DECLARATION

I do hereby declare that this thesis presented for the award of degree of bachelor of Engineering (B. ENG.) in the department of Electrical and Computer Engineering, Federal University Of Technology, Minna, under the supervision of Mr. N. Salawu.

The researcher has acknowledged information derived from published and unpublished works of others.

---------------------------------- 05/12/05 ----------------------------------

SUPERVISOR'S SIGNATURE DATE

CERTIFICATION

I certify that OKEH JOSEPH CHINENYE of MATRIC NO.99/8297EE carried out this project research work, and that it has met the minimum standard deemed acceptable by the department of Electrical & Computer Engineering, Federal University of Technology, Minna.

----------------------------------	5/12/05
STUDENT'S SIGNATURE	DATE
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SUPERVISOR'S SIGNATURE	DATE
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H.O.D'S SIGNATURE	DATE
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EXTERNAL EXMINER'S SIGN.	DATE

ACKNOWLEDGEMENT

My appreciation goes to my dear mother Mrs. Rachael Okeh, my sisters Mrs. Elizabeth Ikeme, Mrs. Esther Nkwazema, my brothers, Mr. John Okeh, Mr. Augustine Okeh, and Pastor Nwabueze Okeh for their contributions both in finance and prayers.

My sincere gratitude goes to my colleagues and friends for their contribution, interest and encouragement towards me, particularly Akinsanya Adeyemi and Mr. Lesor Job. I will equally like to appreciate my project supervisor in the person of Mr. N. Salawu, for his numerous contribution and advice during the course of this research work.

My gratitude goes equally to my beloveth, Miss. Blessing Amadi, for her contributions, comfort and encouragement throughout the period of my study in the university. Above all, my gratitude goes to my good lord Jesus Christ for His infinite mercy, favour, guidance and wisdom throughout my entire life.

DEDICATION

I dedicate this project work to God almighty for his infinite mercy, favour and wisdom throughout my entire life.

I also dedicate this project to my dear mother, Mrs. Rachael Okeh for her cares and concerns towards me.

ABSTRACT

The discovery of optoelectronics e.g. photo resistors, phototransistors, photodiodes and photothyristors which depend for their operation on what is called the inner photoelectric effect (increase in conductivity observed in certain elements and compounds exposed to electromagnetic radiation), leads to the generation of electron-holes pairs in semiconductor has greatly reduced the involvement of human in power switching operations. Thus giving birth to automatic switching system.

The application of light dependent resistor (LDR) in this project work is for automatic switching. The project is all about using miniaturized electronic components such as semiconductor materials (ICs) like LDR, OP-Amps, Optocoupler, Triac, etc, which operates on low voltage or current to control a heavy load current or voltage with high efficiency and at a very cheap cost without human involvement.

The project work is subdivided into three fundamental units. They are:

(1) The power supply unit; this is made up of stepping down the mains supply voltage from 220 or 240V ac to 24V ac, rectifying it and regulating it to ±12V dc.

(2) The sensor unit; this is made up of LDR, fixed resistors and operational amplifiers.

(3) The electrical isolation and switching unit: Which is made of optocoupler and triac. The optocoupler performs two functions. That is:

(i) Isolates the dc side from the ac side electrically and coupled the two sides optically.

(ii) It generates strong pulse, which triggers the triac to conduct bilaterally. The combination of the optocoupler and triac serves as solid- state relay in this project.

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CHAPTER ONE

1.0 INTRODUCTION

The use of miniaturized components in automatic switching in electrical and electronic work have been on the increase over the year. In the past heavy duty power components, which operates on high current, were used and are still being in use in some places for switching. Such heavy components like switchgears, contactors, big cables and bulky control panels that are still in use in some places but are not reliable or efficient. They occupy much space, are costly, waste a lot of energy and are hazardous because of the high current they operate with.

But with rapid advancement in electronic technology which led to the designing of smaller components like semiconductor device, integrated circuits (ICs) and solid state relays which operate on low voltage or current, it is now possible to construct a switching systems that operate on low voltage or current to switch on heavy loads or high current loads that is cheaper to design and construct, last longer and at the same time conserve energy.

The discovery of optoelectronics such as light dependent resistor (LDR), photodiodes, phototransistors and photothyristors which are inexpensive and which depend for their operations on what is called photoconductive effect has reduced the human involvement in the switching operation and had increased in the use of automatic switching system. As a result of this, human and electrical energy are conserved greatly with human errors greatly reduced.

1.1 AIMS AND OBJECTIVES

The aim of this project work is to design and construct a street light control system that is independent of human operation, such that at night or when weather is dark, the streetlight will switch ON and at daytime or when weather is bright, it will switch OFF automatically.

The objectives of this project are as follows:

♦ To demonstrate how a photo resistor can be used to control the action of light dependent events.

♦ To construct an automatic streetlight control system which uses dc (power) control voltage.

♦ To construct a control system in which a semiconductor or solid-state switch replaces a manual or electromechanical operated switch.

♦ To construct an automatic switching system that can efficiently and effectively switch streetlight or any other device that uses the mains supply voltage ON at night or when the weather is dark and OFF at daytime or when weather is bright.

1.2 DESIGN METHODOLOGY

The project work is subdivided into three main units. These include:

(1) The power supply unit: This involves voltage transformation (voltage step-down). This is done using step-down transformer 240V_ 24V with center tap. Rectification (full wave)- done by the use of full wave bridge rectifier IC. Filtering is done by the use of two 2200μF / 25V electrolytic capacitors and voltage regulation which was achieved by the use of one positive and one negative 12V voltage regulator ICs.

(2) The sensor unit: This comprises of light dependent resistor, fixed resistor, operational amplifiers and LED. The LDR and fixed resistors are connected in such away that, there will always be two voltage sources at both night and daytime. The first operational amplifier used here as a comparator compares the two voltages and gives the difference as the output and the second OP- AMP. amplifies the output of the first one by a factor of 3.The LED indicates when the weather is dark.

(3) Electrical isolation, optical coupling and switching unit: This is made of optocoupler or optoisolator which isolators the dc side from the ac side electrically and couples them optically. It also provides strong pulse, which triggers the triac in to conduction. The triac switches on the load. Also a100Ω / 5W choke resistor is connected to pin 6 of the optocoupler to reduce the voltage into it. 39Ω fixed resistor and 10nF /400V mica capacitor are connected in parallel with the triac as snubber network to protect the triac from the switching off inductive loads.

