DESIGN AND CONSTRUCTION OF AN AUTOMATIC STREET LIGHTING CONTROLLER

BY

ADAMU MOHAMMED

2004/18770EE

A THESIS 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 DEGREE (B.ENG) IN ELECTRICAL AND COMPUTER ENGINEERING.

NOVEMBER 2009

DEDICATION

This project is dedicated to God Almighty who Has given me the grace to live, and to the entire Adams family for their support and prayers all through my stay in the university.

DECLARATION

I ADAMU MOHAMMED with matriculation number 2004/18770EE, declare that this work was done by me and has never been presented elsewhere for the award of degree. I also hereby relinquish the copyright to the Federal University of Technology,

ADAMU MOHAMMED

18/12/09

Signature and Date

ENGR. A.G. RAJI
(Supervisor)

Dec 18, 2009

Signature and Date

ENGR. Dr. Y. A. ADEDIRAN
(Head of Department)

(May 6, 2010)

Signature and Date

EXTERNAL EXAMINER

03/03/10

Signature and Date

ACKNOWLEDGEMENT

My endless gratitude goes to Almighty God who for His mercy and protection led me successfully throughout my stay in F.U.T, Minna.

I sincere appreciate my beloved parent; Adamu Adah, Jumai and Ramatu Adamu for their love, prayers, support, care and encouragement. Much love goes to my sisters; Adijatu, Aisha, Fatima, Sa'adatu and my brothers; Abdulmalik, Suleiman, Usman, Kabiru, Abdulrahman for the love and belief they have in me.

I adore with passion the support from my bros, Adegbe, Mariam and Amina Atuluku for coming to my rescue during my project work.

Special thanks to my supervisor, Engr. A.G. Raji whose experience; suggestion and guidance have immensely contributed to the success of this project work. Not forgetting the contribution from my technician Mallam M.B Isa Doko.

Furthermore, my sincere gratitude to my H.O.D. Engr. Dr, Y.A.Adediran for his fatherly advice, the entire staffs of Electrical and Computer Engineering Department for the knowledge contributed in making me a future leader and to all the final year (500L) Electrical and Computer Engineering Student of 2009.

Finally, I deeply appreciate the company and support of my friends; Osadebanwen, Collins, Nicholas, Abdulrahman, Ahmed, Abraham, Basil, Blessing and Rose of global palace. Not forgetting Umoren family; Blessing, Christiana, Mercy, I love you all

ABSTRACT

This project is on the design and construction of an automatic streetlight controller using a Light dependent resistor (LDR) as the sensor.

The project is designed to improve upon the system of streetlight controls which has evolved from the use of electrical components (such as contactors, heavy cables and panels which are very heavy, complex and laborious to install).

Light dependent resistor are better sensors of light and if utilized for the control of streetlights, whose operation is dependent on natural outdoor lighting, then a more efficient and effective streetlight system will be achieved as the triggering of the streetlight will be much more dependent on the environment and not just the circuitry.

TABLE OF CONTENT

CONTENT

CHAPTER ONE

CHAPTER TWO

CHAPTER THREE

CHAPTER FOUR

CHAPTER FIVE

LISTS OF FIGURES

CHAPTER ONE

1.1 INTRODUCTION

The discovery of devices dependent on light like photo-resistors, photocells, photo-transistors which make use of simple sunlight energy to generate electric energy has greatly reduced the involvement of mankind in power switching operation. As a result of this, man made errors are reduced and life becomes more comfortable to live.

The Automatic Street Lighting Control System is an electronic device that involves the natural switching ON when it is dark (at night) and switching OFF when there is any source of light (during the day).

The circuit design requires a 13V dc power supply for operation. The circuit is designed using a light dependent resistor (LDR) as the sensor and an operational amplifier as the comparator for comparing night and day voltages across the LDR sensor. As light falls on the light dependent resistor sensor in the day time, its resistance becomes low therefore low voltage is developed (since 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 light dependent resistor sensor, its resistance becomes higher and enough voltage is developed across the light dependent resistor sensor which in turn forward biases the transistor to saturation state, thereby energizing the PNP transistor power switch and hence power is sent to the load.

Finally, the circuit design is incorporated with a battery and a battery charging circuit that provides a back-up for cases of power failure to help sustain power continuation until power from the Power Holding Company of Nigeria (PHCN) is restored. When the mains is powering the circuit, the battery will be charging up, as soon as there is interruption in power, then the power discharges its stored energy to drive the circuit until power from PHCN is restored.

1.2 AIMS / OBJECTIVES

i. To improve upon the system of street lighting controls which has evolved from the use of electrical components such as capacitors, heavy cables and panel which are very heavy, complex and laborious to install.

ii. To reduce the involvement of man in power switching operation.

iii. To implement an automatic switching system in place of a mechanically-operated switching.

iv. To achieve the control of a street light that is much more dependent on the environment and not just the circuitry.

v. To overcome the wear encountered by the component in a mechanically operated switch.

vi. To implement an automatic control unit that is cost effective.

vii. To increase the power conservative culture.

viii. To make life easy and more convenient for people.

1.3 DESIGN METHODOLOGY

The design requires a 13V power supply which deals with the supply and regulation of DC power, the battery and battery charging unit which provides a back-up for the power supply incase there is power failure from PHCN. A light dependent resistor (LDR) as the sensor which measures the intensity of light from the surrounding is also required. A 555 Timer which functions as a signal conditioning circuit and acts as a Schmitt trigger which triggers the switching of the PNP transistor power switch, is used in place of a relay system to trigger ON the light when it is dark and OFF in the day time.

1.4 SCOPE AND LIMITATION

Various problems are faced by manually operated switch for street lighting in our residential area and industries; problems like

i. Attendance by manual operator
ii. Power wastage during the day when the operator fails to put off the lighting.
iii. Leaving street and industries dark during stormy and cloudy weather.

The above problems are solved by this electronic device "Automatic Street Light Controller", which has a greater electrical advantage.

However, the design is a small scale version of the controller and is limited in its usage. Also, finance and time of research were various limitation of this project.

CHAPTER TWO

2.1 LITERATURE REVIEW

One of the first references to any form of street lighting was in 1405 when Alderman of the city of London was made responsible for ensuring that every house adjoining the highway provided a lit candle from a lantern from dusk until 9pm. Since then the technology of street lighting has made great and significant advances, particularly in view of the development of new light sources and the increased density of fast moving traffic.

Evolution of automatic switches is linked to the quest by man to have his surrounding conditioned to control his device so that life can be made much easier. Series of development has taken place since then. Lamp and lantern greatly improved. As early as 18th century, British law required home owners to place a burning stick or forgot (bundle of firewood) outside their homes in the night as a measure to prevent darkness and thereafter, oil lamps were used and gas lamps to brighten roads and pathways. Later in 19th century an American technologists Charles Brush developed the arc lamp. Today streets are illuminated with electricity.

The first controller to put streetlight ON and OFF was the 'lamp lighter', who went round lighting gas lamps and since then, there have been many methods to control or switch lights individually, in groups, or in large numbers. For many years, the most reliable and economical system has being the solar dial time switch. This is a clock driven by a synchronous electric motor. The solar dial is itself compensating and works automatically for the daily variation of switching ON and OFF time which relates directly to sunrise and sunset. The disadvantage of solar dial time switch is that its automatic switching of streetlight is based on average daylight conditions, and it needs resetting after every power cut. There is a strong argument for a switching device controlled by ambient daylight conditions (example, to switch light on when there is fog or when it is dusk early owing to an overcast sky). The modern photoconductive cell fulfils this requirement and is used extensively for new street lighting control.

This project is embarked on putting in mind the various modifications that can be added to improve the street lighting system in Nigeria. Past projects on this topic have been studied, thereby making an effort to improve on them. This one has a battery charging circuit which provides backup incase of power failure.

Engineering as a field of study is all about making the entire life more meaningful and easier. This is one of the reasons why this project has been put together to serve as a remedy toward the manually operated type of streetlight. This project also serves as a remedy towards the rate of consumption of energy {electricity} particularly in our street lighting control system.

Provision of street lighting system on our roads is very essential but also demands equal measures of input towards controlling them, if desired and maximum utility is to be achieved.

