DESIGN AND CONSTRUCTION OF DARKNESS ACTIVATED STREETLIGHT SYSTEM WITH SOLAR - BACKUP

BY

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DEDICATION

This project work is dedicated to Almighty Allah for giving me life, protection, wisdom and understanding so far.

DECLARATION

I, Ismaila Mohammed hereby declare that this project work is an original concept completely carried out by me under specific rule and efficient supervision of ENGR Abolarinwa .J.A of the Department Of Electrical And Computer Engineering, Federal University Of Technology, Minna, Niger State.

All information derived from published and unpublished works / materials for this work are hereby acknowledged.

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ABSTRACT

With the increasing thrust towards automation, the need for man to ease out some function becomes an issue, which cannot be over emphasized. Hence with the presence of photosensitive semi conductors the issues of automation in connection with light can be easily achieved which is one of the objectives of this work. The main objective of this work is to design, construct and test a darkness activated streetlight system with a solar backup. The major task of this work is to ensure availability of light on the street always and only when light is needed, with solar power backup light is always available when it is dark and with photo resistor light is only available when needed. Both light switching and power switching are automatic.

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CHAPTER ONE

INTRODUCTION

Engineering is all about making life easier through the application of science for the design and building of devices.

In the beginning of energy saving in street lighting, one or more luminaries were switched on and off by time switch (simplified lighting control device), this does save about 50% of energy but destroy the uniformity to an extent which is dangerous .this is not acceptable any more or supported by any national or international standard .most streetlight systems function dependently on human operators. Though these switches function satisfactorily in normal condition, turning the light on and off at the preset time.

The discovery of optoelectronic such as light dependent resistor (LDR), photodiode, photo transistors and photo thyristors which depend for their operations on what is called photoconductivity effect this has reduced human involvement in the switching operation, and had increased in the use of automatic switching systems. As a result of this, human and electrical energy are conserved greatly with human errors greatly minimized [3].

PURPOSE OF STUDY

Streetlight systems, regardless of their size or placement, typically employ normal switch to control overall operating times. These switches can mange the operation of an array of streetlights within a system, or one switch can be present on every light within the system. The purpose of this project is to create a photo sensor that upon sensing changes in light intensity make decision to alter the operation of the streetlight. This streetlight sensor will have the ability to control the intensity of light supplied by the streetlight bulb and also supply light to the street at all times it is needed, making the unit able to react to its surroundings more effectively. Such a sensor will undoubtedly be more reliable than its predecessors and more cost effective, not only due to its ability to reduce the output of unnecessary energy, but also due to its effects on the streetlight bulb it self.

AIM AND OBJECTIVES

The aim of this project is to design and construct a darkness activated streetlight. A low power streetlight sensor that will turn on and off at dusk and dawn respectively, automatically and also construct a continuously powered system in which upon power failure (main power), a solar power sensor design to charge up a battery to serve as back-up for the system supply with the entire system completely independent of human involvement.

The objectives of the project are:

- To construct an automatic switching system that can efficiently and effectively switch streetlight on at night or when the weather is dark and off during the daytime or when the weather is bright .
- To demonstrate how a photo resistor can be use to control the action of dependent events.
- To construct lighting system that will always be available when light is needed.

DESIGN METHODOLOGY

According to Dentsch and Cock 1980, the subject of research methodology refers to the arrangement or collection and analysis of data in a manner that aims to combine the relevance of the research purpose with procedure. Several scientific materials and books about how to begin carrying out the project were consulted. Relevant websites with useful information about the design, construction and implementation of the project were also visited. The aim was to get the most effective and economically viable design for the project; this stage also involved the simulation of the circuit design on an electronic software application (electronic workbench).

The project work was sub divided into six blocks, each block was designed separately and all connected according to the design flow.