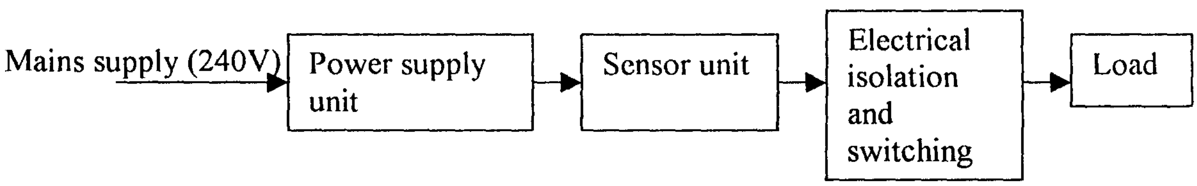

Fig.1.2 (a) block diagram of the subdivision of the project

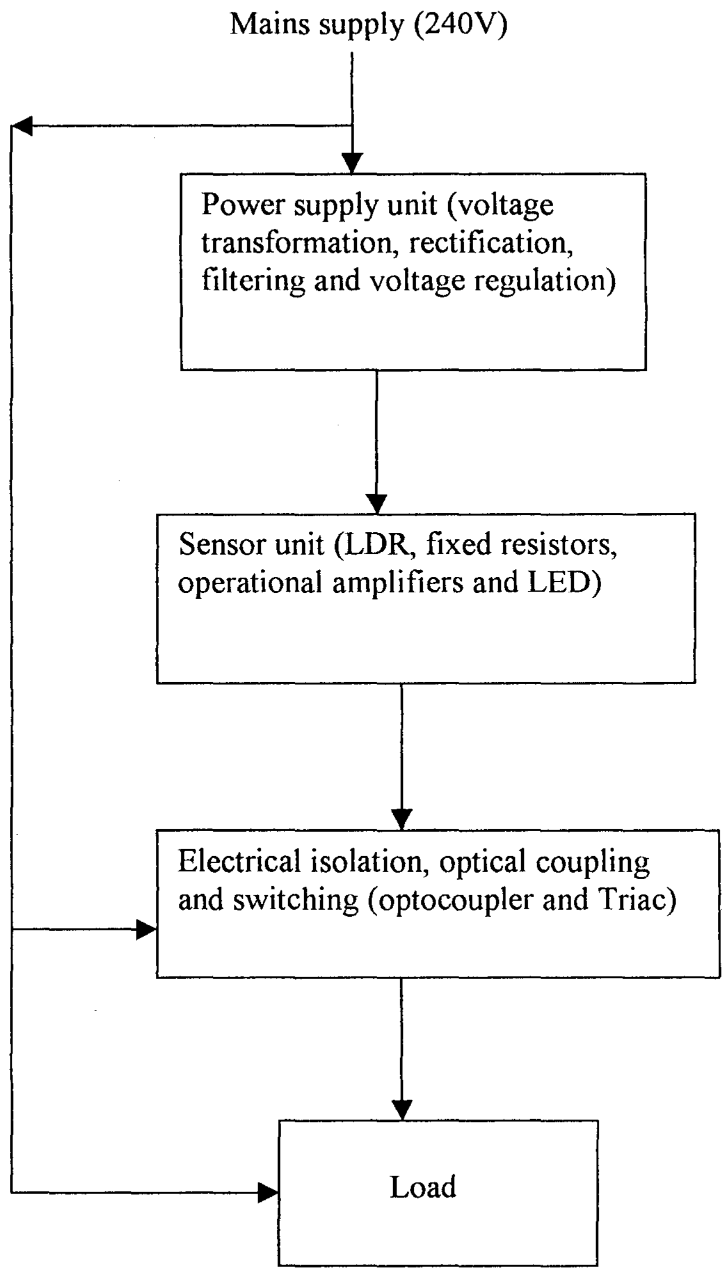

Fig. 1.2 (b) Flow diagram of the project.

DESIGN AND CONTRUCTION OF AUTOMATIC STREET LIGHT CONTROL SYSTEM

BY

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A PROJECT REPORT SUBMITTED TO THE DEPT. OF ELECT. & COMPUTER ENGINEERING, SCHOOL OF ENGINEERING & ENGINEERING TECHNOLOGY, FEDERAL UNIVERSITY TECHNOLOGY MINNA, NIGERIA.

IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF BACHELOR OF ENG'G (B. ENG) DEGREE IN ELECT. & COMPUTER ENG'G DEPT. OF FEDERAL UNIVERSITY OF TECH. MINNA, NIGERIA.

NOVEMBER 2005

1.3 PROJECT'S COMPONENTS AND COSTS

S/N	NAME OF THE COMPONENT	QUANTITY	COST (₦)
1	Light dependent resistor (LDR) ORP12	1	200.00
2	20KΩ fixed resistor	2	30.00
3	10KΩ fixed resistor	7	20.00
4	5W /100Ω choke resistor	1	30.00
5	39Ω fixed resistor	1	10.00
6	330Ω fixed resistor	1	10.00
7	1KΩ FIXED RESISTOR	1	10.00
8	470kΩ fixed resistor	1	10.00
9	2200μF /25V electrolytic capacitor	2	100.00
10	10nF /400V mica capacitor	1	30.00
11	Operational Amplifier μA741	2	100.00
12	Triac BT139 /600V	1	80.00
13	13A socket and plug	1 each	170.00
14	100W /230V bulb	2	80.00
15	Lamp holder	2	70.00
16	Zero-voltage crossing optocoupler (MOC3041)	1	120.00

17	OFF/ON switch (SPDT)	1	30.00
18	10A fuse	1	20.00
19	5V positive voltage regulator	1	50.00
20	12V positive voltage regulator	1	50.00
21	12V negative voltage regulator	1	50.00
22	Vero board	1	70.00
23	Casing materials (plywood)	(Rectangular shape) 9cm by 5cm by 5cm	400.00
24	240/24V step down transformer with center tap	1	150.00
25	Full wave bridge rectifier IC	1	40.00
26	Light emitting diode (LED)	1	10.00
27	Heat sinks	4	160.00
	Total		2140.00

Transportation and cost of internet browsing = ₦ 1800.00

Total cost: ₦1800.00 + ₦2140.00 = ₦3940.00

CHAPTER TWO

2.0 LITERATURE REVIEW

As early as the 18^{th} century, British law requires homeowners to place burning sticks, or fagots, on their public ways as measure to prevent crime. Later oil lamps were used to brighten roads and gas lamps followed these. Then, in 1878 Charles Brush demonstrated his arc light in Cleveland, Ohio, and by the turn of the century arc lamps were familiar sights in the cities throughout the world. Today most of the world's streets are illuminated by electricity, which are controlled automatically.

This project work is designed to switch on the street light at night (or when the weather is dark) when the resistance value of the LDR is at its high value and to switch off the streetlight during the daytime (when weather is bright). This was made possible by the way the LDR was connected with the fixed resistors. This project work can be employed in the switching of floodlights in the stadium. It can also be used at home and factories for switching perimeter (security) light and at the animal farms as part of animal feeder at night when workers might have gone home.

Past students in this university had done different versions of automatic switching system or dark activated switches. For example in 2003 AREMU ABIODU with matric number 97/5946EE and BELLO SULEIMAN ABDULYEKIN with matric number 96/ 5115EE of the department of Electrical & Computer Engineering did light sensitive room activated switch and automatic street light controller respectively. These past projects and many others made use of either LDR or phototransistor as part of their sensor unit. They also used electromechanical relay as their main switching unit. But in this project, LDR was used as part of the sensor unit and semiconductor or solid-state relay or switch (optocoupler and triac) were used as the main switching unit, which is quite different from the past two projects cited above.

The choice of semiconductor relay as the main switching unit was due to the following advantage, which semiconductor relay has over electromechanical relay. They are:

(i) High reliability of semiconductor relay.

(ii) Its low cost.

(iii) It has no acoustical noise.

(iv) It has high input- output isolation

(v) It has high switching speed.

(vi) It has no electromagnetic interference, etc.

2.1 PROJECT OUTLINE

Chapter one gives the insight of what the project is all about. It gives the introduction of the project, project component lists / cost and design methodology.

Chapter two relayed the literature review and the project outline. Chapter three relayed clearly the description of the design stages of the components. It also relayed the theory of components and their design parameters and calculations. The analysis of the behaviors and working of each component including their diagrams were also relayed.

Chapter four relayed the construction methods, construction tools, various test results; theoretical results test procedures, precautions and discussion of results. Also the complete circuit diagram of the project is shown here. Chapter five relayed the conclusion, recommendations and references

CHAPTER THREE

SYSTEM DESIGN AND ANALYSIS

3.0 INTRODUCTION:

The project is subdivided into three main sections. They include (i) the power supply section, (ii) the sensor section, and (iii) the electrical isolation / optical coupling and switching section.

The power supply section is where the entire system gets its electrical energy. It consists of 220 to 240V ac source from the mains, which stepped down to 24V ac by a center tapped step down transformer. The 24V ac was rectified using full wave bridge rectifier IC and the output of the rectifier filtered or smoothen with two (2) 2200uF /25V electrolytic capacitors to give a minimum ripple. The rectified voltage regulated to a constant ±12 dc voltages by the use of one (positive) +12 V and (negative) –12V voltage regulators respectively.

The sensor section comprises of fixed resistors and light dependent resistor (LDR) connected in such a way that there will always be two voltage sources. One voltage source will be fixed; one will vary depending on whether it is day or night. The two voltages are fed into the non-inverting input and inverting input of the general-purpose operational amplifier UA741 used as a comparator. The Op-Amp compares the two voltages and gives out the difference as the output. The output of the comparator is fed to the non-inverting input of the second Op-Amp and zero voltage is fed into the inverting input. The second Op- Amp amplifies the output of the first by a factor of 3 as designed.

The switching section is made of optocoupler and triac. The optocoupler performs two main functions. First, it isolates the dc side (control side) and ac side electrically and couples them optically. Second, it provides enough positive current or impulse to trigger the triac into conduction. The triac in turn switches on the load. Once the triac is triggered it conducts bilaterally until the triggering pulse or current is removed. The combination of the optocoupler and triac forms a solid state or semi conductor relay or switch.

