DESIGN AND CONSTRUCTION OF AN AUTOMATIC STREET LIGHT CONTROLLER

BY

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2001/12014EE

BEING A PROJECT SUBMITTED TO THE DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA

IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF BACHELOR OF ENGINEERING (B. ENG) IN ELECTRICAL AND COMPUTER ENGINEERING

NOVEMBER 2007

DECLARATION

I KASSIM MAHMUD 2001/12014EE declare that this work was done by me and has never been presented else where for the award of a degree. I also hereby relinquish the copyright to the Federal University of Technology Minna.

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DEDICATION

This project is dedicated to ALMIGHTY ALLAH (RABOOL HAR'SH WA MALAIKA), Unto WHOM I solemnly and wholly declared my submission inform of prayers, sacrifices, living and death and in WHOSE unconditional favour, I was given admission (in the first place), learn and now completing my course of study successfully.

Also dedicated to my parents; Alh. Kassim Hana and Haj. Rabi Kasimu, whose love and "hard-line" upbringing as been of tremendous help in my life. To my late uncle Danjuma Ali may His gentle soul rest in the bossom of the Lord (Ameen).

ACKNOWLEDGEMENT

First and foremost, endless gratitude to ALLAH (SWT) for His Mercy and Protection, the Lord of the universe. The Creator, Omniscience WHOSE in His boundless favour see me through, this though and thorough search for knowledge for benefit of mankind.

Sincere appreciation to my beloved parents whose love, concern and cares, help me through my endeavors. Greatly, and worth of mention, is patience and perseverance of my Mother Hajiya Rabi Kassim, for bringing me up from childhood to present moment.

I am indebted to my supervisor Mr. Abraham Usman, whose experience, suggestion and criticism has immensely assisted me in this work.

Furthermore, my sincere gratitude to my H.O.D. Engr. M.D. Abdullahi for his fatherly advises. I highly respect the contribution of the entire staffs of Electrical and Computer Engineering for their love and wisdom. Also to the entire University Management.

I adore with great passion the contribution of my entire family , Alhaji Mabo, Hajiya Lami, Asabe, Larai, Aishat, Tanimu. Etsu, Gambo, Bawa, Maikudi, Talatu and others, for their believe and trust. Also for their financial support throughout my school period.

Worth mentioning, is my fellow comrades in NAKOSS umbrella body of for students from Kogi state which I was a president for long period. Appreciation to the entire final year (500L) Electrical and Computer Engineering students of 2006/2007 session of a particular mention, Abdulrahman Kutigi Legbo and late Abdulmuttalib.

Finally, immeasurable gratitude to ALLAH (SWT) for His mercies and protection, throughout my staying in this institution.

ABSTRACT

This project is design and construction of Automatic Street Light Controller. The design based on the veritable advantage of a Light sensor called LIGHT DEPENDENT RESISTOR (LDR), which is the main component of the circuit, and an operational amplifier (op. amp) 741, connected as a comparator. The circuit is used to detect voltage level of the day and night sense by the LDR. Ambient light intensity of the atmosphere or from another means depending on the way we wish to apply the circuit. The sensor and the comparator from the switching mode voltage level detect circuit, which act by means of a driver (transistor relay) to control the switching either ON/OFF streetlight automatically.

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I = Current

V = Voltage

V_o = Output Voltage

V_{in} = Input Voltage

$V_{d.c}$ = D.C Voltage

$V_{a.c}$ = A.C Voltage

I_C = Collector Current

I_B = Base Current

I_E = Emitter Current

A.C = Alternating Current

D.C = Direct Current

A = Ampere

mA = Milliampere

N_P = Primary turns

N_S = Secondary turns

R_V = Variable resistor

r = ripple

R = Resistor

LDR = Light Dependent Resistor

D = Diode

C = Capacitor

f = Frequency

t = Time

Hz = Hertz

W = Watts

P = Power

PIV = Peak Inverse Voltage

Op.amp = Operational Amplifier

B = Base

C = Collector

E = Emitter

CHAPTER ONE

GENERAL INTRODUCTION

1.0 INTRODUCTION

Electronics has grown significantly. since the discovery of electrical conductivity of the P-N Junction(s) of a semiconductor. This "magical junction" is the basis of modern technology, which this project is borne out of its verse applications.

The Automatic Street Light Controller is an electronic device that automatically "turns-on" street light when it dark (e.g. Night, cloudy atmosphere etc) and "turn-off" when there is light (e.g. day or other photo source). This bridging of Natural phenomena (day/night) with technology is the basis of Applied Science.

This circuit requires 8V dc power supply (with transformer for step-up) for operation. The device has a Light Dependent Resistor (LDR) (a transducer) acting as photo sensor and an operational amplifier (op.amp) as a comparator for comparing night and day voltages across LDR sensor. As light falls on the LDR, during the day, its resistance becomes low and developed low voltage (resistance is proportional to voltage). The voltage across it is not sufficient to bias the transistor hence cut-off state. However, during the night when there is no light falling on the LDR, it resistance becomes higher and enough voltage is developed across Light Dependent Resistor (LDR), which in turn forward-bias the transistor to saturation state, thereby energizing the relay coil and closing it contacts (usually the contact is open) hence power is set to the Load (bulb of shut light) thus, the bulb of Automatic Street Light Controller is nature sensitive (Photo Sensor).

1.1 PROJECT MOTIVATION

In Nigeria today, the major set-back is industrialization and it can not be achieved except by adequate power supply. Though the power sector problem is largely the limited generation capacity, but the little generated in the range of 3000 – 3500MW (statistics) now, more than 32 – 36% is been wasted among is the (ON nig) of light during the day (no power conservation culture) and is also overcomes the wear encounter by the component in a mechanically operating switch.

1.2 PROBLEM DEFINITION AND METHODOLOGY

The problem faced by manually operated switch for street lighting in our residential area and industries are enumerated below:

(i) Problem of attendant by manual operator.

(ii) Problem of power wastage during the day when the operators fail to put off the lighting.

(iii) The problem of leaving street and industries dark during stormy and cloudy weather.

The above problems of switching "ON and OFF" by manual operator are carefully been solve by electronic device "Design and Construction of an Automatic Street Light Controller"

This project as it adequate provide us with the parameters like "electrical advantage", which bothered on Quality and "Load-effort ratio" that deals with efficiency.

1.3 PROJECT OUTLINES

This project is divided into five main chapters, which are enumerated as follow: Chapter One; consist of introduction, motivation behind project, problem definition and methodology.

Chapter Two; review other books and past works (literature review), Theoretical background and basic knowledge.

Chapter Three; Deals with design and analysis, calculations and decision on component selection choice, for building circuit.

Chapter Four; Deals with construction and testing of the built circuit.

Chapter Five; General conclusion, problem encounters, limitations, application and possible recommendation, references and appendixes.

CHAPTER TWO

LITERATURE REVIEW / THEORETICAL BACKGROUND

2.0 LITERATURE REVIEW [5, 8, 9, 10]

Engineering like human, had gone through series of evolution and transformation, although throughout these "man has remain the best engineer".

As early as 18th century, British law required home owners to place a burning stick or fagot outside their homes in night as measure to prevent crime and later, oil lamp were used and gas lamps to brighten roads and pathways. Later in 19th century an American technologists Charles Brush develop arc lamp. Today streets are illuminated with electricity, the switching method in many places particularly African countries are "manual" which consist of circuit breaker with a by pass fuse, a contactor and some miniature circuit breakers (MCB). The number of the miniature breaker depends on the load to be supplied with power. [9, 10]

Engineering as a field of study is all about making the entire life more meaningful and easier through the application of science and technology. An attempt to achieve this, various researches and workshop were embarked upon in order to understand phenomena around us. Though engineer predict that technology will improve as long as life remains. The above mechanical switching described is manual bulk and grossly inefficient.

There arises as need for a control system, which will be automated and reduce human effort an "Electronic Switching System" was developed by all standard more reliable and effective. Human being requires light to carry out many functions particularly in the night. Take example of a street lighting, which is the main aim of this project.

This project in its simplest form is a light dependent regulatory switch controller, in which light dependent resistor (LDR) act as a sensor element and a comparator that is in corporate with a Zener diode to only discriminate the reference voltage across the comparator, such that whenever there is voltage difference between sensor (LDR) and the reference. the transistor will be bias and subsequently turn-on the street light. [7, 8]

2.1 THEORETICAL BACKGROUND

INTRODUCTION [1, 2, 3, 4, 5, 7, 8]

A block diagram of the simple street light automatic controller is as shown in the figure. Every block represent one stage in the whole circuit arrangement. The sensor transducer, which is the Light Dependent Resistor (LDR), is incorporated in the comparator/ control circuit, which is the main circuit.

The design circuiting involves the D.C power supply unit, the control/comparator unit, the switching unit and finally the output.

