DESIGN AND CONSTRUCTION OF REMOTE CONTROLLED ROOM LIGHTING SYSTEM

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Dedication

I dedicate this project work to the memory of my late Dad. Rest in peace Dad, I miss you.

Declaration

I, Peter Darius Yayock, declare that this work was done by me and has never been presented elsewhere for the award of a degree. I also hereby relinquish the copyright to the Federal University of Technology, Minna.

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Abstract

The project presents the design and construction of an infrared remote controlled room lighting system, which is a device that enables the user to operate or control the lightings in a room from a distance of 5 to 10 meters away. The remote control unit transmits a beam of light using an infrared light emitting diode (Ir LED); this light is picked by the receiver unit which is an infrared receiver module. The receiver only activates when it receives a beam of light, there are no accidental activations. In the design, the system was broken down into simpler functional parts namely: The transmitter stage, the detector stage, the inverter stage, the flip-flop stage, the opto coupler stage and the switching stage. The project covers the design and construction of an Infrared remote control transmitter and the design and construction of its corresponding receiver unit. The receiver unit is to control the lighting system logically by responding to beam received by the infrared receiver module from the infrared remote transmitter. Details of the stages are described in the thesis. The project aims at providing an easy means of control for room lightings as well as easy control for the physically challenged. The objectives of the project were achieved at the end of the day.

Table of content

Dedication..ii

Declaration..iii

Acknowledgement..iv

Abstract..v

Chapter One: Introduction..1

1.1 General introduction..1

1.2 Objectives and motivation..2

1.3 The scope of the project..2

1.4 Methodology..3

Chapter Two: Literature review..4

2.1 Historical background..4

2.2 Theoretical background..7

2.2.1 Types of remote control..8

2.2.2 The infrared remote control..8

2.2.3 Radio frequency remote control..8

2.3 The infrared remote controlled room lighting system..9

2.4 Previous works related to this project..10

2.5 Thesis outline..11

Chapter Three: Design and Implementation........................12

3.1 The infrared remote control transmitter........................13

3.1.1 The 555 Timer........................14

3.1.2 Frequency circuit calculation........................15

3.1.3 Duty cycle calculation........................17

3.1.4 Calculation of limiting resistance R_S for infrared LED........................18

3.1.5 The transistor as a switch........................19

3.2 The infrared remote control receiver unit........................19

3.2.1 The power supply unit........................20

3.2.1.1 Transformer........................20

3.2.1.2 Rectifier........................21

3.2.1.3 Filter........................23

3.2.1.4 The voltage regulator........................24

3.2.2 The infrared receiver module........................26

3.2.3 The logic inverter........................28

3.2.4 The D-Flip Flop........................30

3.2.5 The opto coupler........................35

3.2.6 The power switch........................36

3.2.7 The load........................39

Chapter Four: Tests, result and discussion........................40

4.1 Hardware construction procedure and precautions........................40

4.2 Tools and instruments used........................41

4.3 Testing and measurement........................41

4.4 Photographic plates of the constructed work and casings......................42

4.5 Discussion of results..43

4.6 Limitations of the project..44

Chapter Five: Conclusion and recommendations..45

5.1 Conclusion..45

5.2 Problems encountered..45

5.3 Recommendations..45

References...48

List of Figures

Fig. 2.1 The electromagnetic spectrum

Fig. 2.2 Block diagram of the system

Fig. 3.1 Block diagram of the infrared remote control transmitter

Fig. 3.2 Block diagram of the infrared remote control receiver unit

Fig. 3.3 Circuit diagram of infrared remote control transmitter.

Fig. 3.4 Schematic diagram of NE555 timer

Fig. 3.5 Infrared LED protected by limiting resistor.

Fig. 3.6 Block diagram of the power supply unit

Fig. 3.7 Voltage regulator

Fig. 3.8 Block diagram of power supply unit's stages

Fig. 3.9 Wave forms of stages of power supply unit

Fig. 3.10 Infrared receiver module

Fig. 3.11 Schematic diagram of TSOP1738 infrared receiver module

Fig. 3.12 Logic inverter symbol

Fig. 3.13 Inverter 40106 connection diagram

Fig. 3.14 Symbol of D-Flip Flop

Fig. 3.15 Input and output wave forms of clocked D-Flip Flop

Fig. 3.16 Symbol of a falling edge triggered D-Flip Flop

Fig. 3.17 Toggle mode connection of D-Flip Flop

Fig. 3.18 Input and output wave forms of Toggle Flip Flop

Fig. 3.19 MOC3020 opto coupler package

Fig. 3.20 Schematic diagram of MOC3020 opto coupler

Fig. 3.21 AC10DT Triac

Fig. 3.22 Triac symbol

Fig. 3.23 V-I characteristic of a triac

Fig. 3.24 Circuit diagram of the infrared remote control receiver unit

List of Tables

Table 3.1 Truth table of 40106 Logic inverter

Table 3.2 Truth table of D- Flip Flop

CHAPTER ONE

1.0 INTRODUCTION

1.1 GENERAL INTRODUCTION.

Light is one of the key elements of interior design. Most interior spaces constructed in the 20th century were used as much with artificial light as with daylight [1]; because of this, lighting has become a very significant tool for the interior designer. There are three major aspects to lighting: function, aesthetics, and health. The latter factor is often ignored, but insufficient illumination can cause eyestrain and physical discomfort [1]. Light can be diffused and can, in general, be controlled very accurately. Two basic sources of lighting are used in modern interiors: incandescent and discharge lamps [2]. The former is somewhat redder than daylight but contains all colours of the spectrum. Designers and architects strive to build in lighting as much as possible and most interiors require certain flexibility for different functions within the space at different times of the day and night. In certain interiors, such as stores and shops, lighting becomes a display and sales tool, and in apartments, it is only required for certain periods.

Making light available and removing it can be achieved by controlled illumination through lamps. Control of lighting leads to savings from reduced lighting energy use [3]. These lamps are controlled by either putting them ON or OFF at any time of the day or night and this control is not only made possible but can be easier and convenient through the use of remote control which is what this project intendeds to achieve.

The dream of a practical system of remote control of lighting has always tantalized designers. Relays for remote switching have been common place for years. Motor-driven dimmers have proved practical for controlling auditorium lighting but for stage lighting are too cumbersome, expensive, and limited in speed control and are unpredictable in responding to changes [1]. Because of these limitations, more efficient and effective means of remote control of lighting systems is paramount. This project intends to tackle the limitations of past methods of remote control of lighting systems and to come up with a more effective (good response) and economical (cheap) design for the remote control of room lightings.

The project will utilize the basic principle of Infrared signal generation, transmission and reception from the Infrared remote control transmitter to the infrared remote control receiver.

1.2 OBJECTIVES AND MOTIVATION.

1. To design and construct an Infrared remote controlled room lighting system.
2. To be able to switch ON and switch OFF lights using Infrared remote control.
3. To produce a safe, reliable and efficient means of switching ON and OFF of lights.
4. To increase comfort and aid the physically challenged with a means of controlling their lights.

1.3 THE SCOPE OF THE PROJECT.

The project covers the design and construction of an Infrared remote controlled room lighting system. This includes the design and construction of an Infrared remote transmitter and the design and construction of its corresponding receiver unit which will perform the control of the lighting system. The receiver unit is to control the lighting system logically by responding to pulses received by the infrared receiver from the Infrared remote transmitter.

1.4 METHODOLOGY.

The design of this project comprises of two basic sections which are:

1. the design of the infrared remote transmitter and
2. the design of the infrared remote receiver unit.

The first section which is the design of the infrared transmitter determines the frequency of the signal to be transmitted and does the transmission. It comprises of an NE555 timer as its major component and two resistors and a capacitor whose combination sets the frequency of the transmitted signal. The signal is transmitted by an infrared Light Emitting Diode (Infrared LED) while the whole circuit is powered by a 9V battery. The second section which is the Infrared remote receiver unit comprises of an Infrared receiver module, Hex, Inverting Schmitt Buffers, a Dual D Flip-Flop with Set and Reset, an opto coupler, and a Triac as switch. The whole unit is powered by a 5V dc constant voltage supply.

This project is designed to be used with room lightings and not with street lights or flood lights. Based on the design, only one condition is obtainable at a time i.e. the light is either ON or OFF. Two logic circuits are involved in the design; the Hex, Inverting Schmitt Buffers (CD40106) and Dual D Flip-Flop with Set/Reset (CD4013) which are of the Complementary Metallic Oxide Semiconductor (CMOS) class of semiconductors. This class of semiconductors is chosen for its high flexibility, low power consumption, low cost, wide operating voltage range, and for its High Noise Immunity Characteristic [4].

A major improvement of this project over earlier ones is the use of Logic circuits and Triac as the power switch. These were chosen because of their low power consumption and fast and efficient switching capabilities over the relay.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 HISTORICAL BACKGROUND.

The phenomenon of remote control has been in existence for a very long time through the development of electronic technology.

The first primitive but successful remote-controlled dimmer was used in 1890 but not perfected until later [1]; it used a reactor coil operating on a relatively small amount of direct current to control a huge amount of alternating current.

Remote control became a reality largely as a result of the development by George Izenour of Yale University in 1948 of a dimmer using the thyratron, a type of electron tube [1]. The thyratron is a gas-filled discharge chamber that contains a cathode filament, an anode plate, and one or more grids. An inert gas or metal vapour fills the discharge chamber. The grid controls only the starting of a current and thus provides a trigger effect. The normal grid potential is negative with respect to the cathode and prevents electrons from flowing to the plate and exciting a discharge. To cause a discharge, the grid potential is raised enough to start electrons flowing from the cathode. As free electrons stream toward the plate, they collide with gas molecules, freeing other electrons and ionizing the gas within the discharge chamber. When a sufficient number of ions and electrons are present, a "short" occurs, and a large current flows from the cathode to the plate, causing a discharge. The discharge can take place in a few hundred-millionths of a second. The discharge stops when the anode voltage has been sufficiently lowered. Thyratron tubes are today used typically in radar pulse modulators, particle accelerators, lasers, and high-voltage medical equipment. George Izenour's concept brought continuous and instantaneous control to remote systems for the first time.

One of the earliest examples of remote control was developed in 1898 by Nikola Tesla, and described in his patent, U.S. Patent 613,809, named "Method of an Apparatus for Controlling Mechanism of Moving Vehicle or Vehicles" [5]. In 1898, he demonstrated a radio-controlled boat to the public during an electrical exhibition at Madison Square Garden. Tesla called his boat a "teleautomaton". The Germans also used remote control motorboats during World War 1.

