DESIGN AND CONSTRUCTION OF AUTOMATIC STREET LIGHTING USING TRANSISTORISED SENSOR

By

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DECLARATION

I hereby declare that this project is an original work undertaken by me ILLO BENNETT EZEKWESIRI. All materials that led to the successful completion of this project are highly appreciated.

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07/12/05
DATE

CERTIFICATION

This project is an original work undertaken by me ILLO BENNETT EZEKWESIRI and has been read and approved by the undersigned as meeting the requirement of the Department of Electrical and Computer Engineering Federal University of Technology Minna

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DEDICATION

This project work is dedicated to Almighty God who alone is the creator of all beings, the giver of wisdom and sustainer of all knowledge.

ACKNOWLEDGEMENT

Firstly, I give thanks to Almighty God who has always remained with me at all times.

My thanks go also to my Supervisor, Mrs Alenoghena C.O for her tireless effort and unlimited sacrifice of her private time, whose constructive criticism brought out the full potential in me towards the actualization and successful completion of a meaningful project like this. May God continue to have you at His mercy and may He allow your wealth of experience flourish all the time. All your effort to see other people acquire knowledge shall never be in vain. (Amen).

A million thanks to other lecturers of the department, who at one time or the other imparted knowledge in me, may Almighty God bless them all. Amen.

Most importantly, the moral and spiritual support of my mother Mrs Illo Patricia and father Mr Illo Cosmas who always wished me good all the time. Also my brother Illo Maximus for his love, commitment, tolerance, understanding, sacrifice and prayers. My sister late Illo Edith is not left out as this program did not start today. Quite very essential to include my numerous cousins' good friends and well wishers which include Nwodo Jennifer, Ibe Uzoma, late Egwu Grace, Rakiya Sani and so on. May God reward them abundantly. Amen. I proudly appreciate Chief and Mrs Ibe David, Chief and Mrs. Agwu Boniface for their uncountable times of assistance. May the grace of God abide in them now and forever. Amen. To all my aunts and uncles I say big thank you to all of you

This acknowledgement would be incomplete if I fail to reckon with the practical demonstration of assistance from Engr. Mbadiwe Enwerem, the Head of Department of Electrical and Electronics Engineering Niger state Polytechnic Zungeru. May Almighty God continue to guide and guard him and the entire family. Amen.

Finally, I appreciate the entire members of my compound from the landlord to my fellow tenants for their continued corporation.

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CHAPTER ONE

1.0 INTRODUCTION

The design and use of automatic switching device in electrical installation work has improved considerably over the recent years. According to early history of engineering, heavy power components and large control current were used in switching components such as switch, switch gear, heavy cables and bulky control panels. They occupy much space, less reliable and have considerably high price initial cost and high cost of maintenance and are prone to adverse electrical hazard since they operate at high current.

The fast growth in electrical and electronics technology has led to the designing of miniaturized components such as integrated circuit and semi-conductor device that operate at low voltage to control heavy current with high reliability factor and at a much reduced cost. This development has also given rise to the design of an automatic street lighting control, remote process control, motor car security control, elementary and other sophisticated controls at a safer and convenient form.

The discovery of light dependent device such as photo resistors, photocells, photo transistors, photodiodes and photovoltaic cells that make use of simple light energy to generate electrical energy has greatly reduced the involvement of mankind in power switching operations. As a result, man made errors are being reduced and life becomes more comfortable to live. Street light are controlled automatically using electronic circuit incorporated with a contactor or relay. It involves the natural switching OFF and ON-day and night phenomenon independent of human operation.

1.1 AIMS AND OBJECTIVES

This project is aimed at designing and constructing a device to monitor the switching operation of street light with respect to day and night by the use of transistorized sensor.

1.2 OBJECTIVES

This project research work is designed to assist mankind in the control of electrical power switching system in other to reduce the initial human involvement in power switching operation and to equally reduce man made error and make life more convenient. It is also designed to reduce the harzardness of electrical adverse effect of human involvement most time; since it operates on high voltage. It will also save time and make control room neat and safe to work.

1.3 THEORY OF OPERATION OF THE CIRCUIT

When the input head of the system control is connected to a 240V a.c supply at a frequency 50Hz alternating current as being fed into the input of the transformer and 12V a.c supply is being obtained at the output. This makes the transformer to be step-down transformer. The step-down voltage is rectified by diodes D_1 and D_2. The rectified output voltage 12V d.c is filtered by capacitor C_1. The output from networks is regulated to a voltage of 12V d.c, the output. The regulated transistorized sensor is used to vary voltages supplied to the inverting and non-inverting input of the 741Ic, used as a comparator. The output of the 741Ic is connected to the base of the switching transistor. When a positive voltage is obtained at the output of the 741Ic, it switches on the transistor which in turn activates the relay that lights the bulbs. The negative voltage is obtained at the output of the 741Ic. It switches off the transistor which in turn de-energizes the relay making the lighting bulbs to go off

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 STREET LIGHTING

During the olden days, people protected their lives and properties from destruction by men of the under world by the use of charms. This method failed and then came the advent of technology as a new means of solving man's problems. In this stage, lamp holders coupled with a 60w bulb mounted within the surrounding was used to intimidate and scar the evil doers away at night. But as a matter of fact, this manually controlled system posed the problem of switching arrangement as it entails a lot of labour cost

To solve this problem, an automatic lighting that uses timer for its operation was developed. This again has some shortfall as a result of shorter day, longer night or longer day, shorter night-phenomenon. In this case the switching system time control can easily be put off or on by anybody including the vandals and hoodlums as it was easy to operate

This led to the use of the services of watchman (security man) that were paid to protect and guide the lives of people as well as their properties in the dark. These watchmen being human sometimes fall asleep since they can not cheat nature and be awake all night.

In 1405, Alderman of the city of London was made responsible for the first street lighting in the city of London when he directed every house adjoining the highway to provide lit candle in a lantern from dusk till 9.00pm [15]. This of curse has undergone several stages before it got to this standard of automatic lighting using transistorized sensor. Ever, since, the technology of street lighting has made great significance in our society. Particularly in view of the recent development of new light sources and the moving traffic.

Street lighting often referred to as road lighting or public lighting includes the lighting of pedestrian walkways and subways. The main aim of street lighting is to ensure that, in the increasing numbers of vehicles and pedestrians, traffic can use the road safely during the hours of darkness. About 35% of all road accidents occur during the darkness and the installation of street lighting will reduce road accidents considerably.

2.2 DESIGN

The task of designing and commissioning of public lighting installation are more complex than it would appear at first sight. To some extent, it is an art as well as a science that demands large measure of sensibility and personal initiative.

In practice, the basic theory guiding street lighting is that the road surface and the surroundings should appear lit in other that vehicles and objects be seen clearly and easily. The road and the surrounding should be lit brightly so that object can be observed easily. Reflection of light from the road pavements is therefore of prime importance, so surface materials and good light reflection properties should be used. There is need to set lamp close to each other to allow the road surface to be uniformly bright.

2.3 CONTROL

An automatic control deals with the regulation or control of physical variables within a system in response to a command input into the system. Control system span every aspect of human endeavour ranging from voltage regulator, tracking system, radar power switching system speed regulation guided missile system to biological and economic system etc. Knowledge of control is essential whenever it is desired to regulate the flow of information energy and other physical variables such as the control of street lighting system. There are two types of control system, open loop control and closed loop control

2.3.1 OPEN LOOP CONTROL

Open loop is the type that the input command action is independent of the output behaviour. The type of control system used in this project work is called closed loop control and is also called feedback control. Thus, the output or desired internal system variables are feedback. The output response is compared with desired responses for the set command input and the comparator used to actuate the control system.

The first controller to put street lighting ON and OFF was the lamp lighter who went round lighting gas lamps and since then, there have been various control switch methods of light, individually in groups or in large numbers.

Few years ago, the most reliable and economical system has been the solar dial time switch. This is a clock driven by a synchronous electric motor. The solar dial it compensating (work) automatically for the daily variation of switching ON and OFF times which relate directly to sunrise and sunset.

The disadvantage of solar dial time switch is that its automatic switching of street lighting is based on average daylight conditions and needs resetting after every power out. There is a very strong argument for a switching device controlled by ambient day lighting condition for example, to switch light ON when there is fog or when it is dusk, early outing to an overcast sky.

The improved photoelectric cell fulfils this requirement and is used extensively for new street lighting. A photoelectric cell can be generally seen on the top of a lantern, it is quite often wired to a relay which in turn switches numbers of light.

2.3.2 CLOSED LOOP CONTROL

Closed loop is the type that the input command action is dependent on the output behaviour

2.4 LAMP

For the purpose of efficient and economical street lighting, low pressure sodium discharge tubes are ideal and for areas where good service rendering is required, such as city centres, high pressure sodium lamps are now being used. Until recently, colour connected mercury lamps were used in residential and city areas, because they are somewhat whiter than that of sodium. They are somehow expensive to run and are rarely in new installations.

The present and future needs to conserve energy cost will escalate the replacement of tungsten and light voltage mercury vapour by the more efficient sodium light source.

2.5 THEORY OF COMPONENTS USED IN DESIGN

In getting at the final design, the principle of operation of various components as learned on the cause of studies was seriously born in mind. Since various components would function differently under different condition.

Although 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 so much in choosing what we considered the ideal materials needed for perfect construction of the project, as a technical / decision of this nature have to be backed with facts given in this chapter. Source of the theoretical aspect were also considered while some of which guided the choice of suitable replacement with ideal components were not available.

2.6 PHOTOCONDUCTIVE CELLS

This device is referred to as *TRANSISTORISED SENSOR*. It is a two terminal device of semi-conducting material (calcium sulphide, CDs detector). In the dark, the resistance of the device is high. When light falls on it, electron-hole pairs are generated. Its resistance decreases as the intensity of light increases and the resistance increases with decrease in light intensity. This shows an inverse relationship.

Photoconductive cells can have many applications for measuring light levels and they can operate in a wide range of light intensity, but slow to respond to change in the level of illumination. The sensitive elements of this detector are made up of individual grains of this sulphide, and voltage ratings are determined by the contact structures.