The stages involve are:

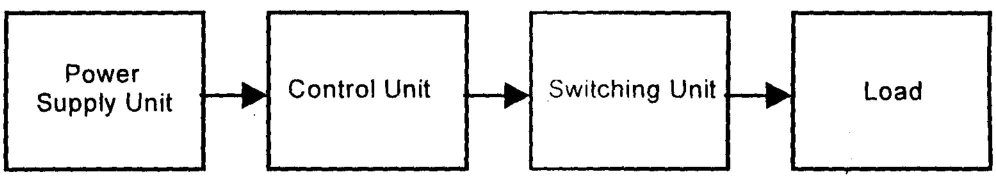


FIG 2.1. **Block diagram of the Controller.**

2.2 D. C. POWER SUPPLY UNIT

Most of the electronic devices requires a D.C source for their operation. Dry cells and batteries is one of the D.C sources. They have advantage of being portable and ripple free.

However, the voltages are low, they need frequent replacement and are expensive as compared to conventionally D.C power suppliers.

Since the most convenient and economical source of power is the A.C supply, it is the advantageous to convert this alternating voltage to D.C voltage. This is usually smaller in value. This process of converting A.C to D.C voltage is called rectification. This is accomplished with the help of rectifier, filter and voltage regulator circuit.

In this particular Project the D.C voltage is optionally useful since the circuit contain electronic component such as Light Dependence Resistor (LDR), operational Amplifier (op-Amp), integrated circuit voltage regulator IGS, transistor all which requires D.C voltage for their operation and proper biasing.

A typical D.C power supply consist of five stages as shown below in Figure 2.2

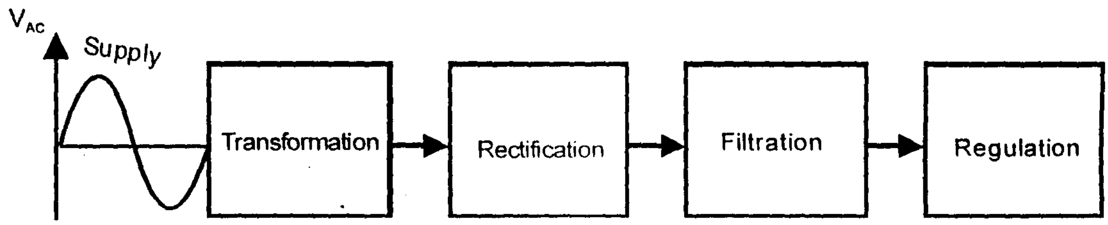


Fig 2.2 **Block diagram of a Regulated D.C Power supply.**

Meanwhile, the following characteristics are to be considered in the choice and design of power supply.

(i) Maximum and minimum Voltage demand of the system.

(ii) Maximum and minimum Circuit /demand of the system.

(iii) Regulator

(iv) Ripple factor

(v) Efficiency

2.2.1 TRANSFORMATION

Transformation is a process of converting A.C voltage from one voltage to another through the use of either step-up or step-down transformer.

TRANSFORMER:- this is a device with non-moving parts that changes the value of line voltage to that required, producing the proper D.C voltage after rectification. Its job is either to step-up or mostly step-down A.C supply voltage to suit the requirement f solid-state electronic devices and the required circuit been fed by obtained D.C power supply.

The transformation also provide isolation from supply liners which usually are above 100v (Killer voltages!). This is an important safely consideration.

Transformer consist of two winding isolated from each other and wound on the same iron core. The primary coil receives the A.C supply from the mains while the secondary produces the output voltage. The figure 2.3 shows the schematic structure of a transformer.

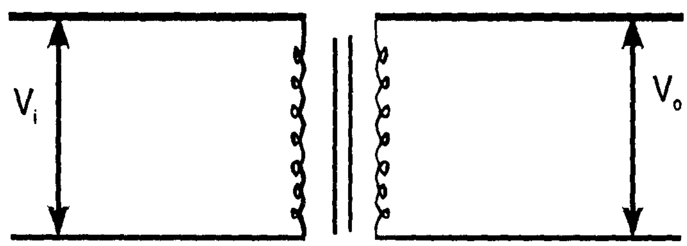


Fig 2.3 **Schematic diagram of transformer, for an ideal transformer the primary winding flux are sinusoidal.**

Therefore, flux $\varnothing = \varnothing_m \text{ Sin } wt$

But e.m.f., $e = \frac{Nd\varnothing}{dt}$ - - - - - - - - 2.1

hence

$e = \frac{N d(\varnothing m \text{ Sin } wt)}{dt}$ - - - - - - - - 2.2

$e = W N \varnothing_m \text{Cos } wt$ - - - - - - - - 2.3

If flux varies sinusoidally, the r.m.s. value of induced e.m.f. is obtained from factor w

$W = 2 \pi F$

E_{rms} of the e.m.f. per turn

$$E_{rms} \quad \frac{1}{\sqrt{2}} w \varnothing_m \text{Cos } wt$$

$$= \frac{1}{\sqrt{2}} \times 2 \pi F \varnothing_m \text{Cos } wt \qquad - - - - - - - 2.4^*$$

$Q = wt = 0$ {angle between the coil windings}

$\therefore E_{rms} = 4.44F \varnothing_m \text{Cos } wt = 4.44 F \varnothing_m$

$e = 4.4 F \varnothing_m$ - - - - - - - - - - 2.4

Total number of induced e.m.f./ turn in the primary is

$E_1 = 444 F N_1 \varnothing_m$ - - - - - - - - - - 2.5

$E2 = 4.44 F N_2 \varnothing_m$ - - - - - - - - - 2.6

Where E_2 is for secondary and N_1 and N_2 primary and secondary number of turns respectively.

From equation (2.5) and (2.6)

$$\frac{E_1}{E_2} = \frac{N_1}{N_2} = K$$

Where k is the voltage transformation ratio.

However the transforms chosen for this power supply is 240/15V. This has the ability of giving peak voltage of $\sqrt{2} \times 15 = 21.2V$.

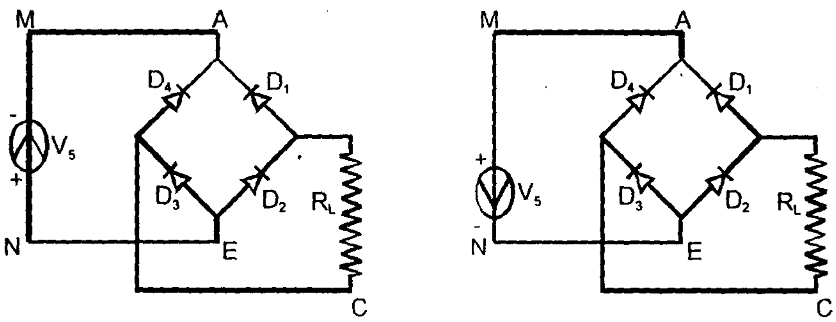
2.2.2 RECTIFICATION

This is the process of converting A.C voltage to a D.C type by the use of 'Diode'. Which in this full-wave rectifier is used.

RECTIFIER

This is an electronic device that offers a low resistance to flow of current in the direction known as reverse bias direction. The circuit that employees rectifier is called 'rectification circuit'.

Rectification can be done with half-wave, full-wave or half-wave centre tapped, but full-wave bridge rectifier is used, which is the more common for electronic circuit. Full-wave bridge rectifier consist of four discrete diodes incorporated together to form bridge rectifier circuit. [5] The full-wave bridge rectifier circuit is a s shown in figure 2.4 (a) and (b) below.



(a) (b)

FIG 2.4 **Negative and positive half –cycle of bridge rectifier circuit.**

During the Negative input half-wave, the secondary terminal N becomes positive and M as Negative. Note that D_2 and D_4 are forward bias and current flow along the path NEBCDAM as shown in fig 2.4(a) hence keep current flowing through load resistance R_L in the same direction. [3.5], the output wave form is shown in figure 2.5.

During the positive input half-wave. the secondary terminal M is positive and N is negative, hence diode D_1 and D_3 become forward biases (conduct), while D_2 and D_4 reverse (block) biased. This result in current flowing along MABCDEN path producing a drop across R_L (Load resistance).

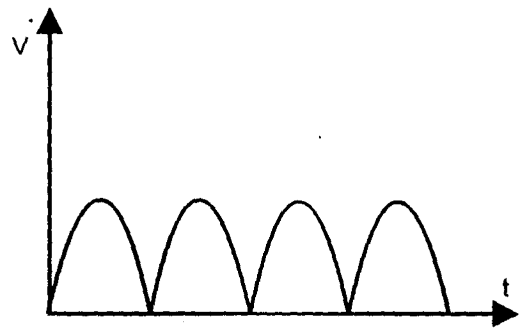


FIG 2.5 **Output wave form of a bridge rectifier.**

2.2.3 FILTRATION

This is a process of removing excess A.C voltage or fluctuations which appears as 'ripples' in the output voltage of a rectified A.C by using filters.