These blocks consist of the power supply unit which involves voltage transformation, rectification and regulation by the use of transformer, diode and capacitor, and voltage regulator respectively. This is followed by sensor unit which sense light intensity and fed a comparator with two voltages one fixed and the other variable depending on the light intensity, the comparator unit which compare the voltages from the sensor unit and produce the difference as an output to the logic unit. the logic unit decide (depending on the output of the comparator) and produce either a high (1) to switch a transistor ON or low (0) to switch it OFF in the switching unit. finally if the transistor is switched ON, it switches a relay connected to the load (power bulb).the back-up power which supply the system power if the mains fail, a solar panel charge up a battery, the battery discharge to the circuit as soon as the mains power fail. This method used was to avoid design mistake and skipping of any section of the device.

SIGNIFICANCE OF STUDY.

The significance of the study is to design a device that will operate completely and efficiently without human involvement thus reduce hardware complexity in switching.

SCOPE AND LIMITATION.

The scope of the design is to sense light and switch off a bulb or sense darkness and switch on light .The limitation is the inability of the device to differentiate between artificial light and sunlight.

PROJECT OUTLINE

* Chapter one talks about the topic introduction, aim/objectives, brief outline on limitation, application and its relevance.
* Chapter two is about the project literature review, principle, recent development and theoretical background.
* Chapter three entails the main objective of the design, design and implementation, analysis, selection of components, coupling of devices and design calculations.
* Chapter four discuss test and measurement of component (hardware) and debugging of the software component and casing of the project.
* Chapter five based on summary, problems encountered and finally recommendation for future work.

CHAPTER TWO

LITERATURE REVIEW

HISTORY AND DEVELOPMENT OF STREETLIGHTING

As early as the 18th century, British law requires home owners to place burning sticks or fagots on their public ways as measure to prevent crime [1]. Later oil lamps were used to brighten roads, the use of gas lamps followed. Then in 1978 Charles brush demonstrated his arc light in Cleveland, Ohio, and by the turn of the century arc lamps were familiar sight in the cities through out the world. Today most of the world streets are illuminated by electricity, which are controlled automatically [2]. The automatic controlled device was made possible by the way the LDR was connected with the fixed resistor [3]

LIGHT DEPENDENT RESISTOR

A light dependent resistor, alternatively called an LDR, photo resistor or photocell is a variable resistor whose value decrease with increasing incident intensity. An LDR is made of high resistance semiconductor .if light falling on the device is of high enough frequency, photons absorbed by the semi-conductor give bound electrons energy to jump into the conduction band. The resulting free electrons (and its hole partner) conduct electricity, thereby lowering resistance.

A photoelectric device can either be intrinsic or extrinsic. In intrinsic device, the only available electrons are in the valence band, photons must have enough energy to excite the electrons across band gap, extrinsic device have impurities added, which have a ground state energy closer to the conduction band.

Two of it earliest application were as part of smoke and fire detection systems, and camera light meters. Because cadmium sulfide cells are inexpensive and widely available, LDR are still used in devices that need light detection capabilities, such as security lamps and clock radios [3]

3 PHOTOVOLTAIC CELL

All these were before the advent of photovoltaic cells. The term "photovoltaic" comes from the Greek words "photo" meaning light and "voltaic" meaning electrical, from the name of the Italian physicist Volta, after whom the measurement unit volts are named. The term "photo-voltaic" has been in use in English since 1849.a solar cell or photovoltaic cell is a device that convert light energy into electrical energy .fundamentally ,the device needs to fulfill only two functions: photo generation of charge carriers (electrons and holes) in a light absorbing material, and separation of the charge carriers to a conductive contact that will transmit the electricity .this conversion is called the photovoltaic effect, and the field of research related to solar cells is known as photovoltaic [4].

The first applications of these cells were in the construction of yard and street lamps in the early nineties (90s). These lamps were not very popular because they were expensive to build, and the technical known-how was still at its beginning .however, within the last twenty five (25) years solar technology has greatly improved [4]

Panels on a rooftop collect energy from sunlight and convert it directly into electricity. solar panel contain semi-conducting material ,when light strikes the material ,electrons move from one layer of the material to another ,forming an electric current. The evelopment of photovoltaic cell technology has brought hope to circumstance of ower failure and to areas that before now could not be supplied with electricity [6]

he development in street lighting technology has come a very long way, and even oday researches are still being carried out to create the lest power consuming ,reliable, vailable, environmental-friendly type of street which this is part of aim of this project ork.