The function of photoconductive cell is to convert the incident radiation to an electrical signal. Its performance is given by the ratio of the electrical output expressed as a voltage to the radiation input expressed as the incident energy. This ratio is known as the responsibility and is expressed is volts per watt (V/W.)

There are many factors that determine the electrical characteristic of CD's detector such as illumination, the wavelength of the incident radiation, the temperature and the device voltage and current. It operation is also affected by the time in which it has been kept in the darkness, the time it has been operating in a circuit and the operating of the device in the previous twenty four (24) hours.

As the intensity of light increases to that of full sunlight, its resistance gradually drops to only a few hundred Ohms (100Ω).

The variation of resistance with illumination is illustrated in the graph below.

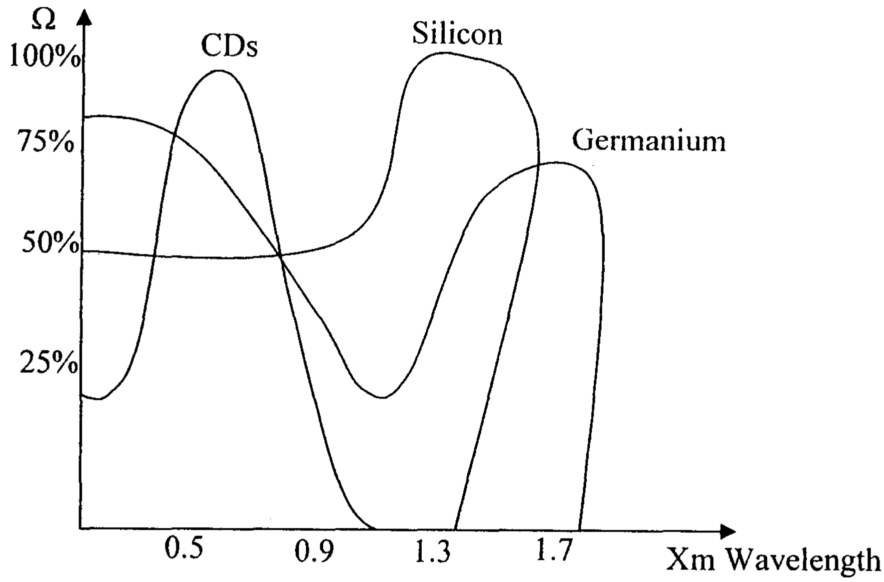


Fig. 2.0 Responsiveness graph of Photo-Transistor

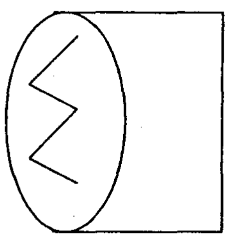


Fig 2.2(a) Light sensitive surface of Transistorised sensor

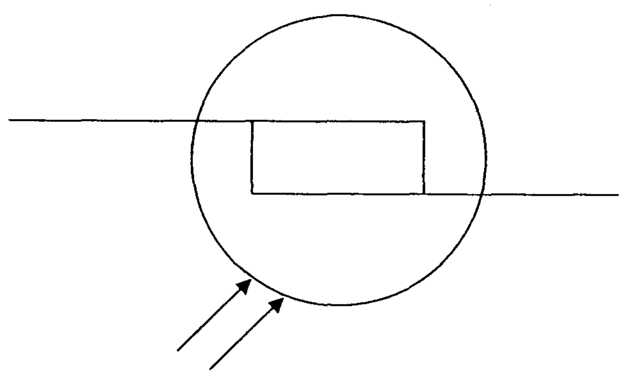


Fig 2.2(b) Symbol of Transistorised sensor

The curve above shows the responsiveness of photo-transistor made of different materials, like (germanium, silicon, calcium sulphide) to a selected group of colours. The CD'S is the most sensitive to visible light and its photo-transistor on the other hand respond best to radiation in the infrared region. The same applied to device made from SPB [4]

2.7 CARBON RESISTOR

Resistors are made of conducting and insulating materials. The proportions of the materials are adjusted during manufacturing to give resistance of various values. Resistors are passive components which offer resistance to the passage of electric current. They are therefore used in a circuit passage. They are used in a circuit to protect electrical equipment against sudden surges of power.

The power rating of resistor is the maximum power in watts which can be dissipated above a certain critical value at which the resistor would be damaged. The value of a resistor could be determined by colour code or by direct measurement using ohmmeter.

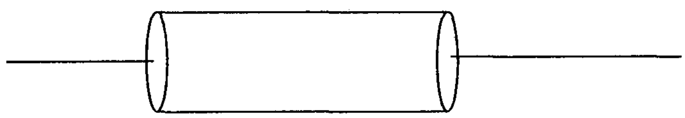


Fig. 2.3: Diagram of resistor symbol

2.8 VARIABLE RESISTOR

This is a resistor with suitable mechanical feature that enable the variations of its resistance from zero to maximum rate value. In this project, a 10kΩ variable resistor is used. It is provided with a node or handle which varies the resistance as it is turned left or right. The action is called presetting and can be used to preset the voltage range within which the comparator works.

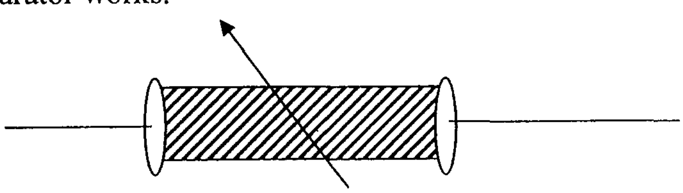


Fig. 2.4: Diagram of variable resistor symbol

2.9 ELECTROLYTIC CAPACITORS

This consists of two conductors or plates that are separated by insulating material called dielectric. When voltage is applied across a capacitor, it becomes charged, that is, it will store a quantity of electrical energy in the electrical field in its dielectric. The charge is proportional to the applied voltage.

Capacitors are used as time switching in transistor switching coupling of one stage to the other and decoupling of one stage to the other and as decoupling devices in amplifiers. They are also used as filter and compensatory networks. They are measured in farad.

Different types of capacitors are as follows: plastic, Mica, ceramic, electrolytic metallized power capacitor, and oil-impregnated –paper capacitor.

2.10 ZENER DIODE

In this type of diode, breakdown occurs at lower and more precise voltage than ordinary diode. They are called Zener diode because they exhibit "Zener effect" a particular form of breakdown voltage. The zener is really uniform and unique in its mode of operation at the breakdown region called *AVALANCHE*. Hence, it is usually connected in the reverse mode. In the forward mode, the zener behaves like a regular silicon diode with a barrier potential of 0.7V.

The zener diode characteristics curve is shown is the figure below.

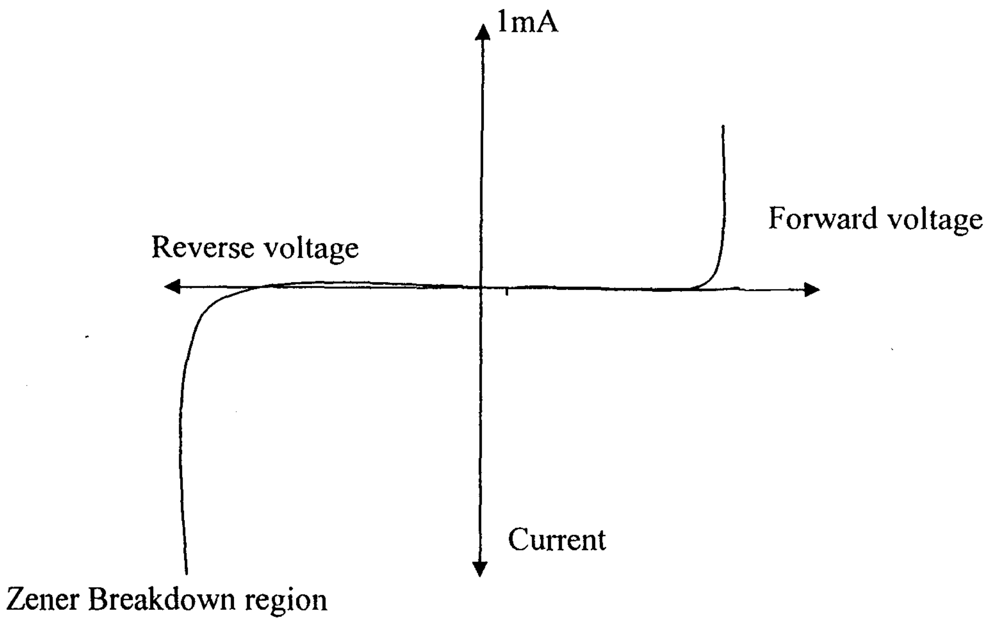


Fig.2.6: voltage-current characteristics curve of a silicon Junction Diode

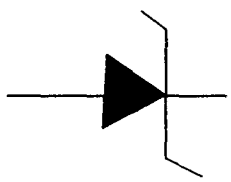


Fig. 2.6.1 Zener Diode Symbol

2.11 TRANSISTOR

The transistor is a semi-conductor device that can be employed to amplify an electrical signal, acts as an electronic switch and perform a number of other functions. Basically, transistors consist of germanium or silicon crystal containing three separate regions. The three 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). These are shown in the figure overleaf.

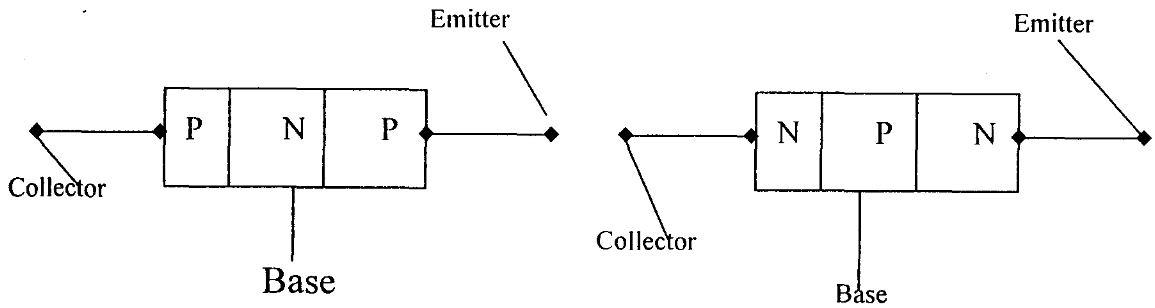


fig.2.7: Diagram of PNP and NPN Junction Transistor.