3.1 POWER SUPPLY UNIT SECTION.

The power supply unit converts the 220_230V ac mains supply to ±12V dc, which is to be constant even if there are fluctuations in the ac supply voltage. This was achieved through the following operations.

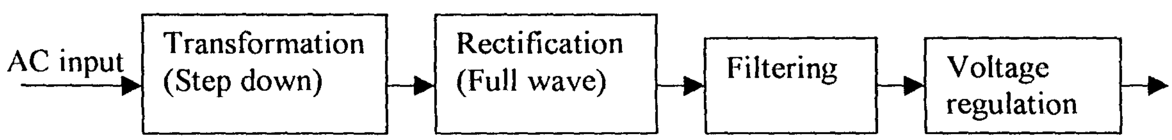
(1) Transformation (Voltage)

(2) Rectification

(3) Filtering or Smoothening

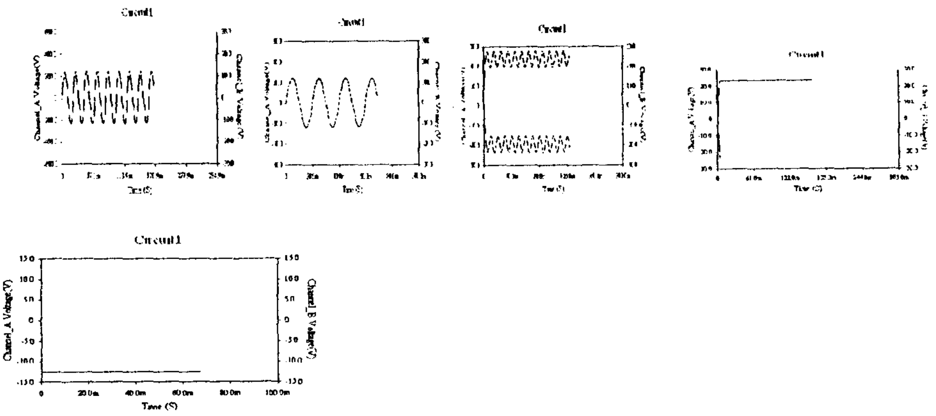
(4) Voltage regulation

The wave forms and block diagrams of these operations are shown in Fig.3.1



(a)

Fig. 3.1 (a) Block diagram of the power supply unit



(b)

Fig.3.1 (b) The waveform of the power supply unit

3.1.1TRANSFORMATION (VOLTAGE)

This involves stepping down the 220-230V mains voltage to 12V-0 –12V using a step down transformer with a center tap. In this project, the two ends were used (i.e.24V). The output current rating of the transformer used is 500mA or 0.5A.

Transformers make use of electromagnetic induction to transfer electrical energy from one winding called the primary winding to the second winding called the secondary winding. An ideal transformer is on that has no losses, i.e. its windings have no ohmic resistance, there is no magnetic leakage and hence which has no I^2R losses. It consists of two purely inductive coils wound on a loss free core. It is impossible to find an ideal transformer in practice.

Transformer equation:

If a practical transformer is efficient and transfers energy from the primary windings to the secondary windings with little energy losses inform of heat, the simple ideal transformer equation can be applied to relate the number of primary coils and primary ac voltage to the number of secondary coils and secondary voltage. The transformer equation is:

$$\frac{\text{Primary ac voltage}}{\text{Secondary ac voltage}} = \frac{\text{Number of primary turns}}{\text{Number of secondary turns}} = K$$

$Vac_1 / Vac_2 = N_1/N_2 = K$

Where K= constant known as voltage transformation ratio.

N_1 = number of turns in the primary windings.

N_2 = number of turns in the secondary windings.

V_2 = secondary ac voltage.

V_1 = primary ac voltage. If $N_2 > N_1$ i.e. $K > 1$, then the transformer is a step down transformer. If $N_2 < N_1$, i.e. $K < 1$, then the transformer is a step up transformer.

Example: For a transformer used in this project with ac primary voltage of 240v and ac secondary voltage of 24V, having 2000turns in the primary coil. Calculate the number of turns in the secondary coil.

Solution: V_1=240V, V_2= 24V, N_1=2000turns, and N_2=?

Using $V_2/V_1=N_2/N_1=K$ or $V_1/V_2=N_1/N_2=K$

$240/24 = 2000/N_2 = 10$

$N_2 = 2000/10 = 200$ turns.

Since $N_2 < N_1$, it means that it is step down transformer.

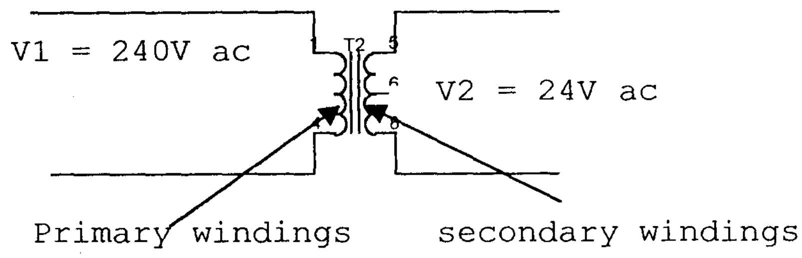


Fig.3.1.1 A step down transformer.

3.1.2 RECTIFICATION

This is a circuit that employs one or more diodes to convert ac voltage into pulsating dc voltage. If one diode is used for the operation, it is called a half wave rectification. But if the diodes are more than one say two or four, it is called a full wave rectification. In this project full wave bridge rectifier was employed. This requires four diodes, which is part of an array of diodes in an integrated circuit. The working of the rectification is as follows:

(a) During the positive input half- cycle, terminal M of the secondary of the transformer is positive and N is negative as shown in Fig. 3.1.2 (b). Diodes $D_1$and D_3, become forward-biased (ON) whereas D_2 and D_4 are reversed-biased (OFF). Hence, current flows along MEABCFN (direction of the arrows) producing a drop across R_L. During the negative input half-cycle, the transformer secondary terminal N becomes positive and M negative. Now, D_2 and D_3 are forward-biased and current flows in the direction of the arrows along NFABCEM as shown in Fig.3.1.2 (c). Hence, we find that current keeps flowing through the load resistance R_L in the same direction AB during both half- cycle of the ac input supply. Point A of the bridge rectifier always acts as an anode and point C as cathode. The output waveforms are shown in Fig. 3.1.2 (d)

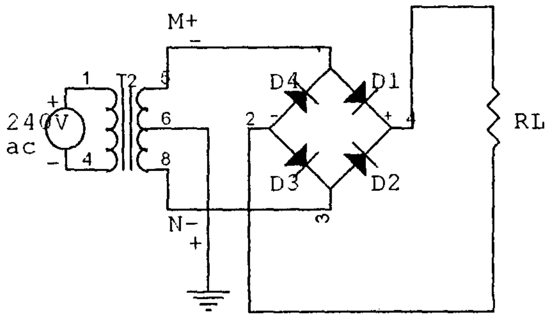


Fig. 3.1.2 (a) Full wave bridge rectification.

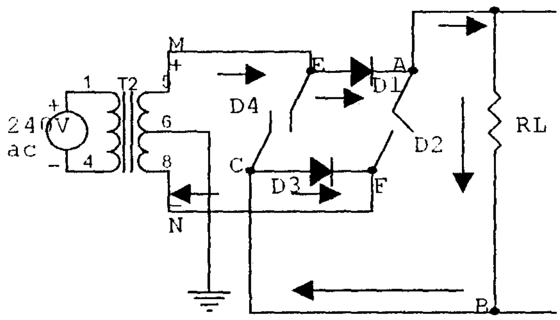


Fig. 3.1.2 (b) Current flow during positive half-cycle.