A filter consist of a single capacitor connected across a pulsating D.C voltages, which smoothens out the ripple voltage. This function of capacitor is due to its property to change and store energy during Non-conducting half-cycle. The effectiveness of capacitive filter is determined by three factors:

(i) Size of the capacitor

(ii) The value of the load

(iii) Time between pulsations (ripples)

The ripple voltage is given by

Vr = Vpp – Vrms - - - - - - - - - - 2.8

Also, Vr = Idc - - - - - - - - - - 2.9

But,

$X_c = \frac{1}{2 \pi f c}$ where $V_r = X_c \; I_{dc}$ - - - - - - 2.9*

Equate the equation

$$Vr = (Vpp - Vrms) = \frac{1}{2\pi fc} Idc$$

$$C = \left(\frac{Idc}{2\pi f} \quad \frac{1}{V_{pp} - V_{rms}} \right)$$

But Idc = Idc/2π

Hence:

$$C = \frac{Idc}{2F (V_{pp} - V_{rms})}$$

Where:

$$Idc = \frac{2}{\pi} Irms \times \sqrt{2}$$

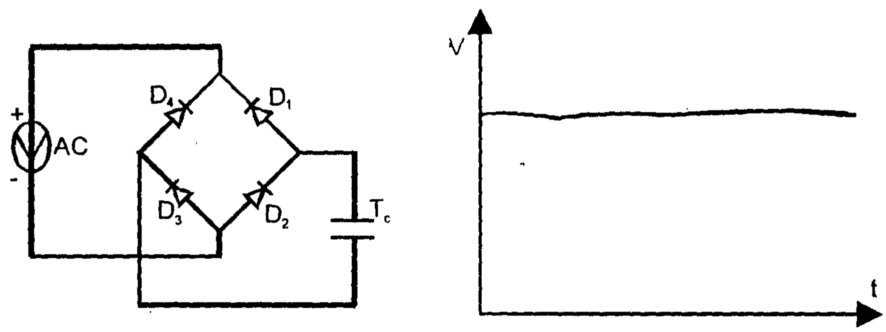


Fig 2.6 **Shows bridge rectifier filter circuit and output wave form**

2.2.4 VOLTAGE REGULATION

The next stage of Power supply is the voltage regulation which makes use of voltage regulator to keep the terminal voltage of D.C supply constant even when A.C input voltage to the transformer varies or the load varies.

Power supply circuit suffers from the draw back that their D.C output voltage change with changes in loads or input voltage. Such D.C power supply is unregulated.

Regulated power supply is obtained by using a voltage regulator circuit. There are various types of regulator circuit such ad Zener diode shunt regulator, transistor series voltage regulator, switching regulators and so on.

All the above mentioned circuit are made from discrete components. The type of voltage regulator used in this project is the Integrated circuit (IC) voltage regulator for D.C voltages. This IC has more improved performance as compared with the other discrete component mentioned. They have unique built-in features such as current limiting self-protection against over temperature and fold back current limiting. [5]

2.3 CONTROL/SENSORY UNIT

This unit concern with detail analysis and operation of the component that make the control/sensory unit. It comprises of series combination of photo-detector and operational amplifier (op-amp) acting as a voltage comparator that compare the voltage of two input signals.

2.3.1 PHOTO DETECTOR

Photo detector are semi-conductor devices that can detect or sense optical signal through electronic processes. They convert the optical signal variation into electrical signal variation that are subsequently amplified and further processed. The photo detector used in this project is a photo resistor. It is also known as the LDR, that is Light Dependence Resistor.

THE LDR SENSOR

Light Dependent Resistor(LDR) Sensor is a photo conductive cell, semi-conductor devices which resistance varies with the intensity of light that falls on it.

This is known as the Actino electric effect. the property whereby contain materials change their electrical resistance or generate a voltage on exposure to light.

The LDR, which is also known ass photo resistor operates on the principle of photo resistively. It acts as light sensitive variable resistor in a current path.

THEORY:

The resistively or change in resistance of a semi-conductor depends on the number of free charge carriers available in it, when the semi conductor is not illuminated, the number of charge carriers is small and hence resistivity is high. But when light in form of photon strikes (photo emission) the semi conductor each photon delivers energy to it, if the photon energy is greater than the energy bond gap of the semi conductor, free mobile carrier are liberated and as a result, resistivity of the semi conductor is decreased.

Cadmium Sulphide (cds) and Cadmium selenide (cdse) which are cadmium compound are part of the general make up of phot conductive cell.

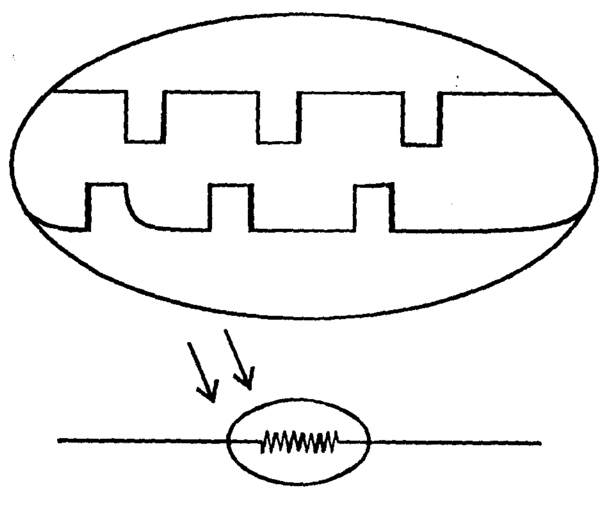


Fig 2.7 **Typical structure and symbol of LDR.**

2.4 OPERATIONAL AMPLIFIER

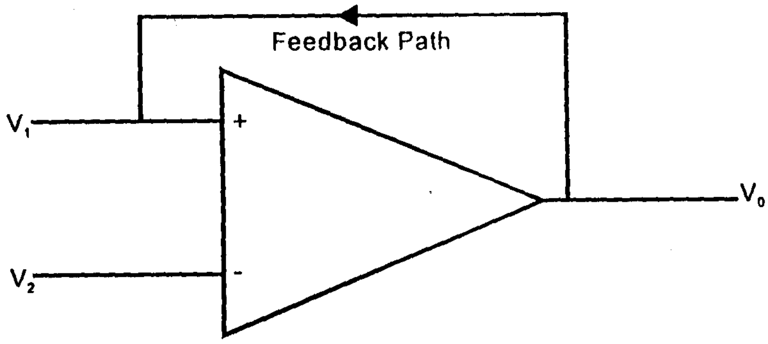


Fig 2.8 **Circuit Symbol of op-amp**

There are different types of Operational Amplifier (op-amp). They are: Inverting amplifier, Non-inverting amplifier, Simmer (Adder), scale amplifier, Differentiator, integrator and comparator. For the purpose of this project op-Amp is used.

2.4.1 PROPERTIES OF AN IDEAL OP-AMP

There exist two golden rule for understanding op-Amp

(I) The input current draw by the op-Amp is zero(0)

(II) The output voltage is the difference between the two input voltages.

Other properties are as follows:

(i) The input impedance is infinite

(ii) The output impedance is zero

(iii) The open loop gain approaches infinity

(iv) Bandwidth is infinite

2.4.2 COMPARATOR CIRCUIT

Comparators are special types of op-amp circuit without Feedback used to compare signal voltage on one of the input terminal and reference voltage on the other input terminal.

When the signal differs from the reference voltage, the output of the comparator from low to high or vice versa is registered. Figure 2.9 shows a comparator circuit. [5]

Signal input is connected tot the inverting input, when Vi is greater than Vref the output voltage Vo goes high, but when Vi is less than Vref, the out put goes low. The comparator can drive a transistor to control variety of devices such as lamps (street light), heaters and motors etc.

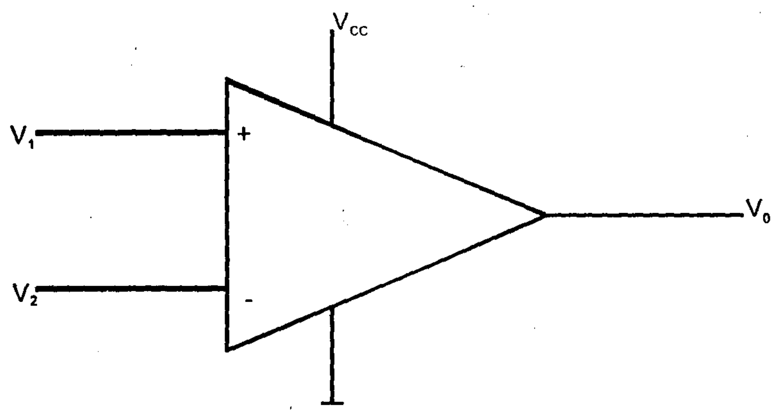


Fig 2.9 **Schematic of a comparator.**

2.5 SWITCHING UNIT

The switching unit comprises of transistor and a relay for triggering the circuit with response to the signal from the control unit.

