DESIGN, CONSTRUCTION AND TESTING OF AN AUTOMATIC LIGHT SENSITIVE SWITCH WITH HIGH AND LOW CUT-OFF VOLTAGE SYSTEM.

BY

BADU STEPHEN

MATRIC NO: 2004/18871EE

OF

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING.

SCHOOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY.

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DECLARATION

I Badu Stephen with Matriculation Number **2004/18871EE** of Electrical and Computer Engineering department, Federal University of Technology Minna, Niger State. Here by acknowledge that this work was carried out by me under specific rules and guidance from my able supervisor **Mr. Stephen Oyewobi** and also humbly acknowledge the authors of the materials from which **I** got the materials to execute my project.

Signature Sbmmbalu. ________ 14/12/2009 ________

Name: Badu Stephen Date

Matriculation NO :(2004/18871EE).

CERTIFICATION

This is to certify that this project Titled "Design, Construction and Testing of an automatic Light sensitive switch with High and Low Voltage Cut-off System" was carried out by **Badu, Stephen (2004/18871EE).**

This was done under strict supervision of **Mr. Stephen Oyewobi** and submitted to the Department of electrical and computer Engineering, Federal University of technology Minaa, Niger State. In partial fulfillment of the requirements for the award of Barchelor of Engineering (B.Eng) degree in Electrical and Computer Engineering.

Mr. Stephen Oyewobi ____________________ Date ____________________

Dr. Adediran Head of Department ____________________ Date ____________________

External Examiner ____________________ Date ____________________

DEDICATION

I hereby dedicate this piece of my project work first and foremost to ALMIGHTY GOD who has been absolutely marvelous and gracious to me. For his inspiration, provision and good health.. And of course to my able family very lovely family. For their love, care advise, supports of any kind and encouragement. Finally to my friends, associates who I don't have their permission to mention their names for their wonderful and amazing support.

ACKNOWLEDGEMENT

My special thanks goes to my project supervisor Mr. Stephen Oyewobi, who has been most understanding and tolerant; and under whose tutelage the entire project work was made a reality.

I also acknowledge the undying support of my wonder family, who stood by me and assisted me during this project work. This assistance in monetary terms, prayer, advice, rebukes, admonition, etc will never be forgotten. I will not forget my friends who also supported me during this work and who also contributed immensely to this work in ways I cannot begin to mention, and whose name I will not mention not because they are unworthy but because I have not gotten approval from them. But most importantly I wish to acknowledge the ever loving presence of God in my work and who always provided a way I thought all hope was lost. To these I cannot mention, it is not because they are not special, but due to space, time or the short human memory should forgive me. May they be rewarded accordingly by God. Amen.

PROJECT ABSTRACT

The Automatic Light sensitive switch with high and Low voltage cut-off system is a Light Dependent and Voltage variation based circuit which implores the characteristics of a photo resistor and comparators to control ON/OFF timing of lighting load. The LDR resistance decreases with presence of visible light. I used four comparators which are built in the LM324 IC chip. Comparators C1 andC2 detects high and low voltage respectively, while C3 compares output from C1 and C2 and produce output to supply C4.variable resistors VR1-VR4 are used to establish reference voltages at the inputs of C1,C2 and C4 respectively.

At power supply of (180-220)V, C1 and C2 produce an output which is compares by C3 and in turn supply C4.output from C4 forward bias transistor which energizes the inductor connected to it, the flow of current into inductor coil magnetize the relay to closed the circuit if its during night period an output is produce. If its during daytime no output will be produce, also if the power supply from PHCN is higher or lower than my reference voltages no output at the load.LDR is connected to the inverting terminal of C4,in the presence of visible light there is no output from C4 because the voltage across the inverting terminal is lower than the non inverting terminal voltage. The objective of this project is to switch ON/OFF lighting points automatically during night and daytime respectively, and also protect the load in case of over and under voltage supply from PHCN. It can be used for streets, security lighting among so many other uses.

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CHAPTER ONE:

1.1 INTRODUCTION

Engineering or Technology is all about making life easier through the application of science for the designing and building of machines and structures. In a bid to do, this; various researches are carried out and are still being carried out to understand phenomena around us and through the application of these understanding, complex methods can be carried out through easier means /methods.

An example of this is **switching.** A switch in its simplest term is used to be described as any mechanical device by means of which two or more electrical conductors may be conveniently connected or disconnected. The basic form of switch consists of two strips of spring metal on which are mounted electrical conductors.

Though this idea of switching still holds and is still being used, but due to the recent field automation, there is a need to condition the factors on which a switching process depends upon such that the switch is self regulatory.

The advantage of this is that the need for mechanically operating the switching is eliminated and it is more convenient. These factors may exist in nature itself.

There are so many things we benefit from nature, and an example of one of those nature gift is LIGHT. Of course at night when darkness is everywhere, we still need light not only in our homes but also on the streets, for security reasons/purposes and so on.

Take street lighting as a case study; the streets light should be ON at night and at any time during the day when there is heavy cloud cover such that it is considered dark.

It will not be convenient to have a human operator to operate the switch as the switching speed will be very slow among so many other things/factors. The best is to have a circuit whose self regulation depends on the intensity of natural light. Once the intensity of light rises to a certain value, the circuit is turned OFF and vice versa.

His project in its simplest term/form is a light dependent regulatory switch; that have an automatic high voltage and low voltage cut-off system sensor. And a light dependent resistor (LDR) as the sensory element. Hence it is a Light Dependent Resistor based circuit and a voltage sensory (voltage variation) based circuit.

The resistance of Light Dependent Resistor (LDR) is of order a few mega-ohms in the presence of darkness while its resistance in the presence of visible light intensity drops to a few kilo-ohms.