2.2 THEORETICAL BACKGROUND

In arriving at the final design, the principle of operation of various components as gained during the course of our 5year studies were seriously brought to mind. Various components would function differently under different conditions. Therefore, a thorough appraisal of the theory behind most components envisaged to be used in the design had to be made. It must be said that this helped a bit in choosing what was considered the ideal materials needed for a good construction of the project.

A block diagram of the simple street lighting automatic controller with a battery backup is as shown in the figure below. Every block represents one stage in the whole circuit arrangement. The circuiting involves;

i. THE POWER SUPPLY UNIT: which consists of the AC power supply unit and the backup
ii. THE CONTROL UNIT: which contains the sensor (light dependent resistor) incorporated into the 555 Timer.
iii. SWITCHING UNIT: which consist of the PNP transistor power switch
iv. LOAD: which comprises of the light emitting diodes (LED)

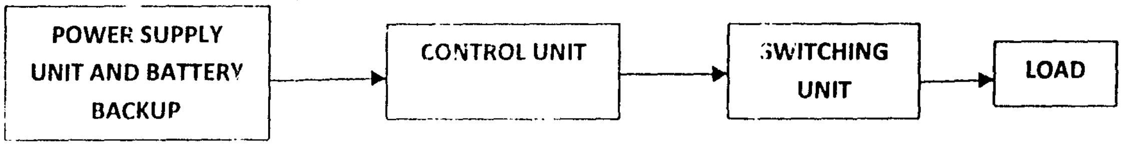


Fig 2.1 Block diagram of the controller

2.3 THE POWER SUPPLY UNIT

2.3.1 BATTERY CHARGING UNIT: Most of the electrical devices require a DC source for their operation. Dry cells and batteries are one of the dc sources. They have advantage of being portable and ripple free. However, the voltages are low, they need frequent replacement therefore, the need for a charging unit that charges the battery.

2.3.2 AC SUPPLY UNIT: AC supplies are the most convenient and economical sources of power. The AC supply unit is more advantageous to convert from an alternating voltage to direct voltages. The process of converting AC to DC is called rectification. This is usually smaller in value. The rectification is accomplished with the help of rectifiers, filter and voltage regulator circuit.

For this project, the DC voltage is useful since the circuit contains electronic component such as light dependent resistor (LDR), operational amplifiers (op-amp), integrated circuit, transistors all which requires DC voltage for their operation and proper biasing. A typical DC power supply consists of five stages as shown in the figure below.

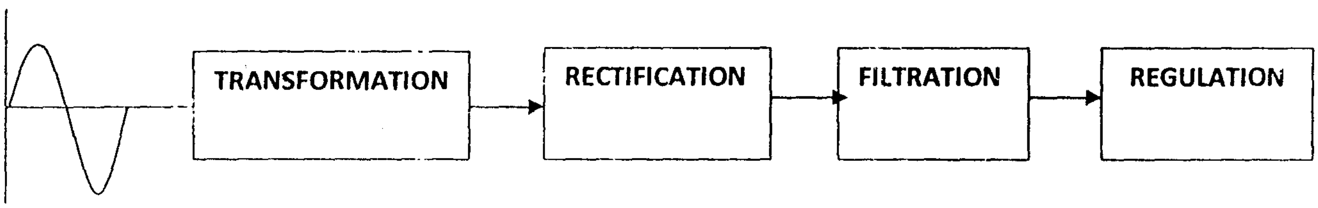


Fig2.2 Block diagram of a regulated dc power supply

2.3.3 TRANSFORMATION

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

TRANSFORMER: This is a static (or stationary) component that is used for transfer of electrical power from one circuit to another without change in frequency. A transformer can raise or lower the voltage in a circuit but with a corresponding decrease or increase in current. The physical basis of a transformer is "mutual induction" between two circuits linked by a common magnetic flux. The coil, in which energy is fed from the AC supply mains, is called primary winding and the other from which energy is drawn out is called secondary winding.

In this project, a step down transformer was used;

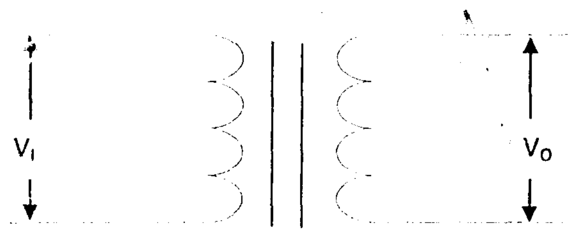


Fig2.3 Schematic diagram of a transformer

For an ideal transformer, the primary winding fluxes are sinusoidal, therefore;

Flux; $\phi_m = \phi_m \sin wt$..2.0

But E.M.F; e = $-N \dfrac{d\phi_m}{dt}$..2.1

Hence;

$$e = -N \frac{d(\phi_m \sin wt)}{dt} \quad \text{.......... 2.2}$$

$$e = -WN\,\phi_m \cos wt \quad \text{.......... 2.3}$$

If flux varies sinusoidally, the r.m.s value of the induced e.m.f is obtained as;

$$E_{rms} = \frac{peak\ value}{\sqrt{2}} = \frac{e}{\sqrt{2}} = \frac{1}{\sqrt{2}} WN\,\phi_m$$

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

$$E_{turn,rms} = \frac{1}{\sqrt{2}} W\phi_m$$

But W = 2∏F

$$= \frac{1}{\sqrt{2}} \times 2\prod F\phi_m \quad \text{..........} 2$$

$$E_{turn,rms} = 4.44\, F\phi_m \quad \text{..........} 2.5$$

$$E_1 = 4.44FN_1\phi_m \quad \text{..........} 2.6$$

$$E_2 = 4.44FN_2\phi_m \quad \text{..........} 2.7$$

Where E_1 is the total number of induced e.m.f in the primary.

N_1 Is the total number of turns in primary winding.

E_2 is the total number of induced emf in the secondary

N_2 Is the total number of turns in secondary winding

From equation 2.6 and 2.7, we have;

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

Where K is the voltage transformation ratio

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

2.3.4 REETIFICATION

Rectification is the process of converting an alternating (AC) voltage into one that is limited to one polarity (DC voltage). The diode is useful for this function because of its nonlinear characteristics (that is, current exists for one voltage polarity, but is essentially zero for the opposite polarity).

RECTIFIERS:

This is an electronic device that offers a low resistance to flow of current in the direction known as forward bias direction. A diode rectifier forms the first stage of a dc power supply.

Rectification is classified as half-wave or full-wave. For this project, a full-wave bridge rectifier is used which is more common for electronic circuit. Full-wave bridge rectifier consists of four discrete diodes connected to form bridge rectifier circuit.

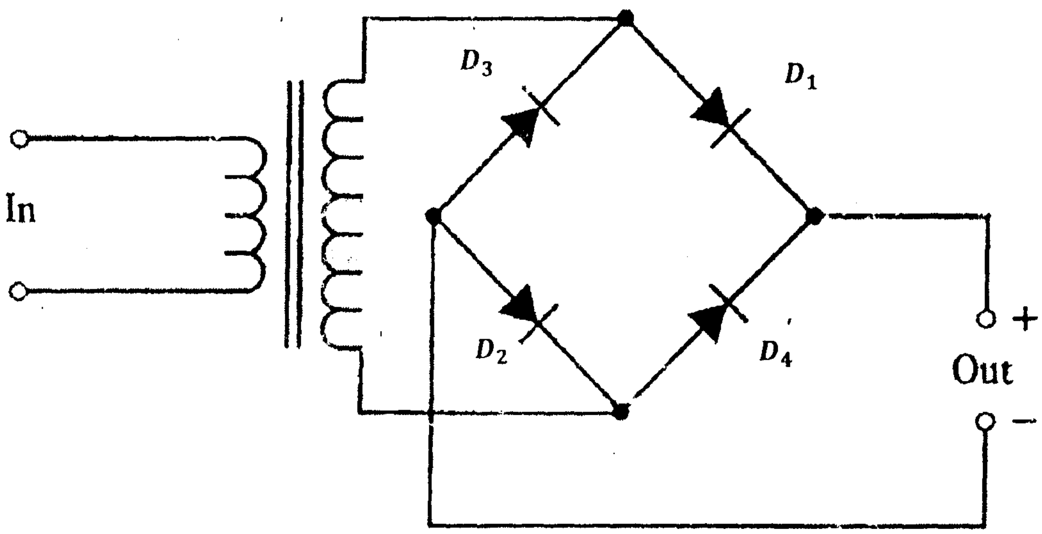


Fig 2.4 The full-wave bridge rectifier circuit

During the positive half of the input voltage cycle, v_s is positive, D_1 and D_2 is forward bias, D_3 and D_4 are reverse biased. During the negative half cycle of the input voltage, v_s is negative, and D_3, D_4 are forward biased. The direction of the current produces the same output voltage polarity as the previous stage..