2.5.1 TRANSISTOR

A transistor is a current amplifier. It is a three terminal semi conductor device usually manufactured from either silicon (si) or Germanium (Ge). They are basically used as either for basically two types of transistors, the Bipolar junction transistor (BJT) and the Field Effect Transistor (FET). FET is better for high frequency response like in micro controllers in

The BJT consist of two junction diode available in two basic convention, namely:

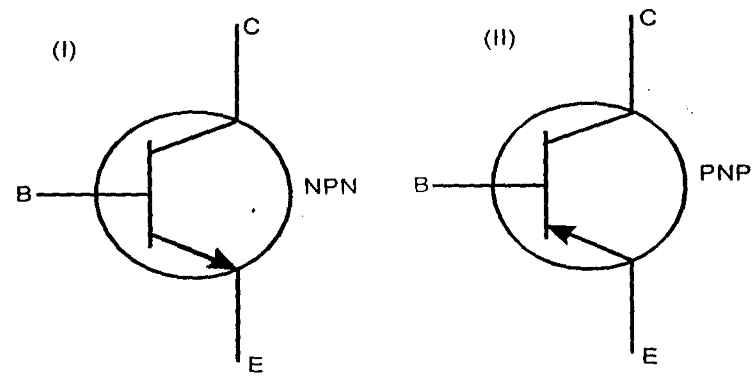


Fig 2.10 **Transistor Symbols**

Its properties meet the following rule:

(1) The collector must be positive than the emitter

(2) The base-emitter and base collector functions behave like diode (npn = np : pn)

(3) Any given transistor has maximum value of Ic, I_B and V_{CE}

(4) If rule 1-3 are properly observed, Ic will be approximately proportional to I_B

$Ic = hfe\ I_B - BI_B$ [4, 5]

2.5.2 THE COMMON-EMITTER CONFIGURATION

There are three basic transistors (BJT) configuration. They are common-base (CB), common-emitter (CE) and common-collector (CC). Common-emitter (CE) is used in this work because of its high value of current gain, voltage gain and power gain at reasonable high resistance as compared to other configuration. [2]

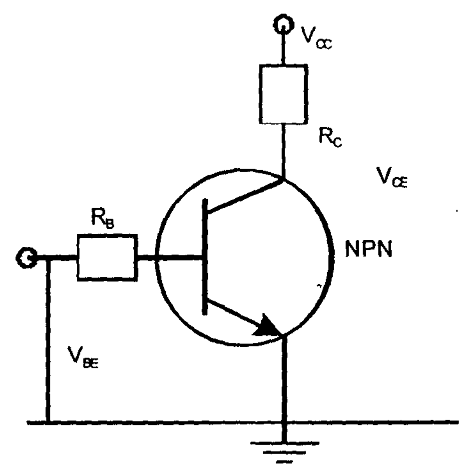


Fig 2.11 **Common-emitter configuration of transistor**

The CE configuration has a grounded Emitter, which is common to both base and collector as shown in figure 2.11 above. In CE, the input current and output voltage are taking as independent variable. while the output current are dependent variable and written as:

$V_{BE} = f_1 (V_{CE}, I_B)$ .... (1) Input characteristic curve

$I_C = f_2 (V_{CE}, I_B)$ .... (2) Output characteristic curve

The curves are shown in the figure below:

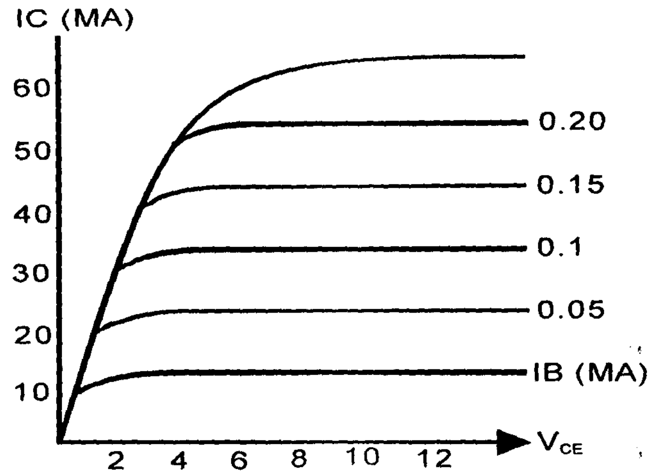


Fig 2.12 **CE Characteristic curve**

2.5.3 TRANSISTOR AS A SWITCH [2, 3, 4]

Not only does transistors function as signal amplifier, they are also used as switch (electronic switch). An ideal transistor switch works on the common-emitter configuration (CE), which is so conditioned to bypass linear state of its function by going extremes of: 'Saturation region or the cut-off state'. In the switching circuit of figure 2.13(a), if the voltage in the base-emitter function is reverse biased (R/B) as well as that of collector-emitter is R/B, the circuit operate at 'cut-off state' that is point 2, in figure 2.13(b), the collector current (output current) is practically zero, except for leakage I_{CO}, V_{CE} is almost equal to V_{CC}. Hence at cut-off the transistor switches whose contact is the collector-emitter terminal will open.

When a positive voltage is applied to the terminal, such that the base-emitter as well as the collector-emitter are all forward bias (F/B), then the voltage drop on the load (V_{CE} or V_O) will approximates V_{CE} 0. Hence, maximum collector current (I_{CCmax}) will trigger the switch to 'saturation state' point 1 in figure 2.13 (b).

This two distinct state are made 'OFF' and 'ON' state (that is 'cut-off' and 'saturation' respectively).

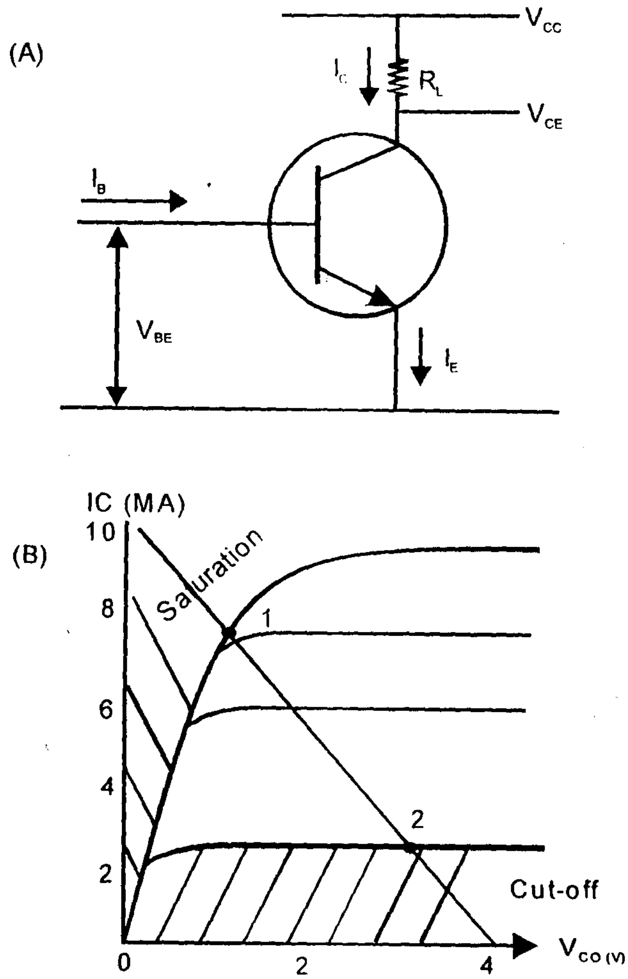


Fig 2.13 (a), (b) Diagram of transistor switch and its output wave-form

(i) Saturation state (Closed Switch)

(ii) Cut-off State (Open state)

No output current to close the circuit

BJT has zero power consumption in switching mode while no heating effect (since the transient state is bypass) The characteristics of switch result in large power gain, [2,5].

2.6 RELAY

Since the load, which is a bulb (220. 15W), is not electronic circuit, it requires large power handling switch like, relay triac circuit breaker, etc. Relay is chosen because of its range of current handling.

A relay is an electromagnetic device that open or closed contact to effect the operation of another device in the same circuit from mains, they are used as protective and control device, used as switch. However in this project it is been used for switching.