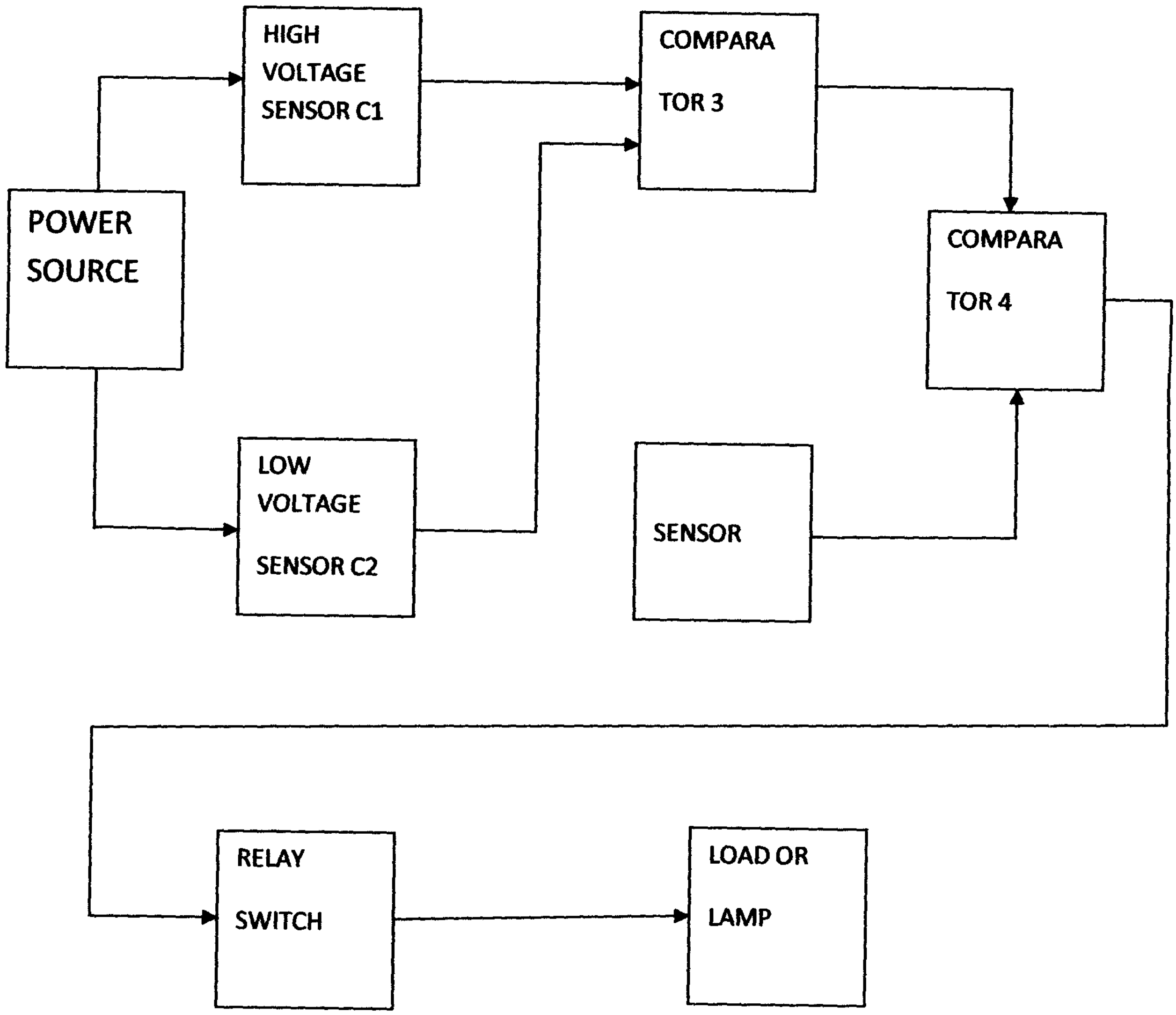


Figure 1.0: showing a block diagram of light sensitive switch with high and low voltage cut-off system.

1.2 METHOD OF OPERTATION:

It is a light Dependent Resistor and Voltage variation sensitive based circuit which will perform the specified function automatically. The darkness resistance of the LDR is of the order of a few mega-ohms, while its resistance in the presence of visible drops to a few kilo-ohms. When light falls on LDR as shown in the figure 1.0 above; there is a voltage across the LDR but its less Vcc. This voltage is fed into the inverting terminal of comparator four (4) as shown above. There are two situations which determine the functionality of the circuit. Such as the case of low voltage and high voltage supply. In this project, low and high voltage supply from PHCN (i.e. Power Holding Company of Nigeria Plc) is taken to be between 180V – 220V. Which indicate normal circuit situation of operation. Under this condition, the circuit will turn ON as expected otherwise it will turn OFF. Note that over voltage is taken to be voltage supply above 400V, and under voltage supply is the supply below 180V.

Under normal condition (i.e between 180V – 220V), the step down transformers are connected in series to obtain 400Vwhile their output is cascaded to obtain 12V. This is passed to the non inverting terminal of the comparator one C1 which is the comparator that takes care of high voltage situations. Any time there is high supply from PHCN it will detect it and produce no output. Inverting terminal of C1 is supply with an input voltage of 6V (Vcc) taken from **7806** voltage regulator which is also the reference voltage. Comparator produce an output if voltage across the inverting terminal is equals one third of Vcc or in other words if voltage drop across the inverting is greater than non-inverting terminal. Comparator C2 is used in the circuit to detect low voltage supply, and the inverting terminal is supply with 6V voltage from **7806** voltage regulator IC voltage.

In my project I employed various variable resistors (VR1-VR4). VR1 is connected to the filtered output of capacitor, VR2 is connected to C1, VR3 is connected to C2 and VR4 is connected to C4. Such that voltage levels can be varied according to the operation of my circuit. For instance if the supply from PHCN is 400V, this voltage is step down by transformers in the circuit and the output is fed into high and low comparators (C1 and C2 respectively). C1 will not produce output because its meant to cut-off when the voltage is beyond 220V and equally C2 will not produce output because voltage across the non inverting is greater than the inverting terminal.

Comparator 3 which does the comparism between the C1 and C2 voltages will no have output to compares and so no input to the non inverting of C4. If its during day time, the voltage drop across LDR will negligible to supply inverting of C4, because the resistance value of LDR reduces in the presence of visible light. Hence no output to forward bias NPN transistor, as such no current to energize the inductor coil to make normally open relay switch to close. Finally no output will be produced.

However if the supply is 220V the step down output is fed to CI and C2, C1 will produce an output and C2 will not produce output because of prevailing circuit conditions. This output from C1 and C2 is passed to the C3, since inverting terminal has voltage greater than non inverting, C3 will produce an output to supply C4. If its during day time, voltage across inverting will be less than non inverting terminal because LDR resistance reduces with presence of light intensity, hence no output to supply transistor which in turn will not produce output to energize inductor coil connected to transistor. As a result the circuit remains open and no output will be produced. If its during the night period and the above condition is maintained the voltage across the inverting terminal will be greater than non inverting terminal, hence C4 will produce output which will forward bias transistor in the circuit and in turn energizes the inductor coil to close the relay circuit and an output will be produced.

Finally if the supply is 180V and its during night period with all circuit conditions remain the same as explained above, there will be output. Otherwise if its day time there will no output from load of the circuit.

1.3 PROJECT MOTIVATION

Over the years, several attempts have been made by difference students in FUT Minna and beyond to make life more meaningful through the use of Technology. Basically using LDR to provide Automation to some circuits. But there has been a prevailing problem, which is protecting the life span of these bulbs which is very crucial. My project attempt to provide solution to this by using cut-off system in addition to LDR sensor. These cut-off circuits protect the bulb in case of power fluctuation.

1.4 PROJECT AIM AND OBJECTIVES:

i) Design a circuit that automatically regulates lighting system. (ii) Construct the circuit. (iii) Test the circuit to ensure it is functioning well.

1.5 PROJECT OUTLINE:

My project outline is divided into five chapters for better comprehension.

First is the project Abstract. Chapter one deals with general introduction, principle/method of operation, project motivation, aim/objectives and scope of the project.

Chapter two is base on Literature review and Theoretical Background of my project. While chapter three talks about the design, implementation, Calculations and construction, chapter four is basically on Testing, Results and. Finally chapter five is based on conclusion, problems encounter during the project from design through to implementation of project and possible recommendations and references and appendix.

CHAPTER TWO:

LITERATURE REVIEW/THEORETICAL BACKGROUND.

2.1 Literature Review

Over the years switching systems were basically on manual operation that requires an operator. The industrial revolution came with the technology for the design of mechanical switching system consisting of levers and gears, which are bulky, and at the same time produce wear hence it is unreliable.