Initially, remote control technology was developed only for military use until later in the late 1940's when the first non-military uses for remote controls appeared for example, automatic garage door openers [6].

In 1903, Leonardo Torres Quevedo presented the Telekino at the Paris Academy of Science, accompanied by a brief, and making an experimental demonstration. In the same time he obtained a patent in France, Spain, Great Britain, and the United States. The Telekino consisted of a robot that executed commands transmitted by electromagnetic waves. It constituted the world's first apparatus for radio control [5] and was a pioneer in the field of remote control. In 1906, in the presence of the king and before a great crowd, Torres successfully demonstrated the invention in the port of Bilbao, guiding a boat from the shore. Later, he would try to apply the Telekino to projectiles and torpedoes, but had to abandon the project for lack of financing.

The first remote-controlled model aeroplane flew in 1932, and the use of remote control technology for military purposes was worked intensively during the Second World War, one result of this being the German Wasserfall missile [5].

By the late 1930s, several radio manufacturers offered remote controls for some of their higher-end models. Most of these were connected to the set being controlled by wires, but the Philco Mystery Control (1939) was a battery-operated low-frequency radio transmitter, thus making it the first wireless remote control for a consumer electronics device [5].

The first remote intended to control a television was developed by Zenith Radio Corporation in 1950 called "Lazy Bone" [6]. The Lazy Bone could turn a television on and off, and change channels. However, it was not a wireless remote control but was attached to the television by a bulky cable. It turned out that consumers did not like the cable because it caused frequent tripping.

Zenith engineer, Eugene Polley created the "Flash-matic" the first wireless TV remote in 1955. The remote gave power to viewers. It allowed audiences, for the first time, to interact with their TV without touching it. The Flash-matic operated by means of four photocells, one in each corner of the TV screen. The viewer used a directional flashlight to activate the four control functions, which turned the picture and sound on and off, and turned the channel tuner dial clockwise and counter-clockwise.

However, the Flash-matic had problems working well on sunny days, when the sunlight sometimes changes channels at random. It was in June of 1956, that the practical television remote controller first entered the American home and since then there have been continuous development and improvement of remote controls.

The infrared remote works by using a low frequency light beam lower than the eye can see, but which can be detected by a receiver in the device to be controlled.

A great advantage of the infrared remote was its ability to control only the intended device, unlike the radio frequency (RF) type which travels through walls thus interfering with devices in other rooms.

Today, remote controls are more precise and development has reached a stage where mobile phones can be used as remote control for various devices [7].

2.2 THEORETICAL BACKGROUND.

The remote control is a device which operates wirelessly. Remote control makes use of the electromagnetic spectrum [8] to send control signals to the device to be controlled. The electromagnetic spectrum includes radio waves, microwaves, infrared light, visible light, ultraviolet light, x rays, and gamma rays. Visible light, which makes up only a tiny fraction of the electromagnetic spectrum, is the only electromagnetic radiation that humans can perceive with their eyes.

The Electromagnetic Spectrum is shown by Fig. 2.1.

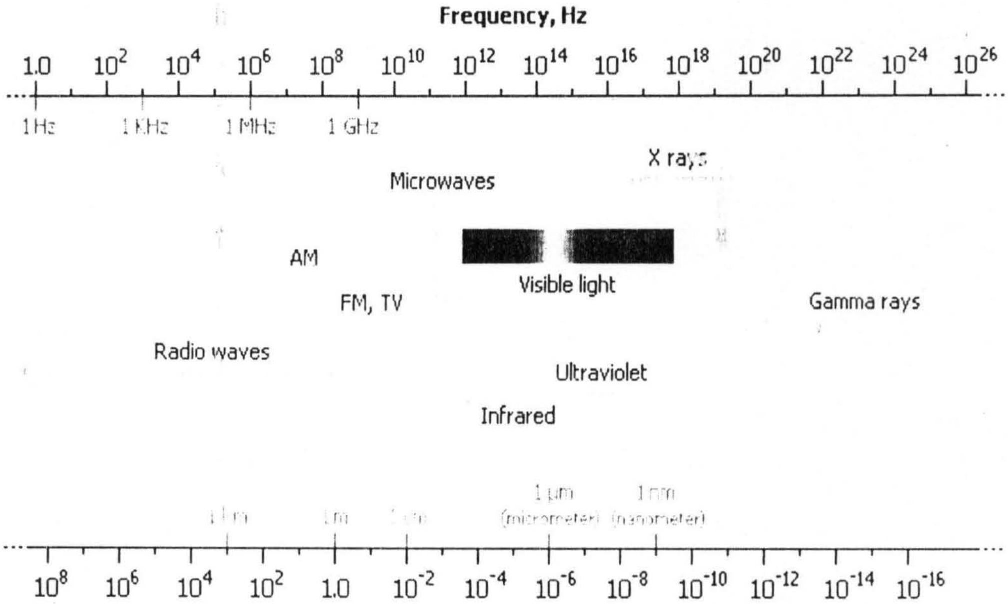


Fig. 2.1: The Electromagnetic Spectrum.

Source: Microsoft Encarta Encyclopedia, 2009.

2.2.1 TYPES OF REMOTE CONTROL.

Remote controls are basically of two types from which other types emerge. The basic types are:

1. Infrared (IR) Remote Control.
2. Radio frequency (RF) remote control, which could be Bluetooth, Wi-Fi etc.

2.2.2 INFRARED REMOTE CONTROL.

Infrared Remote Control makes use of infrared light. The signal produced by this remote control does not travel long distances. The signal is transmitted by an infrared transmitter (Infrared LED) at a particular frequency and is received by an infrared receiver module which operates at a range of frequencies comprising that of the transmitted signal. This type of remote control is mostly employed in electronics whereby the user is not far from the electronic device or appliance to be controlled.

2.2.3 RADIO FREQUENCY REMOTE CONTROL.

This works at frequencies in the range of radio frequency which ranges from 3kHz to 300GHz [9] higher than the infrared remote frequency. The control signal is combined to a carrier signal by a process known as modulation [10]. The modulated signal travels through space and is received by a receiver unit which detects out the control signal from the modulated signal using any demodulation technique. These remote controls can send signals over long distances and through obstacles such as walls etc. They are applicable in areas such as garage door control, water tank control system etc. Disadvantages of this remote control technique include its cost and use of complex circuitry.

2.3 THE INFRARED REMOTE CONTROLLED ROOM LIGHTING SYSTEM.

The infrared remote controlled room lighting system comprises of six (6) functional Blocks which are:

- **A.** The infrared transmitter section.
- **B.** The infrared Receiver stage.
- **C.** The Logic Inverting stage.
- **D.** The toggling stage.
- **E.** The coupling stage.
- **F.** The power switching stage.

They are connected as shown in Fig. 2.2.

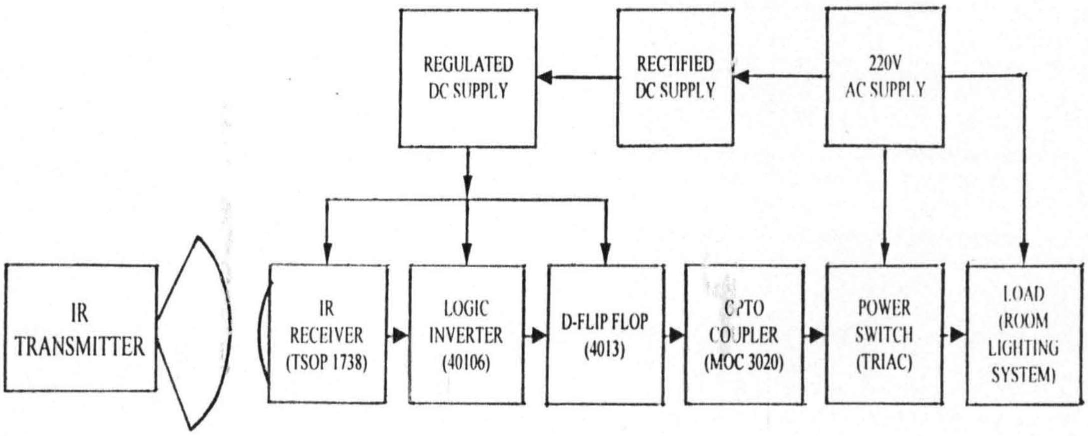


Fig. 2.2: Block Diagram of the System

The transmitter stage is designed to generate an average frequency within the range of 30 kHz to 60 kHz. The frequency rate of the output pulse is determined by the values of two resistors 'R_1 and R_2' and the timing capacitor 'C_1' of the 555 timer [11]. The signal generated by the timer is picked up by the infrared receiver module whose output is normally HIGH and goes LOW on receiving the signal. The sensitivity of the receiver stage is set by the values of R_1 and C_1 of the receiver unit. The value for resistor R_1 may be as high as 10kΩ and the capacitor C_1 may be 40μF [12]. These will prevent the detector unit from turning on under normal lighting conditions. The output of the receiver stage which is at LOW level is then inverted by the Hex, inverting Schmitt buffers. The output of the inverter is now fed to the CLOCK input of the Flip-Flop which is a D-type Flip-Flop and it stores the information it receives through its D (Data) input until it receives contrary information when the transmitter switch (push Button) is pressed again. The output of the Flip Flop triggers the opto coupler which in turn triggers the gate of the Triac which acts as the power switch and switches the lighting system of the room.

Despite the short comings of the infrared remote, this project stands out for its:

1. simple circuitry.
2. universality.
3. low cost and use of readily available components.
4. high power control ability.

2.4 PREVIOUS WORKS INVOLVING THE USE OF INFRARED REMOTE CONTROL.

There are projects that have been done involving the use of infrared remote control. These include the Design and Construction of a remote controlled power supply unit by Danbaki Anthony Bulus, Electrical and Computer Engineering Department. 2006, the Design and construction of an Infrared power controlled switch by Olutade Tolulope Ayobami, Electrical and Computer Engineering Department. 2006, and the Design and Construction of a three speed Infrared remote controlled fan regulator by Adeniyi

Adewale Ebenezer, Electrical and Computer Engineering Department. 2007. All these show how the infrared remote control can be used in different applications.