OLAR POWERED LIGHTS

Expectations are increasing for solar-powered LED lighting to become the nvironmentally friendly outdoor lighting for the 21st century by using the natural nergy contained in sunlight as the light source to power LEDs, which offer utstanding environmental performance and maintainability. Also, the fact that they ave their own independent system for generating power means that they can be nstalled in places where running underground power lines would be difficult and can unction as emergency lighting when utility power has failed, such as in the event of an arthquake. As a result, huge demand is anticipated in the future as the next generation f lighting that meets the three all-important criteria of being environmentally friendly lus offering safety and peace of mind.

Sharp introduced its first solar-power LED street light in October 2005, and hey have since been installed in a variety of locations, including schools, parks, and ommercial establishments. Now, high-intensity LEDs brighter than ever before and levising a new method of dispersing the light enables the LN-LW3A1 to achieve a rightness rivaling 32-W inverter fluorescent lamps, which continue to grow as the dominant product for outdoor crime-deterrence lighting applications, and the LN-LS2A1 to achieve a brightness comparable to 20-W fluorescent lamps, which are currently the mainstream for security lighting.

Solar-powered LED lights are stand-alone lighting systems that generate electricity from the energy of sunlight during the day and supply that electricity to power lights at night. The LN-LW3A1 can reduce emissions of CO_2, a cause of global warming, by approximately 48 kg per year. The LEDs used in the light-generating section have a service life of approximately 40,000 hours, and can be used for approximately 10 years before requiring replacement. In addition, they use no mercury, an environmentally hazardous substance.

They generate no CO_2 emissions and work by storing electricity generated by sunlight during the day in storage batteries to provide illumination at night.

The operation of the LN-LW3A1 eliminates approximately 48 kg of CO_2 emissions per year compared to using lighting units powered by conventional utility sources. The integrated LEDs use no mercury, an environmentally hazardous substance, and also emit no ultraviolet light. Further, because they have a long service life requiring replacement only once every 10 years, almost no time and effort is involved in maintenance.

The light from the LN-LW3A1 is not bright enough to enable a person to make out the general facial features of a pedestrian on a darkened street or walkway at night from up ɔ four meters away, regarded as the minimum distance required to take evasive action

fter judging the other person to be suspicious

CHAPTER THREE

SYSTEM DESIGN AND ANALYSIS

.1 MODE OF OPERATION

The project involves an LDR, a solar panel, a battery, a light source and a controller board. The device work on the principle of automatic switching ON and OFF of the light source and also automatic switching between two power sources.

The darkness activated streetlight system make use of sensor to sense environmental light intensity and then switches the light ON or OFF, if the weather is dark, it will automatically switch ON light regardless of the period of the day. the photo resistor (light sensor) sense environmental light intensity as its input which depend on the time of the day (day or night) or on weather condition (bright or cloudy).

At night, the resistance of the LDR can be as high as 1MΩ, and the voltage due to the input signal is less than the set comparator reference voltage, the output of the comparator goes high, then the output of the comparator will drive transistor which serve as switch to the relay and a reply to their ON state which consequently switches ON the light bulb. During the day, the resistance of the LDR can be as low as 15Ω, the voltage of the input signal is greater than the set comparator reference voltage and it produce a low output which cannot drive the transistor and then switches OFF the relay and also switches OFF the light.

.2 SYSTEM DESIGN

The project work is sub divided into six main sections as stated earlier in the design methodology. They include:

1. the power supply section

2. the light sensor section
3. the comparator section
4. the logic unit
5. the switching section
6. the back-up power supply section