With the emergence of the computers age electronic switching circuit using discrete components tends to be more reliable than the mechanical counterpart because they are lighter in nature and operates faster.

Suleiman Salihu Adekson designed and constructed switch controller, which he titled "Light Activated Switch Control". In his work, the switch controller has to be presented to a given resistance R at room temperature. Hence, this work is accurate because during stormy or cloudy day where light intensity reduces and temperature decreases that result in poor visibility, the switch control ought to be achieved by incorporating a Zener Diode to only discriminate the reference voltage across the comparator such that whenever there is voltage difference between the sensor (LDR) and reference, the street lights turned ON.

In September 2003, an attempt was made by Bello Suleiman Abdulyekin in his project titled "Design and Construction of Street Light Automatic Controller".

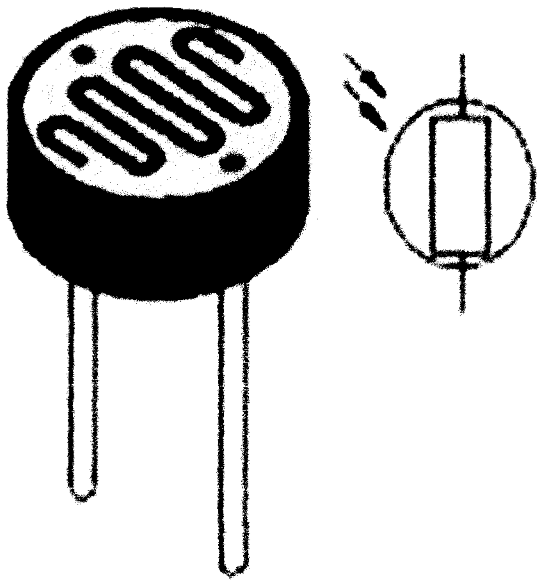
In his own case, he equally used LDR as his sensor in the circuit, the principle of operation is that when enough light falls on the LDR, its resistance R is low, the developed voltage across the LDR is inadequate to drive transistor in the circuit to energize the relay, so transistor is cut-off an no power is applied to the load. However, when there is little or no illumination on the LDR, the resistance increases dramatically. The voltage at the surface of LDR rises. If the components of the circuit are properly chosen , enough forward bias of the bias of he base emitter is developed to increase the collector current appreciably. This current energizes the relay coil thereby closing the normally opening contact, thus power is applied to the load. However if the load is a streetlight bulb, it will be turned ON automatically as night falls and turned OFF during the day time.

Also **Aremu, A. also made an attempt in his project titled "Automatic Light sensitive switch".** And his principle of circuit operation was the same as that of Bello Suleiman in project in the year 2003. All these people in their attempts at different times, they have one perculiar problems the life span of bulb is not protected and can easily be damage by voltage fluctuations..

2. 2 THEORY:

The resistivity (and hence resistance) of a semiconductor depends on the number of free charge carriers available in it. When the semiconductor is not illuminated, the number of charge carriers is small and, hence sensitivity is high. But when light in the form of photons strike the semiconductor, each photon energy is greater than the energy band gap of the semi conductor, free mobile charge carriers are liberated and, as a result resistivity of the semi conductor is decreased.

Photoconductive cells are generally made of Cadmium Sulphide (CdS) and Cadmium Selemide (CdSe). Spectral response of CdS cell is similar to human eye; hence such cells are often used to simulate the human eye. That is why we find use in light metering circuits in photographic cameras. The diagram below shows LDR and its symbol.



(a) (b)

Figure2.0 showing the LDR and it symbol

As seen from figure 2.0, the two ends of the photosensitive semiconductor strips are brought out to connecting pins below the base. The terminal of characteristics of photo conductive cell is shown below. It depicts how resistance of the cell varies with light intensity. Typically the dark resistance of the cell is 1MΩ or even larger. Under illumination, the cell resistance drops to s value between 1-ohms and 100-ohms depending on surface illumination.

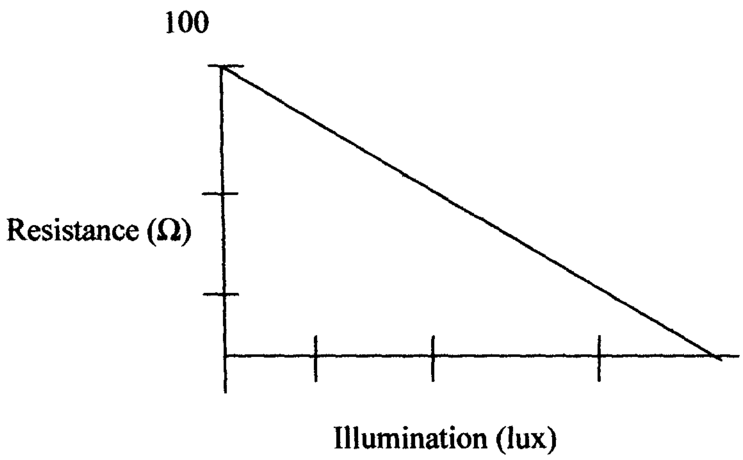


Figure 3.0 LDR Resistor Vs illumination graph.

There are other photo detectors life, photo diode and photo transistor but I have decided to use Light Dependent Resistor because of the following reasons:

i) The output signal of a photo diode can be inconveniently small at low light levels.

ii) The additional current gain of a photo transistor does not improve its ability to detect very low light levels.

iii) An LDR is very sensitive from full light to extreme darkness.

2.3 TRANSISTOR SWITCH:

The transistor is an active (three terminal) semi conductor device capable of amplification, oscillation and switching action. The transistor is the essential ingredient of every electronic circuit, from the simplest amplifier or oscillators to the most elaborate digital computer. The name "**Transistor**" is an acronym for Transfer resistor. Transistor is an active component, a device, which can amplify, modulating an output signal with more power in it than the input.

$I_E = I_B + I_C$ .... (1)

This relationship holds for any transistor in any circuit. There are three main transistor configurations; common base in which the base is common both emitter and the collector; common emitter in which emitter is common to both base and the collector; and the common collector in which collector is common to both base and the emitter.

I have chosen a common emitter configuration.

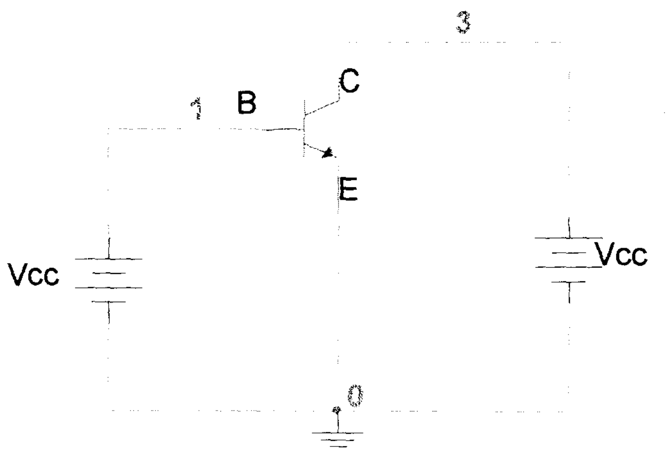


Figure 5.0 showing a transistor connected in the common emitter configuration

The ratio of the collector current (output current) to the base current (input current) is called transistor beta, β and is given by

$\beta = I_C/I_B$ ....(2)

To bias a transistor, I have decided to use voltage divider bias for it to provide good biasing stability and is commonly used for transistor incorporated ICs. Considering the diagram below.