The output waveform is shown below.

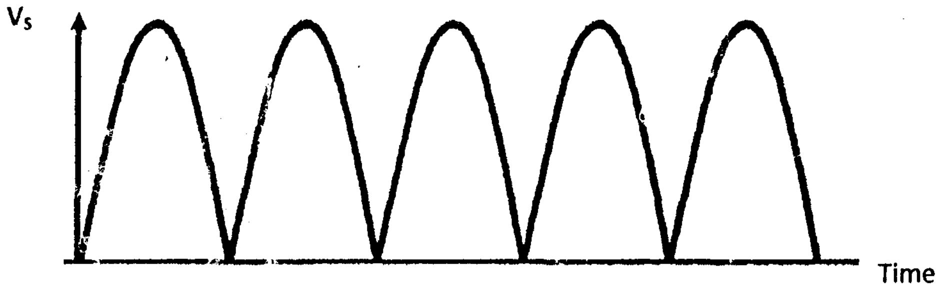


Fig2.5 The output waveform of the full wave rectifier

2.3.5 FILTRATION

This is a process of removing fluctuations which appears as ripples in the output voltage of a rectified ac by using filters.

FILTERS:

A filter is the circuit used to remove the ripple in the output voltage of a rectified AC. It consists of a single capacitor connected across a pulsating DC voltage, which smoothens out the ripple voltage. The capacitor is an energy storage device. When the rectifier produces a peak output, load current flows and charges the capacitor. When the rectifier output drops off, the capacitor discharges and furnishes the load current. Since the current through the load has been maintained, the voltage across the load will also be maintained.

The effectiveness of a capacitor filter is determined by three factors;

1. The size of the capacitor
2. The value of the load
3. The time between pulsations (ripples).

These three factors are related by the formula,

$$T = R \times C$$

Where T is the time in seconds (s)

R is the resistance in ohms (Ω)

C is the capacitance in farads (f)

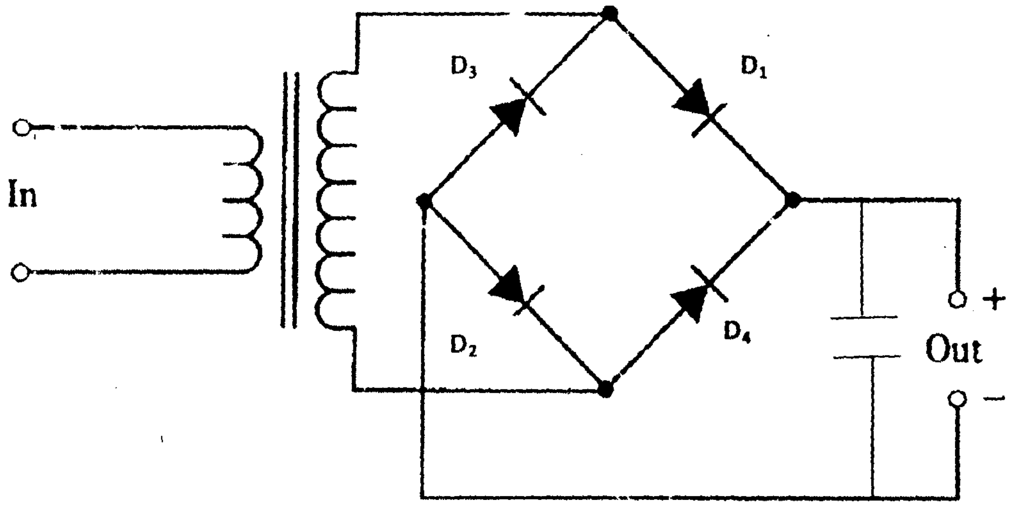


Fig2.6 Bridge rectifier filter circuit

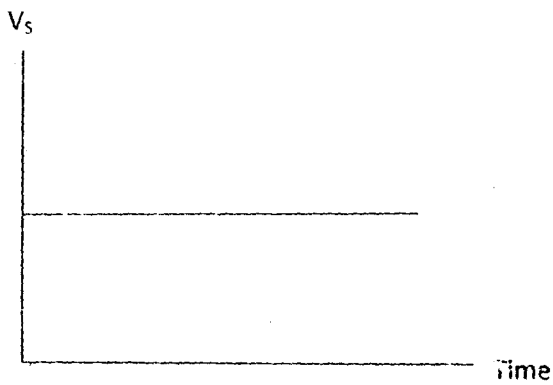


Fig2.7 Output waveform

2.3.6 VOLTAGE REGULATION

The regulation of a power supply is its ability to hold the output steady under conditions of changing input or changing load. The output also tends to change as the ac input voltage changes. This can cause some electronic circuits to operate improperly. Since a stable voltage is required, the power supply must be regulated.

Regulated power supply is obtained by using a voltage regulated circuit. There are various types of regulated circuit such as Zener diode shunt regulator, transistors series voltage regulator, switching regulators and so on. All the above mentioned circuits are made from discrete components.

The type of voltage regulator used in this project is the integrated circuit (IC) voltage regulator for dc 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 temperate and fold back current limiting.

2.4 CONTROL UNIT

This unit comprises the combination of photo-detector (LDR) and operational amplifier (op-amp) acting as a voltage comparator that compares the voltages of two inputs signals.

2.4.1 PHOTO-DETECTOR

Photo-detectors are devices that convert optical signals into electrical signals. They are semi-conductor devices that can detect or sense optical signal through electronic processes. These signals are subsequently amplified and further processed. An example is the LDR.

2.4.2 LDR SENSOR

Light dependent resistor (LDR) sensor is a photo conductive cell. It is a two terminal semi-conducting device whose resistance varies with the intensity of light that falls on it. Its resistance decreases as the intensity of light increases and the resistance increases with decrease in light intensity.

The resistivity or change in resistance of a photo conductive cell depends on a number of free charge carriers available in it. When the photo-conductive cell is not illuminated, the number of charge carriers is small and hence resistivity is high. But when the light in form of photon strikes the photo-conductive cell, each photon delivers energy to it, if the photon energy is greater than the energy band gap of the photo-conductor, free mobile carriers are liberated and as a result the resistivity decreases.

Photo conductive cells have many applications for measuring light levels and they can operate in a wide range of light intensities. The sensitive element of this detector is made up of individual grains of calcium sulphide (CdS) and cadmium selenide (CdSe) which are cadmium compounds and are part of the general make up of photoconductive cell.

There are many factors that determine the electrical characteristics of the photoconductive cell.

1. The wavelength of the incident radiation
2. The temperature
3. The device voltage and current.

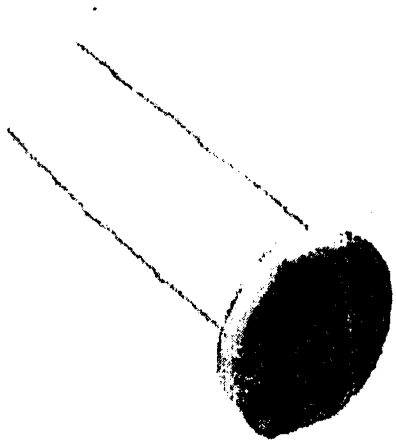


Figure 2.8(a): CdS Stereogram

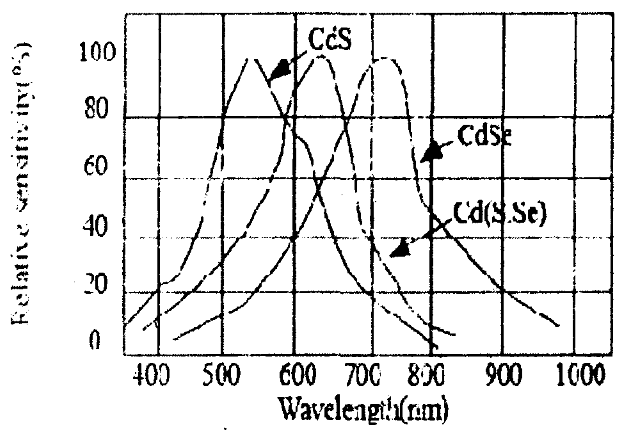


Figure 2.8 (b): CdS Sensitivity Scope

2.4.3 555 TIMERS

The 555 timer was chosen is a general purpose IC that can be used for precision timing, pulse generation, pulse width modulation e.t.c. the 555 timer can operate in both astable and monostable modes, with timing pulses ranging from microseconds to hours. It also has an adjustable duty cycle and can generally source or sink output currents up to 200mA.