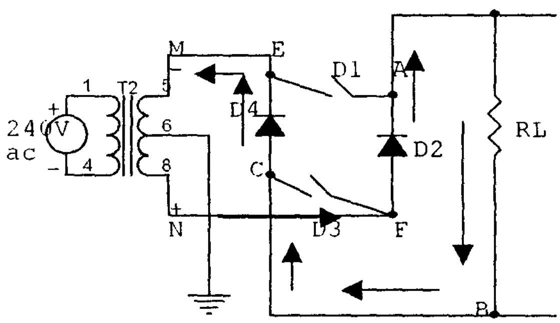
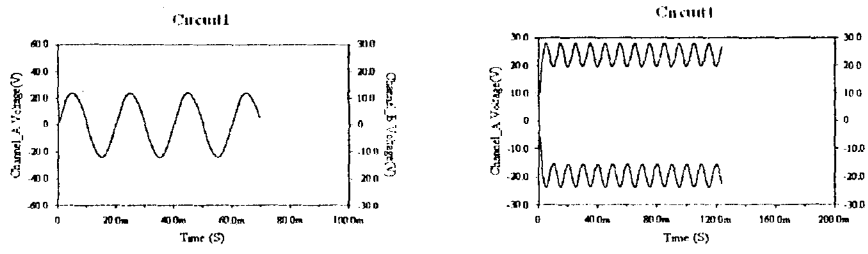


Fig. 3.1.2 (c) current flow during negative half-cycle.



(i) (ii)

Fig. 3.1.2 (d) (i) Input wave form and (ii) Total output waveform

The output dc voltage $V_L$dc is:

$V_L(dc) = 2\sqrt{2}V_p / \pi$ or $0.636V_{Lm}$.

The full wave bridge rectifier was chosen because of the following advantages. They are:

♦ Smaller transformer is needed for the operation.

♦ It is suitable for high voltage applications.

♦ The bridge rectifier is cheap.

♦ It has less peak inverse voltage, PIV, rating diode, i.e. 2Vm compared 1.21Vm for half wave.

♦ It has lower ripple factor compared to half wave rectifier.

3.1.3 FILTERING OR SMOOTHENING

The output of the rectifier consists of two components. They are;

(i) The dc component and

(ii) The ac or ripple component.

The purpose of filtering or smoothening is to reduce the ripple component to a minimum value. The shunt capacitor filter shown in Fig. 3.1.3 (a) was employed in this project.

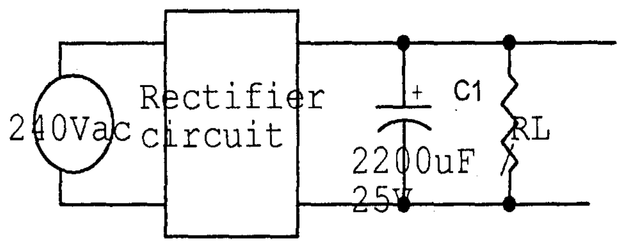
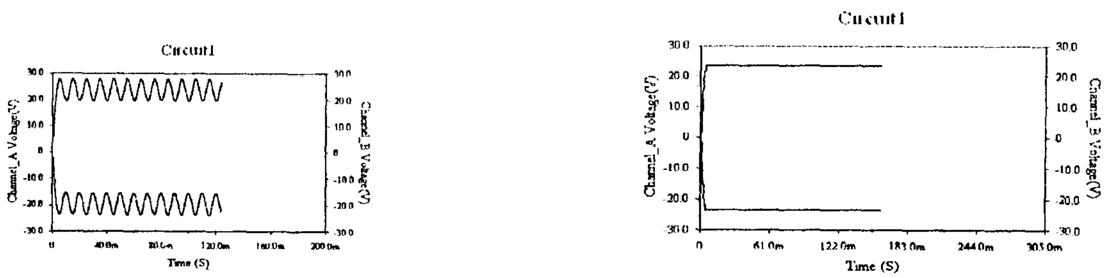


Fig. 3.1.1(a) Shunt capacitor filter.

In this circuit, a suitable capacitor C is connected across the rectifier and in parallel with the load R_L to achieve filtering action. This filter circuit depends for its operation on the property of a capacitor to charge up (i.e. store energy) during conducting half-cycle and to discharge (i.e. deliver energy) during non-conducting half-cycle. A capacitor opposes any changes in voltages. When connected across a pulsating dc voltage, it tends to smoothen out or filter out the pulsation (or ripples). The filtering action of the simple capacitor filter when used in a full-wave rectifier is in Fig. 3.1.3 (b) below.



(i) (ii)

Fig. 3.1.3 (b) Waveform of full wave rectifier (i) Without filter, (ii) With filter.

Increasing the filter capacitance that is using a bigger capacitor tend to reduce the ripple magnitude. It has been found that bigger capacitance has the following advantages.

♦ It increases V_{dc} towards the limiting value V_p;

♦ It reduces the magnitude of ripple voltage;

♦ It reduces the time of current pulse through the diodes;

♦ It increases the peak current in the diode.

The ripple factor, γ, can be calculated with the formula below.

$\gamma = 1 / 4\sqrt{3}\, f\, C\, R_L$ OR $I_{dc} / 4\sqrt{3}\, f\, C\, V_p$ for a full wave rectification.

Where: f = frequency usually 50Hz.

C = the capacitance value of the capacitor.

R_L = the load resistance.

V_p = peak rectifier output voltage.

I_{dc} = output current.

From the above formula it can be deduced that ripples increases with increase in the load (i.e. output) current.

3.1.4 VOLTAGE REGULATION

In an unregulated power supply, the output voltage changes whenever input supply voltage or load resistance changes, i.e. it is never constant. The change in voltage from no-load to full load condition is called voltage regulation. The aim of a voltage regulation circuit is to reduce these variations to zero or, at least, to a minimum possible value.

Two main types of regulator are available in integrated circuit form. They are, linear and switching regulators. In linear regulator, the transistor operates somewhere between saturation and cut-off. It is always ON and dissipates power. Hence, its efficiency (output /

input power) is 50% or less. In switching regulators, the transistor operates like a switch, i.e. it is either saturated or cut-off. Hence, its power efficiency is 90% or more.

The linear regulators may be in form of series regulator or shunt regulator, and switching regulator can be of two basic types, i.e. step down or inverting type. Two linear regulators were used in this project. They are negative and positive 12V (± 12V) linear regulators. The percentage regulation or, simply, regulation of a power supply is given as

% Regulation = $(V_{NL}-V_{FL}) / V_{FL} * 100$

Where, V_{NL} = no load or open- circuit terminal voltage of the supply.

V_{FL} = full-load terminal voltage of the supply. In an ideal or perfectly regulated dc power supply, the percentage regulation is zero.

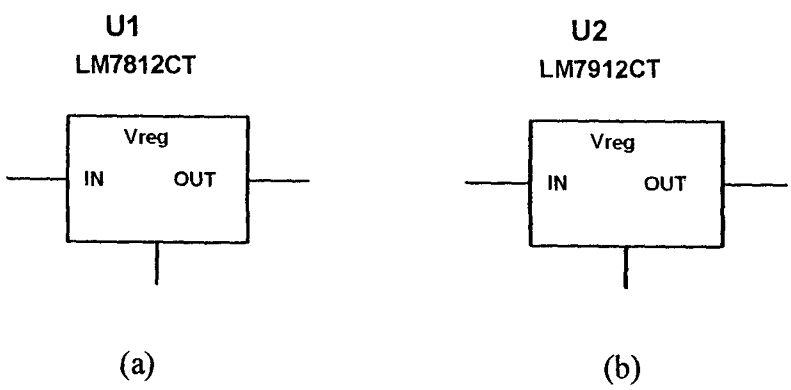


Fig. 3.1.4 (a) circuit symbol of positive 12V regulator, and (b) circuit symbol of negative 12V regulator.