2.5 THESIS OUTLINE.

In this thesis, there are five chapters. Chapter one introduces us to what the project is all about. It gives the objectives of the project and presents its scope and how it was carried out. Chapter Two is a review of the literature of the remote control which includes the history of the remote control, how it developed through the ages and the theory on which the infrared remote was based. Chapter three is the design and implementation of the project which includes block diagrams, circuit diagrams and calculation. The chapter four of the thesis is about the construction of the project, its testing and discussion of the results from the test of the project. Chapter five, which is the last chapter of the thesis, is a summary of the project work, the results obtained and problems encountered. It also contains recommendations on how the project can be improved for better operation and maximum satisfaction.

CHAPTER THREE

3.0 DESIGN AND IMPLEMENTATION

The infrared remote controlled room lighting system is designed based on two basic systems. These are:

1. the infrared remote control transmitter and
2. the infrared remote control receiver unit.

Each of the systems contains other subsystems which are interconnected together as shown by the block diagrams of Fig. 3.1 and Fig. 3.2.

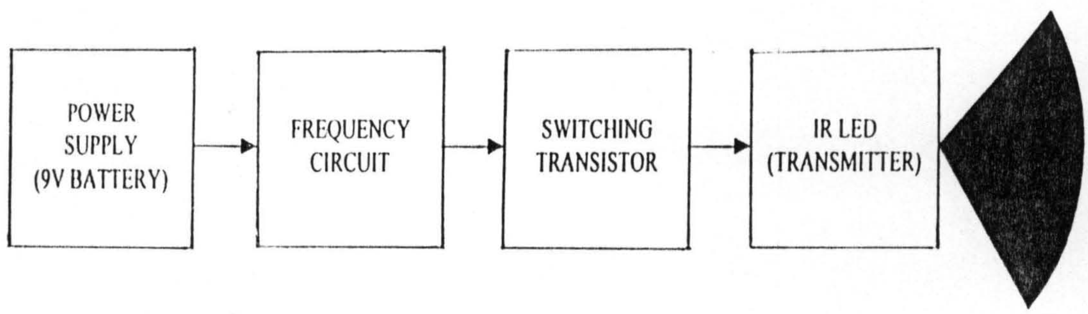


Fig. 3.1: Block Diagram of the Infrared Remote Control Transmitter.

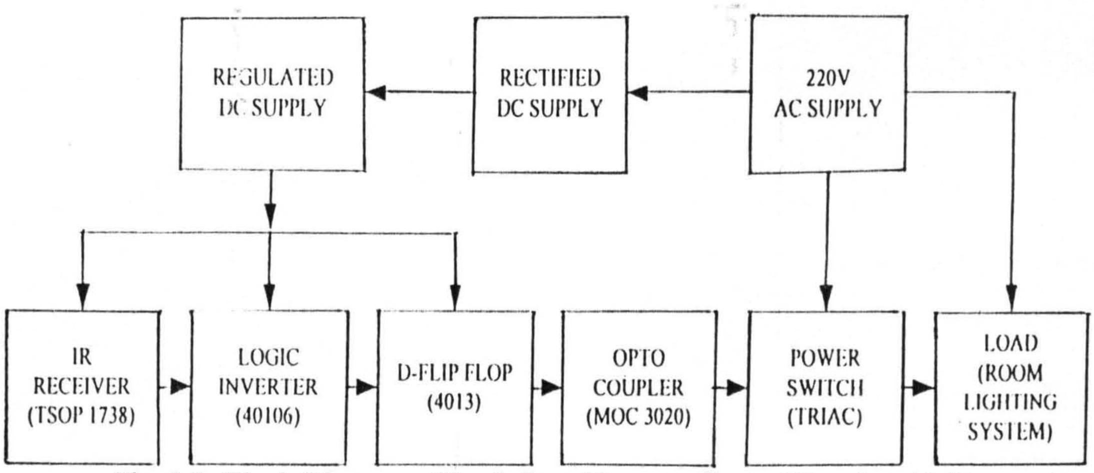


Fig. 3.2: Block Diagram of the Infrared Remote Control Receiver Unit.

3.1 THE INFRARED REMOTE CONTROL TRANSMITTER.

The design of the infrared remote control transmitter unit was based on the simple ON/OFF generation of a constant amplitude non modulated infrared signal. It is designed to meet the operating requirement of the infrared receiver module used in the infrared remote control receiver unit which is 38kHz. This was done to ensure that the receiver unit is able to respond well to the bursts produced by the transmitter and use the response to control the room lighting system. The circuit diagram of the infrared remote control transmitter is as shown by Fig. 3.3.

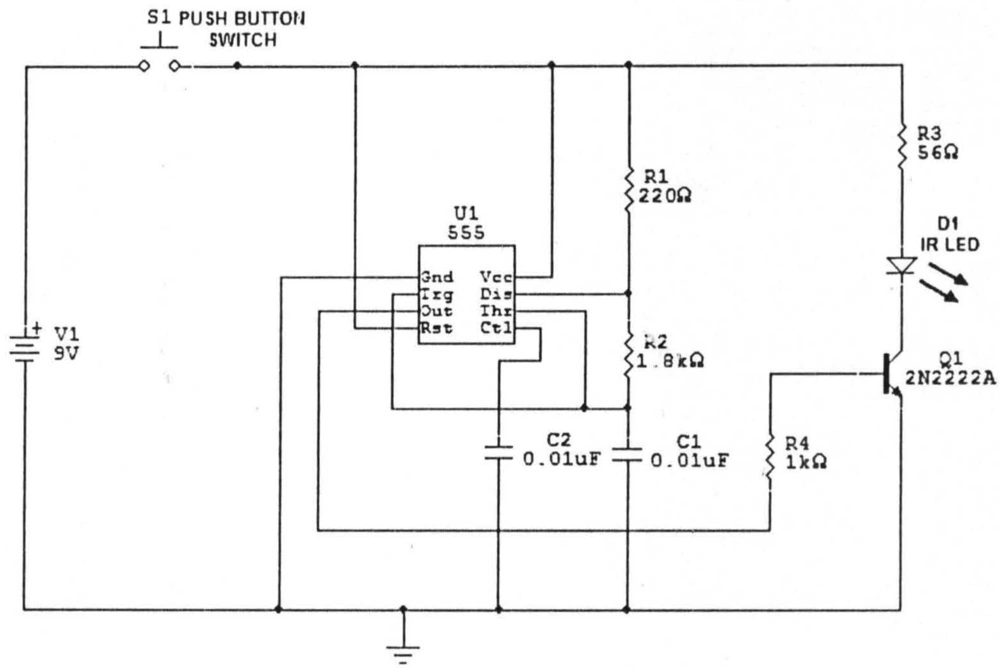


Fig. 3.3: Circuit Diagram of Infrared Remote control Transmitter.

The transmitter was designed around a 555 timer as seen in Fig.3.3. The 555 timer was configured in the astable mode.

The transmitter circuitry was powered by a 9V battery is expected to consume as little power as possible with the infrared signal being as strong as possible to achieve control over a considerable distance.

3.1.1 THE 555 TIMER

The 555 timer is an integrated circuit which comprises of basically two comparators and a Flip Flop as can be seen in Fig. 3.4.

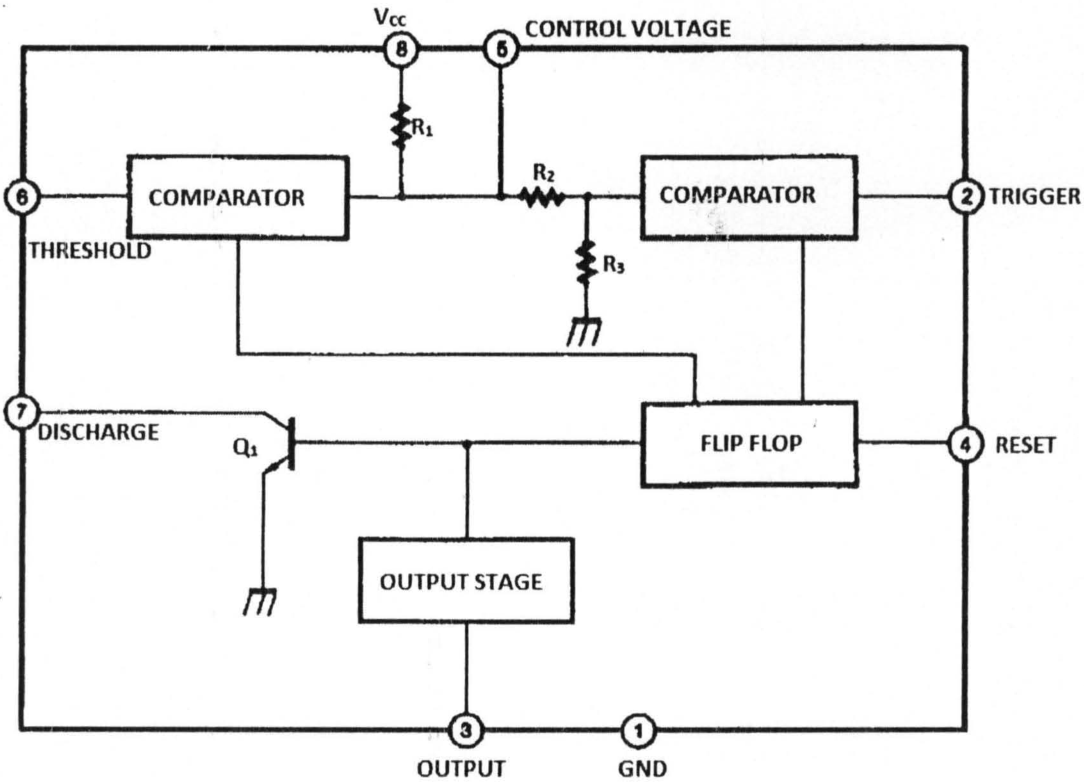


Fig. 3.4: Schematic Diagram of NE555 timer.

The Threshold input (Pin 6) is connected to the Trigger input (Pin 2) and the external components R_1, R_2 and C_1 form the timing network which sets the frequency of oscillation of the circuit.

When the switch is closed, power is supplied to the circuit. At this stage, the timer will trigger itself and free run as a multivibrator. The external capacitor charges through resistors R_1 and R_2, and discharges through resistor R_2. Thus the duty cycle may be precisely set by the ratio of these two resistors. In this mode of operation, the capacitor charges and discharges between 1/3 V_{CC} and 2/3 V_{CC}. Also, the charge and discharge times, and therefore the frequency are independent of the supply voltage. The result of these charging and discharging processes is a rectangular wave output whose duty circle is dependent on the values of resistors R_1 and R_2.