2.6.1 PRINCIPLE OF OPERATION OF RELAY

Relay operate on the principle of electromagnetic induction (Attraction). As shown in figure 2.16 below, when the terminal 1 and 2 are connected to source, an electromagnetic field is form, the armature is attracted to the core. It there is sufficient current to overcome the restoring force of the spring, it will force contact 3 to close with contact 4 open, thereby making the relay open and close contact. [2]

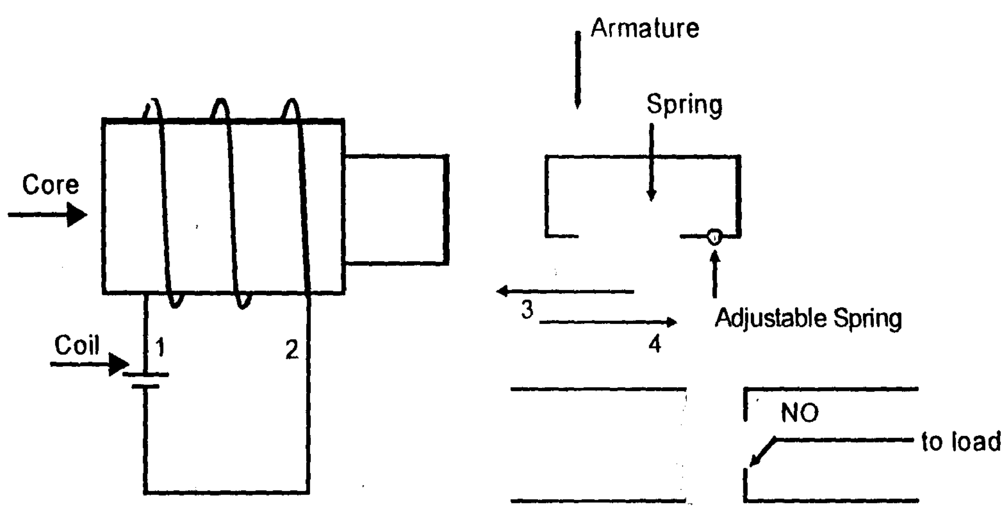


Fig 2.14 **Schematic diagram of Relay and its Symbol**

2.7 ZENER DIODE

The Zener diode is a junction diode that has specific reverse breakdown voltage. Unlike the rectifier diode, Zener diode operate at its breakdown voltage. Figure 2.15 shows the characteristic curve of Zener diode when reverse bias no current flow until reaching its breakdown voltage when current suddenly begins to flow. In forward bias, it works like any other diode. the breakdown voltage across the Zener remain constant, while current increase largely.

Zener diode are used for shunt stabilization for voltage reference as used in this project to discriminate the reference voltage of the comparator with respect to signal voltage. [5]

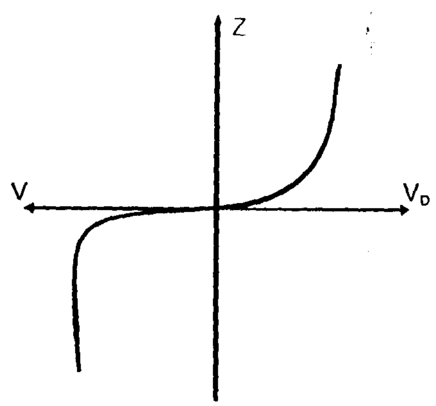


Fig 2.15 **Characteristic curve of Zener Diode**

2.8 LIGHT EMITTING DIODE

Light emitting diode (LED) is a semi conductor device which emits visible light when forward biased. The colour of the emitting light depends on the type of material used and are always encased to protect their delicate views. It is rugged and has a life of more than ten thousand hours. The symbol of the light emitting diode is shown in figure 2.16 [3]. It is been used in this project as a limiting Register.

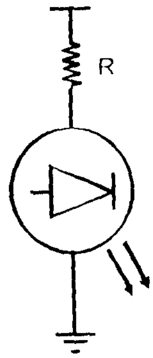


Fig 2.16 **Symbol of LED**

CHAPTER THREE

3.0 INTRODUCTION TO SYSTEM DESIGN

System design is the process of analyzing and determining component values to specification required on appropriateness of the target goal. When design street light controller it is required to study the specification providing the manufacturer in component data book.

The design work was carried around the following subsystem:

- Power Supply unit
- Light detector / controller unit
- Switching circuit unit
- AC Power Switch / load unit

3.1 POWER SUPPLY UNIT

The power supply comprises a 12V / 0.5A transformer wired to a full-wave bridger rectifier to produce a D.C. voltage that is smoothened by a 25V / 1000µf capacitor and regulated by a 7808 (8 volt 1amp) regulator. The wiring is shown below in fig 3.0

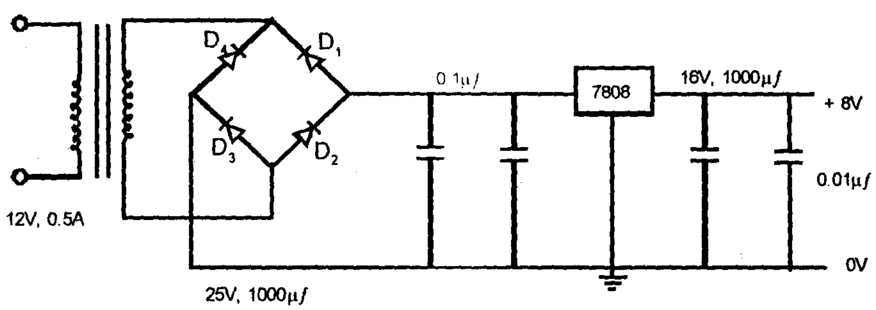


Fig. 3.0 **Power Supply unit**

The 12V rms secondary voltage was converted to a pulsating DC voltage with an amplitude.

$V_{peak} = [\ V_{rms} \times \sqrt{3} - 1.4]\ V$ - - - - - - - 3.1

Where:

Vpeak = peak amplitude rectify voltage factor

1.4 = two diode forward voltage loss in the rectifier

The value of the smoothing capacitor was calculated from:

Ø = It = CV

CV = IT

Taking differential on both side

CDV = TDI

C = Value of capacitance

DV = Ripple voltage on DC output

T = $^{1}/_{2F}$ = ½ x main frequency

DI = Average current change

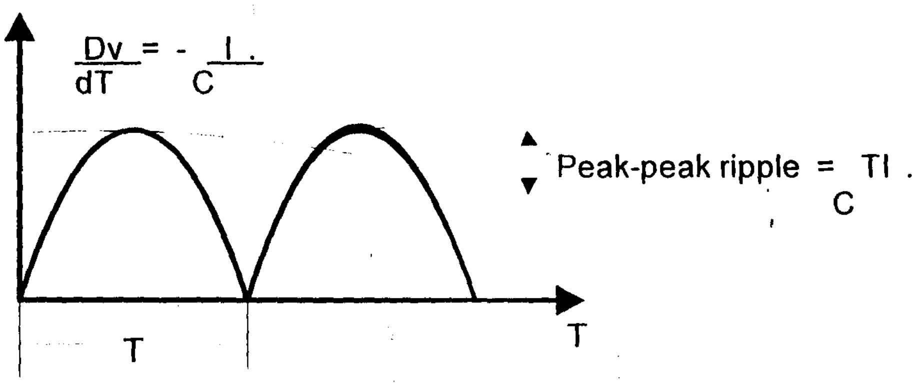


Fig. 3.1 **Relationship between rectified DC voltage and superimposed AC ripple voltage**

There is a worst – case design of ± 10% line-voltage variation the ripple as to be kept less than 2 volts peak – to – peak

Therefore:

2 = T (dv / dt) = IT/C

To deliver 0.5A from the DC source

$2 = {}^{IT}/_{C} = {}^{0.01 \times 1}/_{C}$ - - - - - - - 3.3

From which C = 2500μF. A 25 volt electrolytic capacitor was choosen.

A 1000 μF capretance was used, instead as the circuit draws less than 0.5A at maximum current drain.

The smoothened DC voltage was feed into on 8 volt, 1 amp regulated, where it was regulated down to 8V to power the system

3.2 LIGHT DETECTOR / CONTROL UNIT

The light detector was design around a Cds Light dependent Resistor (LDR). Whose resistance varies inversely with the amount of light reaching its sensitive surface.