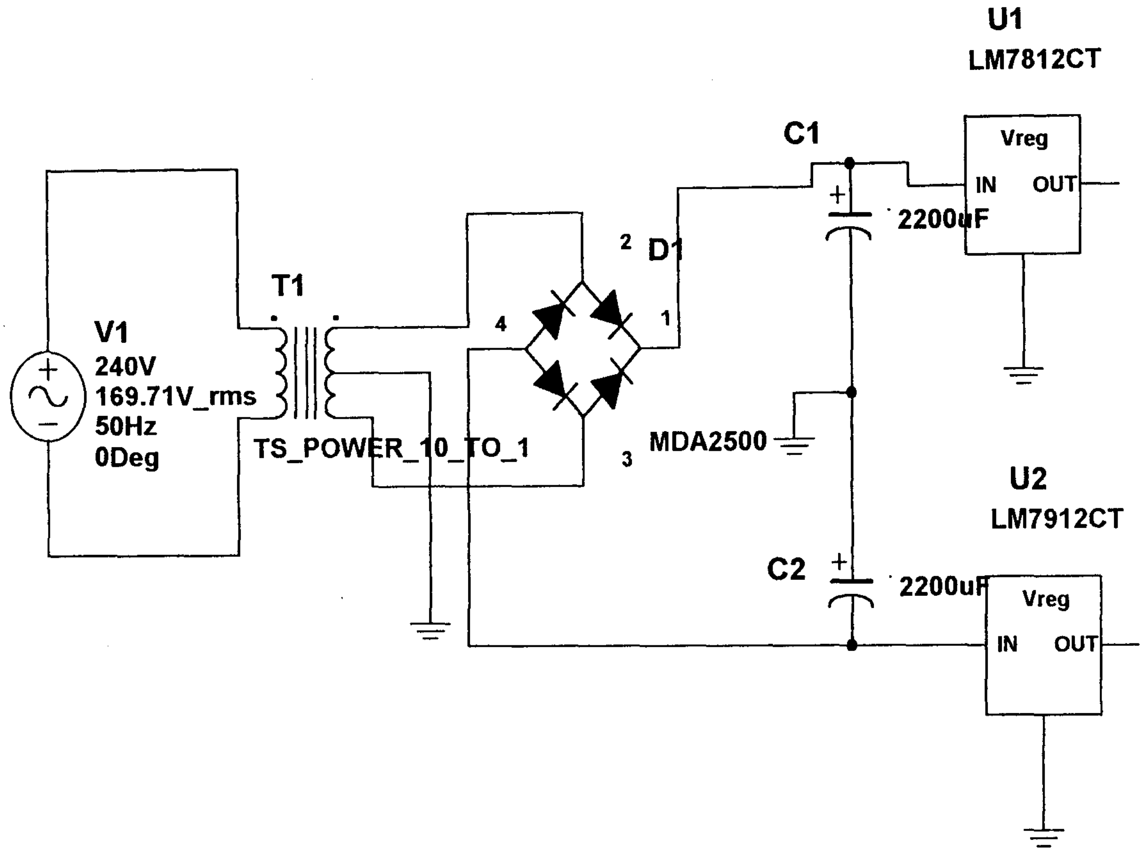


Fig. 3.1.4 (c) Complete circuit of power supply unit.

3.2 SENSOR UNIT.

The sensor unit consists of a light dependent resistor,(LDR) and fixed resistors connected as voltage dividers to give two different dc voltages. One of the voltages is obtained by connecting a fixed resistor of 20KΩ and LDR, making voltage to vary depending on the amount of illumination on the LDR, while the second voltage source obtained by connecting two-fixed resistor of 10KΩ each in such away that the voltage remains constant and is used as a reference voltage. The voltages are fed to the non-inverting and inverting inputs of the general purpose OP- Amp μA741 used as a comparator respectively. The difference between the voltages comes out of the output terminal of the comparator. The second Op-Amp amplifies the output of the first Op-Amp by a factor of 3 as per design.

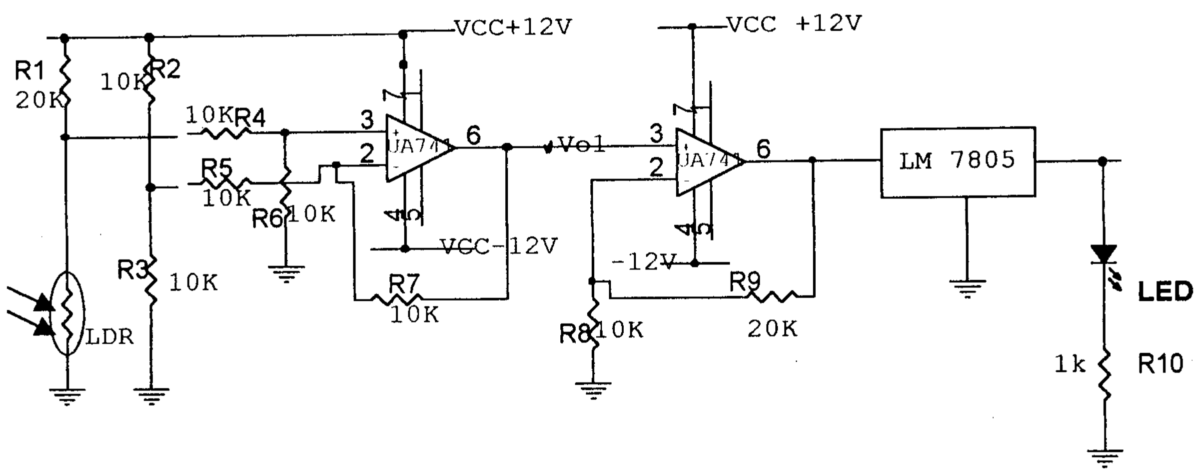
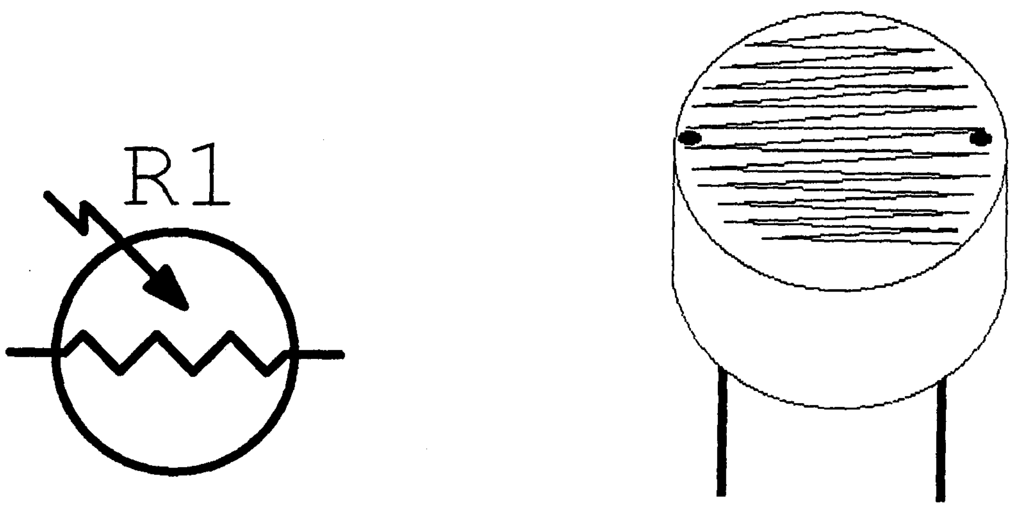


Fig. 3. (a) The sensor unit.

3.2.1 LIGHT DEPENDENT RESISTOR (LDR).

The light dependent resistor or photo resistor is a two-terminal semiconductor device whose terminal resistance will vary with the intensity of the incident light. It is a transducer (sensor), which convert brightness (light) to resistance. It is made from Cadmium Sulphide (CdS) or Cadmium selenide (CdSe) and resistance decrease as the brightness falling on it increases. The resistivity of a conductor depends on the number of free charge carriers available in it. When the semiconductor (LDR) is illuminated, the number of charge carrier is small, and hence resistivity (resistance) is high. But when light in form of photons strikes the LDR, each photon delivers energy to it. If the photon energy is greater than the energy band gap of the LDR, free mobile charge carriers are liberated and, as a result, resistivity (resistance) of the LDR decreases.

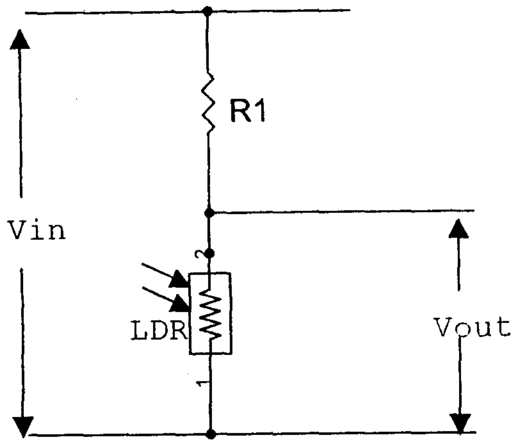
As seen in Fig.3.2.1 (a), a thin layer of photo resistive semiconductor material is deposited inform of a long strip zigzagged a crossed a disc-shaped ceramic base with protective sides. The LDR at dark has a resistance value of about 1MΩ or above. Under illumination, the cell resistance drops to a value of about 200Ω. LDR is an inexpensive semiconductor material and is a simple detector which is widely used as in light measurement, light-detecting circuit and ON / OFF circuits which is what it is used in this project work.