Resistor R_1 was chosen to be a resistor with very high resistance because it was observed that a duty circle of around 50% can only be achieved if R_2 is far greater than R_1. This enables the charging and discharging times to be approximately equal.

A resistor of value 1.8kΩ was chosen as R_2 and 220Ω as R_1. The value of C_1 for which the required frequency can be obtained was calculated and the closest practical value available was used in the project.

3.1.2 FREQUENCY CIRCUIT CALCULATION.

The frequency of oscillation of the circuit is generated by the 555 timer, resistors R_1, R_2 and capacitor C_1 combination. The circuit was connected using the Astable Mode Configuration.

A frequency of 38kHz is required and resistors R_1 and R_2 are available as 220Ω and 1.8kΩ respectively. The value of capacitor C_1 was determined to meet this frequency requirement.

For any 555 timer in astable mode, the capacitor alternatively charges towards V_{out} and discharges towards zero. This charge and discharge occur in every period of oscillation.

The time constant t is equivalent to kRC, i.e.

$$t = kRC \qquad (1)$$

Where R is value of resistor,

C is the value of capacitor

k is a constant (0.693)

For 1 period of oscillation of the RC circuit, the capacitor charges for say t_{charge} seconds and discharges for $t_{discharge}$ seconds. Therefore,

$$t_{charge} = 0.693 R_T C_1 \qquad (2)$$

Where $R_T = R_1 + R_2$ and

$$t_{discharge} = 0.693 R_2 C_1 \qquad (3)$$

Adding equations (2) and (3) wil give the period of oscilation.

Therefore, period of oscilation

$$T = t_{charge} + t_{discharge}$$
$$= [0.693(R_1 + R_2)C_1] + [0.693(R_2)C_1]$$
$$= 0.693(R_1 + 2R_2)C_1 \qquad (4)$$

But frequency

$$f = \frac{1}{T}$$
$$= \frac{1}{0.693(R1 + 2R2)C1}$$
$$= \frac{1.44}{(R1 + 2R2)C1} \qquad (5)$$

We have

R_1=220Ω, R_2=1.8kΩ and required frequency f=38kHz.

Substituting these values in equation (5) to obtain C_1 we have

$$38 \times 10^3 = \frac{1.44}{(220 + 2 \times 1.8 \times 10^3)C_1}$$

Making C_1 the subject we have

$$C_1' = \frac{1.44}{38000(220 + 2 \times 1800)}$$

$$= 0.00992\mu F$$

$$\approx 0.01\mu F$$

A Capacitor of 0.01µF was used which was also readily available.

Generated frequency

$$f = \frac{1.44}{(220 + 2 \times 1800)0.01 \times 10^{-6}}$$

$$= 37696Hz$$

$$\approx 37.7kHz$$

This value is close to the required centre frequency of 38kHz.

3.1.3 DUTY CYCLE CALCULATION

$$\text{Duty cycle} = \frac{R_1 + R_2}{R_1 + 2R_2} \times 100\% \qquad (6)$$

Substituting values of R_1 and R_2 into equation (6) we have

$$\text{Duty cycle} = \frac{220 + 1.8 \times 10^3}{220 + 2 \times 1.8 \times 10^3}$$

$$= 52.87958\%$$

$$\approx 52.9\%$$

3.1.4 CALCULATION OF LIMITING RESISTANCE R_S FOR INFRARED LED.

The infrared LED was protected by a limiting resistor R_S connected as shown by Fig. 3.5.

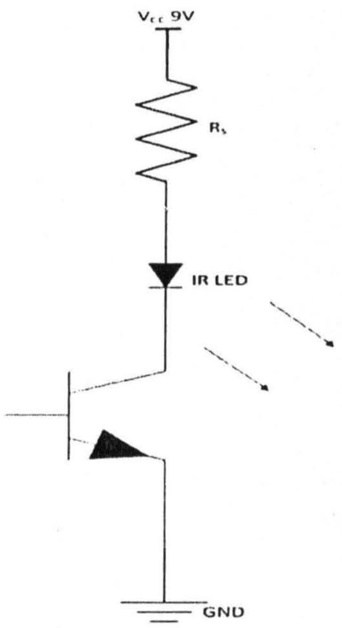


Fig. 3.5: Diagram of Infrared LED Protected by a Limiting Resistor.

We know that in a series circuit,

Voltage across the circuit=sum of voltages across each component of the circuit

$$V_S = V_R + V_{LED}$$

$$= I_{LED} R_S + V_{LED} \quad (7)$$

But

V_S=9V

A voltage of 2V across the infrared LED and maximum current of 125mA to flow through it were chosen.

$$9 = 125 \times 10^{-3} \times R_S + 2$$

$$R_S = \frac{9-2}{125 \times 10^{-3}}$$

$$= 56\Omega$$

Resistor R_S ensures long life of the Infrared LED by ensuring it is operated on a current of magnitude less than the infrared LED's maximum rating.

3.1.5 THE TRANSISTOR AS A SWITCH.

The transistor was incorporated in the infrared remote control transmitter to act as Switch to the Infrared LED. This was to ensure that the infrared LED produces a signal only when it is required.

The switching action of the transistor is controlled by the transistor's base-emitter diode. When the base-emitter diode is forward biased by the 555 timer, the transistor turns ON and when base-emitter diode is reverse biased, the transistor turns OFF.

3.2 THE INFRARED REMOTE CONTROL RECEIVER UNIT.

The infrared remote control receiver unit comprises of the following different sections:

1. the power supply unit,
2. the infrared receiver module,
3. the Logic Inverter,
4. the Toggle Flip Flop,
5. the Opto coupler,
6. the power switch (Triac),
7. the Load (Room lighting system).

3.2.1 THE POWER SUPPLY UNIT.

The power supply unit comprises of a step down transformer, a full wave bridge rectifier network, a filtering capacitor and a voltage regulator all connected as shown by Fig. 3.6. It was designed to produce a constant 5V dc supply to the infrared remote control receiver unit.

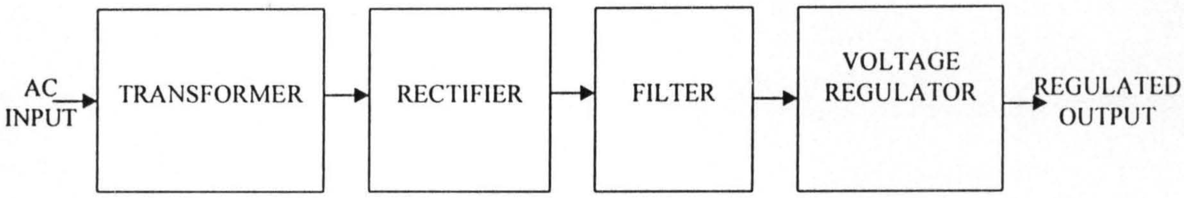


Fig. 3.6: Block Diagram of the Power Supply Unit.

3.2.1.1 TRANSFORMER.

The transformer used for the power supply unit is a 230/9V, 200mA 50Hz transformer. It produces an ac output voltage of 9V across its secondary terminals whenever a voltage of 230V ac is applied to its primary terminal and when a voltage less than 230V is applied to the primary terminals, an output voltage of value less than 9V ac is available across the secondary terminals. This is obtained from the voltage transformation ratio k which is calculated thus:

Let V_S be secondary voltage and VP be the primary voltage, then transformation ratio

$$k = \frac{V_S}{V_P} \qquad (8)$$

Since V_S=9V and V_P=230V, the transformation ratio of the transformer from equation (8) is

$$k = \frac{9}{230}$$
$$= \frac{1}{25.56}$$

Thus,

$$V_S = V_P.K$$
$$V_S = \frac{V_P}{25.56}$$

The transformer's form factor is obtained by

$$formfactor, f = \frac{V_{rms}}{V_{dc}} \quad (9)$$
$$= \frac{\frac{V_{max}}{\sqrt{2}}}{\frac{2V_{max}}{\pi}}$$
$$= \frac{\pi}{2\sqrt{2}}$$
$$\approx 1.111$$

The output of the transformer is fed into the bridge rectifier network to be rectified to dc. The transformer also provides isolation from the supply line which is an important safety consideration [2].

3.2.1.2 RECTIFIER.

The rectifier used is the bridge rectifier network. The bridge rectifier network comprises of four rectifier diodes and rectifies the stepped down ac from the transformer into pulsating dc. The bridge rectifier was chosen in this design for the following reasons:

1. no centre tap is required on the transformer, thus reducing cost of the transformer.
2. much smaller transformers are required.
3. it is suitable for high voltage applications.
4. it has less Peak Inverse Voltage (PIV) rating per diode.

Efficiency of rectifier

$$\eta = \frac{Power_{dc}}{Power_{rms}} \times 100\% \qquad (10)$$

$$= \frac{Voltage_{dc}(V_{dc})}{Voltage_{rms}(V_{rms})} \times 100\%$$

But

$$V_{rms} = 9V \text{ (From transformer specifications)}$$

$$V_{dc} = \frac{V_{rms}}{formfactor}$$

$$V_{dc} = \frac{9}{1.11}$$

$$V_{dc} = 8.11V$$

Efficiency of the rectifier is then

$$\eta = \frac{8.11}{9} \times 100\%$$

$$\approx 90.10\%$$

Ripple content of the pulsating dc output

$$V_{L(ac)} = \sqrt{(V^2{}_{rms} - V^2{}_{L(dc)})}$$

$$V_{L(ac)} = \sqrt{(9^2 - 8.11^2)}$$

$$V_{L(ac)} = 3.9V$$

Ripple factor

$$\gamma = \frac{V_{L(ac)}}{V_{L(dc)}} \tag{11}$$

$$= \frac{3.9}{8.11}$$

$$= 0.48$$

$$\equiv 48\%$$

The rectified dc output is passed through the filter for filtering.

3.2.1.3 FILTER

Filters in dc power supply minimize the ripple content in the rectifier output. They do this by converting the pulsating dc output from the rectifier into a non varying dc. The type of filtering used is the Capacitor Input Filter. It is a filter in which a large capacitive electrolytic capacitor is connected across rectifier output, parallel to the voltage regulator or load as the case may be. The filtering action depends on the ability of a capacitor to charge up during conducting half cycle and to discharge during the non conducting half cycle.

