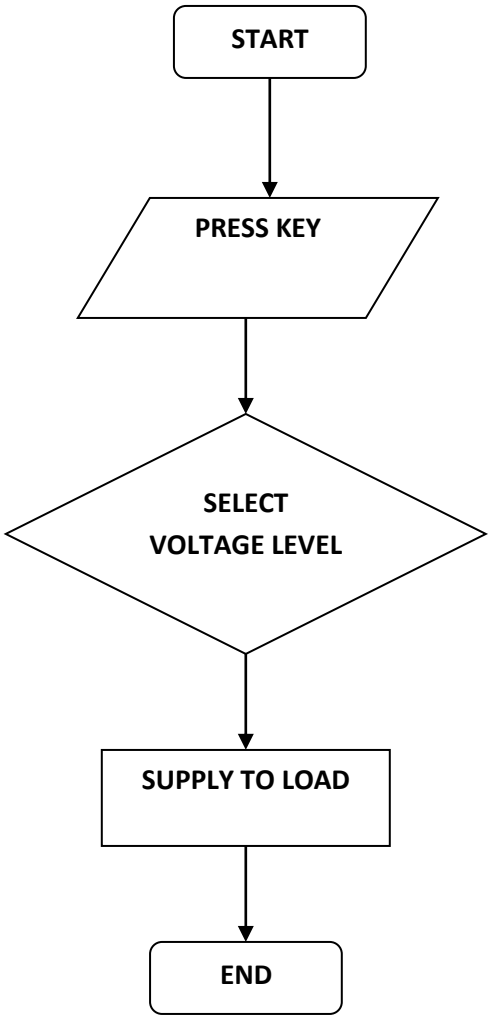


Figure 2: Program flow chart

(V) SENSOR UNIT, SWITCHING UNIT AND LAMP UNIT

In this design, the sensor used is a phototransistor. It is a light sensitive device which is used to receive the infrared signals being transmitted from the remote control circuit. The switching unit consists of an Optocoupler, Triac, Diac and variable resistors. The optocoupler is used as a switch to drive triac. For this purpose MOC3021 was chosen due the fact that its output is designed to be connected directly into the triggering circuit of the triac, where it is operating from and floating at full AC mains potential. The output diac is connected to the triac gate triggering circuit in much the same way as discrete diac. The lamp used as a load is 240V, 100W filament bulb with maximum current of 0.42A.

CONSTRUCTION AND PACKAGING

The construction of a system's receiver and remote control units is described in detail in this section. The process entailed assembling the circuit on a breadboard and then transferring it to a Vero-board for additional testing. It also involved testing individual components before construction and analyzing system performance using software. Using the Vero-board, the entire system was successfully tested.

In terms of packaging, blue plastic enclosures were used for the device's final construction due to their non-conductive, robust, lightweight, and affordable qualities. The enclosures were 125mm×25mm×55mm for the remote control and 150mm×105mm×60mm for the receiver. The enclosures had precisely cut, clean edges, front-facing indicator holes, and back-facing power cord apertures. The provided diagram illustrates the full system package.



Figure 4: System casing and packaging

RESULTS

The whole system was tested with various trials of selecting various voltage levels by pushing the buttons on the remote control which was aimed at the receiver at a reasonable distance to yield the output voltages, and the results are shown in Table 1.0 below.

BUTTON/KEY	VOLTAGE
OFF	0
1	98
2	113
3	116
4	195
5	197
6	200
7	The same voltage as the mains supply.

Table 1.0: Voltages at various Illumination level.

The remote control is used to operate the light dimmer at various distances. The distance is measured in meters and the following results tabulated as shown in table 2.0 below.

Distance (m)	Remote control status
1	Working
2	Working
3	Working
4	Working
5	Working (partially)
6	Not working
7	Not working
8	Not working

Table 2.0: The working state of Remote control

The experiment proved that remote buttons can effectively adjust voltage, allowing for variable light dimming. At close ranges, the system communicated effectively, but

a partial functional state at 5 meters showed possible signal limitations. Beyond 5 meters, the "Not working" indicator denotes the need for signal optimization. Overall, the remote control light dimmer system demonstrated effective dimming capability and revealed areas in which remote communication range may be extended.

CONCLUSION

The successful development and use of the microcontroller-based remote-controlled light dimmer system represent a key milestone in contemporary lighting control technology. Through user-friendly interfaces, the study successfully illustrated the viability of remotely altering lighting levels to improve convenience and energy efficiency. Transducers, microcontrollers, infrared communication, and switching networks were all integrated to demonstrate how diverse this project was. The project's results offer insightful information for further user-centered design, signal optimization, and remote lighting control in the future. With implications for both residential and commercial settings, where flexible and effective illumination control is vital, this initiative adds to the expanding landscape of smart lighting solutions.

RECOMMENDATION

The fundamental purpose of the remote-controlled LED dimmer has been achieved and worked as intended. We might want to include voice control in place of button pressing to make it more practical and convenient. Then, instead of using buttons to control the light, we can merely give simple commands like "on," "off," "up," and "down." The system can also be improved to control more electrical appliances such as washing machine etc.

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