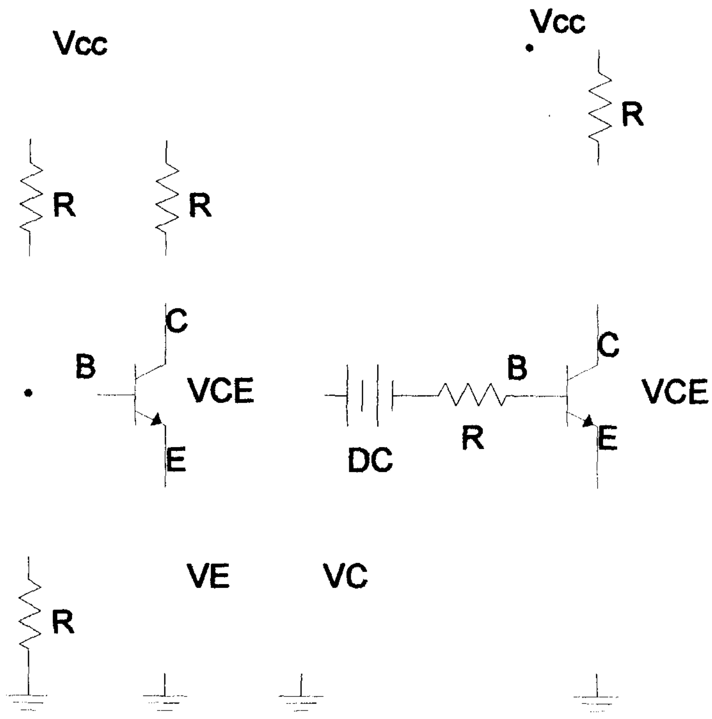


Figure 6.0 Voltage divider bias arrangements

The transistor is always D.C biased to set its operating points.

$V_{TH} = VccR2/ (R1+R2)$ (voltage divider)..(3)

$R_{TH} = R1R2\ (R1+R2)$...(4)

V_{TH} is the effective voltage as seen by the base and R_{TH} the effective resistance as seen by the base.

$V_E = V_{TH} - V_{BE}$ ....(5)

$I_E = V_E/R_E = V_{TH} - V_{BE}(R_E \approx V_{TH}/R_E)$..(6)

Since $V_{BE} \ll V_{TH}$.

V_{TH} is the diode reverse voltage which has to be overcome for the diode to conduct. For Silicon (Si) semi conductor, $V_{BE} = 0.7v$ while for Germanium type, $V_{BE} = 0.3v$, $\mathbf{Vc = Vcc - I_C R_E}$.. **(7)**

$\mathbf{V_{CE} = Vc - V_E = Vcc - I_C R_L - I_E R_E}$.. **(8)**

$\mathbf{\approx Vcc - I_C (R_L + R_E)}$ ....**(9)**

The base current is set by Vcc and by R1 and R2. In this project the role of R1 is taken over by the LDR and R2 by the variable resistor which is used to adjust the sensitivity of the transistor. The Beta sensitivity K_β, is the influence the beta value has on the transistor. D.C operating point and is given by

$\mathbf{dI_C/I_C = K_\beta dI_\beta/\beta}$... **(10)**

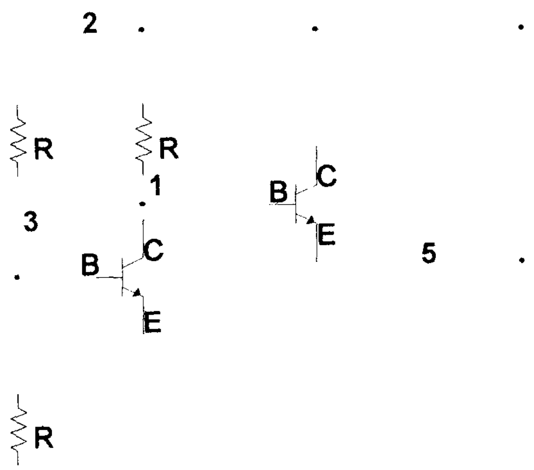
$\mathbf{K_\beta = \beta/I_C \times dI_C/dI_\beta = 1/(1 + \beta R_E (R1//R2))}$...**(11)**

Changes in β-values are caused by variations in the operating conditions or by the substitution of one transistor with another. Since the operating condition of the circuit in this project varies with variation in the light intensity, it therefore becomes very important a means of controlling β-sensitive. The range of K_β is given as

$\mathbf{0 \leq K_\beta \leq 1}$... **(12)**

2.4 TRNASISTOR SWITCHING:

Two transistors cascaded can be used as a switch and I have employed this in my project



10 Figure 7.0: transistor switch

The above figure 7.0 shows this principle. Transistor T1and T2 and are NPN transistors. When transistor T1 is conducting because it's dark, T2 will either be at cut-off region depending on the supply from PHCN. For example, if T1 is conducting and the supply from the PHCN is higher than the normal the T2 will cut-off reversed biased and forward bias the transistor T2.

On the other hand if the supply from PHCN is lower than the normal reference voltage with T1 conducting, T2 will conduct.

When a transistor is switched ON, it must pass through different stages.

i) Transistor OFF. The base-emitter junction is reversed biased and only a leakage current flows in the collector circuit.

$I_C = I_{CEO}$..(13)

ii) Transistor in active region of operation

$IC = I_{CEO} + h_{fE}I_B$..(14)

iii) Transistor in saturated condition.

$I_C = Isat$...(15)

At switch OFF, the sequence is reversed and the is the time taken to pass through these stages is the switching time.

The choice of component is to some extent is a matter of compromise, since the transistors are saturated when "ON", the amplitude of the output voltage waveform is independent of the value of the collector resistor. The selection of this resistor is therefore a compromise between economy of current and speed of operation. The choice of transistor is largely determined by the required speed of operation. I choose the combination of comparators and the transistors because of all combinations I tried, they where the fastest as per switching speed. The characteristics and other properties of these transistors are given in the appendix. Before attempt an in-depth analysis of this stage, I will first of all mention the importance of waveform generation stage. Now that we know how to trigger the circuit ON, the question is what factors have to be put into consideration which will be responsible for triggering the circuit-OFF.