For full wave rectifiers,

$$\text{Ripple factor } \gamma = \frac{1}{4\sqrt{3}fCR_L} = \frac{I_{dc}}{4\sqrt{3}fCV_{ip}} \tag{12}$$

Where I_{dc} is the maximum load current

V_{ip} is the peak output voltage

f is the frequency of the ac supply.

C is the capacitance to be used.

We know that

Peak Voltage, V_p = RMS voltage, $V_{rms} \times \sqrt{2}$

Secondary voltage of the transformer = 9V,

Peak secondary voltage = 9V × √2

=12.73V.

From equation (12), a 1000μF capacitor gives ripple factor

$$\gamma = \frac{200 \times 10^{-3}}{4\sqrt{3} \times 50 \times 1000 \times 10^{-6} \times 12.73}$$

$$= 0.045353516$$

$$= 4.5\%$$

A 2200μF capacitor gives a ripple factor

$$\gamma = \frac{200 \times 10^{-3}}{4\sqrt{3} \times 50 \times 2200 \times 10^{-6} \times 12.73}$$

$$= 0.020615234$$

$$= 2.1\%$$

The 2200μF and 1000μF capacitors were available for the same price. The 2200μF was chosen in the design since it gave a better value of ripple factor. Also using a capacitor with high capacitance has the following advantages:

1. it increases the dc voltage output V_{dc} toward the limiting value of the input voltage to the filter.
2. it reduces the magnitude of ripple voltage.
3. it reduces the time of flow of current pulse through the diode
4. increases peak current in the diode.

The filtered output is then fed into the voltage regulator to be regulated.

3.2.1.4 THE VOLTAGE REGULATOR

The voltage regulator is an integrated circuit that is capable of maintaining a constant dc output voltage irrespective of variations of the ac input voltage and output load resistance. The voltage regulator used in this design is the L7805CV regulator which is a 3 pins integrated circuit having an input, common and regulated output terminals. The 7805 voltage regulator is shown in Fig. 3.7.

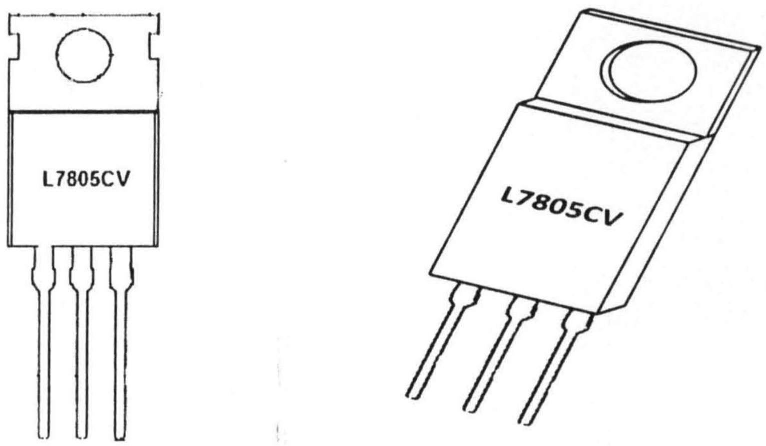


Fig.3.7: Voltage Regulator.

This voltage regulator provides a constant 5V dc supply at its output terminals which is more efficient to drive the infrared receiver circuit than a non-regulated supply. The voltage regulators of this class (78XX) require an input voltage that must be at least 2V above the output voltage [2]. This is required in order to maintain regulation. It also justifies the use of a 230/9V transformer rather than 230/6V transformer for the power supply unit.

The complete power supply blocks with their corresponding output wave forms are shown by Fig. 3.8 and Fig. 3.9 respectively.

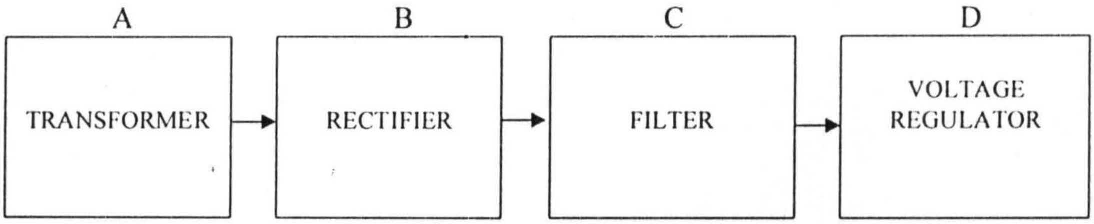


Fig. 3.8: Block Diagram of Power supply unit's stages.

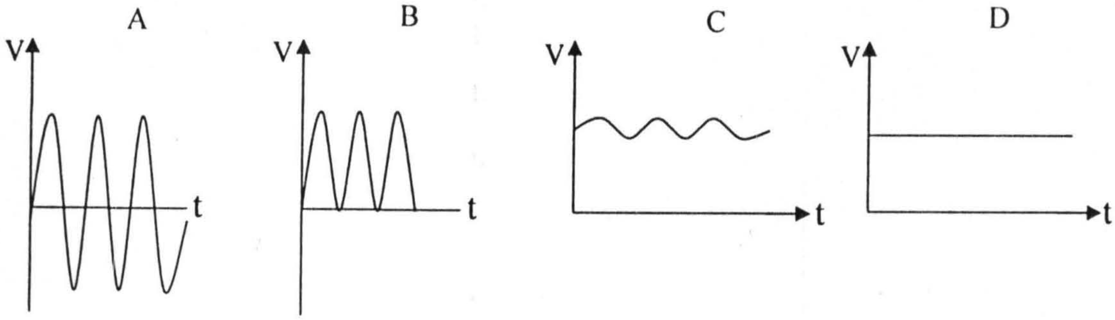


Fig. 3.9: Wave Forms of Stages of Power Supply unit.

The output from this power supply unit was used to power the entire infrared remote control receiver unit.

3.2.2 THE INFRARED RECEIVER MODULE.

The infrared receiver module (TSOP1738) provides the interface between the infrared remote control receiver unit and the infrared remote transmitter. It is an integrated circuit with three (3) terminals and receives infrared signals from an infrared transmitting device. Its three terminals are the ground terminal, power supply terminal and output terminal.

The infrared receiver module is shown by Fig. 3.10.

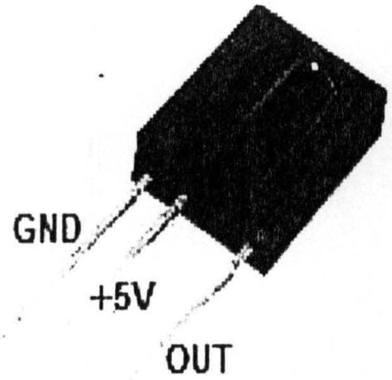


Fig. 3.10: Infrared Receiver Module.

The infrared receiver module comprises of an Automatic Gain Control circuit, Band pass filter, a demodulator and control circuit connected as shown in Fig. 3.11.

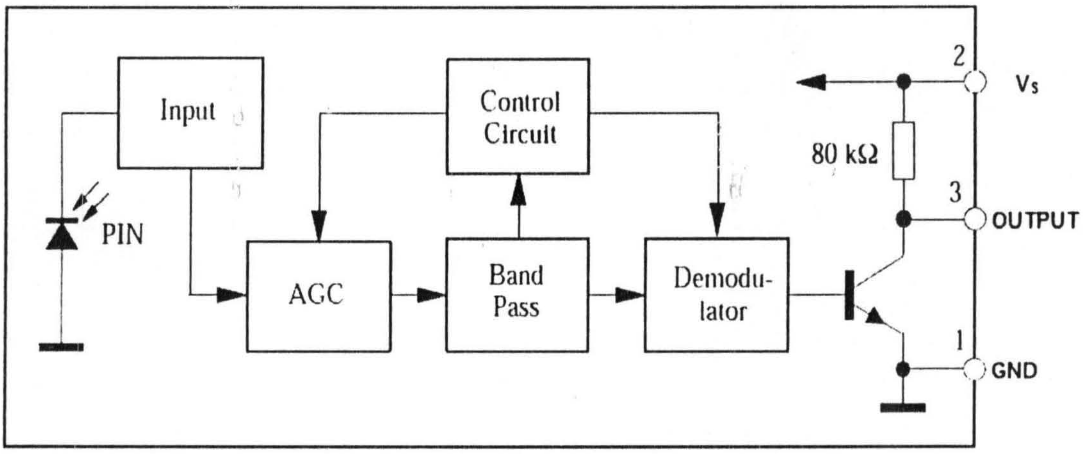


Fig. 3.11: Schematic Diagram of TSOP1738 IR Receiver Module.

The infrared receiver module is capable of receiving infrared signals of frequencies around 38kHz. When no signal is received by the infrared receiver module, its output terminal produces a HIGH signal which is inverted to a LOW signal by the Logic Inverter. This prevents the D-Flip Flop from being clocked. When the receiver module receives an infrared signal, its output produces a LOW signal which is inverted to a HIGH signal by the Logic Inverter in the circuit. This HIGH output of the Logic Inverter then clocks the D-Flip Flop, enabling it to toggle its output. This operation ensures that the circuit only works when a signal is received by the receiver module from the transmitter.

The circuit of the TSOP1738 is also designed such that unexpected output pulses due to noise or disturbance signals are avoided. These disturbances are suppressed by the band pass filter, integrator stage and Automatic Gain Control combination.

The disturbances suppressed include:

1. dc light (e.g. from Tungsten bulb or sunlight).
2. continuous signal at 38kHz or at any other frequency.
3. signals from fluorescent lamps with electronic ballast.

THE LOGIC INVERTER.

The Logic Inverter is a Logic element which produces an output signal of opposite state to that of its input. It produces a LOW output when its input is HIGH, and produces a HIGH output when there is a LOW signal at its input.

The Logic Inverter used in this project is a Hex, inverting Schmitt Buffers (CD40106). It is a fourteen pins integrated circuit containing six inverter gates in it.

Fig. 3.12 shows the symbol of a Logic Inverter.

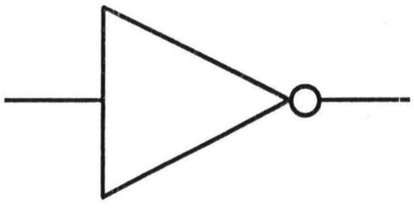


Fig. 3.12: Logic Inverter Symbol.