The 555 timer was chosen in this project because of its low cost and availability. It is available in the 14-pin dual in-line package and the 8-pin mini-DIP. The pin numbers shown in this project are for the NE555 timer in the 8-pin package.

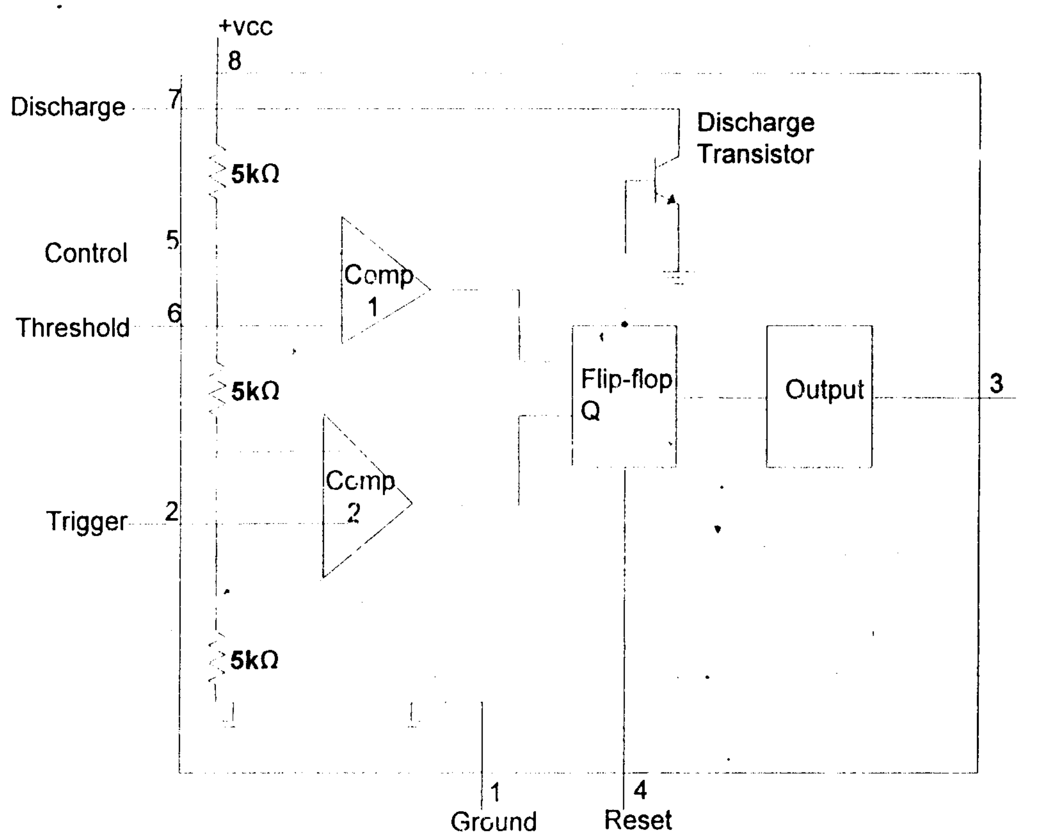


Fig2.9 Function block diagram of the NE555 IC Timer

The circuit consists of two comparators, which drive an RS flip-flop, an output buffer and a transistor that discharges an external timing capacitor.

Comparator1 is called the threshold comparator which compares its input with an internal voltage reference set at ($\frac{2}{3}V_{CC}$) by the voltage divider R_1, R_2 and R_3. When the input level exceeds the reference level, the threshold comparator output goes low, producing a low output at flip-flop terminal Q. this turns the discharge transistor on.

Comparator2, called the trigger comparator, compares its input trigger voltage to an internal voltage reference set to ($\frac{1}{3}V_{CC}$) by the same voltage divider network as before. When the output trigger level is reduced below this reference level, the comparator output goes high, causing the RS flip-flop to reset. Output Q goes high and the discharge transistor turns off.

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

The transistor is a semi-conductor device that can be employed to amplify an electrical signal, it act as an electronic switch and perform a number of functions. Basically a transistor consists of a germanium (Ge) or silicon (Si) crystal containing three separate regions. The three separate regions may consist of either two P-type regions separated by an N-type region (PNP) or two N-type regions separated by a P-type region (NPN). They are shown in the figure below;

Fig2.10a PNP Transistor

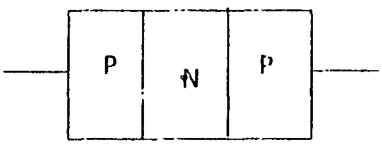
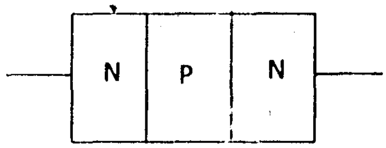


fig2.10b NPN Transistor



The transistor action depends on the connection, that is. emitter-base junction must be forward biased and the collector-base junction must be reverse biased. The three configurations of the transistor are common-base, common-emitter and common-collector. The choice of these connections depends on the impedance and gain required by the circuit

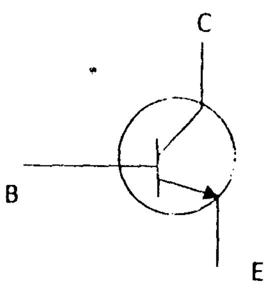


Fig 2.11a NPN schematic

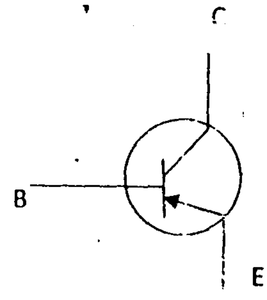
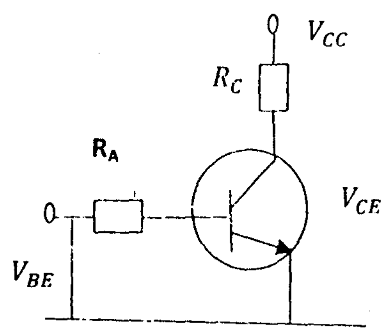


fig2.11b PNP schematic

2.5.2 THE COMMON-EMITTER CONFIGURATION

The common-emitter is used in this project because of its high value of current gain, voltage gain and power gain at reasonable high resistance as compared to other configurations.

Fig 2.12 common-emitter configuration of transistor



The common-emitter configuration has a grounded emitter, which is common to both base and collector as shown in the figure above. In common-emitter, the input current and

Output voltage are taken as independent variable, while the output current is dependent variable written as

$V_{BE} = F_1 (V_{CE}, I_B)$ 1

$I_C = F_2 (V_{CE}, I_B)$ 2

The curve is as shown in the figure below.

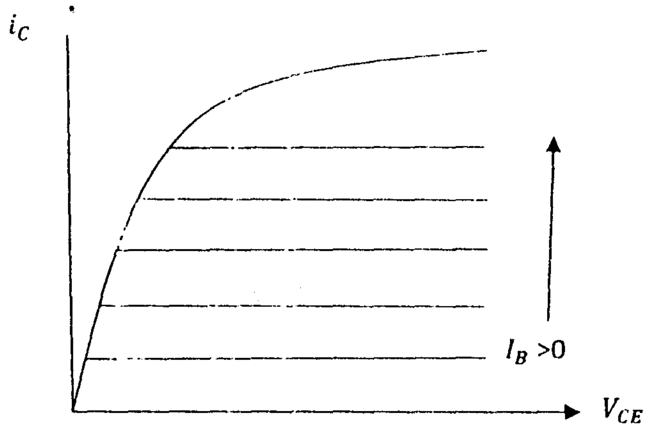


Fig2.13 Common-emitter Characteristic curve

2.5.3 TRANSISTOR AS A SWITCH

Transistor also operates as switches in electronic circuit. An ideal transistor switch works on the common-emitter configuration, which is so conditioned to by pass linear state of its function by going between saturation regions or the cut-off state. Bipolar Junction Transistor has zero power consumption in switching mode while no heating effect (since the transient state is bypass). The characteristics of the switching result in large power gain.