The LDR's resistance change is converted to a voltage change by the circuit shown in fig. 3.2

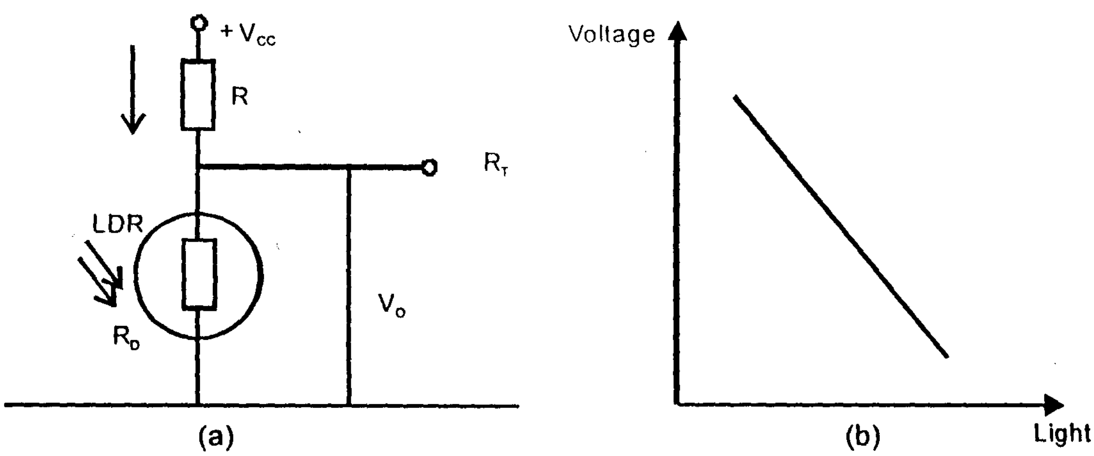


Fig. 3.2 **Resistance – voltage variation (a) circuit (b) curve**

The variation of the LDR's resistance causes RT (Total divider Resistance) to change in effect causing a change in I.

The voltage V_O across the LDR is then given by:

$V_{D\,(LDR)} = I\,R_{D\,(LDR)}$

$$= \left\{ \frac{V_{CC}}{R + R_D} \right\} \quad X \; \frac{R_D}{1} \qquad - \; - \; - \; - \quad -3.4$$

From the equation above:

$I \approx 1/R_D$ and $V_O \; \alpha \; 1 / R_D$

The plot of the relationship between Ambient light level reaching the LDR and the output voltage of the potential divider is shown in fig. 3.2

R was made fairly large relative to the in light resistance of the LDR (measure at about 1 KΩ and also relative to the dark resistance of about 250 KΩ.

1.1 SWITCHING CIRCUIT

The switching circuit comprises of 741 operational amplifier (op-amp) and resistor establishing the switching threshold. The switching circuit is exemplified below in fig. 3.3.

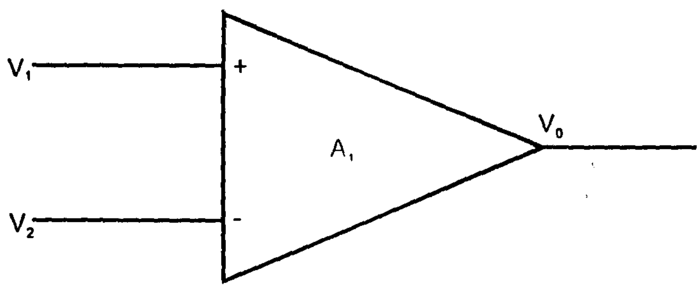


Fig. 3.3 **DC Comparator**

A comparator is op-Amp without positive feedback, it forms the basis of switching subsystem. A compare for is a high gain DC amplifier whose output voltage is the difference between the two applied inputs voltages (V_1 and V_2).

For the comparator shown above.

If $V_1 > V_2 \Rightarrow V_0$ = high (output V_O, is high)

If $V_1 \not> V_2 \Rightarrow V_0$ = low (output V_O, is low)

However, when V_1 and V_2 are very close together or the input voltage varies slowly, the output voltage is no longer deterministic i.e. The output V_O, randomizes or become transient output, between high state and low state.

To prevent this oscillation (transient. state) positive feedback is employed to provide snap action response

The modified comparator with positive feedback is shown in fig 3.4.

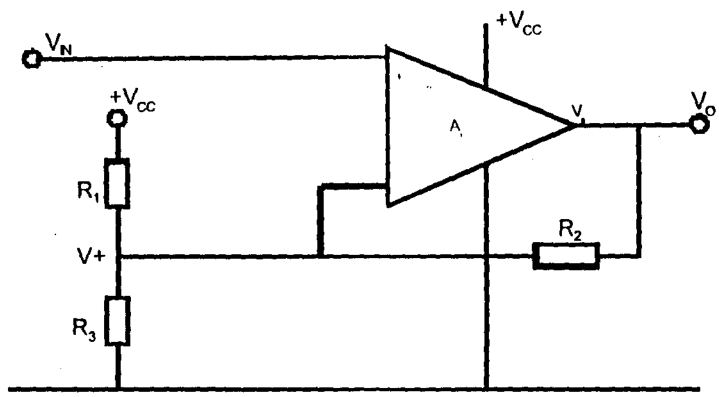


Fig. 3.4 **Comparator with positive feedback**

The circuit above has two separate well defined switching thresholds:

V_{ON} and V_{OFF}.

Assuring the output is initially at HIGH

$$V_{SWITCHES}(1) = V_t(1) = \frac{V_{CC} \times R_3}{(R_1 || R_2) + R_3}$$

With the output at low:

$$V_{SWITCHES}(2) = V_t(2) = \frac{V_{CC} \times (R_2 || R_3)}{R_1 + (R_2 || R_3)}$$

The difference in the switching thresholds i.e. $V_{t(1)} - V_{t(2)}$ is the hysterisis.

Assuming equal value of network resistance as used in the design.

$R_1 = R_2 = R_3 = 33K\Omega$

$$V_{+(1)} = \frac{8 \times 33}{(33//33) + 33} = \frac{8 \times 33}{16.5133} = \frac{8 \times 33}{49.5} = 5.33V$$

$$V+(2) = \frac{8 \times (33//33)}{49.5} = \frac{8 \times 16.5}{49.5} = 2.66V$$

Clearly, V+ (1) = 2/3 VCC and V+(2) = 1/3 VCC respectively.

The implication of this, is that circuit switches ON and OFF at two different voltage. The inherent hysterisis prevents random switching when the input voltages are closed together.

The light detector was wired to the Schmitt trigger as shown below:

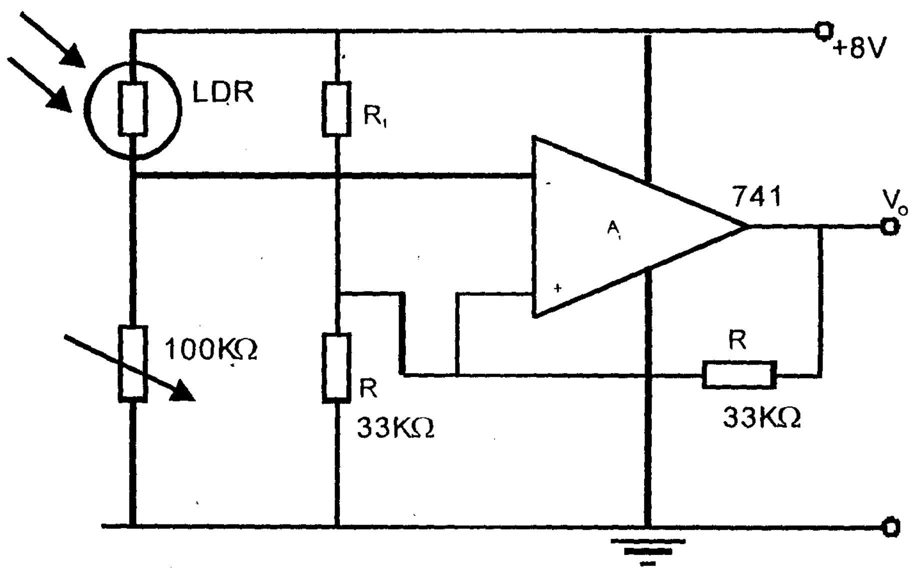


Fig. 3.5 **Light Detector and switching circuit**

The resistance values were chosen to prevent the least loading on the power supply. The 741 (op-Amp) has a bipolar junction transistor (BJT) architecture and hence the output does not provide a end-to-end swing. It was discovered that when the output was supposed to be at OV 1.7V was measured. In consequence, when a transistor is connected directly to the output of the comparator, there will always be On state. To avoid thus three-series-connected rectifier diode was wired to the 741 (Comparator) output, before driving the transistor that switches the relay. This is shown in fig. 3.6

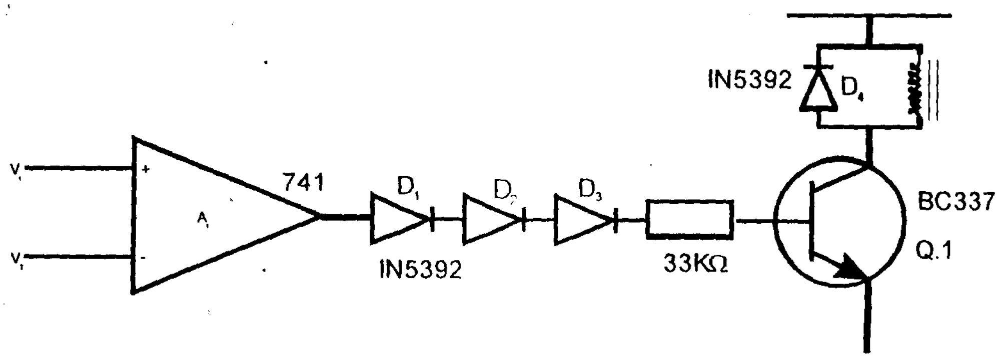


Fig. 3.6 **Circuit connection of switching unit.**

D_1 – D_3 used to provide standing logic OV DC, output D4 protect BC 337 transistor against damage.