The CD40106B Hex Schmitt Trigger is a monolithic complementary MOS (CMOS) integrated circuit constructed with N and P-channel enhancement transistors. Six Logic Inverters are integrated in the 40106 IC as shown in the connection diagram of Fig. 3.13.

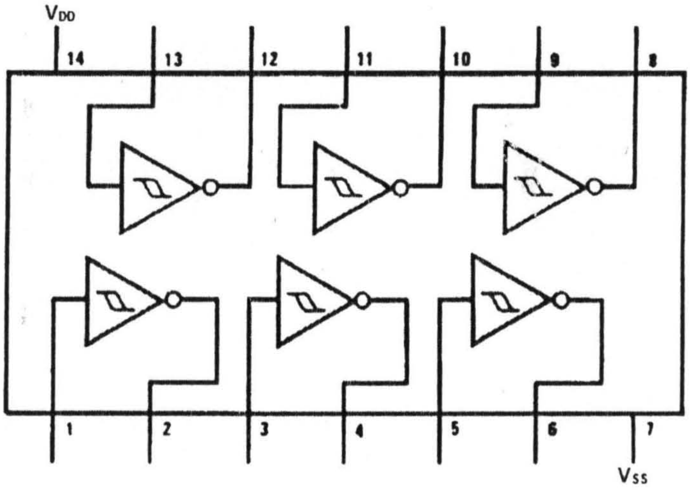


Fig. 3.13: Inverter 40106 Connection Diagram.

Let A be the input of a Logic Inverter in the 40106 IC, and X be the output of the same Logic Inverter. The Truth Table of the operation of the Logic Inverter is as shown in Table 3.1.

Table 3.1: Truth Table of 40106 Logic Inverter.

A	X
0	1
1	0

1=HIGH, 0=LOW.

When the infrared receiver module of the infrared remote control receiver unit does not receive an infrared signal from the transmitter, it produces a HIGH output which is fed into the input of one of the 40106 Hex, Schmitt buffers. The inverting buffer inverts this HIGH signal to LOW and it is fed into the CLOCK input of the D-Flip Flop of the circuit. This LOW signal does not trigger the D-Flip Flop to toggle.

When the infrared remote control transmitter button is pressed and the infrared receiver module receives the signal from it, its output goes LOW and this LOW goes into the 40106 inverter where it is inverted to a HIGH signal. This HIGH signal clocks the D-Flip Flop, enabling it to toggle its outputs.

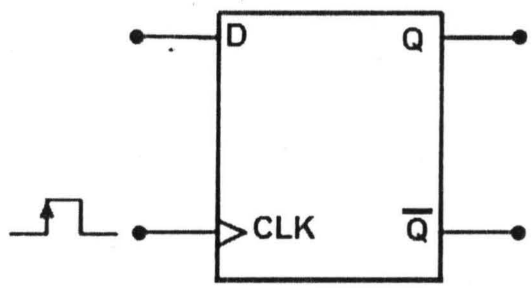
In using the 40106 Hex, Schmitt Inverting Buffers, any unused input is either connected to V_{DD} or to V_{SS} while any unused output is left open. This is to ensure stability in the operation of the Hex, Schmitt Inverting Buffers IC. As a precaution, the unused inputs of the Hex, Schmitt Inverting Buffers IC were connected to ground while the unused outputs were left open.

The output of the Hex, Inverting Buffers IC was used as clock signal for the D-Flip Flop in the Infrared remote control receiver circuit.

THE D-FLIP FLOP.

Flip Flops are memory elements which are made of an assembly of Logic gates connected together in a way that permits information to be stored. The Flip Flop used in this project is the D-Flip Flop, where the D stands for Data.

The symbol of the D-Flip Flop is shown in Fig. 3.14.



D=Data, CLK=Clock, Q=Output, $\bar{Q}$=Invert of Q output.

Fig. 3.14: Symbol of D-Flip Flop.

The D-Flip Flop is an edge triggered Flip Flop, i.e. it changes its state either at the positive edge (rising edge) of the clock pulse or at the negative edge (felling edge) of the clock pulse for positive edge triggered and negative edge triggered D-Flip Flops respectively. It is sensitive to its input only at this transition of the clock.

The operation of the D-Flip Flop is such that the Q output goes to the same state as that is present on the D input when a rising edge occurs at the CLK input. In other words, the level present at D is stored in the Flip Flop at the instant the rising edge occurs. The truth table of a D-Flip Flop is shown by Table 3.2.

Table 3.2: Truth Table of D-Flip Flop.

INPUTS		OUTPUT
D	CLK	Q
0	↑	0
1	↑	1

The operation of the clocked D-Flip Flop is explained by the input and output waveforms of Fig. 3.15.

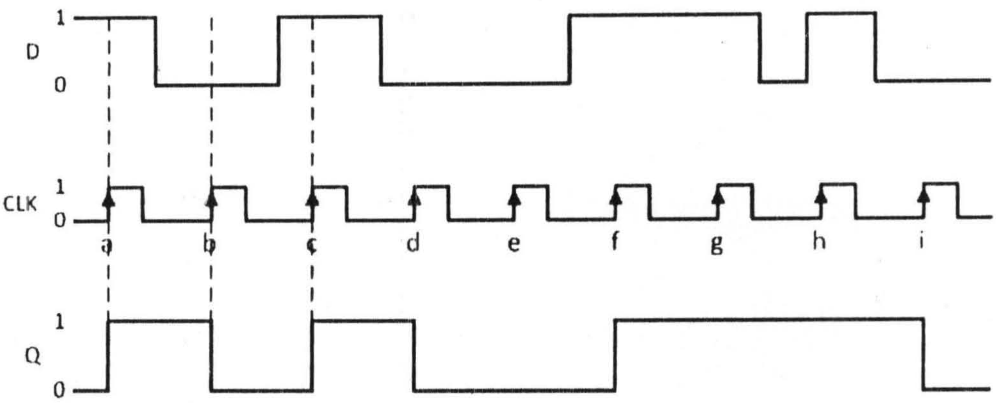


Fig. 3.15: Input and Output Waveforms of Clocked D-Flip Flop.

Assuming the Q output is initially 0. When the first rising edge of the clock pulse occurs (point a), the D input is 1, therefore, Q goes to the 1 state. Between points a and b, D input level changes but it has no effect on Q. The Q output stores the 1 that was on D at point a until another rising edge of the clock pulse occurs.

When the second rising edge of the clock pulse occurs (point b), D is 0 at that time and so, Q goes to 0 and remains 0 until another clock pulse occurs. Similarly, Q takes on the levels present on D when the rising edges occur at points c, d, e, f, g, h and i.

For a negative edge triggered D-Flip Flop, the operation is the same as above except that Q will take on the value of D when a negative going transition occurs at the CLK terminal.

The symbol of the D-Flip Flop that triggers on the negative going transition will have a bubble on the CLK terminal as shown I Fig. 3.16.

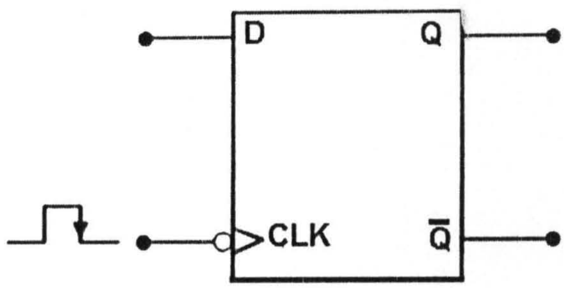


Fig. 3.16: Symbol of a Falling Edge Triggered D-Flip Flop.

The toggle operation of the D-Flip Flop was achieved by connecting the $\bar{Q}$ output of the D-Flip Flop to the D input as seen in Fig. 3.17.

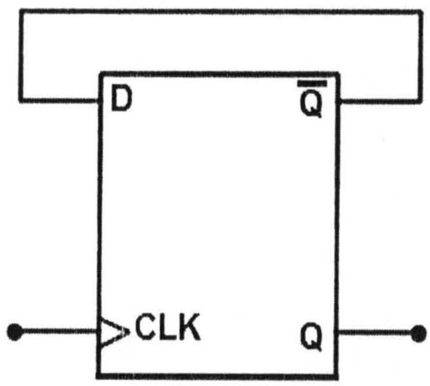


Fig. 3.17: Toggle Mode Connection of D-Flip Flop.

The waveforms for the toggle mode are shown in Fig. 3.18.

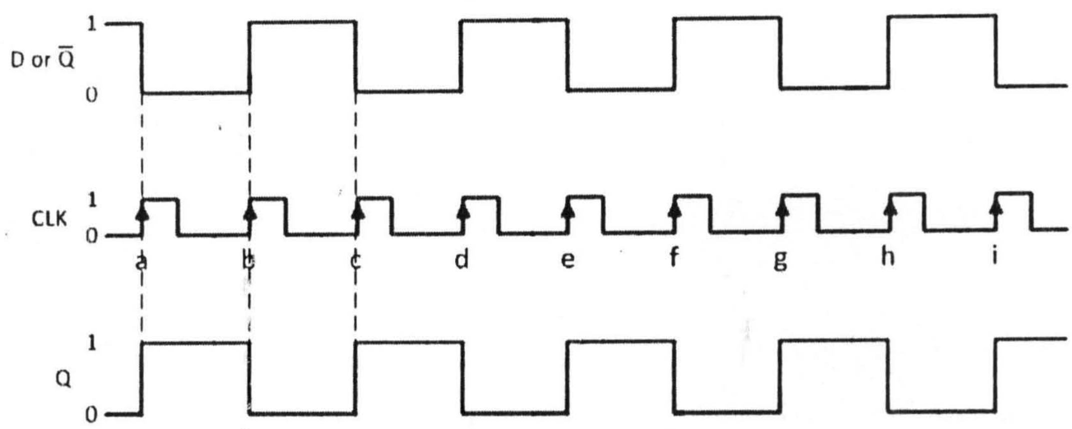


Fig. 3.18: Input and Output Waveforms of Toggle Flip Flop.

It can be seen from the waveforms of Fig. 3.18 that at the occurrence of clock pulse a, b and c, $\bar{Q}$ is present at D and the Q output is the opposite state of the D or $\bar{Q}$ terminal. This is same for the d, e, f, g, h and i clock pulses. Also it can be seen that the Q output toggles its state on every positive edge of the clock pulse.