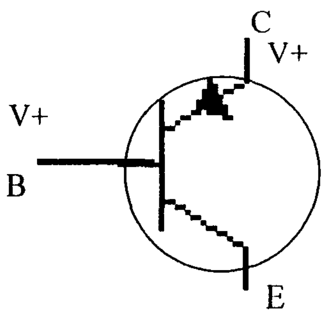


Fig . 7(a) Diagram of PNP

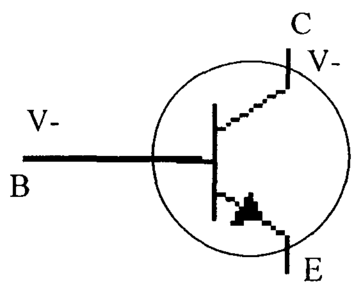


Fig. 7(b) Diagram of NPN

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

2.12 DIODES

The word diode is a compound word meaning two electrodes "di" for two and "ode" for electrode. It is therefore possible to produce a crystal at its half P-type and half N-type with a junction.

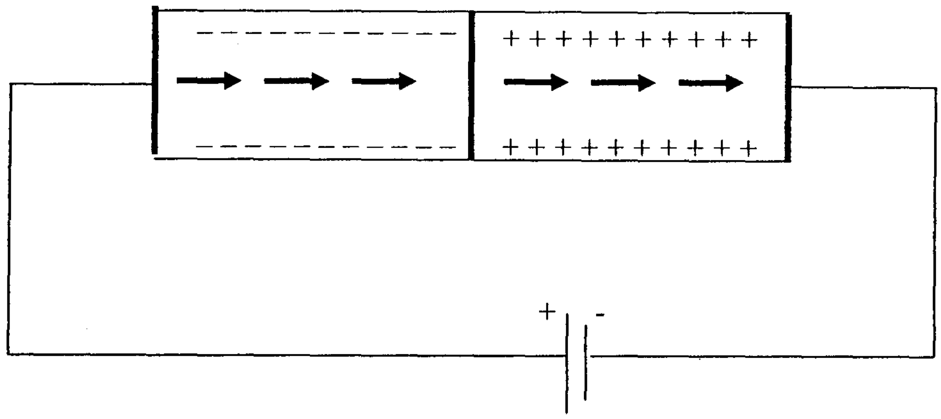


Fig. 2.3(a) Circuit of forward biasing junction diode

The Junction is where the P-type (donor impurity) and N-type (acceptor impurity) regions meet. A (P-μ) crystal like this is commonly called a diode.

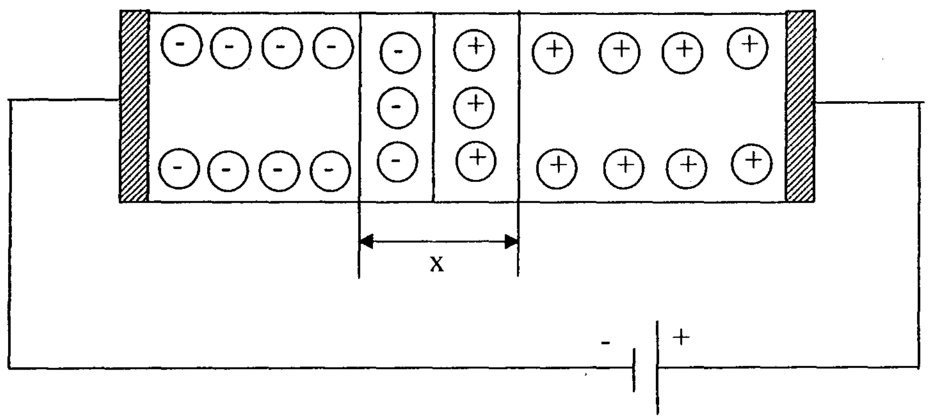
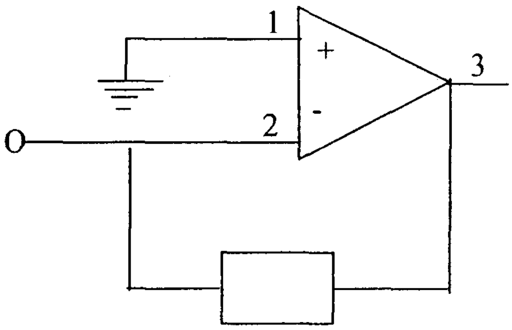


Fig. 2.8(b): Circuit of Reverse Biasing Junction Diode.

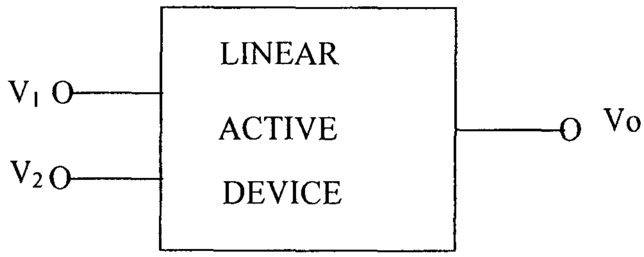
The above diode is reverse bias because the polarity of the applied voltage is reversed. The barrier potential is approximately equal to 0.7V for silicon diodes and 0.3V for germanium diodes. The P (+) region is called the anode and the N (-) region is called the cathode. Hence, a diode is a two terminal or two leg devices (8).

2.13 DIFFERENTIAL AMPLIFIER

Operational amplifiers connected in differential mode are used in comparing the magnitude of two signals. If one signal is applied to the inverting input and the other to the non-inverting input, the output of the amplifier is zero only when the two signals are equal and the output is saturated either positively or negatively when the inputs are equal. The output is negatively saturated when the voltage at the inverting terminal is greater than at non-inverting terminal.



Circuit of Differential Amplifier



Symbol of Differential Amplifier

The figure overleaf represents a linear active device with two input signals V_1 and V_2 and one output active signal Vo, each measured with respect to ground.

In an ideal differential amplifier, the output signal Vo, is given by:

$$V_0 = A_d(V_1 - V_2)$$

where A_d is the gain of the differential amplifier.

Thus, it is seen that any signal that is common to both input will have no effect on the output voltage. However, a practical differential amplifier cannot be described by the above equation because, in general, the output depends not only upon differential signal V_d of the two signals but also upon the average level called the common mode signal V_c

where $V_d = (V_1 - V_2)$ and

$V_c = ½ (V_1 + V_2)$

For example, if one signal V_1 at the non-inverting terminal is 150V, and the other $V_2 = 50V$, the output will not be exactly the same as if V_1=1050V and V_2 = 950V, though the difference V_d = 100V is the same in the two cases.

2.14 RELAYS

A relay is a device that operates by a variation in the condition of one electric circuit to effect the operation of other devices in the same or another electric circuit.

Current relays may operate on over-current, under current or a combination of both. Voltage relays may be of either the solenoid or the inductive type. They may be of the over voltage or under voltage. A timing relay measures a definite time under which a certain event or sequence of events in the control scheme should occur. There are many designs of timing relays but all have the same common purpose.

For the purpose of this project, a timing relay of magnetic type whose operation is electromagnetic in nature is used. The relay was used as switch to close the contact or open the contact depending on the output of the control unit. The principle of operation of electromagnetic relay is as follows:

In actual fact, the electromagnetically operated switch is within the class of mechanically operated switches, but it is placed in a separate class because the electromagnetic mode of operation makes it possible for one switch to control the operation of another. This type of switch is known as electromagnetic relay.

It consists of three main elements, a magnetic circuit, a winding for exciting the magnetic circuit and a group of contact springs. In a typical design, the magnetic circuit consists of a frame (sometimes called the heel piece), a core upon which the coil is located and a movable part called the armature.

When sufficient current passes through the coil magnetic attraction moves the armature towards the core and into the position shown by dotted lines. The armature when moving must overcome the compression force of the contact springs and that of any auxiliary spring, which may be present. In doing so, it closes electric circuits, which are connected through the contact. When the relay is not energized, the restoring energy of the contact spring moves the armature away from the core and into the position shown by the solid lines.

2.15 TRANSFORMER

This is an active component that is used for transfer of electric charges from one or more circuits to one or more other circuits without change in frequency usually with change of voltage and current. The purpose of a transformer is to change an alternating current (a.c) from one value to another. To increase the voltage of an a.c supply require the use of a step up transformer, while to decrease the a.c voltage requires a step down transformer. A step up transformer is a transformer with greater number of windings in the secondary coil while a step down transformer has a greater number of windings in the primary coil.

Transformers make use of electromagnetic induction to transfer electrical energy from one coil to another. A changing current through one coil (the primary coil) induces a current to flow in a nearby coil (secondary coil). These are both current and voltage transformer. A step down transformer is used in this project work. If the efficiency of a transformer is 100%, then the power in the secondary coil equals the power in the primary windings.

Mathematically expressed as

$$I_pV_p = I_sV_s \text{ .... (1) as Power, } P = IV$$

or

$$V_p/V_s = I_s/I_p \text{ --------------- (ia)}$$

Where I_p = Current in primary winding

V_p = Voltage in primary winding

I_s = Current in secondary winding

V_s = Voltage in secondary winding

Since the product of the number of turns in the primary winding and the voltage in the secondary is equal to the product of turns in the secondary winding and the voltage in the primary winding,

Then

$$N_p \times V_s = N_s \times V_p \text{ ---------------- (2)}$$

i.e. $N_p/N_s = V_p/V_s$ ------------------- (2a)

Therefore equation (1a) can be modified to give:

$V_p/V_s = I_s/I_p = N_p/N_s$

Where N_p = Number of turns in the primary winding and

N_s = Number of turns in the secondary winding.

2.17 EFFICIENCY OF THE TRANSFORMER

The efficiency of any machine is the ratio of the output power to the input power expressed in percentage. Efficiency of any machine can never be 100%. This is due to losses. This also is applicable to a transformer.