When the voltage in the base-emitter region is reverse biased as well as that of collector-emitter is reverse bias, $V_1 < V_{BE}$ (ON), then $I_B = I_C = 0$ and the transistor is cut-off. Since $I_C = 0$, the voltage drop across R_C is zero. Therefore, the output voltage is $V_0 = V_{CC}$, and the power dissipation in the transistor is zero, thereby making the light output to be zero with zero current.

But when a positive voltage is applied to the terminal, such that the base-emitter as well as the collector-emitter are all forward bias, then $V_1 = V_{CC}$ and if the ratio of R_B to R_C is less than β, where R_C is the effective resistance of the load, then the transistor is usually driven into saturation, which means that a collector-cur: V_{CC}) is induced that would turn on the load.

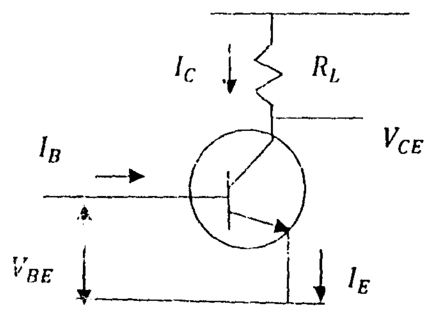


Fig2.14 Diagram of a transistor switch

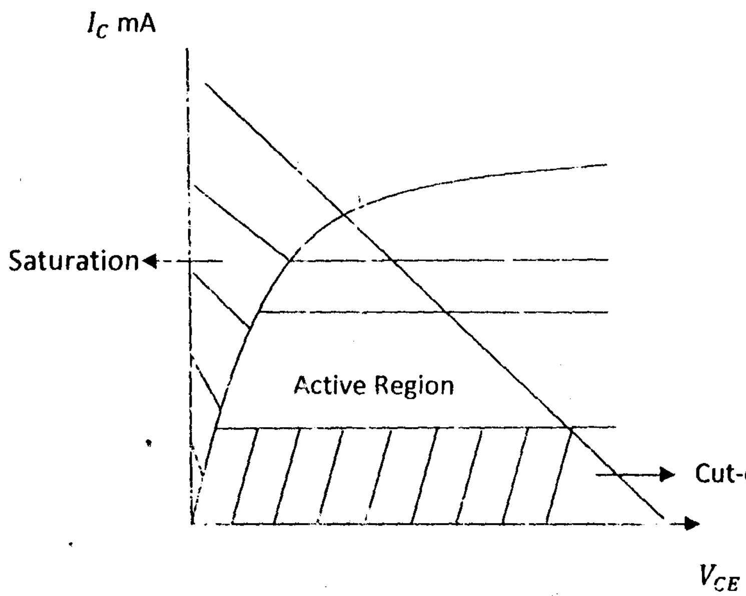


Fig2.15 Output wave form

2.6 ZENER DIODE

They are called Zener diode because they exhibit the 'Zener effect', a particular form of voltage breakdown. The Zener diode is a junction diode that has specific reverse breakdown voltage unlike the rectifier diode. Figure 2.17 shows the characteristic curve of zener diode when reverse biased. No current flows until reaching its breakdown voltage then current suddenly flows.

When a Zener diode is forward biased, it behaves like a regular silicon diode with a barrier potential at 0.7volts. Zener diodes are used for shunt stabilization for voltage reference as used in this project to discriminate the reference voltage as the comparator with respect to signal voltage. Zener diode is uniform in its mode of operation and irreplaceable by any other electronic device.

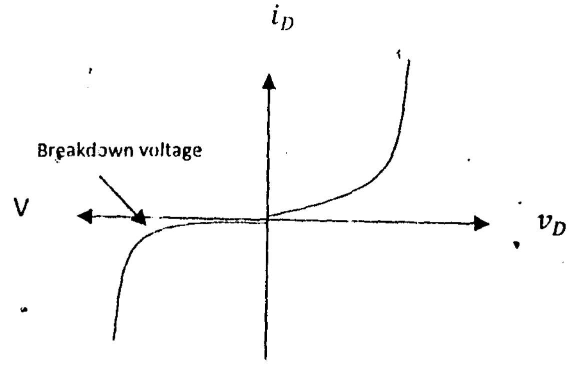


FIG 2.16 Diode I-V Characteristic showing breakdown effects

2.7 LIGHT EMITTING DIODE

Light emitting diode (LED) is a semi conductor device which emits visible light when forward biased. The color of the emitted light depends on the type of material used. LED is always encased to protect their delicate views. It is rugged and has a life of more than ten thousand hours.

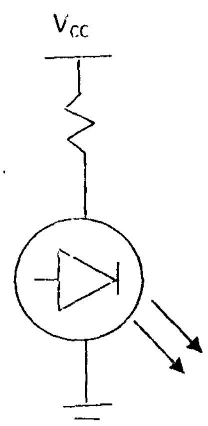
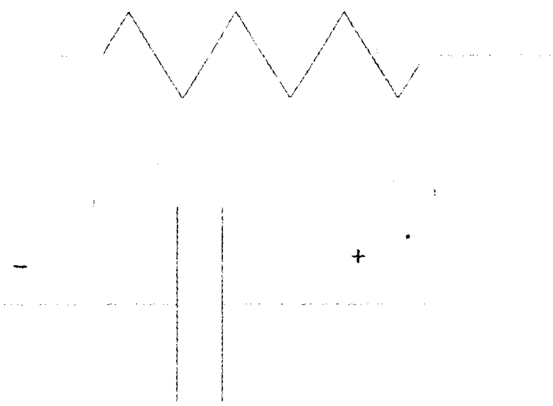


Fig 2.17 Symbol of an LED

2.8 OTHER PASSIVE COMPONENTS

Passive component are component which cannot amplify power and require an external power source to operate. They include resistors, capacitors and transformers e.t.c. their application ranges from potential dividers to control of current (as in resistor), filtration of ripples voltages and blocking of unwanted dc voltages (as in capacitors). They form the element of signal conditioning in circuits. Their schematic diagrams and symbols are shown below.



Resistor

Capacitor

Fig 2.18 Schematic representation of the passive component

CHAPTER THREE

3.1 INTRODUCTION TO SYSTEM DESIGN

The Light Emitting Diode based lighting system was designed with the following objectives in mind;

i. To design a lighting system implementing solid state opto-electronic devices, unlike gas-based lighting systems (CFL, incandescent bulbs e.t.c.)

ii. To design system with power storage back-up in the event of a mains failure.

iii. To design an automatic switching unit dependent on presence or absence of light.

The objectives were obtained with the diagrammatized system block shown below.

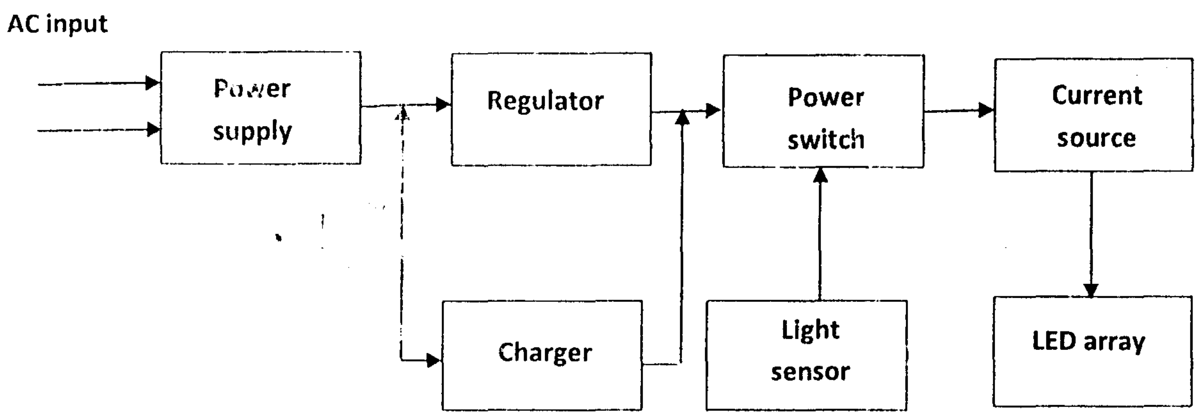


Fig3.1 system block diagram

The system comprised the following subsystems:

- Mains derived power supply
- LM317T 13-volt regulator
- LM317T 12-volt charger
- Light sensor (LDR)
- PNP transistor power switch

- Programmable current source
- 21-diode white LED array.