2.5 TRANSFORMER:

2.5.1. Working principle of a Transformer:

A transformer is a state (or stationary) piece of apparatus by means of which electric power in one circuit is transformed into electric power of the same frequency in another circuit. It 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. In its simplest term or form, it consist of two inductive coils which are electrically separated but magnetically linked through a path of low reluctance as shown in figure 12.0 below. The two coils posses' high mutual inductance. If one coil is connected to a source of alternating voltage, an alternating flux is set up in the laminated core, most of which is linked with the other coil in which it produces with the other coil in which is linked with other coil in which it produces mutually-induced e.m.f (according to Faraday's law of Electromagnetic induction)

e = MdI/dt.. (16)

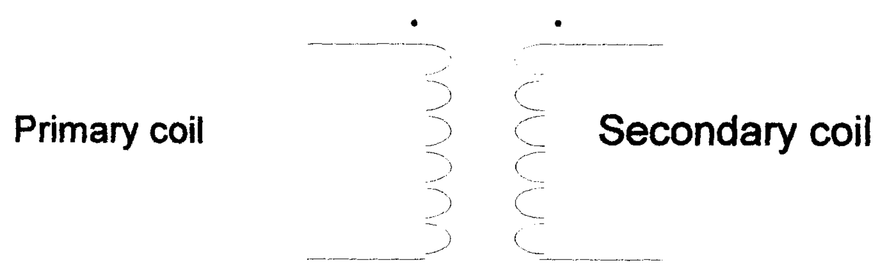


Figure 8.0: Laminated core.

If the second coil circuits are closed, current flows in it and so electric energy is transferred (entirely magnetically) from the first coil to the second coil. The first coil, in which electric energy is fed from the A.C supply mains, is called **primary winding** and the other from which energy is drawn out, is called **secondary winding.** In brief, a transformer is a device:

i) Transfers electric power from one circuit to another.

ii) It does so without a change of frequency.

iii) It accomplishes this electromagnetic induction and

iv) Where the two electric circuits are in mutual inductive influence of each other.

Construction ally, the transformers are of two general types, distinguished from each other merely by the manner in which the primary and secondary coils are placed around the laminate core. These two types are known as

i) core-type and

ii) shell-type.

2.5.2. Step-Down Transformer:

For the purpose of my project am using a step-down transformer. By definition this is a type of core-type or shell-type of transformer in which voltage from the primary winding is step-down from the secondary terminal. These types of transformers are used to residential purposes, industries and so on.

2.5.3 Elementary Theory of An Deal Transformer:

An ideal transformer is one which has no losses i.e. its windings have no ohmic resistance, there is no magnetic leakage and hence which has no **I_2R** and core losses. In other words, an ideal transformer consists of two purely inductive coils wound on a loss-free core. It may however, be noted that it is impossible to realize such a transformer in practice, yet for convenience, we will start with such a transformer and step by step approach an actual transformer.

2.5.4EMF Equation of a Transformer:

Let N1 = Number of turns in primary.

N2 = Number of turns in the secondary.

Φm = maximum flux in core in Webers Bm x A

f = frequency of A.C input in Hz.

As shown in figure 16.0, flux increases from its zero value to maximum value **ϕm** in one quarter of the cycle i.e1/4*f* second

Therefore average rate of change of flux = ϕm/(i/4*f*)

4*f*ϕmWb/s or volt.. (17)

Now, rate of change of flux per turn means induced e.m.f in volts.

Therefore average e.m.f/turn = **4*f*ϕm** volt

If flux ϕ varies **sinusoidally**, then, rms multiplying the average with form factor.

Form factor = rms value/average value = 1.11.. (18)

= (induced e.m.f/turn) x No. of primary turn.

$E1 = 4.4fN1\phi m = 4.44fN1BmA$.. (19)

Similarly r.m.s value of the e.m.f induced in secondary is,

$E2 = 4.44fN2\phi m = 4.44fN2BmA$... (20)

It is seen from (i) and (ii) that

$E1/N1 = E2/N2 = 4.44\phi m$... (21)

It means that emf/turn is the same in both the primary and secondary windings. In an ideal transformer on no-load, V1 = E1 and E2 = V2; where V2 is the terminal voltage.

2.6 CAPACITOR:

A capacitor is a passive electrical circuit component consisting of , in its simplest form, two metal electrodes or plates separated by a dielectric (insulator). The purpose of a capacitor is to store electric charges energy by electrostatic stress in the dielectric.

figure 9.0 parallel plate capacitor

The diagram above shows two parallel plates (electrodes separated by a dielectric and connected to an external battery. Such plates separated by a dielectric medium constitute a capacitor plate X is joined to the positive end of supply and plate Y to the negative end of the supply. When such a capacitor is connected across a battery, there is a momentarily flow of electrons from X to Y. as negatively charged electrons are width drawn from X, it becomes positive and as these electrons collect on Y, it becomes negative. Hence a potential difference is established between the two plates. The transient flow of electrons gives rise to a charging current. The strength of the charging current is maximum when the two plates are uncharged but it then decreases and finally ceases when potential difference across the two plates becomes very slowly and opposite to the battery e.m.f.

2.6.1 Capacitance of a capacitor.

Capacitance of a capacitor is the property by two conductors separated by a dielectric, whereby an electric charge becomes stored between the conductors. The symbol of capacitance is C; while its unit is the farad F.

supposing a charge Q Coulombs is applied to one of the two plates of a capacitor and if a potential difference of V volts is established between the two, then its capacitance **is** C

Q/V = charge/potential difference..(22)

From this we conclude that capacitance is the charge required per unit potential difference. The unit of capacitance is Coulombs/Volts which is also called Farad.

A capacitor has a capacitance of IT when a charge of 1volt per second across the capacitor produces a current of 1 ampere through it.

From the above equation

Q = CV = IT.. (23)

Taking the derivative dv/dt Cdv = Idt

I = Cdv/dt...(24)

This implies that the current flowing through a capacitor is not simply proportional to voltage, but to the rate of change of voltage.

2.6.2 Energy stored in a capacitor.

Energy stored up in the electrostatic field setup in the dielectric medium. This energy is released by discharging the capacitor by connecting a resistance across it. Suppose at any stage of changing, the potential difference across the plate is V, by definition, it is equal to the work done in shifting one coulomb of charge from one plate to another. If 'dq' is the charge net transferred, the work done is

dw = V x dq...(25)

Now q = CV; dq = C x dv

dw = CV xdv..(26)

Total work done in giving V units of potential is W = CV x dv = C

W = 1/2Cv^2 if C is in farads and V is in volts, then

W = 1/2CV^2 joules = 1/2QVjoules = Q2/2Cjoules..(27)

2.6.3 Uses of Capacitor:(1) Filtering. (2) Wave shaping. (3) DC blocking.

(4) oscillators.

2.7 COMPARATOR It is circuits which compares two signals applied to it, and generate an output which is the differences between the two inputs signals

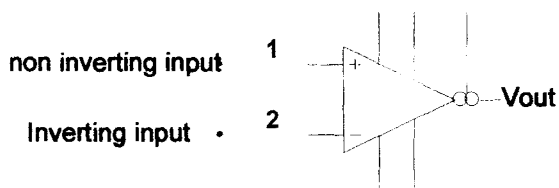


Figure 10:showing symbol of a comparator

or voltage levels.

If V1 and V2 are equal, then Vo should ideally be zero. This is because the comparator in it simplest form, its design to produce an output only if there is difference in the applied voltage between two inputs of the comparators.

Even if V1 differs from V2 by a very small amount, Vo is large because of amplifiers high gain. Hence, circuit of figure 10 above can detect very small level changes which is another way of saying that it compares two signals.

Comparators can be used as amplifiers in which thee application of voltage to the terminals determine whether the comparator/amplifier is in inverting or non inverting configuration.