Mathematically, the efficiency of a transformer is expressed thus,

Efficiency, μ = (Power in secondary / Power in primary) x 100%

μ = (Output power + losses) 100%
Input power

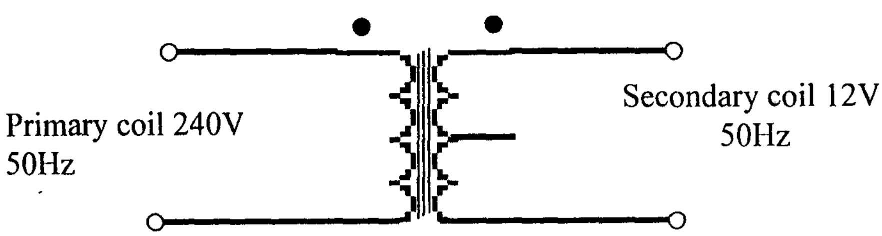


Fig. 2.11 Circuit of Transformer

CHAPTER THREE

3.0 DESIGN ANALYSIS AND METHODOLOGY

This chapter gives a complete (total) description of the various modules (steps) used in the design of the automatic street lighting system using transistorized sensor.

The theoretical background of each module is extremely treated. Below is the block diagram of an automatic street lighting system.

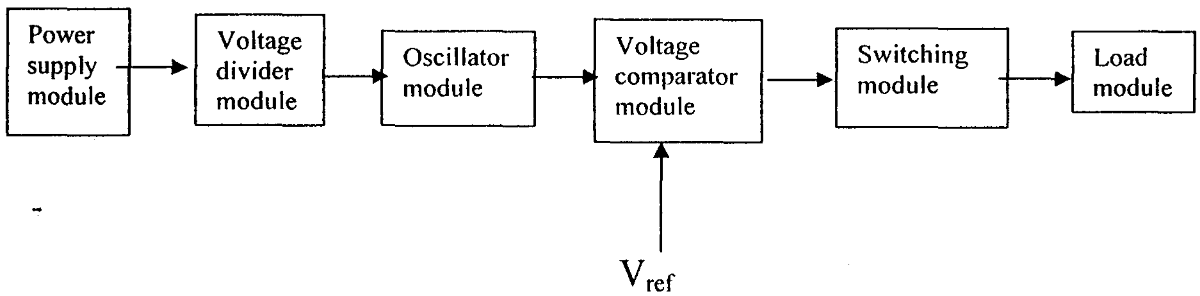


Fig. 3.0 Block diagram of automatic street lighting system.

The six sub system of the automatic street lighting system are the power supply module, voltage divider module, oscillator module, voltage comparator module, switching module and the load module as illustrated by the block diagram shown in Fig. 3.0.

The power supply module is the power-house of the entire circuit of the automatic street lighting system. Its output voltage, usually rectified is fed into A.S.L system and this subsequently affects the entire system with the desired result achieved.

This is achieved when the transducer transistorized sensor senses darkness, it reduces the source voltage by half, subsequently causing the oscillator module to be energized, and this in turn via this output pin drives the switching module via the comparator module. Hence, the load at the output is energized and the project aim achieved.

3.1 POWER SUPPLY MODULE

Most electronic circuit use direct current (d.c) supply for operation and the conversion of an a.c supply can be achieved through the power supply module of the A.S.L (automatic streetlight control) system is shown overleaf:

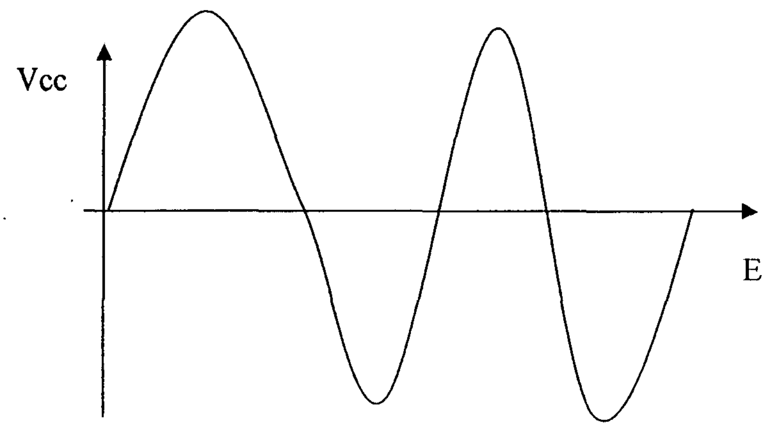


Fig. 3.1(a) Graphical Representation of Power Supply Module.

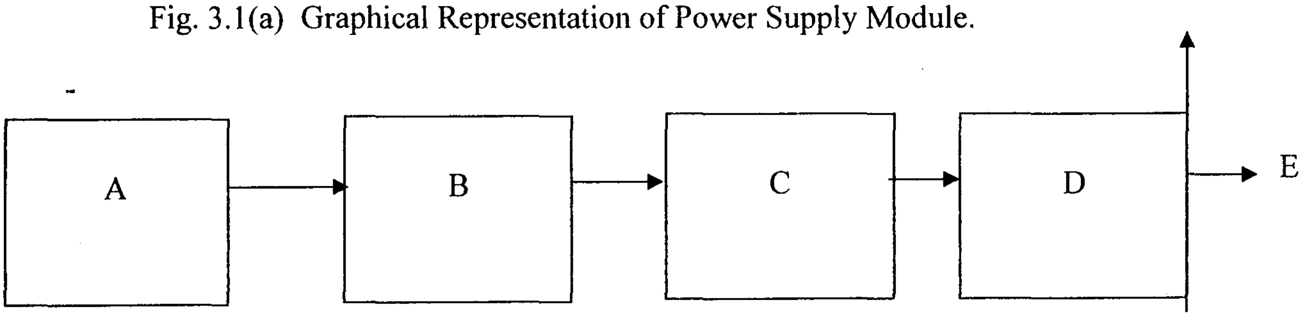


Fig. 3.1 (b) Bolck diagram of Power Supply Module

3.1.1 TRANSFORMER STAGE

A 240V_{rms} step-down transformer is used to reduce the 220Vac from PHCN (Power Holding Company of Nigeria) to 12Va.c. This is fed to the rectifier to produce the required 12Vac by the Automatic street lighting system.

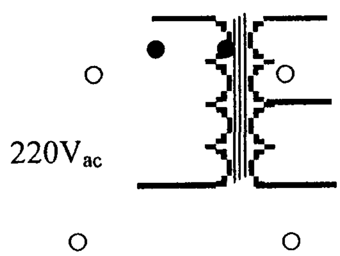


Fig. 3.2 A transformer circuit symbol

3.1.2 RECTIFICATION STAGE

The term rectification is defined as the process of changing an alternating current (a.c) into a direct current (d.c) without an intermediate transformation of engery-or-process of changing pulsating a.c voltage to d.c voltage by eliminating the negative half cycle of the alternating voltage. This project adopts the use of a full wave bridge rectifier because of its ability to produce the approximate varying and reference voltage.

The maximum instantaneous voltages between the terminals are:

$$V_{max} = V_{rms}\sqrt{2} \text{ --------- } (1)$$

The four diodes in Fig. 3.3 below are arranged in a diamond configuration called full wave bridge rectifier.

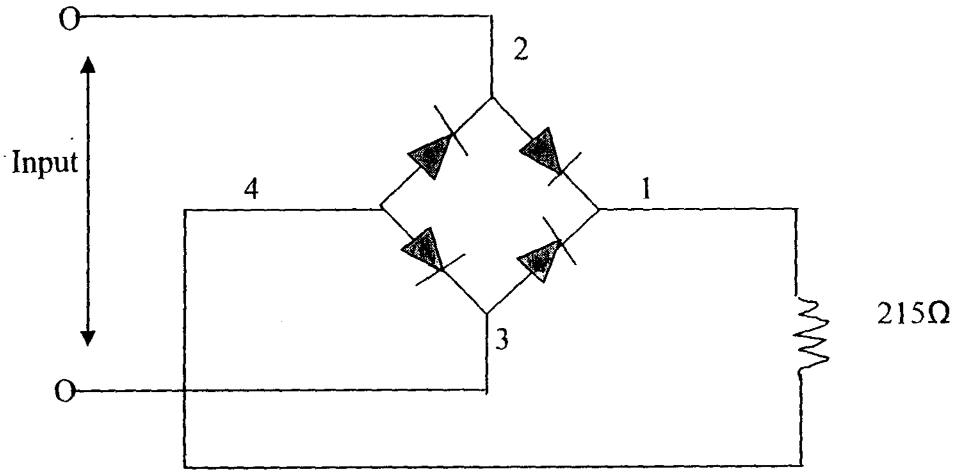


Fig. 3.3 Circuit of Bridge Rectifier

3.1.3 SMOOTHING AND FILTERING

The main function of the filter is to maximize the ripple content at the full wave bridge rectifier output. The input and output waveform of the filtering circuit is shown in the figure below:

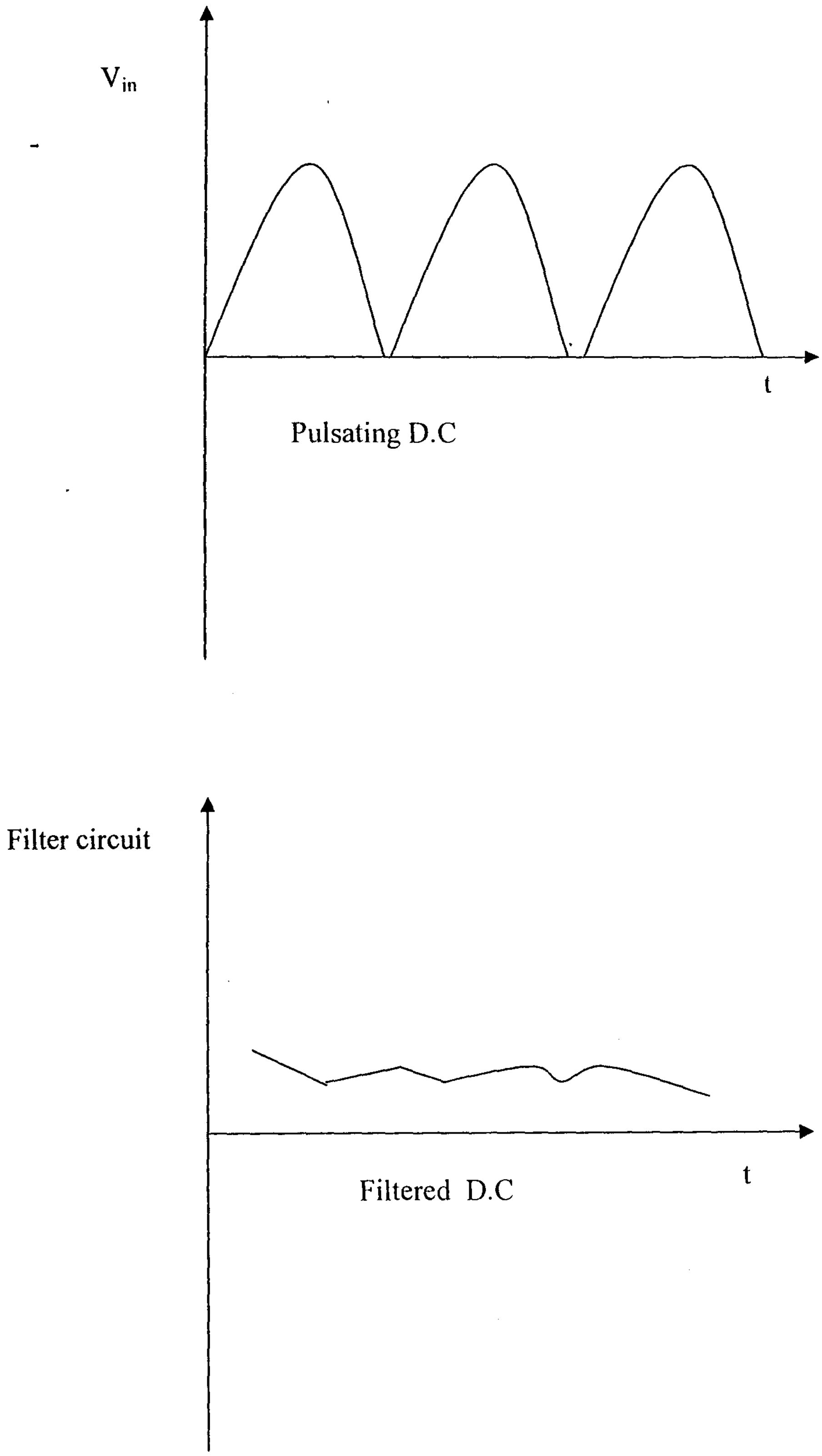


Fig. 3.4 Diagram of the Filter Circuit.

The electrolytic capacitor depends on its operation, the property of the device to charge up (that is to store charge) during the conducting half-cycle discharge and during the non-conducting half-cycle. Below is the input and output waveform to the shunt capacitor and the approximated ripple voltage.

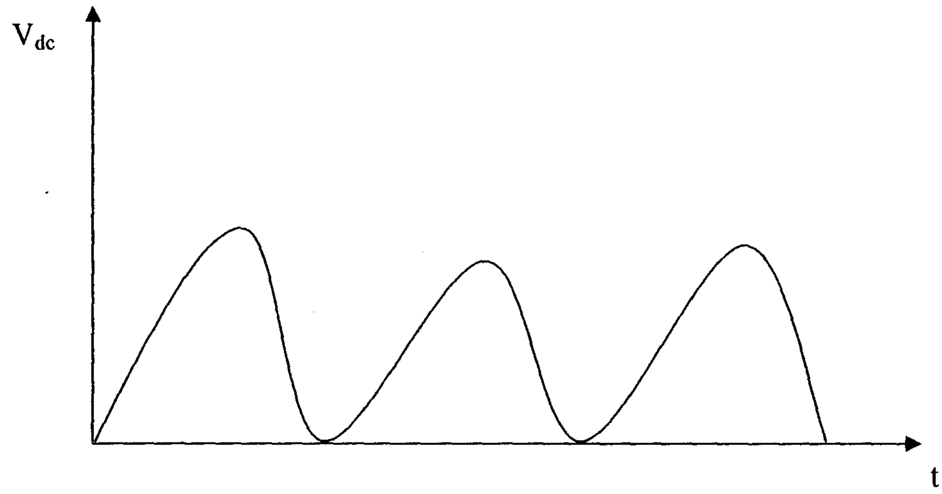


Fig. 3.4 (a) Input waveform of the shunt Capacitor

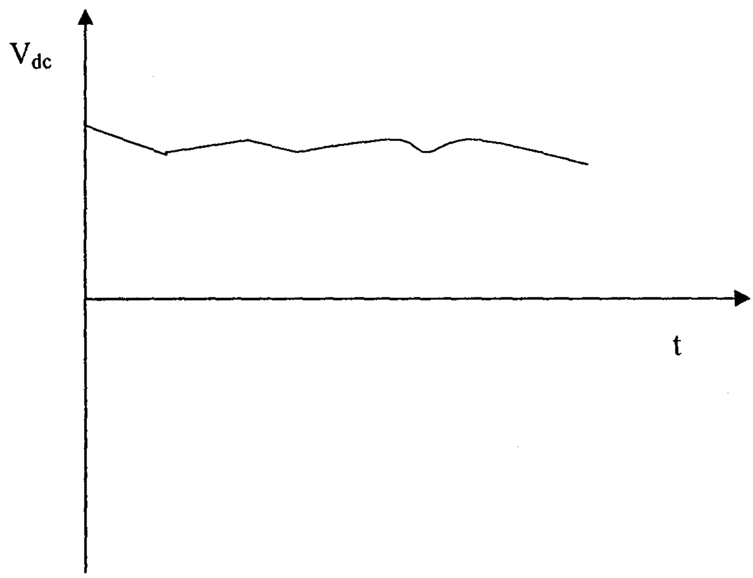


Fig. 3.4 (b) Output Waveform of the shunt Capacitor

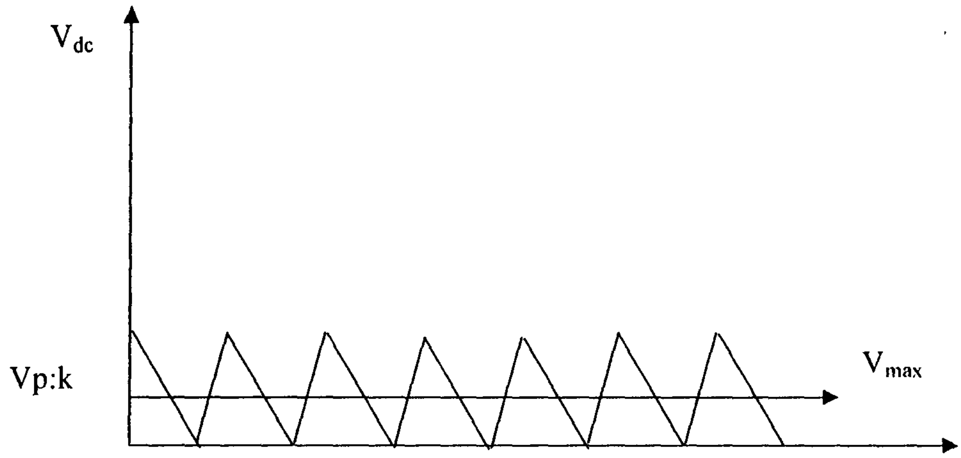


Fig. 3.4 (c) Approximated Ripple Voltage

3.1.4 DESIGN/CALCULATION

The direct current (dc) voltage V_{dc} is given by

$V_{dc} = 2V_{max}/\mu =$ 0.636 V_{max} ---------- (2)

It must be noted that the peak inverse voltage PIV be greater than V_{max}.

Also note that V_{rms} = 12V

From ---------- (1)

$V_{max} /\sqrt{2} = V_{rms}$

i.e. V_{max} = $V_{rms} \times \sqrt{2}$

recall V_{rms} noted as 12V

: V_{max} = 2V x √2

= 12V x 1.414

= 16.968V ---------------- (3)

Allowing a safety margin of 1.5

Then PIV = 1.5 x 16.968V

= 25.452V

The value of the PIV, 25.452V, prompted the need of selecting a 2A bridge rectifier with a maximum peak inverse voltage of 100V.

3.2 DESIGN OF RIPPLES VOLTAGE/POWER

The ripple voltage can be approximated by a triangular waveform which has a peak-to peak ripple voltage and a period of time (T_r)

Consider the charge lost during the capacitor discharge as d_q

Then in time T_r

$$d_q = I_{dc} . T_r$$

$$V_r\,(P\text{-}P) = d_q/c \;=\; I_{dc} \times T_r/c \;\ldots\ldots\ldots\ldots(4)$$

But

$$I_{dc} = V_{dc}/R_L \text{ and } T_r = 1/F_r \ldots\ldots\ldots\ldots(5)$$

Substituting ....(5) into ....(4) gives

$$V_r\,(p\text{-}p) = V_{dc}/R_L \quad X \quad (1/F_r/C)$$

$$V_r(p\text{-}p) = V_{dc}/R_L \; X \; (1/F_r)/C$$

$$V_r\,(p\text{-}p) = V_{dc} / F_r R_L C \ldots\ldots\ldots\ldots (6)$$

$$\text{But } V_{rms} = V_r(p\text{-}p) / 2\sqrt{3}$$

Hence,

$V_r\,(p\text{-}p) = V_{rms} \times 2\sqrt{3}$.................. (7)

And ....(6) can be written as

$V_r\,(p\text{-}p) = V_{dc} / F_r R_L C = V_{rms} X\, 2\sqrt{3}$

i.e. $V_{dc} / F_r R_L C = V_{rms} X\, 2\sqrt{3}$............(8)

$V_{rms} = (V_{dc} / F_r R_L C) / 2\sqrt{3}$.................(9)

$V_{rms} = V_{dc} / 2\sqrt{3}\, F_r R_L C$............(10)

It must be noted that for a bridge rectifier $F_r = 2f$

Where F_r is ripple frequency and f is the normal frequency.