3.2 MAINS DERIVED POWER SUPPLY

The local AC mains were used to supply primary power to the system. The mains voltage was stepped down to 15-volts using a 220V /15V 3A transformer. The low voltage AC was then rectified and regulated to about 13-volts as shown in figure 3.1.

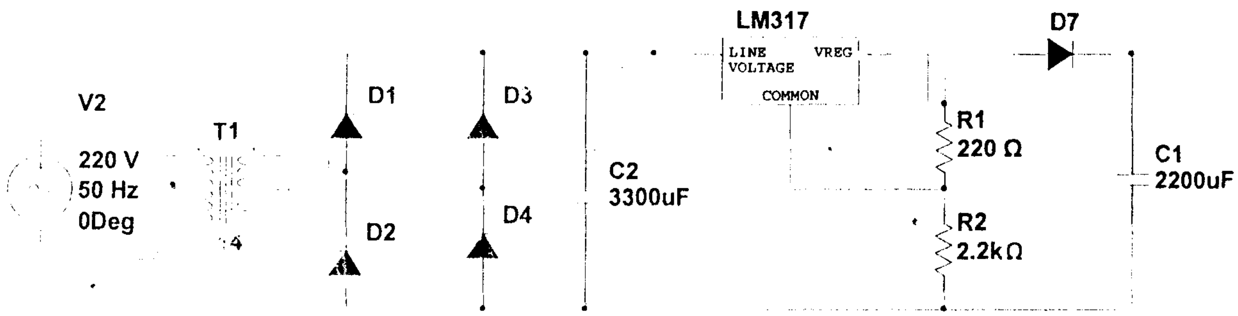


Fig3.2 system block diagram

D_1 - D_4 form a full-wave bridge rectifier that converts the 15-volt AC input to a pulsating DC voltage of magnitude given by the relation:

$V_{dc} = V_{rms}\sqrt{2}$ - 1.4

V_{dc} = $15\sqrt{2}$ - 1.4

= 19.7V

The resulting DC voltage was smoothened by a capacitance deduced from the expression;

Q = CV = IT

$C = \frac{IT}{V}$

I = Maximum, load current

$$T = \frac{1}{F} = \frac{1}{2F}$$

V = peak-peak AC ripple voltage.

I_{max} Was evaluated using the summation below;

Battery charging current = 1A

LED current = (55mA × 7) = 385 mA (7-arm LED array)

Losses = 115 mA

$\sum I_{max}$ = 1A + 385mA + 115mA = 1.5A

The peak-to-peak ripple voltage was determined by the minimum input required by the LM317T devices to maintain regulation. For a regulated 13.75V output, the regulator requires precisely 15V. Calculating;

$$C = \frac{It}{V} = \frac{1.5 \times \frac{1}{2 \times 50}}{\{17.7 - 15\}} = \frac{1.5 \times 0.01}{4.7} = 3192\mu F$$

The value was increased to 3300µF for improved system specification.

The DC voltage was regulated down to 13.75V to drive a 7-arm LED array of 3-seried LEDs. The smoothened DC voltage was also fed into an LM317T regulator to provide the charging current for the power storage battery.

3.3 LM317T 13-VOLT REGULATOR

The LM317T device is a 3-terminal adjustable regulator configured as shown below.

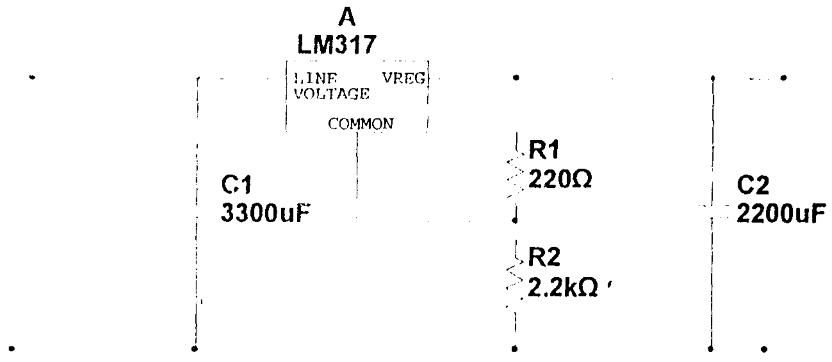


Fig 3.3 LM317 regulator

The output voltage is given by the formula

$$V_{out} = 1.25\left(1 + \frac{R_2}{R_1}\right)$$

1.25 Is the internal reference voltage

R_1 And R_2 are the resistances indicated in fig3.2.

The regulator output was adjusted to be slightly above the battery maximum terminal voltage so that power can be drawn from the mains during period of mains availability in the dark, rather than from the battery which should be charging.

3.4 LM317 12-VOLT BATTERY CHARGER

A second 317 device was used to provide battery charging current to a 12volt DC backup. The 317 was used in the constant-current constant-voltage mode. At the commencement of the charging process, the regulator operates in the constant-current mode in which the battery is charged at a steady current programmed by a current sensing resistor.

At the end of the constant-current charging phase, the charger enters the constant-voltage phase in which the battery is held (or floated) at a potential determined by the values of the voltage determining system elements. The charger is as shown below;

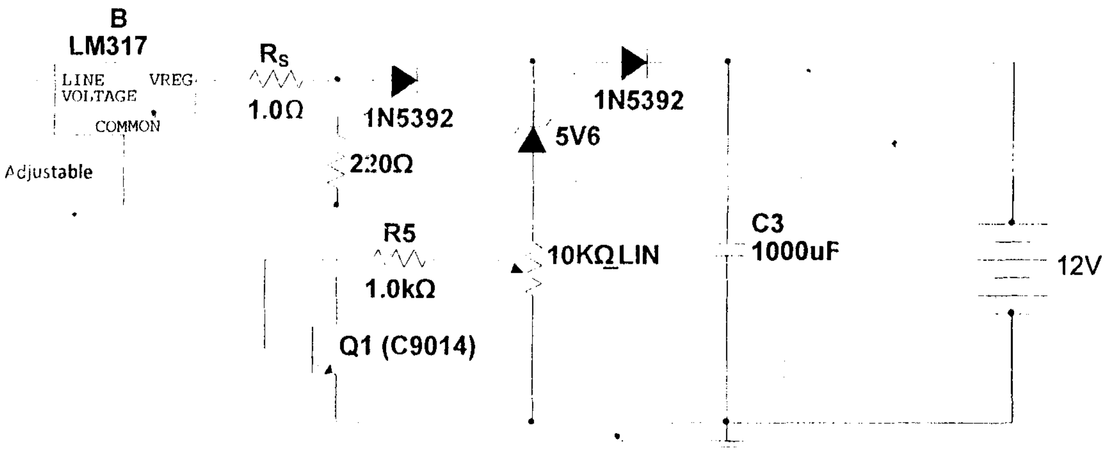


Fig 3.4 Constant-current Constant-voltage charger

The maximum battery charging current was set by a 1Ω resistance. The value of the current is evaluated from the expression;

$$I_{out} = \frac{V_{ref}}{R_S} = \frac{1.25}{1\Omega} = 1.25\text{A}$$

The float voltage was set by the adjustment of the 10KΩ potentiometer. It was adjusted to yield a battery voltage of 13V. The zener diode determines the battery minimum terminal voltage.