2.7.1 Operational Amplifiers

An operational amplifier or OP- AMP is a very high gain differential amplifier with high input impedance and low output impedance. Typical uses of op amp are to provide voltage amplitude changes (amplitude and polarity), oscillator, filter circuits, and many types of instrumentation circuits. An op-amp contains a number of differential amplifier stages to achieve a very high voltage gain..

2.7.2 Inverting Operational Amplifier

The basic operational amplifier is shown in figure 11.0. this circuit gives a closed- loop gain R2/R1 when this ratio is small compared with the amplifier open-loop gain and, as the name implies, an inverting circuit. The input impedance is equal R1. The closed-loop band width is equal to the unity-gain frequency divided by one plus the closed- loop gain. The only cautions to be observed are the R3 should be chosen to be equal to the parallel combination of R1 and R2 to minimize the offset voltage error due to bias current and that there will be an offset voltage close at the amplifier output equal to close-loop gain times the offset voltage at the amplifier input.

Vout =- R2/R1Vin.. (22)

2.7.3 Non Inverting Operational Amplifier

Figure 11.0 below shows a high input impedance non-inverting operatonal amplifier circuit. This circuit gives a closed-loop gain equal to the ratio of the sum of R1 and R2 to R1 and a closed-loop 3dB band width equal to the amplifier unity gain frequency divided by closed-loop gain. The primary difference between this connection and inverting circuit is that the circuit output is not inverted and that the input impedance is very high and is equal to the differential input impedance

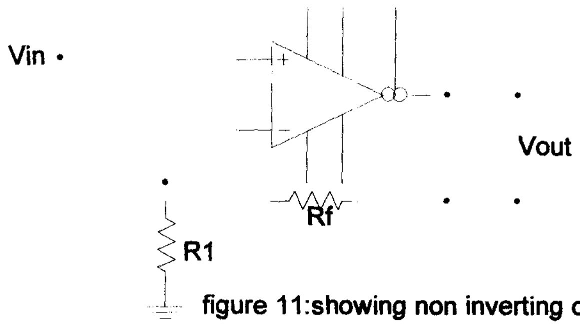


figure 11:showing non inverting op amp

multiplied by loop- gain.

Vout = (R1 + R2)/R1x Vin.. (23)

2.7.4 Uses Of Operational Amplifiers

Operational amplifiers are the most important simple linear and non linear integrated circuits. They perform wide variety of linear and non- linear signal-processing functions. They are produced as in expensive circuit modules from various manufacturers.

2.8 THE OUTPUT STAGE

The output stage consists of relay drivers to which the lighting load is connected. A relay switch is a signal-activated switching device. In most cases a relatively weak current or voltage is used to make the relay switch a higher current or voltage. A relay may be electromechanical or full electronic. An electromechanically relay is an electromagnetic switch consisting in one form or a multi turn coil wound on an Iron core near an armature with a movable contact.

CHAPTER THREE:

DESIGN AND IMPLIMENTATION

3.1 Principle of operation

The principle of operation of this project involves an electronic control of security lamps with the use of electromechanical device in the presence and absence of light. Also instance of over voltage and under voltage has been taken of via the use of various comparators.

Specifically this project is designed to put ON security lamps when darkness is casted on the sensor and also to turn OFF the lamps when there is visible light. The light to be used is the normal daylight and the darkness, that which is available in the light.

3.2 Power circuit:

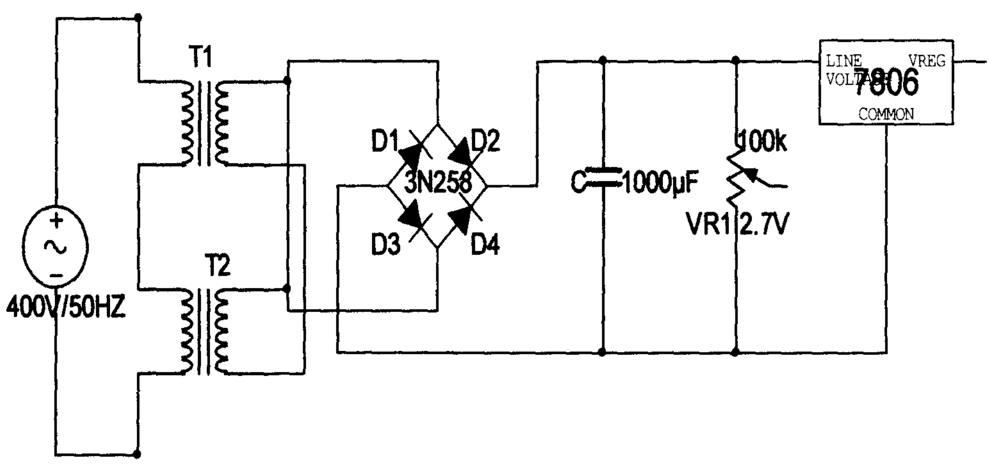


figure 10 shows the power circuit of light sensitive switch

The power circuit shown above consist of two transformers connected in series ,each of 230V/50hz input with an output of (12×2)V . The output of the two transformers are cascaded to obtain 12V. Two transformers are used to be able to measure 400V, which represent the abnormal situation where the circuit is expected to switch OFF. This 12V AC power is rectified into DC by a bridge rectifier consisting of four Diodes (D1,D2,D3 andD4) each with 3N258. The remaining ripples is filtered out by an electrolytic capacitor (1000μF). DC output from capacitor is used to connected variable resistor VR1. But is very important to note that 400V AC power is taken to 5V DC power for my circuit.

Therefore if **400V...............5V**

Then 220V.......................X; therefore my X = 220×5/400 =2.7V

This 2.7v is the voltage across VR1=2.7V. so my VR1 was adjusted to 2.7V.

The last component of power circuit is 7806 IC which is voltage that provide 6v VCC needed by comparators in the circuit. The function of this power is to transform AC to DC which is needed in the circuit.

3.3 cut-off system of Light Sensitive Switch:

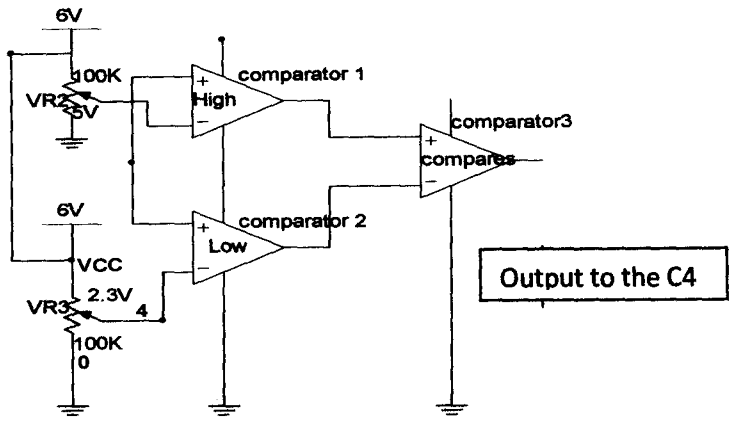
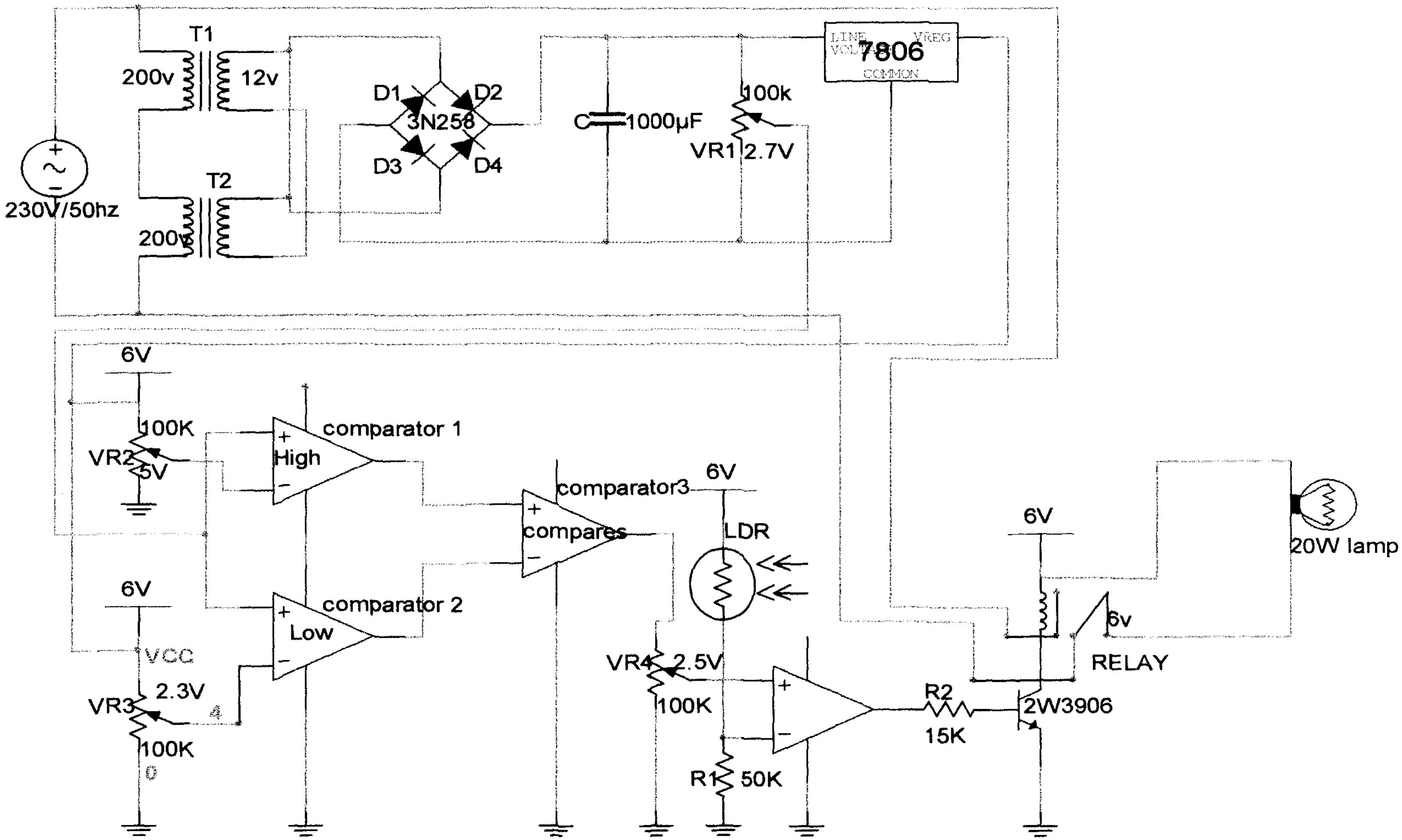


Figure 11 showing cut-off system of light sensitive switch

Basically from figure 11 above, the function of cut-off system is to serve as a protective device that protects the bulb should in case of any power or voltage fluctuations. The circuit consist of three comparators label CI, C2 and C3.

Comparator C1 is design to detect over voltage and cut-off in order to prevent and protect the circuit load(lamp). While comparator C2 is design to sense under-voltage and cut-off to protect the bulb. Comparator C3 is meant to compare the output from C1 and C2 and produce an output to comparator C4. But all the comparators are embedded in LM324 IC or chip. VR2 and VR3 are connected to C1 and C2 respectively, and the voltage VR2 = 5V which is the reference voltage and VR3= 2.3V.

3.4 Output circuit of Light Sensitive Switch.



complete circuit diagram

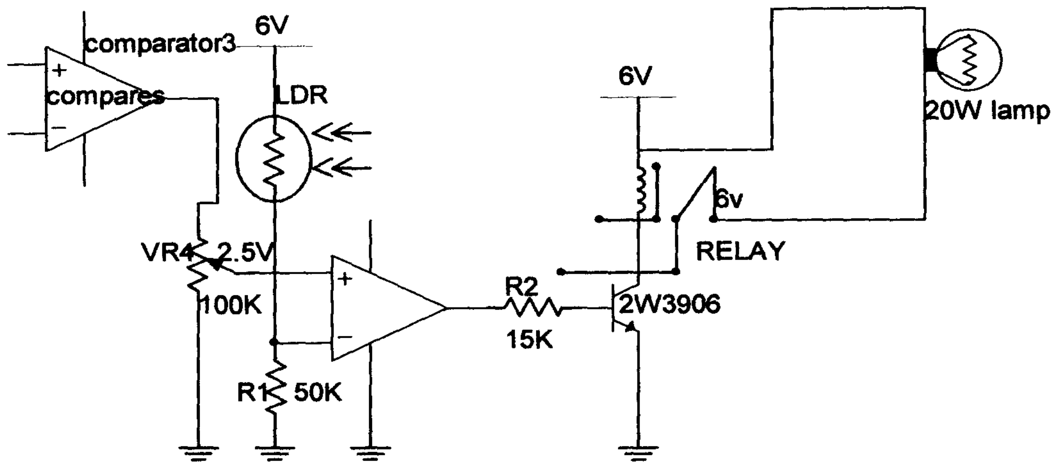


Figure 12 showing output stage of light sensive switch

This output stage consist of sensor LDR whose is in the order of few mega ohms but reduces to few-kilo ohms in the presence of visible light, comparator C4 which provide output to forward bias NPN transistor. We also inductor coil which energizes relay switch in order to supply the load.

3.5 complete circuit of Automatic Light Sensitive Switch with cut-off system

Figure 13 above, shows complete circuit diagram of my project.

As shown in the figure 13 above comparator one (C1) deals with high voltage situations. According to Prof. Oria Osifo in His book (fundamental of electrical installations) he stated that the life span of a lamp reduces as a result frequent switching, over voltage and under voltage which he did not mention. However, so as to combat the issue of over voltage, the variable resistor VR2 (100KΩ) is used to give C1 an input voltage at the inverting terminal which is the reference voltage. While VR3 is used to set the reference voltage of C2. Note, the voltage at non inverting terminal is less than the voltage at the inverting terminal. That is to say at normal condition (180V- 220V) the above statement holds. Once the voltage supply from PHCN drops below 180V there is no output from comparator C2. And vice versa.

Also from schematic diagram shown in figure 13 above, as for the issue of high voltage. The comparator C1 is used to put a stop to the functionality of the circuit.