$V_{rms} = V_{dc} / 2\sqrt{3}X\ 2fR_L$

$V_{rms} = V_{dc} / 4\sqrt{3}R_L Cf$

$V_{rms} \times 4\sqrt{3}f R_L C = V_{dc}$

$V_{rms} / V_{dc} = 1 / 4f R_L C = \gamma$

Where $\gamma = V_{rms} / V_{dc} = 0.0386$

$f = 50Hz, \quad C = ?, \quad V_{max} = 16.968V$

$V_{rms} = 12V, R_L = 215$ (Assume Load Value)

But $V_{max} = I_{dc} \times R_L$

:. $R_L = V_{max} / I_{dc}$

Hence. $\gamma = 1 / 4\sqrt{3}fC (V_{max} / I_{dc})$

$$\gamma = I_{dc} / 4\sqrt{3}fCV_{max} \quad \text{.........(11)}$$

But $V_{dc} = 0.636V_{max}$

$V_{dc} = 0.636 \times 16.968$

$V_{dc} = 10.792V$

And $I_{dc} = V_{dc} / R_L$

$I_{dc} = 10.792 / 215$

$I_{dc} = 0.050A$

:.

$\gamma = 0.050 / (4 \times 1.732 \times 50 \times C \times 16.968)$

i.e $0.0386 = 0.050 / 5877.887\,C$

$226.886\,C = 0.050$

:. $C = 0.050 / 226.886$

$C = 2.20 \times 10^{-4}\,F = 220 \times 10^{-6}\,F = 220\mu F$

3.2.1 VOLTAGE REGULATOR AND STABILIZATION

In order to obtain desired d.c voltage for the circuit operation, voltage regulator Ic's (Integrated Circuit: an electronic circuit formed on a single block of material by earthing) are employed. In this project, the voltage regulator Ic used is a 12V regulator Ic (7812Ic). Shown overleaf is the diagram of voltage regulator Ic.

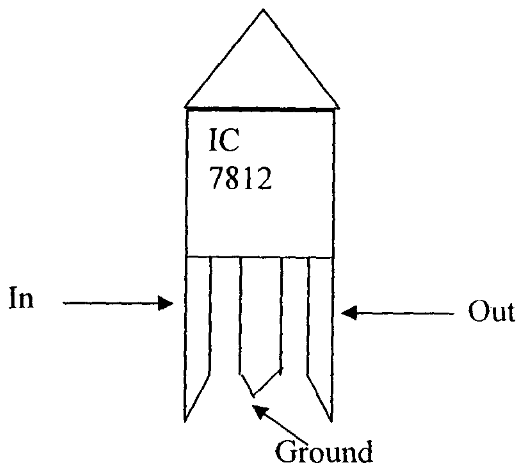


Fig. 3.5 Diagram of voltage regulator Ic (7812)

This stage stabilizes the output voltage irrespective of variation in input voltage or load. It could be:

i. series control
ii. series shunt control
iii. shunt control

Series type is commonly used as it can be used in high voltage application. In this project, series type was also employed for effectiveness of the system.

3.3 SERIES TRANSISTOR STABILIZER

- The Zener diode maintains the base of the transistor at a constant potential. The emitter follows the base potential so that it is below the base voltage for a normal bias (0.6V for silicon) [6], Thus keeping the output voltage constant.

3.3.1 OPERATION OF SERIES TRANSISTOR STABILIZER

When V_1 reduces owing to increased input voltage (within a safe limit)V_2 rises, increasing the forward bias on the transistor. This causes greater collector emitter current to flow and that raise the voltage drop across the load such that V_1 is restored to its normal value. Therefore, if V_1 goes up as a result of load reduction or increased input voltage, then V_2 is reduces so that load receives less current. That will eventually neutralize the effect of the initial rise in output voltage such that a stabilized output voltage is achieved.

3.3.2 ANTI-SURGE MODULE

SURGE: This is a sudden rush of current, a violent oscillatory disturbance or the like Owing to the overhead high tension cables, power supply from the generating station is susceptible to surge. This may be attributed to the falling of trees on the power line during storm, bird perching on the power line which eventually result in a short circuit fault either line to line, line to neutral or line to ground. Hence, the supply voltage is abnormal-in most cases, the consumer is affected in an area where the step down transformer has no fuse and as such the abnormal current flows through the conductor (put in place of the fuse). This abnormal current then flow to the consumer electrical appliances and in the absence of anti-surge circuit, the entire system may be destroyed or partly affected. In consideration of this, an anti-surge circuit was incorporated –into the system in order that the entire system be protected from any surge occurrence. overleaf is a diagram of anti-surge, circuit for the 12V power supply circuit.

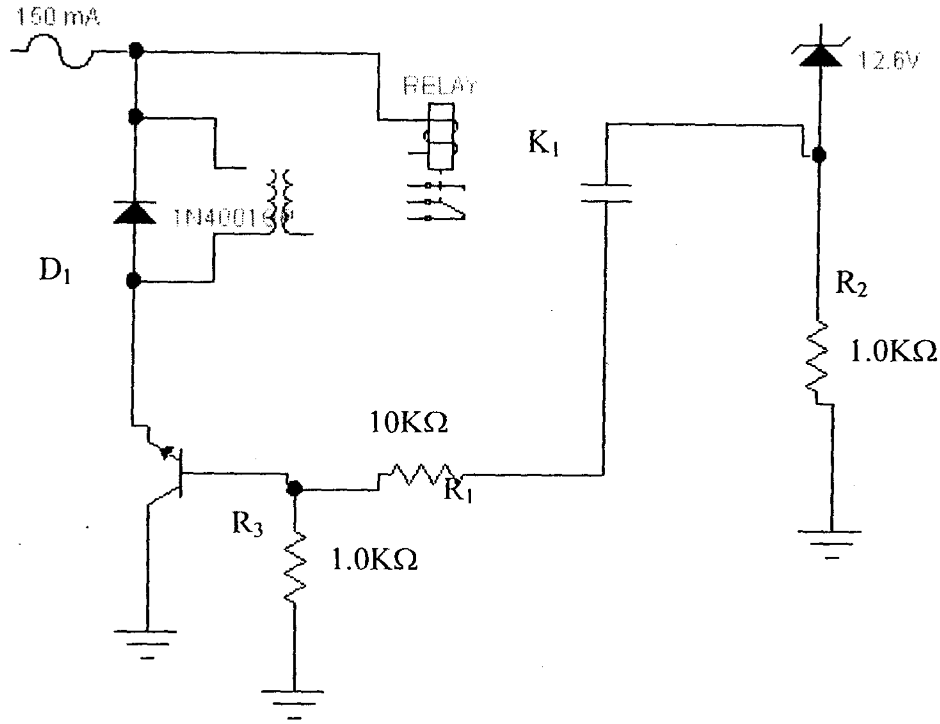


Fig.

3.6: The diagram of anti surge circuit.

3.4 VOLTAGE DIVIDER MODULE

It is sometimes necessary to determine the voltage drop across any two or more resistor in series. It can be established in such case, that the voltage drop across a resistor with each other is directly proportional to the value of that resistor.

In this project, a transistorized sensor of resistance 10kΩ and 10kΩ respectively was connected such that the point between was connected to the oscillator via the switching transistor Q_1. The transistorized sensor on seeing darkness causes the supply source voltage to multiply by half (that is half the source voltage, 6V). The figure overleaf shows the voltage divider module.

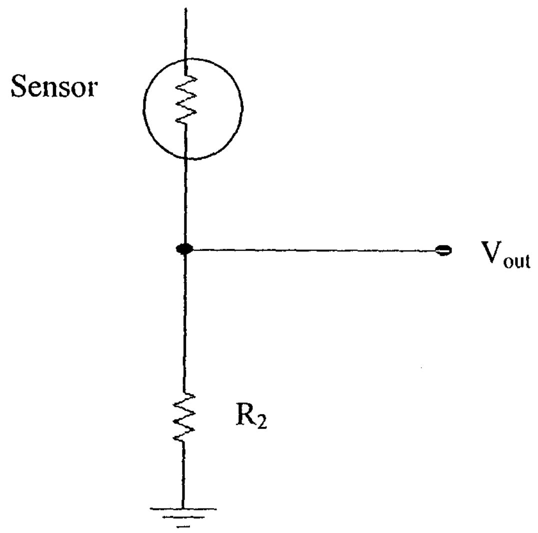


Fig. 3.7: Voltage divider module.

$R_1 =$ 20kΩ (Transistorized sensor resistance when there is no darkness)

$R_2 =$ 10kΩ

$R_1 =$ 20kΩ (Transistorized sensor senses darkness)

$V_{out} = (V_{in} \times R_2)$

When $V_{in} = 12V$

Hence,

$$V_{out} = (12V \times 10k\Omega) / (10k\Omega + 10k\Omega)$$

$$V_{out} = (12V \times 10^3\Omega) / (20k\Omega)$$

$$V_{out} = 120{,}000V\Omega / 20 \times 10^3\Omega$$

$$V_{out} = 1.2 \times 10^5 V / 2.0 \times 10^4$$

$$V_{out} = 6V$$

The V_{out} (output voltage) calculated is the required voltage necessary to drive the voltage comparator module via the oscillator.

3.5 OSCILLATOR MODULE

Oscillators are electronic circuit means to generate pulse in an intermittent manner or in a continuous manner. In other words, whenever it is desired to generate pulses to drive any system, the oscillator circuit is always the desired electronic circuit. They are either connected in ASTABLE or MONOSTABLE mode. The monotable is designed to release a pulse at a time interval T1.1RC while the astable mode is designed to generate continuous pulses.

. In this project, the oscillator module is connected in an astable mode, so that on receiving signals from the voltage divider module via the switching transistor, it releases pulses required to drive the voltage comparator module. Below is the diagram of the oscillator module of the automatic street lighting system (A.S.L system).