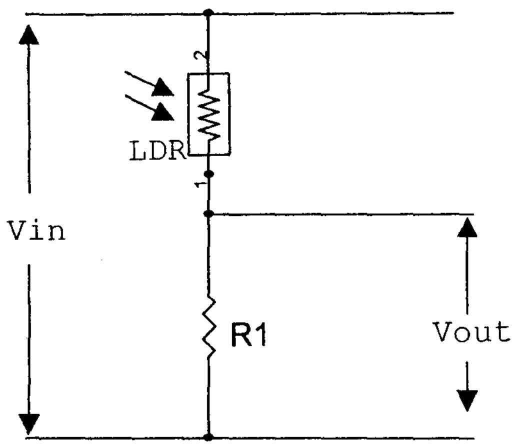
(b) (a)

Fig. 3.2.1 (a) Diagram of LDR. (b) Circuit symbol of LDR

The sensor unit is based on the fact that the resistance of LDR decreases in the presence of light and increases when dark covered. This gives varied voltages at daytime and night. The possible voltage divider connections of LDR with fixed resistor are shown below.



(c)



(d)

Fig. 3.2.1 (c) &(d) possible voltage divider connections of LDR with fixed resistor.

For (c) $V_{out} = (R_{LDR} / (R_{LDR} + R_1)) * V_{in}$

For (d) $V_{out} = (R_1 / (R_1 + R_{LDR})) * V_{in}$

3.2.2 COMPARATOR AND AMPLIFIER

The general-purpose operational amplifier μA741 was used as comparator. V_2 is from the voltage divider comprising the LDR and 20KΩ resistor, while V_1 is the reference voltage. The first OP-Amp (comparator) compares the two voltages V_1 and V_2 and the output Vo1 is: $Vo_1 = R_2/R_1 (V_2 - V_1)$. Since $R_2/R_1 = R_4/R_3 = 1$

$\therefore Vo_1 = V_2 - V_1$.

The second OP-Amp amplifies the output of the first OP- Amp by a factor of 3, and the output voltage of the second OP- Amp is now V_{out}.

$V_{out} = (1 + (R_6/R_5))(Vo_1 - 0) = (1 + (20K/10K)) * Vo_1 = 3\ Vo_1$.

The voltage regulator is used to produce a constant 5volt for the input of the optocoupler

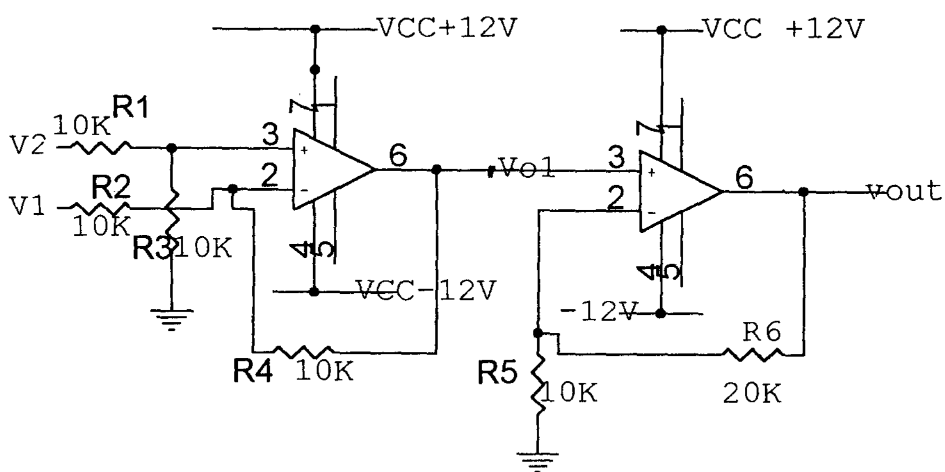


Fig. 3.2.2 The comparator and amplifier circuit.

3.3 ELECTRICAL ISOLATION/OPTICAL COUPLING AND SWITCHING UNIT.

This unit is made of optocoupler and Triac. The combination of the ICs forms a semiconductor or solid-state relay. This relay is used in place of an electromechanical relay to switch electricity to a load in many applications. The relay is purely electronic, normally composed of a low current control side (equivalent to the coil on an electromechanical relay) and a high- current load side (equivalent to the contacts on a conventional relay). A solid state relay typically feature electrical isolation to several thousand volts between the control and load sides. Because of this isolation, the load side of the relay is actually powered by the switched line, both line voltage and a load (not to mention a control system) must be present for the relay to work.

The reasons for choosing semiconductor relay for this project are as follows:

- No mechanical moving parts compared in an electromechanical relay.
- No arching in contacts.
- No contact materials, which will war out in, frequent use.
- No acoustical noise.
- No electromagnetic interference.
- High reliability.
- Long operating life span.
- Resistance to shock and vibration.
- High input- output isolation, etc.

3.3.1 OPTOCOUPLER OR OPTO ISOLATOR

The combination of a miniature light source and a photo detector in the same package has led to a very useful family of devices commonly referred to as optoisolators or optocouplers. The device optocoupler consists of an infrared emitting diode (IRED) at the input stage, and a silicon photo detector at the output stage. Internally, the optocoupler uses a glass dielectric sandwich to separate input from the output. The coupling medium between the IRED and sensor is the infrared transmitting glass. This provides one-way transfer of electrical signal from the IRED to the circuitry. The signals existing at the input and output of an optocoupler are always electric, while the input and output are always optical. The light source circuit is the driving or the control section of the device, while the photo detector circuit is the controlled or driven section. In electronic circuits, optocoupler are used to provide optical coupling and electrical isolation. Advantages of optocoupler are that there is no electrical connection between the input and the output and the feed back between the photo detector and the light source. The isolation resistance is between input and output may be as large as 10^{12} -$10^{14}\Omega$, and the transfer capacitance does not exceed 2pF, being as a fraction of Pico farad in some devices.

Two types of optocouplers are used for triggering triac. They are: The non-zero voltage crossing optocoupler and zero voltage crossing optocoupler. The non-zero voltage crossing optocoupler will activate at any phase difference between the outputs when the input is activated. That means if you activate the optocoupler while the voltage difference is at its maximum, it will activate, causing a large voltage and current changes (which can cause interference if not filtered properly). The zero-crossing voltage optocoupler will not activate until the voltage differential between the outputs is zero. Even if you turn on the optocoupler while the voltage is at its greatest difference, it will not activate the output until the voltage differential is zero, therefore avoiding rapid voltage changes. The zero voltage crossing optocoupler was used in this project.

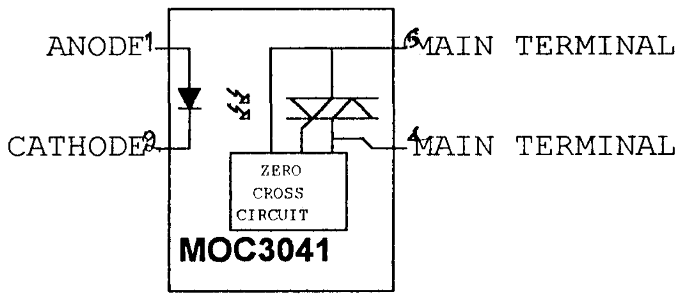
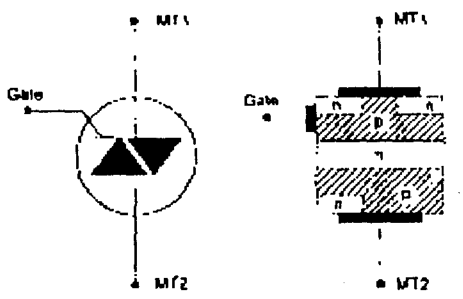


Fig. 3.3.1 (a) internal structure and pin out of zero-crossing optocoupler

The zero- voltage crossing optocoupler from MOTOROLA MOC3041 used in this project, has photo triac as its photo detector and a zero- crossing circuit. The device was designed to limit turn-on voltage to less than 20V. This reduces the amount of radio frequency interference and electromagnetic interference generated when the thyristor switches on.