The BC 337 transistor has a typical gain of 200. The relay has a resistance of 400Ω at a nominal coil voltage of 6V.

$$I_{COIL} = \frac{V_{coil}}{R_{coil}} = \frac{6}{400} \quad 15mA$$

Ic – Collector current is used to drive the relay hence:

$I_c = I_{COIL} = 15mA$

$$I_c = \beta\, IB: IB = \frac{I_c}{\beta} = \frac{15mA}{200} = 75\mu A$$

But:

$$R_B = \frac{V_B - V_{BE}}{I_B} =$$

Where:

V_B = 741's high state output at positive saturation = 6.5 V_{ON}

V_{BE} = 0.7V (Siticon semiconductor)

V_{BE} = $(3V_F + 0.7)$ = 2.8V

Where: VF – forward biasing of the diode D_1 D_3 (Also silicon)

$$R_B = \frac{6.5 - 2.8}{75 \times 10^{-6}} = 49K\Omega$$

Allowing for overdrive of 1.5V (i.e. 6.5 – 6.0). hence the base resistance was reduced to 33KΩ

3.4 AC POWER SWITCH / LOAD UNIT

The power switch comprises a relay and BC 337. The relay is on electromechanical switching device, whose switching characteristics can be altered by passing current through the Armature mounted on electromagnet called the core.

A relay with change-over contact was used. One of the two 240 – Volt feed was connected t the NO contact, since it is desired to energize the relay, and turn-ON the connected bulb (Load) when 741 switches high.

The complete wiring for the power switch is shown below:

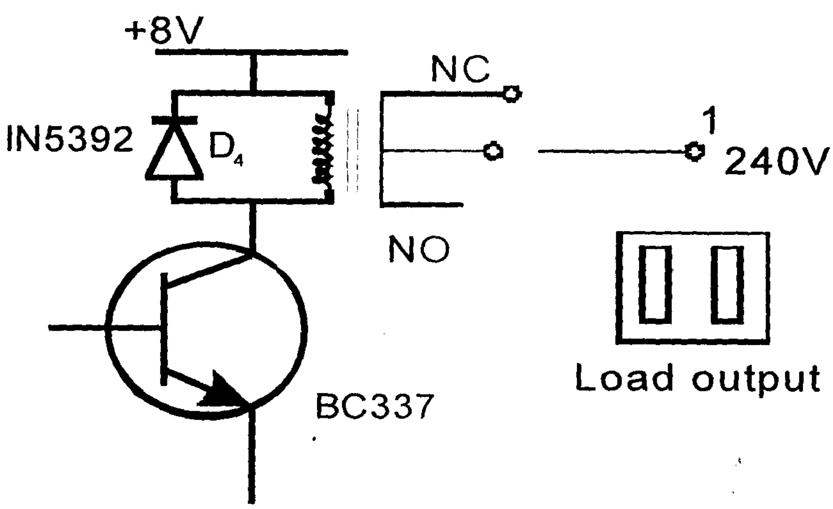


Fig. 3.8 **AC power switching circuit**

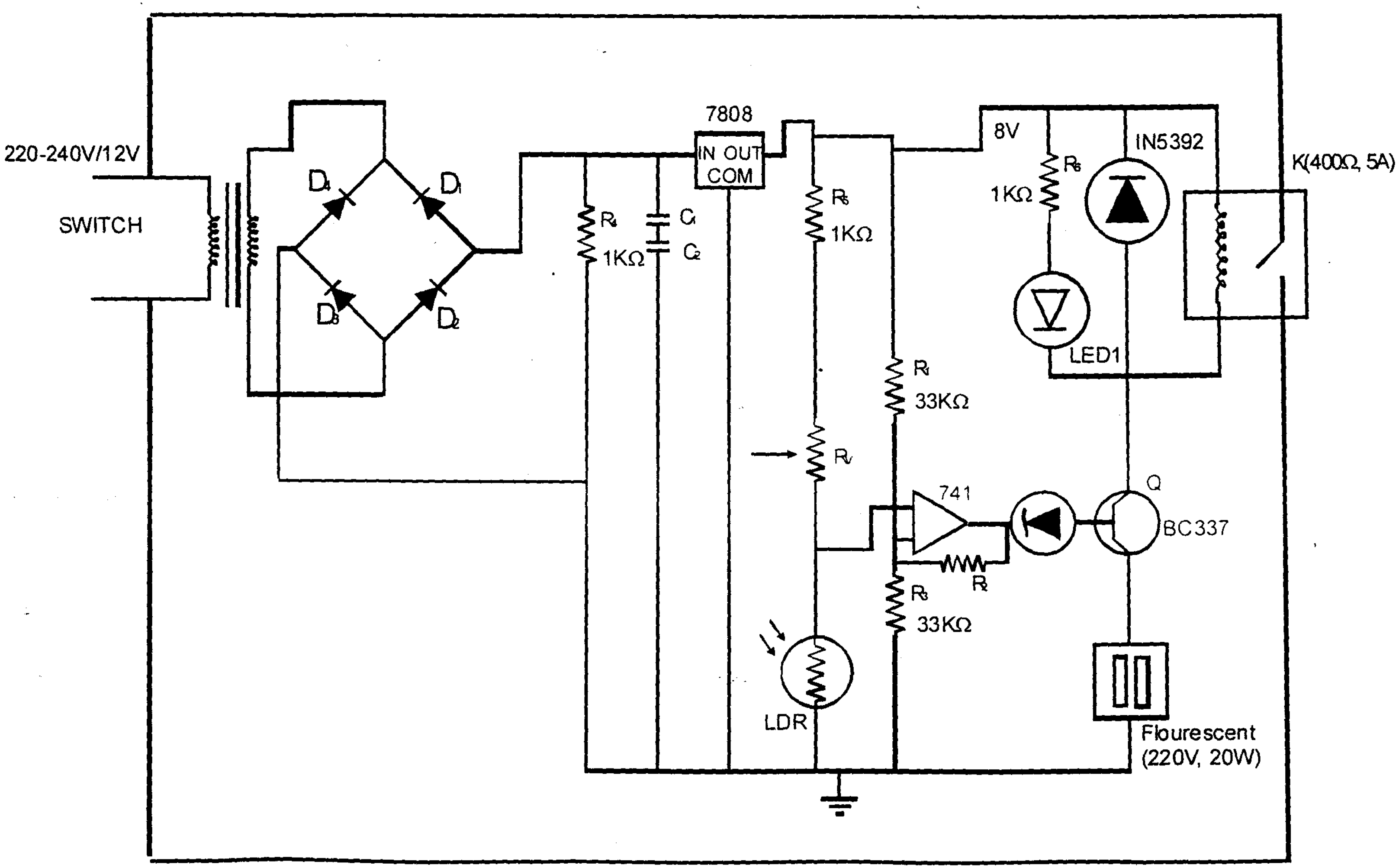


FIG. 3.9 COMPLETE CIRCUIT DIAGRAM

CHAPTER FOUR

4.0 CONSTRUCTION AND TESTING

4.1 CONSTRUCTION

This is the process of putting together all varies components of the various subsystem of the controller discussed in the previous chapter on bread board and tested. The satisfied results where then mounted on vero-board and soldered.

The construction process depends on the circuit diagram shown in figure 4.3

4.2 COMPONENT TESTING

This involves testing each component used in this project, using MULTIMETER so as to ensure good exact component are used in conformity with design circuit. This is necessary because the use of faulty component could result in malfunctioning of the design.

4.3 EXPERIMENTAL SET-UP

The block of the circuit below illustrate the experimental set-up of street light controller system. The supply is 8V d.c. source. This is used to supply the circuit at +8V with a maximum current of 0.5A. The oscilloscope was used to monitor the voltage level at different points, while the multimeter was used in testing the readings.