This Q output controls the switching operation of the infrared remote control receiver unit.

The Logic circuit (40106) used in this project is a Dual type D-Flip Flop IC. Only one of the two D-Flip Flops was used and other unused inputs (D, CLK) of the second D-Flip Flop were connected to ground while the unused outputs (Q, $\bar{Q}$) were left open. This was done to achieve stable operation of the chip.

THE OPTO COUPLER.

Opto couplers are devices that are used for interfacing between electronic controls and power control of resistive and inductive loads.

The opto coupler used in this project is the MOC3020 Opto coupler. It is an optically isolated triac driver device containing GaAs infrared emitting diode and light activated silicon bilateral switch. The package and schematic diagram of the MOC3020 opto coupler are shown by Fig. 3.19 and Fig. 3.20 respectively.

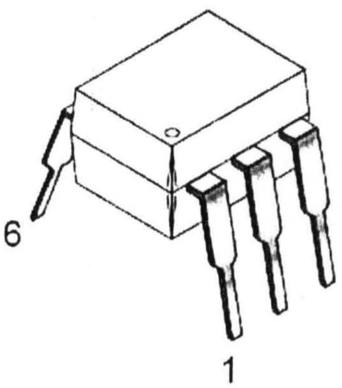
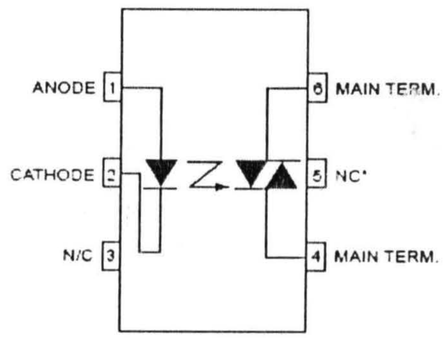


Fig. 3.19: MOC3020 Opto Coupler Package.



N/C=NOT CONNECTED.

Fig. 3.20: Schematic Diagram of MOC3020 Opto Coupler.

The opto coupler has various applications which include industrial controls, static ac power switches, incandescent lamp dimmers, motor control, lamp ballasts etc.

The output of the D-Flip Flop was connected to the LED of the opto coupler while the light activated silicon bilateral switch was used to control the gate of the triac used in the circuit. When the output of the D-Flip Flop is HIGH, the LED in the opto coupler turns ON. The light from this LED activates the light activated bilateral switch of the opto coupler, thus allowing current flow to the gate of the triac. When the output of the D-Flip Flop goes LOW, the LED in the opto coupler turns OFF and the light activated silicon bilateral switch also deactivates, thus stopping current flow to the gate of the triac.

THE POWER SWITCH.

The power switch used in the project is a triac. The Triac is a member of the thyristor family. But unlike a thyristor which conducts only in one direction (from anode to cathode) a triac can conduct in both directions. Thus a triac is similar to two back to back (anti parallel) connected thyristors but with only three terminals.

The triac used in this project is the AC10DT Triac. It has a voltage rating of 400V and current rating of 10A. The image of the AC10DT Triac is shown in Fig. 3.21.

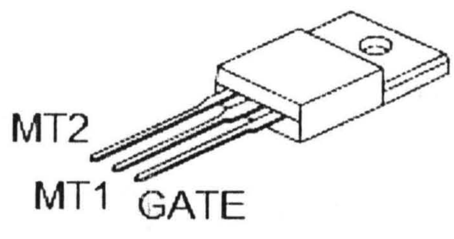
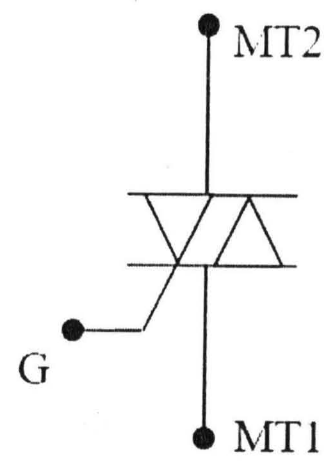


Fig. 3.21: The AC10DT Triac.

Its operation is such that when the gate terminal is triggered, the diac in it is activated and there is current flow to the external circuit connected to it. When the trigger signal is removed from the gate terminal, the diac in the triac gets deactivated and the external circuit connected to the triac receives no current. The symbol of the triac is shown in Fig. 3.22.



MT1=MAIN TERMINAL 1, MT2=MAIN TERMINAL 2, G=GATE

Fig. 3.22: Triac Symbol.

Triacs switch from a blocking to a conducting state for either polarity of applied anode voltage with positive or negative gate triggering. This is seen from the V-I characteristic of the triac as shown in Fig. 3.23.

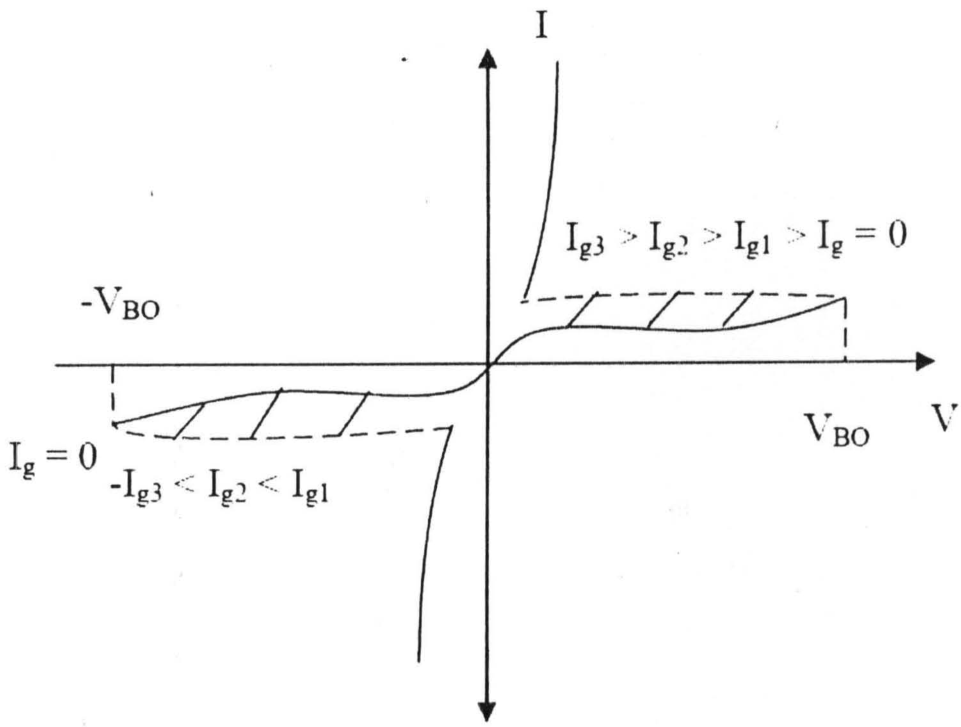


Fig. 3.23: V-I Characteristic of a Triac.

From a functional point of view a triac is similar to two thyristors connected in anti parallel. As shown in Fig. 3.23, with no signal to the gate the triac will block both half cycle of the applied ac voltage provided its peak value is lower than the break over voltage (V_{BO}) of the device. However, the turning on of the triac can be controlled by applying the gate trigger pulse at the desired instance.

The load which is the room lighting system is then to be connected to the triac as seen in the circuit diagram of the infrared remote control receiver unit in Fig. 3.24. This load is either turned ON or OFF by the triac which is coupled to the control circuit and is controlled by it.

THE LOAD.

The load for this project is the room lighting system of a building. This could be the lighting of a bed room, living room or any small area of the building. The room lighting is connected to the infrared remote control receiver unit and the unit is used to control by the unit. The total current required by the lighting system connected to this unit should not exceed the maximum current rating (10A) of the triac as this will affect its operation. For illustration purpose, a single 220V, 20W tungsten filament lamp was used as the load.

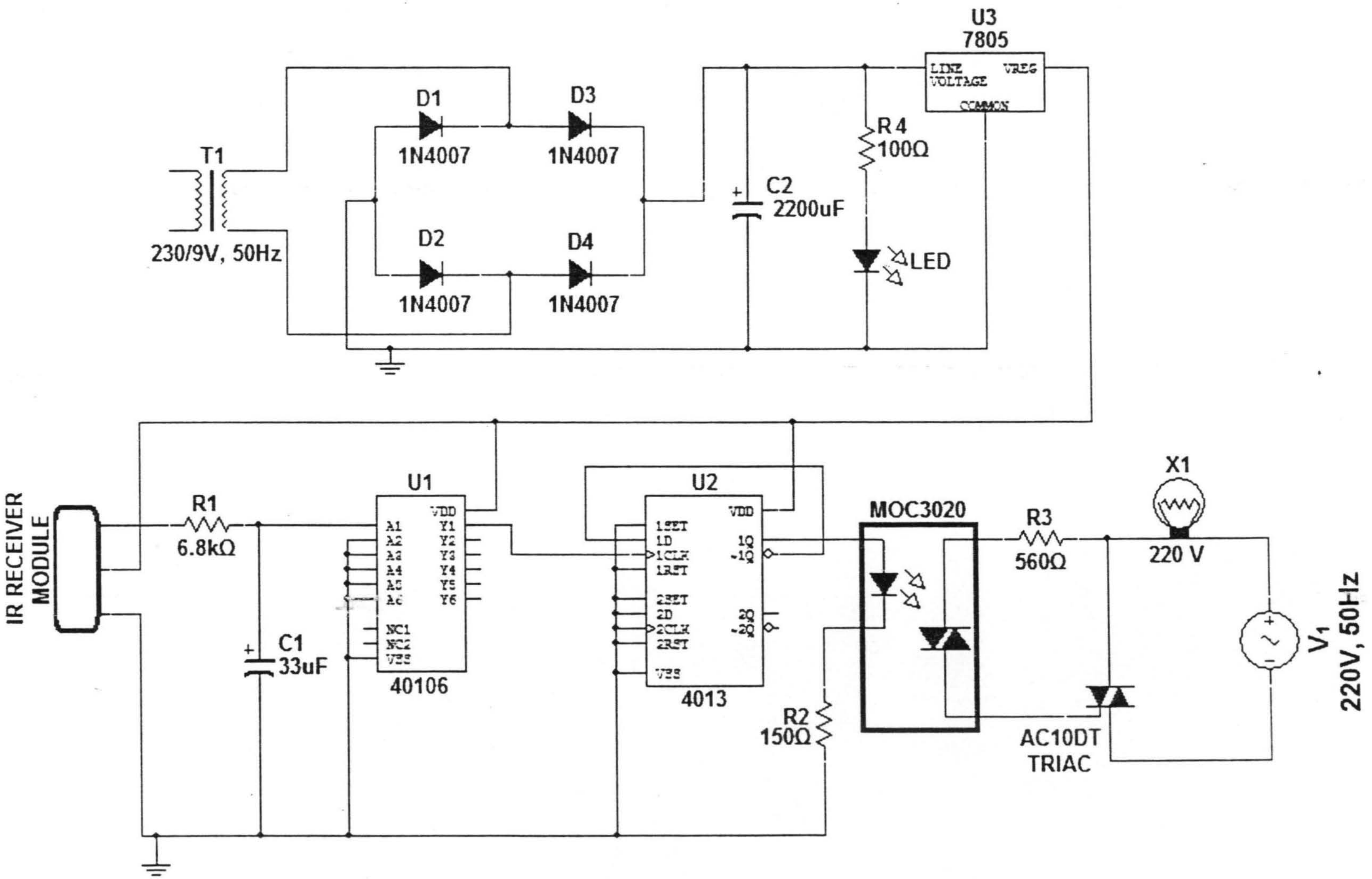


Fig. 3.24: Circuit Diagram of the Infrared Remote Control Receiver Unit.