3.5 LIGHT SENSOR/DETECTOR

The light detector was designed around a CdS light dependent resistor (LDR) whose resistance varies inversely with the amount of light reaching its sensitive surface. The LDRs resistance change is converted to a voltage change by the circuit below;

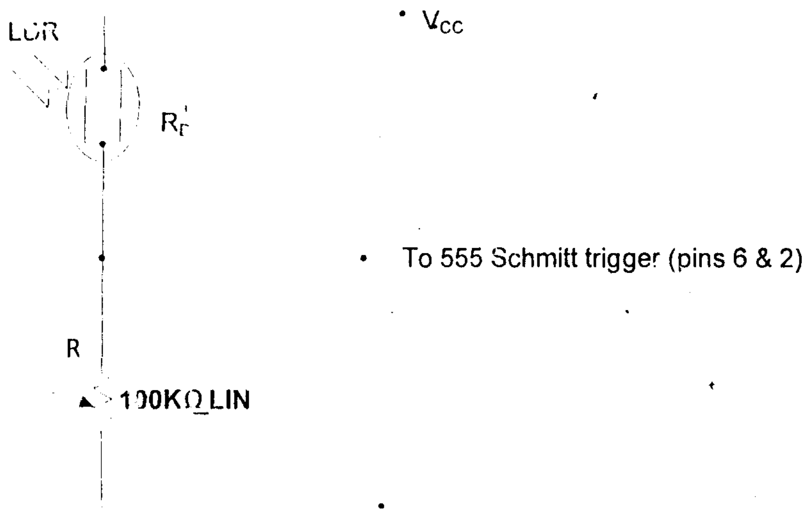


Fig 3.5 Resistance-voltage variation by the LDR

The variation of the LDR's resistance causes R_T (total divider resistance) to change, in effect causing a change in current. The voltage V_D across the LDR is then given by;

$$V_{D(LDR)} = I \times R_{D(LDR)} = \left(\frac{v_{CC}}{R + R_D}\right) \times R_D.$$

3.6 PNP POWER SWITCH

Instead of an electromechanical relay, a solid state device (transistor) was used to switch the LED voltage. A TIP42 device was used, controlled by an NPN device, via the wave form-shaped light sensor output as shown below;

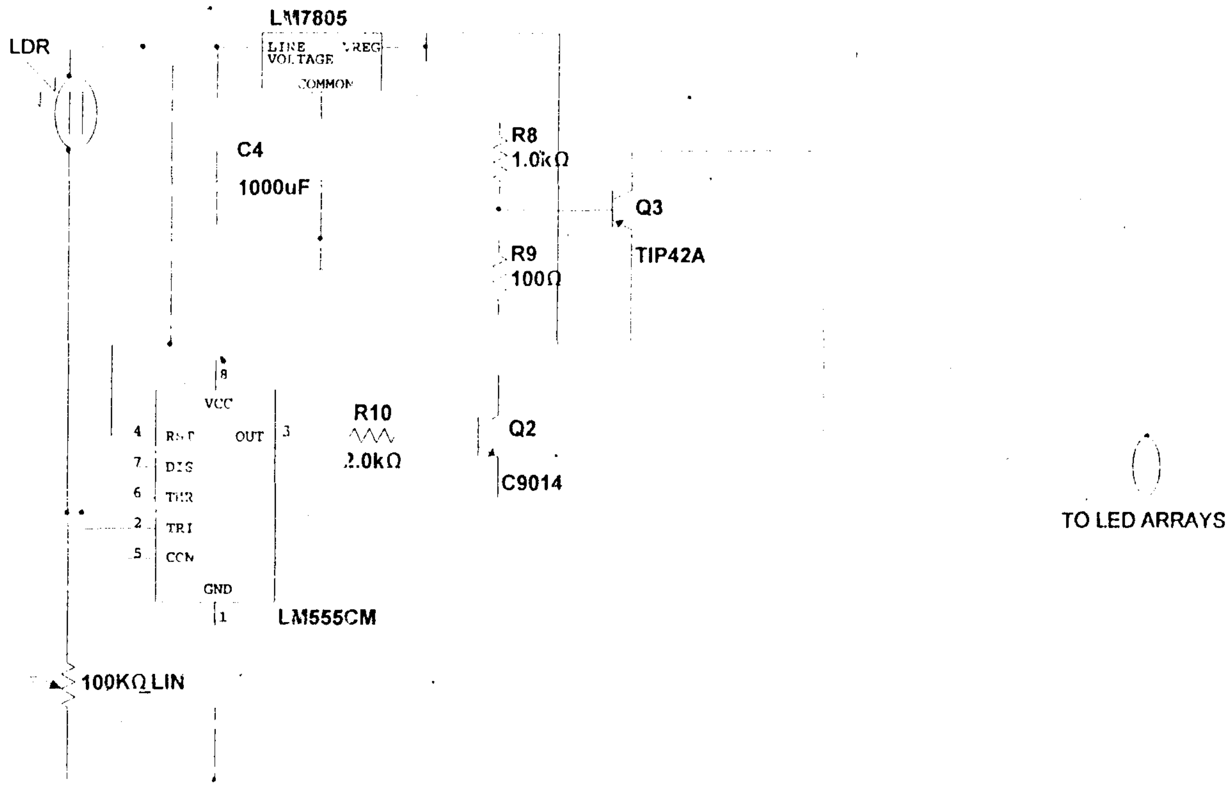


Fig 3.6 light sensor / power switch

An LDR and a 55 Schmitt trigger were used to detect and process the presence of visible light. The LDR was converted to a potential divider as indicated in fig3.5. The slowly-varying DC output of the divider was pulse-shaped into a discrete output by the Schmitt trigger designed around a NE555 device.

In the dark, the LDR resistance is high, the potential at pin 6 and 2 is lower than the lower switching threshold of $\frac{1}{3}V_{CC}$, that is, 1.67V. Therefore pin3 (output) is high thereby forward biasing Q_2 and Q_3. With Q_2 ON, the voltage at its emitter circuit is switched to its collector circuit, and the LED array is powered.

However, during the day, the resistance of the LDR is relatively smaller than the 100KΩ series resistance, taking the potential on pins 6 and 2 higher than the upper switching threshold of $\frac{2}{3}V_{cc}$, that is, 3.3V. Pin3 hence switches low, cutting off Q_2 and Q_3. Thereby interrupting LED current flow extinguishing the LED lamps.

3.7 PROGRAMMABLE CURRENT SOURCES

To prevent power losses associated with resistive current limiters and,to allow a wide raise of system operation, programmable current sources were used. LM317 regulators were also used as shown below;