At normal condition (180V- 220V) the voltage at the inverting input which is from VR2 is greater than the voltage at the non inverting terminal of comparator C1. At this condition no output voltage at C1. Whenever there is the case of over voltage supply by PHCN, the reversed is the case.

Comparator three (C3) does the comparism between the high and the low state. If there is a case of low voltage, the two inputs would be of logic zero which brings a logic zero to the output. If the voltage is normal but, not above 230V then the output would be 1. But if there is a case of high voltage the inputs would have logic 1 (i.e. about 400V). at this point the differences between the inputs is not 1/3 of Vcc = 6V. Therefore output is zero.

As shown in the schematic diagram above, comparator four C4 the sensor brings about the variation in voltage due to variation of the light intensity across R1. This varied voltage is then compared with the voltage which is provided by the used of variable resistor VR4. This voltage is called the reference voltage. Whenever light intensity decreases, the resistance of the sensor (LDR) is increased. This decreases the voltage across the inverting input of the comparator C4. As a result of this and the proper setting of VR4, the comparator C4 will switch from low to high. That is to say, at darkness, the comparator C4 produces an output which is high. This then turn ON Q1(transistor) which in turns pulls the relay driver R1.

3.6 Comparator stage

This is achieved with the use of an operational amplifier LM324 which has four (4) inside the IC, each has two inputs terminal: inverting and non inverting input. Figure 13 below shows an integrated circuit (IC) LM324.

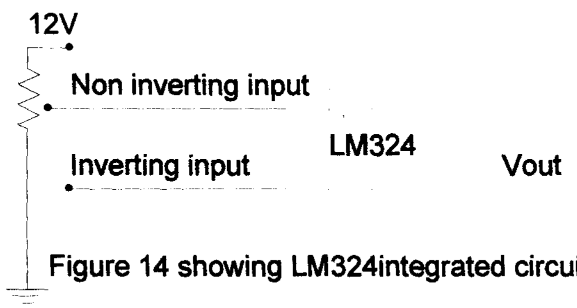


Figure 14 showing LM324integrated circuit

This stage compares voltages at the inverting terminal with that at the non inverting input, which is the reference voltage. With this, there are three possible situations with three possible results respectively.

When the input is equal to the reference voltage

Result: the output voltage is zero.

ii) when the input voltage is less than the reference voltage.

Result :the output voltage is more positive (i.e high)

iii) when the output voltage is more than the reference voltage.

Result: the output is low.

This can further be illustrated with the following formulae.

Vout = AoVin.Note that Ao = open loop voltage gain = 20,000 or more. Therefore Vin = V^+ - V^- , where V^+ is the voltage at non inverting input and V^- is the voltage at inverting input.

3.7 Transistor Switching Circuit.

The switching transistor switches on the relay whenever it is biased and vice versa. This is effected by the output of the comparator. When this is high it allows certain current to flow through the base of the transistor Via Rb. As a result, there is an amplification of current since transistors are current amplifiers. This amplified current are driven by certain voltage which is applied at the coil of the relay causing it to energize and then, pulling the contacts together. This is analyzed mathematically below.

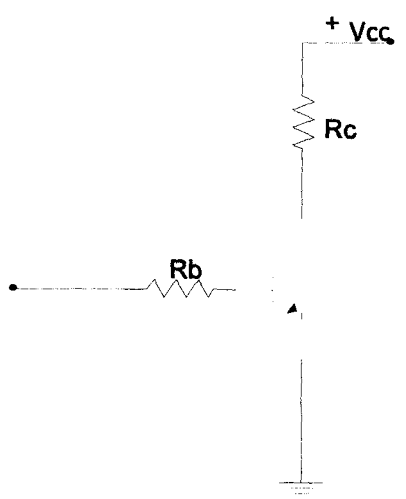


Figure 15 is shown below.

3.8 Calculation of Ic, Ib and Rb

In this project Ic is the collector current of the transistor in the circuit, Ib is the base current and Rb is the base resistance of the transistor, and the evaluation is done as shown below.

$Vcc = V_{CE} + IcRc$..(24)

Where Vcc = 6v for my project, V_{CE} is the collector – emitter voltage and Ic is the collector current and Rc is the collector resistor. But Rc = 110Ω for my project. Therefore substituting the value of Vcc and Rc into equation 28 above;

$6V = V_{CE} + Ic \times 110$..(25)

But V_{CE} is 0 at saturation

Therefore Ic = 6/110 = 0.0545A or Ic = 54mA

But dc transistor current gain is given by $h_{fe} = Ic/Ib$....................................(26)

But Ic = 0.0545A

And the value of h_{fe} ranges from 0 – 300

Let $h_{fe} = 300$

300 = Ic/Ib but Ic = 0.0545A

Ib = 0.0545/300 = 0.0001818A or 0.1818mA Vin = 5V

Vin = VBE + IbRb..(27)

CHAPTER FOUR

4.1Testing and Results

During testing of my project, first when I plug in my supply to the Ac source, the output from the two transformers in series connection at the input level and output which is cascaded, I did not get 12V as expected. When I checked my connections, I discovered that my cascaded was not properly done. I effect the correction immediately. With high reference voltage my circuit was responding fine. That is there was output when it was expected, there was no output produced during the day. While the lower reference voltage even when I covered sensor with my hand representing the dark period there was no output. Instead during day when I allow light intensity to fall on sensor there was output at the load. During troubleshooting I find out that my sensor was faulty, immediately I replace it with new one.

Finally my circuit function well as expected and stipulated by my design. So the aim/objectives of my design implementation was finally achieved. Which design, testing, construction of Automatic Light sensitive with Automatic high voltage and Low voltage cut-off system.

4.2 PROJECT LIMITATIONS

My project was tested using 20W bulb and it works fine. This was done 6V relay switch, however for higher Wattage I recommend the of 12V 30A relay. And because of voltage even when light has not drop to 180v, the bulb was blinking indicating an insufficient voltage for the circuit.

CHAPTER FIVE

5.1 CONCLUSION:

At the end of the project, the practical was tested to find out if the set objectives/goals of the project were met. It was find out that the constructed project work functioned properly.

The unit responded well to changes in light levels. At times when darkness is not that much the lighting load comes ON but it's not very bright. To put very simply, the project meets the design specification and the proposed goals

5.2: RECOMMENDATIONS:

The project forms a vital part of the university education and is of many benefits to the students for it is more effective and has impact. I recommend that:

1) Practical design should carry about 30% of students work load right from their first year so that they wound have built their confidence by time they get to their final year.

2) Components should be provided to students to enable them embark on the construction of many project there by strengthening their hands.

3) There should be a provision for students to know their individual project work topic and respective supervisors before on industrial attachment.

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APPENDIX

Components of the circuit	**Cost**
Step down transformer (220V – 12V)	N150.00 × 2 = N300.00
Bridge rectifier	N140.00
Filtering capacitor 1000μF	N30.00
Variable resistors (4) each 100KΩ	N30.00 × 4 = N120.00
7806 positive series IC	N60.00
Comparators (4) LM324 IC	N250.00
Resistors (2) 100KΩ and 15KΩ	N10.00 × 3 = N30.00
Transistor	N150.00
Casing	N3,500.00
Bulb (20W)	N130.00
LDR	N450.00
Wires and Jumpers	N170.00
Relay Switch	N110.00