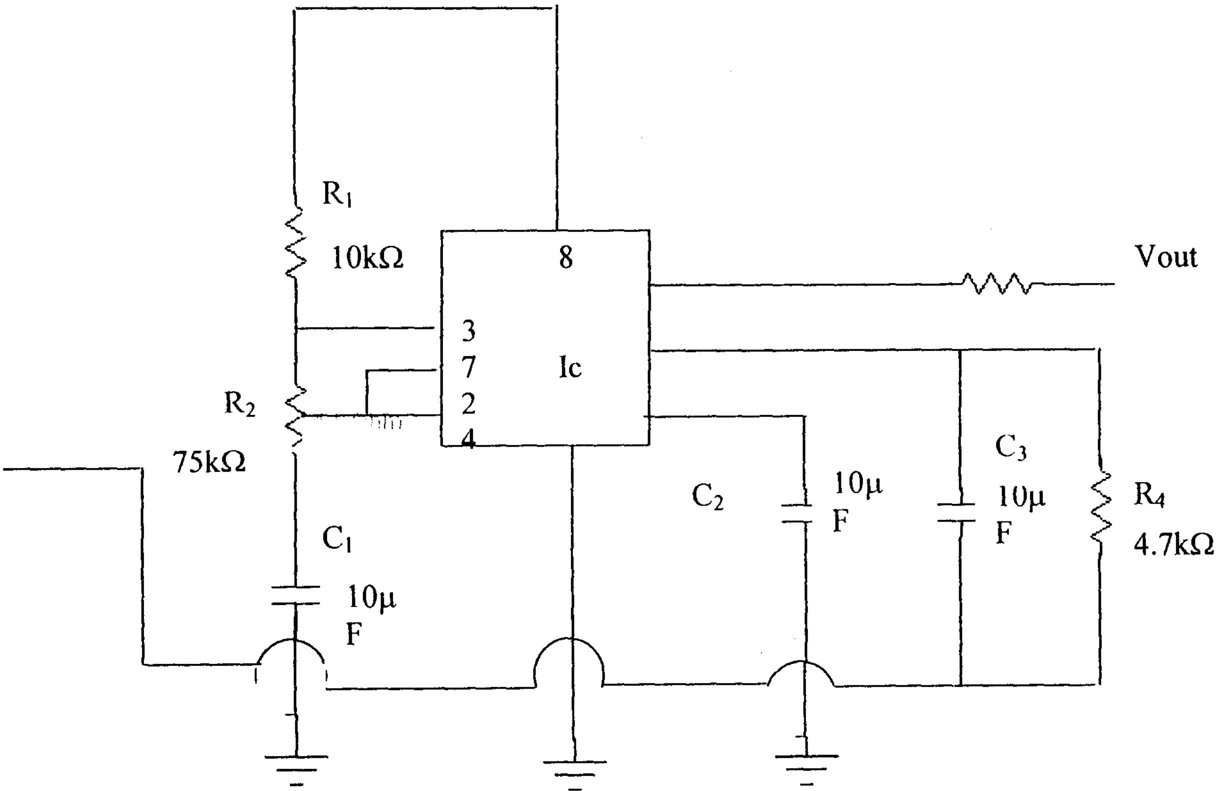


Fig. 3.8: the oscillator module of the A.S.L system

3.6 VOLTAGE COMPARATOR MODULE

A comparator is a device for making comparison. Voltage comparator as the name implies is a circuit that compares the magnitude of the two analogue signals (usually voltage) between the inverting and non –inverting logic output. It is similar to a differential amplifier operating in an open loop mode.

However, because of its high gain, the output is normally saturated in either high or low state depending upon the relative amplitude of the two input voltages. With this condition, the input provides a logic state output, which is indicative of the amplitude relationship between two analog signals.

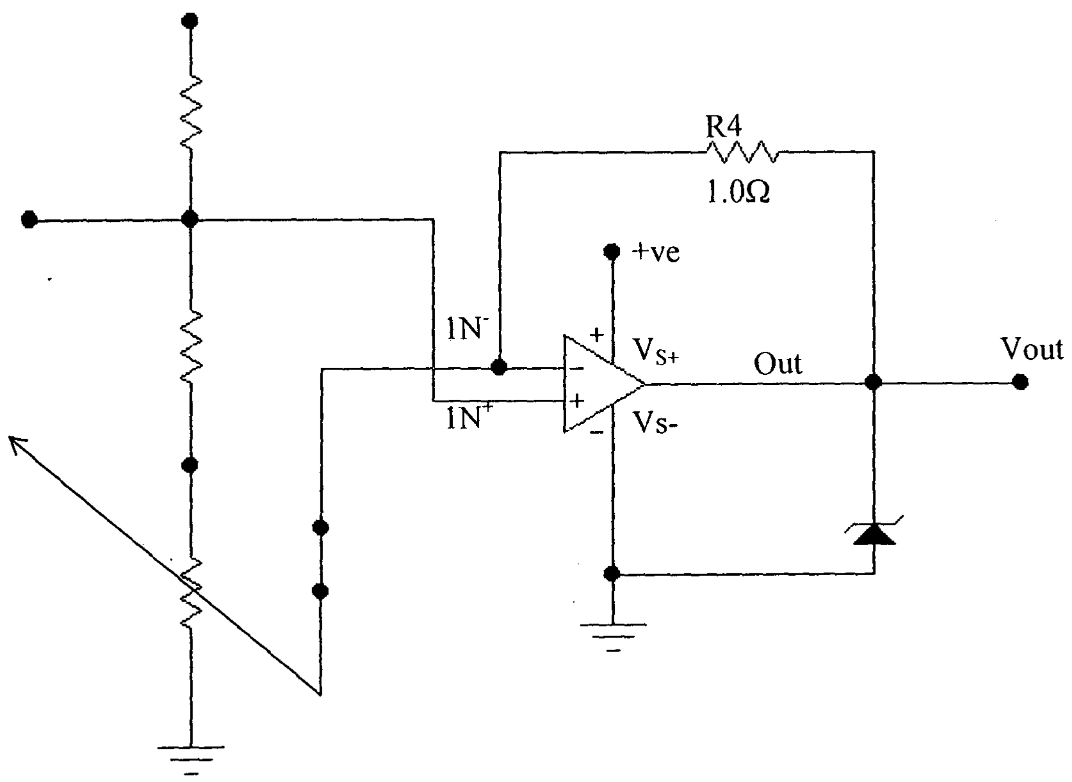


Fig. 3.9: Voltage comparator Circuit

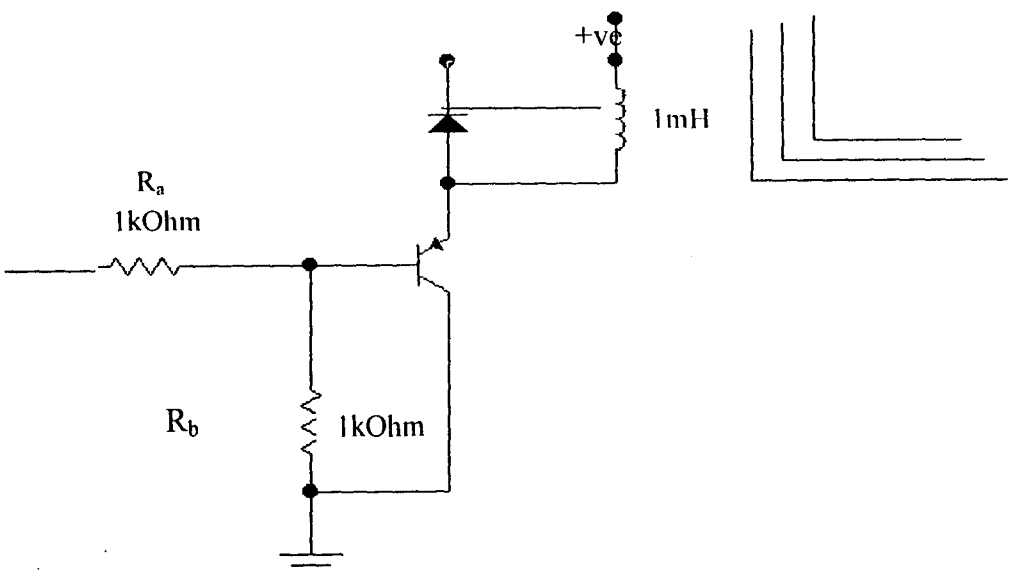
3.7 SWITCHING MODULE

- Switch means turning ON or OFF directing an electric current, or redirecting an electric circuit. The switching modules interface the entire system with the load. Without this module, the aim of this project will not be achieved. The comparator, 6V, Energizes the switching circuit through a parallel combination R_a and R_b, the switching module on receiving signal energizes the local connected to the socket outlet of the system.

For this design, a transistor and relay was used for the switching module. The choice of the transistor was based on its reliability, durability, responsiveness and its snap action.

Thus with the aid of the transistor switch, a relay can be turn ON and OFF by small signal in the cut-off region (open) whereas on the other level the transistor operate in the saturation region and create a short circuit.

An NPN high speed switching transistor (2N2222) silicon type was used and was connected in common emitter configuration with its collector output connected to the relay coil (the small signal from the logic circuit (comparator module) will produce a higher switched output voltage current at the collector output required to drive the relay coil which inturm energize the load at the socket outlet. Below is a diagram of the switching module.



sFig. 3.10 the switching module

3.7.1 CALCULATION FOR DESIGNING TRANSISTOR SWITCHING

Characteristics of 2N2222A transistor

I_{Bmax} = 0.02A

$I_{C\ max}$ = 0.8A

V_{BE} = 0.6V

B = 40

V_{cc} = 12V

R_a = ?