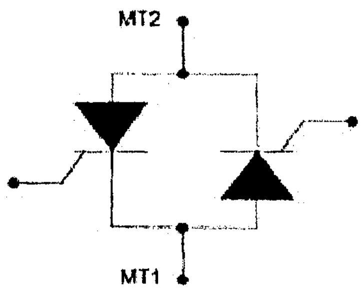
3.3.2 TRIAC

The traic is a bidirectional triode thyristor, which is a solid-state device that acts like two silicon-controlled rectifiers (SCRs) that have been connected in parallel with each other (inversely) so that the other will conduct the positive half-cycle and the other will conduct the negative half-cycle. This means that the triac can be used for control in ac circuit. Before the triac was designed as single component, two SCRs were actually used for this purpose. Fig. 3.3.2 (a) and (b) shows the symbol for the triac, and its P-n structure. The terminals of the triac are identified as main terminal 1 (MT1), main terminal2 (MT2), and gate. The multiple Pn structure is actually as combination of two four-layer (pnpn) junctions.



(a) (b)

Fig. 3.2.2 (a) circuit symbol of triac (b) Diagram of its Pn structure (courtesy of Philips semiconductor)



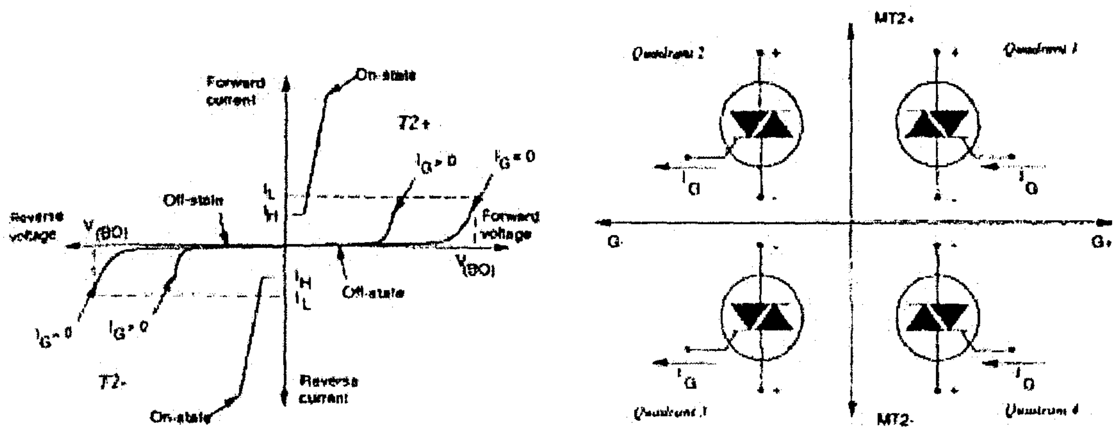
(c)

Fig. 3.2.2 (c) Two SCRs connected in inverse parallel configuration to the equivalent circuit for a triac.

The triac is required in circuits where ac voltage and current need to be controlled like SCR controls dc current. Another difference between the triac and SCR is that a positive or negative gate pulse can turn on the triac. The gate pulse need only be momentary and the triac will remain in conduction until the conditions for commutation are satisfied.

3.3.2.1 OPERATION OF THE TRIAC

The operation of the triac can best be explained by the two SCRs model in Fig. 3.3.2.1 (a) . From this it can be seen that the SCRs are connected in an inverse parallel configuration. One of SCRs will conduct positive voltage and the other will conduct negative voltage. Unlike the two SCRs, a single gate triggers the triac. This prevents problem of one SCR not firing at correct time and overloading the other. In the 1960s and 1970s when triacs were not available, Two SCRs were actually connected together and used as a device to control current in an ac circuit.



(a) (b)

Fig. 3.3.2.1 (a) A graph of the positive and negative voltage and current characteristics of a triac. (b) The four quadrants identified for the graph to describe the voltage polarity of the triac when it is in conduction.

In selecting triac for this project, the following were put into consideration. The voltage and current the triac can handle. The triac used was able to handle the highest voltage present in the mains voltage. For 230V ac the highest voltage is around 325V, so at least 400V triac model is suitable. But I used Triac, BT139 / 600V to be on a safe side and in case inductive load may be connected to the circuit. Also for a reliable project work a triac of double current rating than the circuit was designed to handle was used. The circuit was designed for least 5A but the triac used was 10A. The combination of optocoupler and triac was employed in this project work as a solid state or static switch.

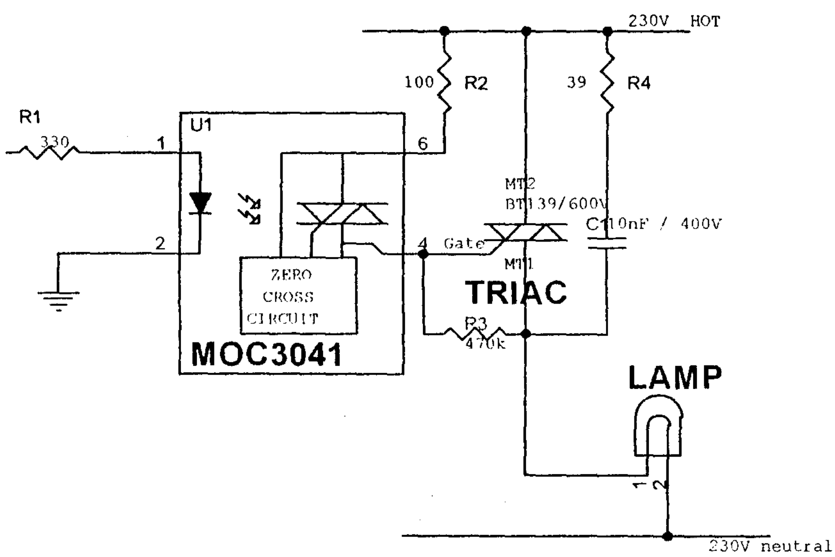


Fig. 3.3.2 A static switch controlled by an optocoupler

A static switch controlled by an optocoupler is shown in Fig.3.3.2, the MOC 3041 optocoupler has an IRED and a small phototriac with zero-crossing detector triggering. When the IRED is on, the triac will fire at each zero crossing of the voltage across it, and the current is used to trigger the main triac. The 100Ω (choke resistor) protect the triac against excess current. The triac in MOC3041 can stand the 120V (actually, it is rated at 250V) when it is not conducting and it is, the main triac is also on, so the voltage across it is small. The 330Ω limit the current entering the optocoupler. The 470KΩ resistor connected between the gate and MT1 is to help in the turn OFF of the gate. When there is no current in the optocoupler, the voltage across the load is zero. The circuit includes a dv /dt snubber network connected across the power triac , this is to protect it from inductive kick-back when it is switched off. This is made of 39Ω resistor in series with 10nF / 400V capacitor which are connected in parallel with the power triac.

CHAPTER FOUR

4.0 CONSTRUCTION, TESTING AND RESULTS

After the completion of the design phase of the system, the circuit diagram was simulated on multisim 2001 package in a computer. Because the multisim 2001 package do not have LDR and zero-voltage crossing optocoupler triac driver among its components, the result of the simulation was not too satisfactory. However, the project was then implemented on a project or breadboard to make sure it works properly. After designing on the project board it was taken to my supervisor Mr. N. SALAWU for inspection and verification. After which he made his observation known to me. After careful study of his suggestions, few modifications were made on the design before it was finally transferred to Vero-board for the final construction.

4.1 CONSTRUCTION

The tools used in the construction are:

- ♦ Soldering- iron (60Watt).
- ♦ Soldering lead.
- ♦ Solder sucker.
- ♦ Long nose pliers.
- ♦ Cutter, and electrician knife.
- ♦ Screwdrivers (flat and star ended).
- ♦ Digital multimeter
- ♦ Connecting wires.
- ♦ Vero board.