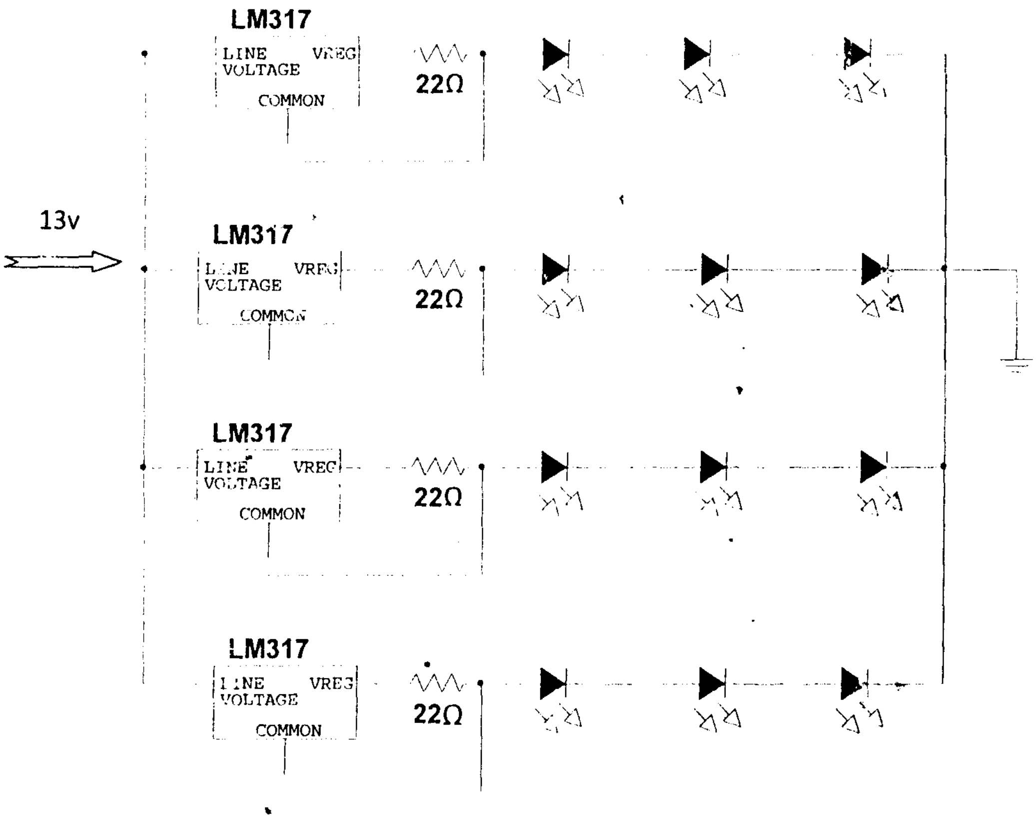


Fig 3.7 programmable current sources

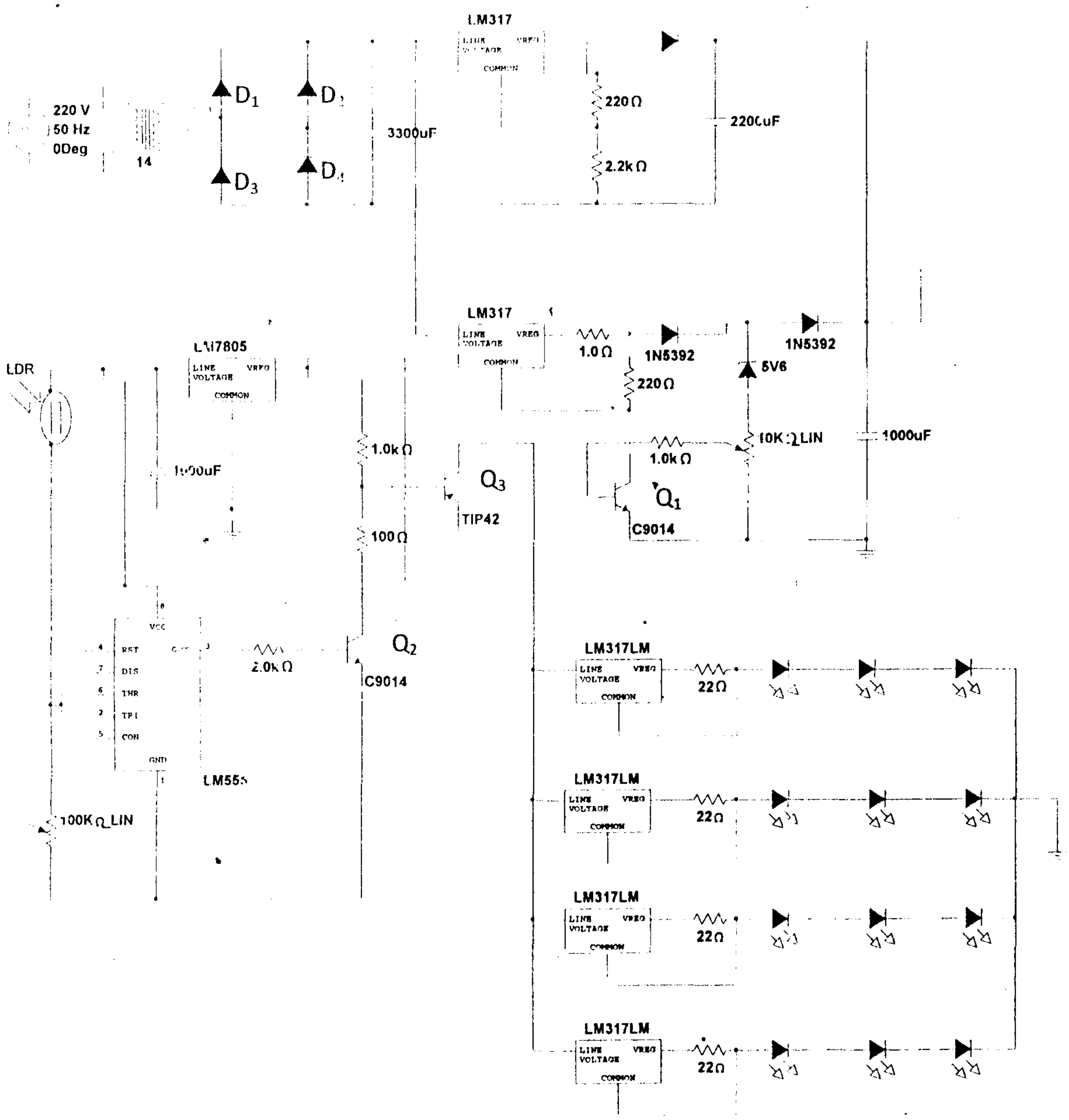
Seven 317 regulators were configured as current generators. Each 317 was programmed to source a set current of magnitude;

$$I_{Out} = \frac{V_{ref}}{R_S} = \frac{1.25}{R_S}$$

A maximum forward current of 55mA was chosen for each 3-LED string. The LED's each have a V_f of about 2.6V. The LED current was programmed using a resistance calculated. Th following expression was done using the above expression.

$$R_s = \frac{V_{ref}}{I_{out}} = \frac{1.25}{55mA} = 22\Omega$$

CIRCUIT DIAGRAM



CHAPTER FOUR

CONSTRUCTION, TEST, RESULT AND DISCUSION

4.1 CONSTRUCTION

The various components in the individual subsystems of the controller was first designed on a bread board and tested to check the workability. The satisfied result were then transferred into a vero-board where soldering was carried out.

When bread boarding, the circuit was done accordingly following every step as shown in the circuit diagram. After a satisfactory performance of the circuit on the breadboard, each segment of the circuit was carefully transferred one after the other until the complete circuit was achieved on the vero-board (permanent circuit board) were the components were soldered to the board permanently.

4.1.1 CASING CONSTRUCTION

The second phase of the project construction is the casing of the project. A perforated ceiling board casing was used to house the design circuit after completion. The perforation gives it ventilation and heat dissipation from the transformer and other component.

4.2 TEST

During the transfer of these components to the vero-board, each unit was tested one after the other before completely mounting or soldering them. This is to ensure that each stage functions appropriately as designed and this will also go a long way to ease troubleshooting in case of faults.

4.3 RESULT

During the Dark, when the resistance of the Light Dependent Resistor (LDR) is high, it was noticed that all the LED arrays were powered ON. At this period the mains supply charges the battery. When the mains availability was removed, the LED arrays were still ON, showing power continuity by the battery source, which is now discharging its stored energy.

During the Day, when the resistance of the LDR is relatively small, the LED arrays were OFF.

4.4 PROBLEMS ENCOUNTERED

The various problems encountered were;

i. Finance
ii. Non-availability of some components
iii. Component setting in bread board and vero-board
iv. Soldering problem.

CHAPTER FIVE

CONCLUSION AND RECOMMEMDATION

5.1 CONCLUSION

The project which is the design and construction of an automatic street light controller has been achieved. The performance of the project after test met design specifications. The general operation of the project and performance is determined by the LDR reactance with day and night. At night when the LDR resistance is high, the LED is turned on, while during the day when the LDR resistance becomes low, the LED is turned off. The triggering of the streetlight will be much more dependent on the environment and not just the circuitry. The construction was done in such a way that it makes maintenance and repairs an easy task and affordable for the user should there be any system breakdown.

This project has really given me more exposure on digital and analogue electronics, which is one of the major challenges I shall meet in my field in the nearest future. The project was quite challenging and tedious but eventually was a success.

5.2 RECOMMEMDATION

I would recommend that further work be done on a microcontroller-base automatic streetlight controller, and also the department should acquire more research oriented books in the departmental library, to make enough materials available for students.

REFERENCES

[1] Charles A. Schuler, "Electronics Principles and Applications", Fifth Edition, *Glencoe Mc Graw-Hill*, 8787 Orion place, Columbus pp. 221-295

[2] Donald A. Neamen," Electronic Circuit Analysis and Design", Second Edition, *Mc Graw Hill, University of New Mexico*, PP.50-965

[3] Theraja B.L. and Theraja A.K. "a Textbook of Electrical Technology" *Nirja Constructions and Development Company Limited, Ram Nagar*, PP. 1497-1709

[4] Harowitz P, Hill W, "The Art of Electronics" Second Edition, *Cambridge University Press UK*, pp. 175-182.

[5] Lionel Warnes, "Electronics and Electrical Engineering Principle and Practice", Second Edition, *Palgrave Malaysia*, 1998, pp71-72

[6] http://www.engtips.com

[7] http://www.datasheet.com