R_b =

V_{BB} - 2V

From the switching module shown in fig 3.1.0 above, by Ohm's law

I_cR_c = V_{cc}.......... (12)

Where R_c is the collector resistance, that is the relay resistance usually obtained by the digital multimeter equals 410Ω

From........... (12)

I_c = V_{cc} / R_c

I_c = 12 / 410

I_c = 2.9×10^{-2}A

I_c = 0.029A

Ignoring any leakage current, I_{CBO}

I_{BM} = I_c / B

$I_{BM} = 0.029 / 40$

$I_{BM} = 7.25 \times 10^{-4}A$

$I_{BM} = 0.000725A$

The current through R_a necessary to ensure cut-off for an over-driver switch by thumb rule equals to $2I_{Bmin.}$

$\therefore \quad I_b = 2 \times 0.000725$

$I_b = 0.00145$

Apliying kirehpoff's voltage rule

$I_bR_b = V_{BB} - V_{BE}$

Then $R_b = (V_{BB} - V_{BE})/I_b$

$R_b = (2V - 0.6V) / 0.00145$

$R_b = 965\Omega$

Using Kirchoff voltage rule on the input with $I_b = I_a$

$I_aR_a = (V_{in} - V_{BE})$

$\therefore \quad R_a = (V_{in} - V_{BE})/ I_a$

$V_{out} = 120/20$

$V_{out} = 6V$

$R_a = (8 - 0.6) / 0.000725 \quad = 7.4 / 0.000725$

R_a = 10206.89Ω

R_a = $10.206k\Omega$

R_a = $10k\Omega$

Hence,

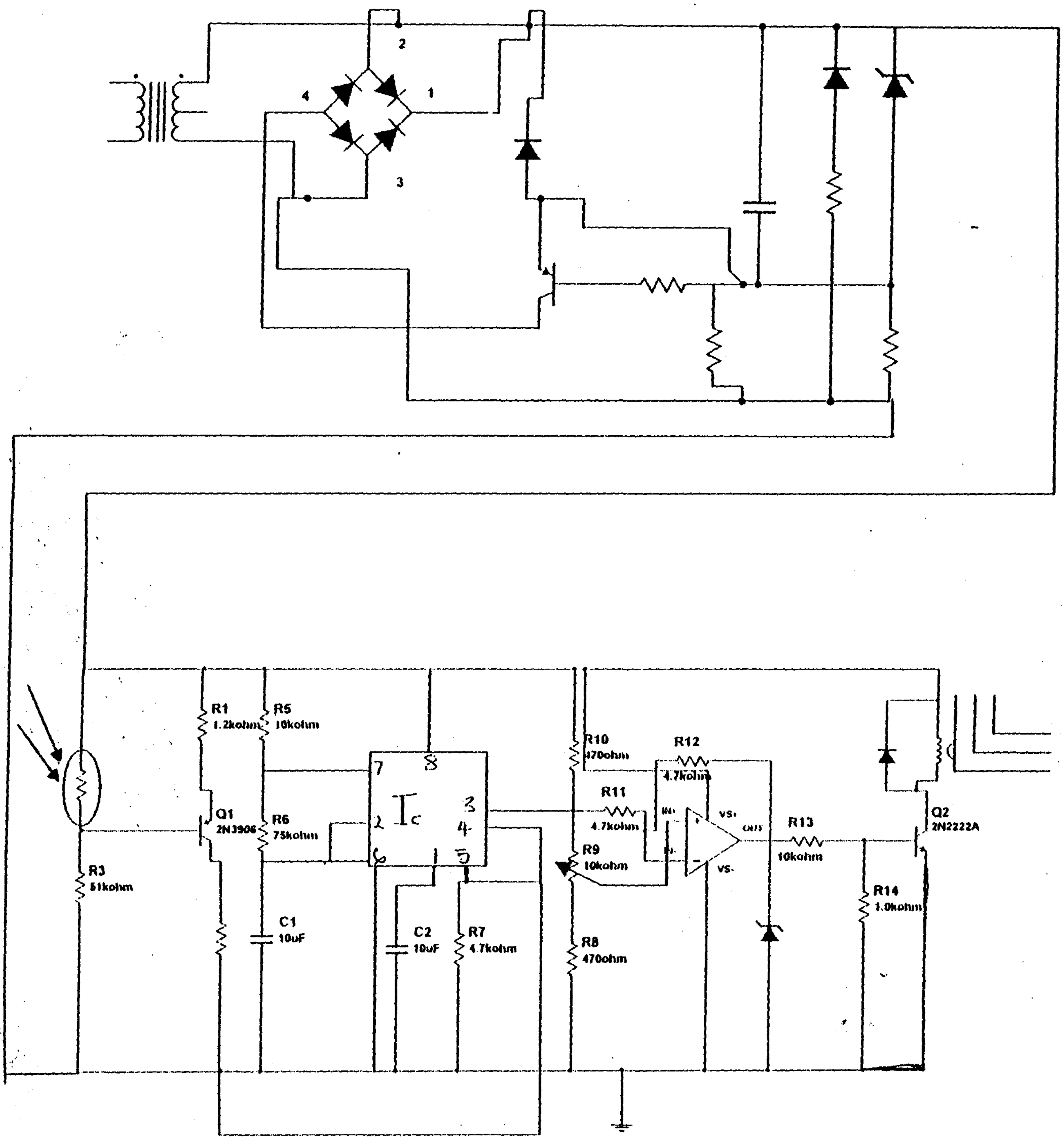
R_a = $10k\Omega$ and

R_b = 965Ω

3.8 LOAD MODULE

The load is usually a sodium lamp of high or low capacity depending on the level of development of the area it is required.

The poles carrying the bulbs were made of metal rods of about 30cm in length curved in opposite directions.



CIRCUIT DIAGRAM OF AUTOMATIC STREET LIGHTING CONTROL SYSTEM USING TRANSISTORISED SENSOR

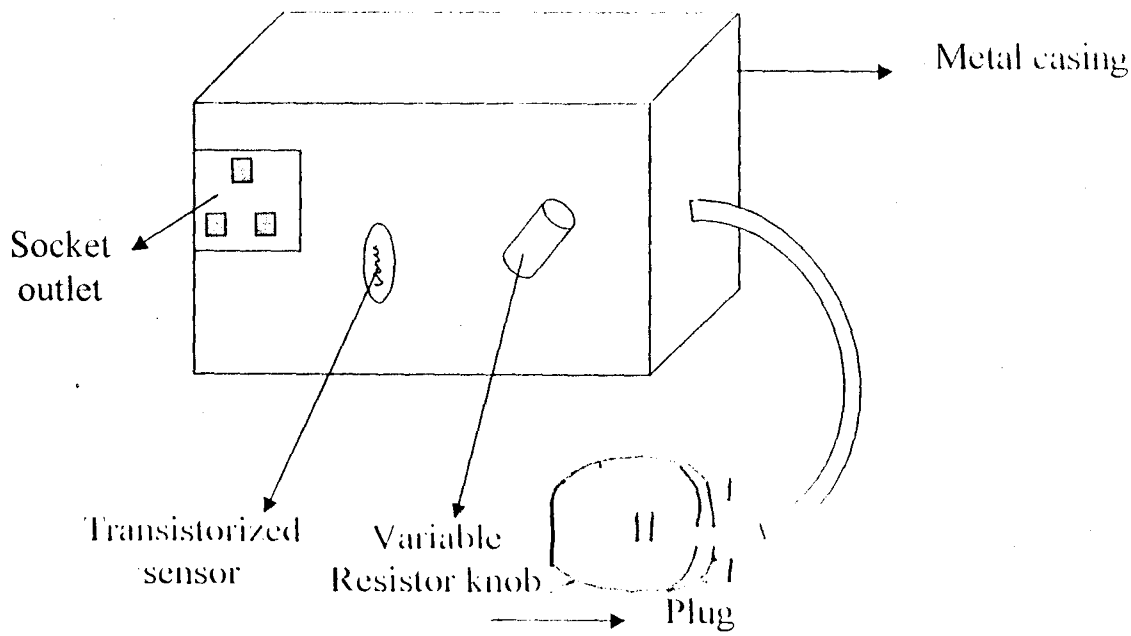
CHAPTER FOUR

4.0 CONSTRUCTION / MODELLING AND TESTING

4.1 CIRCUIT CONSTRUCTION

The layout of the circuit is shown in Fig. 4.1 below. The entire tapped Transformer, Rectifier, Filter, Regulator, Sensor, Comparator and Switching modules were implemented on Vero iron board as shown below. The choice of material used for the construction of casing for the system is dependent on cost, reliability, durability, overall weight and physical outlook of the system design. Therefore, the casing was made of metal of light weight with the following dimension:

Length..................22cm
Breadth.................12cm
Height..................15cm
Thickness...............0.3cm



The relay in turn was emerged and makes a close contact thereby switching "ON" the bulbs on the street lighting poles. There are six bulbs in all. Immediately the dark shadow or dark material was removed, light ray falls on the transistorized sensor thereby energizing the relay and turns OFF the bulbs.

The process of switching "ON" and "OFF" was repeated for several times (about 10 times) to ensure the reliability of the circuit design and construction. It was confirmed very reliable and active.

4.5 DISCUSSION OF RESULT

This project actually may seem simple but it was very demanding and task full. It was really not easy to get adequate design of this project and that of obtaining the required components that got burnt or damaged while in the construction stage. They are Zener diode, resistor and semi-conductor device because they are very fragile and sensitive to heat. Another difficulty encountered was that of finance, even though the project seems simple in outlook, most of components that constitute the design are scarce and very costly because of environmental factor. This necessitated very careful soldering techniques to avoid unnecessary damages and cost incurred.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

This project report has given a comprehensive and details of the design and the materials as well as the components used in this project work. The simplicity of the design outlook was a result of meticulous and compatible selection of materials and components employed and this brought about the portability of the design model. The Automatic Street Lighting System, (A.S.L) using transistorized sensor in highly economical and safer to operate in the sense that it reduces constant human interference and involvement in power switching. It is generally cheap and easy to maintain.

5.2 RECOMMENDATION

This project work is indeed very interesting and educative but it demands a high theoretical knowledge. It has also boosted the practical knowledge I acquired during my six months Industrial Training (SIWES) program.

In addition, this project is a prototype, which could be improved on and modified to construct a real life street lighting system by introducing a three-phase contactor such that the relay can now operate the exciter coil. This could be used in the school street lighting design and in Minna as a whole. In a case where the school wants to construct street lighting system on campus, it will only require an incorporation of some other components in the circuit design.

I also recommend that the amount of light intensity required by the transistorized sensor should be noted for the different seasons of the year so that this lighting system using transistorized sensor can be effective throughout the year.

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