4.1.1 CONSTRUCTION STEPS

(I) The circuit was first implemented on a breadboard and few adjustments and modifications made before finally transferring it to a Vero board.

(II) The position of the components on the Vero board was made in such away that unnecessary distance between components were eliminated to reduce the length of connecting wires used, and thus reduce the over all circuit capacitance and resistance.

(III) Components like resistors, LDR, capacitors, regulators and triac were soldered directly on the board, while appropriate IC sockets were soldered on the board before the operational amplifiers and Optocoupler Ics were inserted on them.

(IV) Heat sinks were used for the regulators and triac. These are to conduct heat away from them.

(V) A digital multimeter was used to check voltages at each section including the output. The contacts of the components were equally checked for continuity and short-circuiting where necessary.

4.2 PRECAUTIONS

(a) The use of little but enough solder for any joint was ensured for proper contact.

(b) Overheating of the soldering iron was prevented, this is to ensure that excessive heat do not damage the components.

(c) Heat sinks were used where necessary to conduct heat away from the components like regulators and triac.

(d) IC sockets were soldered on the Vero board first, before the main ICs were inserted into them, rather than soldering the components directly on the Vero board. This is to ensure that the ICs are not damaged during soldering.

(e) Test for continuity and short circuiting were done using digital multimeter, this is to ensure proper working of the construction

4.3 TESTING AND RESULTS

Though the first testing was done on the breadboard, the real testing was done after the necessary construction work have been carried out on the Vero board. The circuit gave interesting and desired results. The results obtained from the circuit design /construction and the expected results are shown in table 4.3.1 The output of the project work was found switch the load (two 100W / 230V bulbs) ON and OFF as designed.

This was demonstrated by covering the LDR head with a dark material (causing the resistance value of the LDR to be high up to 1MΩ) and the load switches ON (simulating night) and immediately the dark material was removed (simulating day) the load switches OFF (making the resistance value of the LDR to be low down to 200Ω)

TABLE 4.3.1 THE OBTAINED RESULTS AND EXPECTED RESULTS

ACTION	CIRCUIT RESULT	EXPECTED RESULT
When dark covered	Switches ON the Load	Switches ON
When Uncovered	Switches OFF the Load	Switches OFF

4.4 DISCUSSION OF RESULTS

The result of the project work compared favourably well with the expected result, this could be as a result of choices made in regard to different components used especially the choice of solid state relay in place of electromechanical relay. The only visible defect was the blinking of the load (two 100W / 230V bulbs) when the LDR head was not completely covered by the dark material. This could be due to the use of general purpose OP-Amp μA741 as comparator instead of using a comparator like LM339 or LM 311. This is because the response time of the former is higher (about 50μs) than the later (about 200ns).

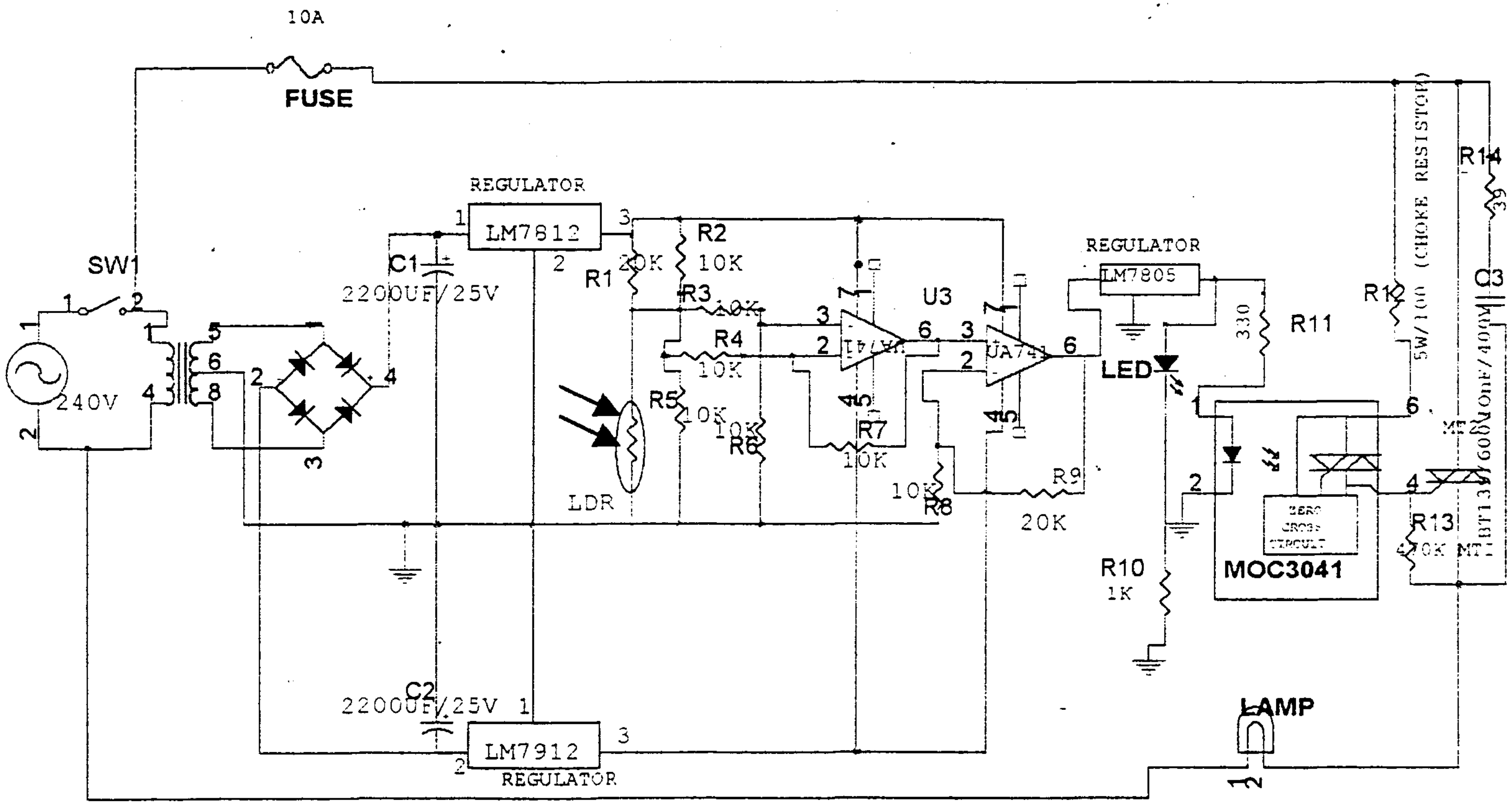


Fig. 4.5 Complete circuit diagram of automatic streetlight control system

CHAPTER FIVE

CONCLUSION, RECOMMENDATION AND REFERENCES

5.1 CONCLUSION

The automatic street light control system had been successfully designed, constructed and tested. The obtain results compared favourably well with the expected results. The practical results were in conformity with all the theorem, hypothesis and theoretical design procedures applied within the limit of research, design and constructional errors. During the course of this research work more knowledge about optocoupler, triac and other semiconductor devices and their applications were acquired. The total cost of constructing this project was very minimal and quite reasonable, bearing in mind that subsequent production will result in further drop in cost.

Before the completion of this project work, certain problems were encountered, and they include: (i) the costs of components in Minna were very high compared to the cost of the same components in Kaduna or Lagos.

(ii) The inability to get the zero-voltage crossing optocoupler triac driver (MOC3041 or equivalent) here in Minna which led my ordering for it from Lagos, although it was quite cheap there.

This project work can also be employed in the switching of floodlights in the stadiums. It can also be used at homes and factories for switching perimeter (security) light and at animal farms as part of animal feeder at night.

5.2 RECOMMENDATIONS

The use of comparator LM339 orLM311 instead of the general purpose OP-Amp μ741 should be employed in future project work on this top. Also for the construction cost to be reduced, any future researcher on this project or any other project should source his or her components from kaduna or Lagos, because components here in Minna are costly. This is due to the fact that only one or two shops deals with project parts and in most cases one will be faced with non-availability and this is time consuming also. Also the project work can be implemented using microcontroller, since everything nowadays is being computer related.

Finally, since the cost of production is very low, the electrical and computer engineering department should go into its production and sell them to interested people to generate funds for the department.

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