CHAPTER FOUR

4.0 TESTS, RESULT AND DISCUSSION

4.1 HARDWARE CONSTRUCTION PROCEDURE AND PRECAUTIONS.

The construction was first done on a breadboard where the components were connected using connecting wires together with the connectivity provided by the breadboard. This was done to verify the workability of the design. The construction was then carried out by placing and soldering the components on a Vero board.

The construction was carried out with much care and precautions as follows:

1. the components were laid out on a Vero board which has copper tracks on one side and were soldered firmly in place.
2. care was taken to position capacitors and integrated circuits with respect to polarity for easy connection.
3. IC sockets wee used so that the integrated circuits are not damaged by the heat from the soldering process.
4. soldering of the components was done quickly and efficiently using sufficient heat to avoid damage to the components as well as dry joints.
5. adequate amount of soldering lead was used to avoid bridging of the copper tracks of the Vero board.
6. after each soldering, the bit of the soldering iron was cleaned to ensure proper heating and melting of the soldering lead.
7. jumpers (connecting wires) were used for connection where the copper tracks could not be used.

4.2 TOOLS AND INSTRUMENTS USED.

1. soldering iron
2. cutting plier.
3. knife.
4. digital multimeter.
5. metre rule.

4.3 TESTING AND MEASUREMENT

The construction was thoroughly tested to verify component connection to the board and obtain the operating distance of the entire work as follows:

1. the continuity of the jumpers were tested using a multimeter set to continuity. This was carried out without powering the circuit.
2. adjacent tracks of the Vero board were tested to ensure there was no bridge where not required.
3. the constructed infrared remote control transmitter was tested using a digital camera to confirm the generation of infrared pulse.
4. the constructed infrared remote control receiver unit was powered and the constructed infrared remote control transmitter was used in conjunction with it to determine the distance of coverage. This was done using a fresh battery in the transmitter and placing the two units apart in an open space.
5. the lighting connected to the receiver unit was reliably controlled (ON and OFF) each time the transmitter's push button was pressed.
6. the test was repeated for different distances between the transmitter and receiver unit and control was achieved up to a measured distance of 8metres. This was achieved under daylight.

7. the test was also carried out in the dark and control was achieved op to a distance of 10.2metres.

4.4 PHOTOGRAPHIC PLATES OF THE CONSTRUCTED WORK AND CASINGS

The constructed Infrared Remote Control Transmitter on Vero board was photographed and is shown in Plate 4.1.

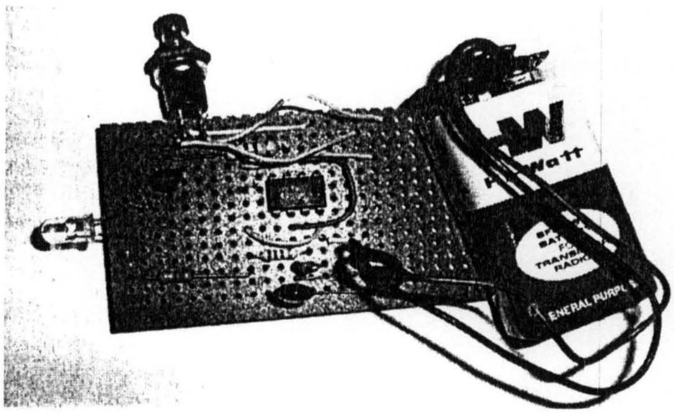


Plate 4.1: The Infrared Remote Control Transmitter on Vero Board.

The Vero board construction of the Infrared Remote Control Receiver Unit was as shown in Plate 4.2.

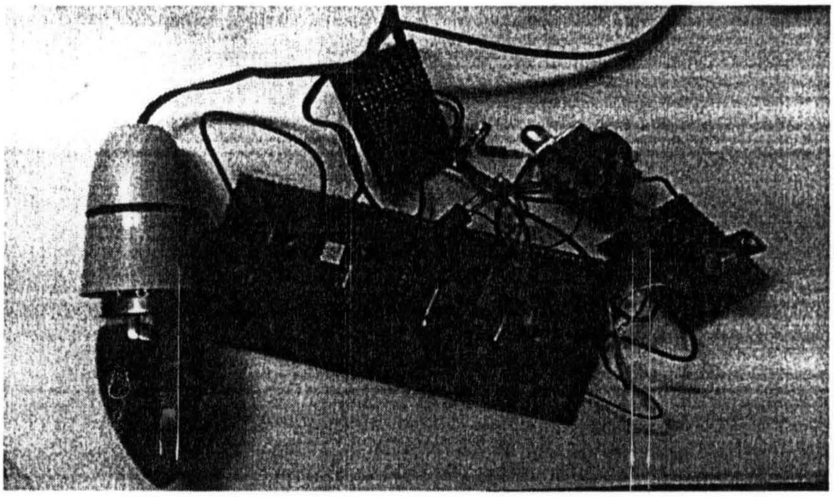


Plate 4.2: The Infrared Remote Control Receiver Unit on Vero Board.

The photograph in Plate 4.3 shows the constructed infrared Remote Control Transmitter after it was cased.

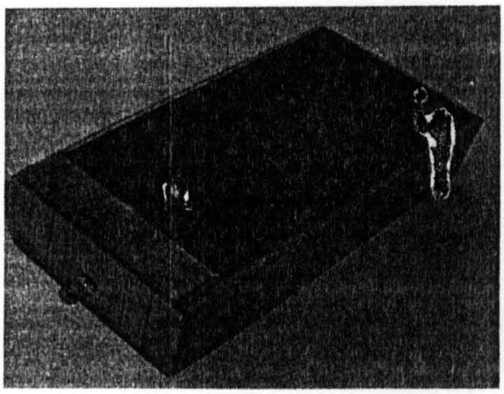


Plate 4.3: The Infrared Remote Control Transmitter in its Casing.

The Infrared Remote Control Receiver Unit was photographed after it was cased and is shown in Plate 4.4.

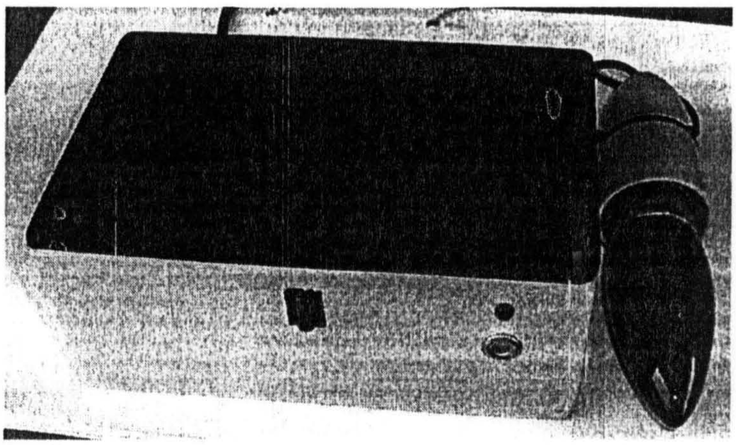


Plate 4.4: The Infrared Remote Control Receiver Unit in its Casing.

4.5 DISCUSSION OF RESULTS.

A convenient and reliable infrared link was established between the infrared remote control transmitter and infrared remote control receiver unit and the lighting system was efficiently controlled. This is in line with the objectives of the project work.

An operating distance of 5m is guaranteed under daylight. This is a value limited by daylight which reduces the intensity of the infrared signal produced. More operating distance will be achieved if used in an environment having no white light.

4.6 LIMITATIONS OF THE PROJECT.

Since generation of infrared pulse was used, if two or more of such receiver units are placed close to each other, pressing the infrared remote control transmitter's button could operate the device it is not intended to operate. This problem can be solved by encoding the infrared signal so that only the intended device is controlled at any point in time. Also, the infrared remote has a short operating distance. If a long remote control operating distance is required, radio frequency remote control method should be considered.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS.

5.1 CONCLUSION.

Conclusively, it is obvious to have an easy and reliable means of controlling a system. The use of remote control to control lighting is an adequate, easy and cheap option. The project after construction was tested and accurate control of the lighting system and objectives of the project were successfully achieved.

5.2 PROBLEMS ENCOUNTERED.

It was observed that the infrared receiver module was sensitive to daylight as well as other white lights from the surrounding. This effect was minimized by placing a resistor in series with the output terminal of the infrared receiver module and a capacitor across it. These reduced the effect of daylight as well as white lights. Also during the construction, the project did not work with the transistor driver opto coupler used. This was however solved by using a diac driver opto coupler.

5.3 RECOMMENDATIONS

Since the field of electronics is ever dynamic, there will always be room for improvement on existing designs with new technology for better performance. With the knowledge and experience gained from this project work, the following are hereby recommended:

1. infrared LEDs capable of producing high power signals should be used to improve on the distance of operation.

2. triacs with high ratings should be used so that the circuit can control larger lighting loads.
3. a transformerless power supply should be used to minimize cost as well as reduce the size, weight and space required by the work.
4. signal coding should be used so that the system can be used to control multiple appliances.

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