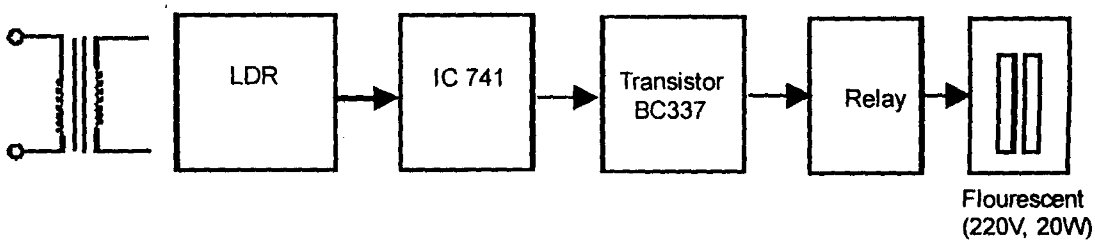


Fig. 4.1 **Block diagram of street light controller**

4.4 SYSTEM OPERATION

The complete circuit diagram of figure 4.3 below shows that the LDR and variable resistor RV constitute a voltage divider network which forward biases the emitter base of Q. When enough light facts on the LDR it resistance is low, the develop voltage across LDR is inadequate to drive Q sufficiently to energize the relay (R) so Q is cut off and no power is applied to the load. However when there is little or no illumination on the LDR, the resistance increases dramatically.

The voltage at the surface of the LDR rises. If the component of the circuit are properly chosen enough forward bias of the base-emitter is developed to increase the collector current appreciably. This current energizes the relay coil thereby closing the normally open contact, thus power is applied to the load. However, the load been a street light bulb will be turn – ON automatically as night falls and turn – OFF at daybreak.

R_V is a sensitivity control, which is adjusted for the level of light as desired to turn off the bulbs.

4.1 SYSTEM TESTING

During testing, the contact terminal of the relay were connected to t bulb (220V, 20W). With the supply of 12V d.c.. 0.5A, is turned ON. The bulb turn – ON as light intensity decrease and turn – OFF as the intensity increases.

4.2 CASING CONSTRUCTION

An perforated ceiling board casing was used to house the designed circuit after completion.

It is been perforated to given ventilation (because temperature the working reliability of most electronic components) and heart dissipation from the transformer and other component. The case dimensions is shown below in figure 4.2.

4.2.1 FACTORS CONSIDERED BEFORE CHOICE OF DIMENSION

i. Space occupied by the component

ii. Portability of the project

iii. Allowance (space) for heat dissipation

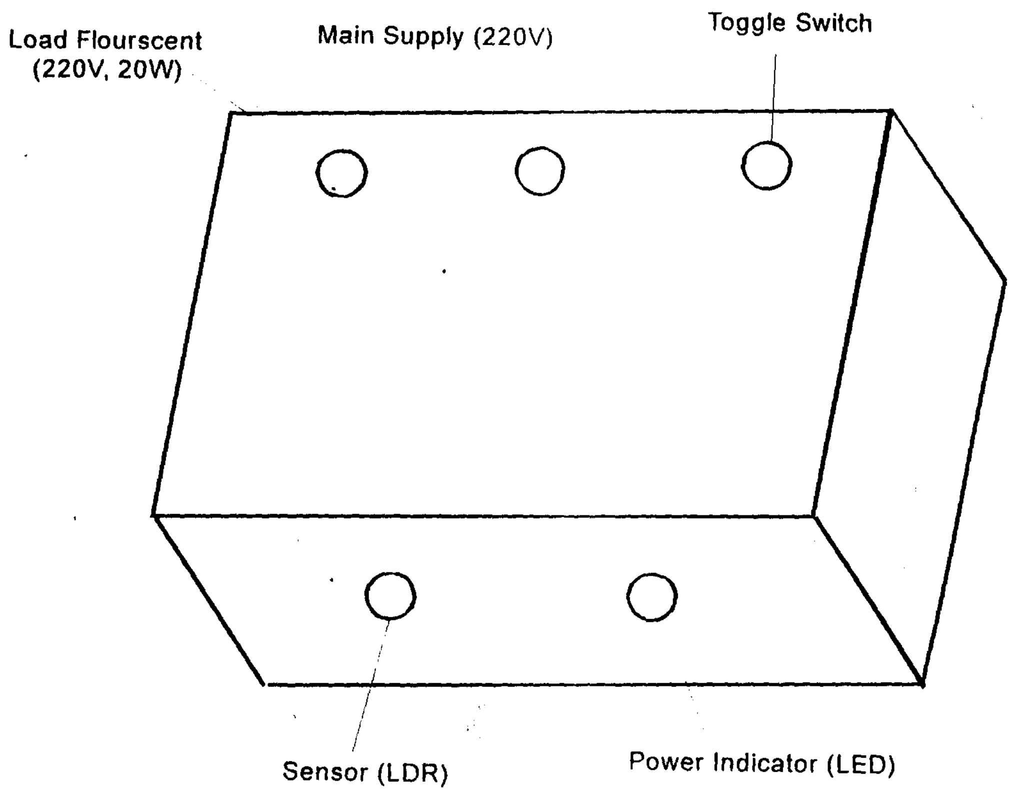


Fig. 4.2: **Case Design**

4.3 RELIABILITY AND PRODUCT LIFECYCLE

This electronic system works for approximately 12 hours (with average of strong necher and sunny evening) i.e. between 7pm – 7am. Electronic components do follow a constant failure rate (CFR) curve of the bathtub model with reliability

$R = e^{-\lambda T}$ - - - - (4.1)

Assuming the project last for a year 365¼ days, for 12 hours each, the reliability if given.

Table 4.3: Calculating reliability of the system [6]

Component	Number used ni	Basic failure rate (% 10^3 hr)	Weighting factors to			Overall failure rate λ_{oi} =niλi wewtwr %/10^3 hr)
			Environment WE	Temperature WT	Rating WR	
Transistor	1	0.08	2.00	1.50	2.00	0.48
Diode	9	0.05	2.00	1.50	1.50	2.025
Capacitor	4	0.2	2.00	1.50	3.00	7.20
Transformer	1	0.01	1.50	1.50	1.50	0.03375
LDR	1	0.06	2.0	1.50	1.50	0.270
Resistor	6	0.05	2.0	1.50	2.0	1.80
Relay	1	0.02	1.50	1.50	1.50	0.0675
741	1	0.05	2.00	1.50	1.50	2.25
Connector	50	0.001	2.0	1.5	--	0.15

$\lambda_1 = \Sigma\lambda_{oi}$ = 13.327% 110^3 hours

From the result we obtain failure rate

λ_T = 1348% 110^3 hours

Or λ_T = 0.135 110^3 hours

Total operating time, t_t = 365 ¼ x 12 hours 4383 hours

System reliability

$R(t) = e^{-\lambda t}$

$R(4838) = e^{-0.135x4383x10^{-3}}$

= 0.56

i.e. the system is reliable up to 56% its design characteristic for one year when operated for 12 hours.

4.4 COST ANALYSIS

Cost plays a vital role in any engineering design and construction. The cost of any project determines how prosperous that particular project is going to be used. Inview of this, the cost estimation of the street light controller is shown in the table below:

Table 4.4 Cost estimation of system

S/n	Items	Quantity	Cost (₦)
1	240/12V transformer	1	300.00
2	Rectifier diode	9	150.00
3	741 – op – Amp	1	120.00
4	Capacitor	4	60.00
5	Regulator	1	80.00
6	LDR	1	860.00
7	Resistor	6	200.00
8	LED	1	40.00
9	Transistor	1	100.00
10	Zener diode	1	60.00
11	Relay	1	300.00
12	Flexible connecting wire	1	150.00
13	Connector	1	100.00
14	Vero boad	1	180.00
15	Woden casing	1	200.00
16	Lead	1	200.00
	TOTAL		**3,100.00**

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 APPLICATION AND LIMITATION

The streetlight controller designed and constructed has many applications depending on the input signal from the senor. Apart from the street light it has application in automatic door control, automatic switch control, security lighting and many other useful applications. This design may not be applied directly to three – phase streetlight, unless a contactor is incorporated in the circuit for high durability of the system.

5.2 PROBLEMS ENCOUNTERED

The various problems encountered are

i. Finance

ii. Non-availability of some component

iii. Component setting in bread board and vero board

iv. Soldering problem

5.3 RECOMMENDATION

The design has been achieved by using discrete component such as resistors, transistors, diode and simple regulating IC etc. where the exact value of a component could not be found equivalent value is used.

Due to sensitivity of this work, further work is necessary to improve on the performance and high efficiency.

5.4 CONCLUSION

The aim of this project is to design, construct and test an automatic streetlight controller, which have been achieved. Infact, the setup was tested with a florescent lamp for a period of 24 hours, the desired result was obtained.

A lot of experience has been acquired in this project within the time available. I apply most of the knowledge acquired in the class room to practical life problem.

In conclusion, this project in addition to its motive have exposed me to some problem encountered in electronic / electrical design work and behaviour of instruments, the general precaution need in design, construction and testing, it has exposed me also to some of the challenges expected of a university graduate.

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