This are shown in the block diagram below

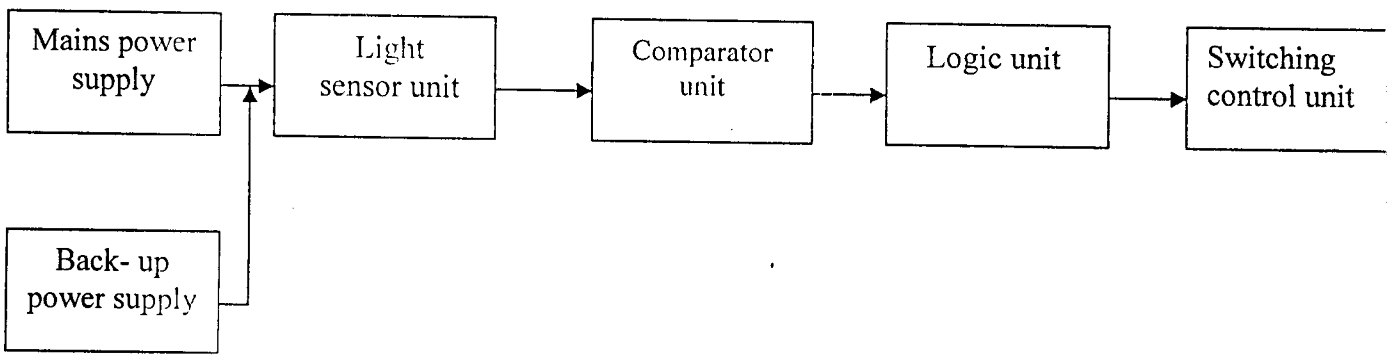


Fig 3.1 Block diagram of the project

.3 SYSTEM REVIEW

The power supply section is where the entire system gets its main electrical energy. It consists of 220-240 ac sources from the mains, which stepped down to $12v_{ac}$ by a 230/12v step down transformer. The $12v_{ac}$ was rectified using full wave bridge rectifier arrangement of four 1N4007 diodes and the output of the rectifier was filtered or smoothens with a 2200uf/16v electrolytic capacitor to give a minimum ripple, and a 10kΩ resistor to limit the output current. The rectified voltage regulated to a constant $8v_{ac}$ voltage by the use of a 7808 voltage regulator.

The backup power supply section takes over power supply if the main source above fails or not available .it consist of a 5v solar panel which can produce a maximum of 5v on a sunny day ,the output of the panel charge up two 6v rechargeable batteries connected in series to produce 12v.the 12v from the battery and 12v from the mains are fed into a change over relay ,the relay is a normal open (NO) type , if there is power from the mains, it will close and supply from mains, and if not it will open and thus supply from battery and close again as soon as the mains is restored. The final output of the change over relay either mains or battery will be fed to the voltage regulator whose output regulated voltage of 8v provide the entire system power.

The sensor section comprises of a fixed resistors and light dependent resistor (LDR) connected in such a way that there will always be two voltage sources. one voltage source will be fixed and the other varying depending on weather condition, either day or night, the two voltages are fed into the non- inverting and the inverting inputs of the LM339 IC used as a comparator .the comparator compares the two voltages and give out either logic 1 or 0 depending on the values of the inverting and the non-inverting inputs, these constitutes the comparator section.

The logic unit consist of 555 timer IC which on receiving an input from the output of the comparator section produces a high (pulse 1) as output and if there is no output from the comparator it produces a low (pulse 0) thus it serve as decider whether to trigger the switching transistor or not depending on the output of the comparator.

The switching section consist of a BC547 NPN transistor and a normal open electromechanical relay, the 555 timer IC in the logic section provide the current to trigger the transistor into conduction ,the transistor in turn supply to the relay and it closes and switch ON the bulb.

POWER SUPPLY SECTION

The power supply unit converts the 220-240vac mains to 12vdc which is to be constant, even if there are fluctuations in the ac supply voltage. This was achieved through the following operations:

1. transformation
2. rectification
3. filtering or smoothing

The block diagram of these operations are shown in the figure below

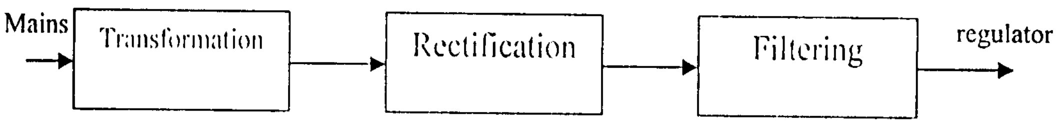


Fig 3.2 block diagram of power supply unit

1.1 TRANSFORMATION OF VOLTAGE

This involves stepping down the 220-230v mains voltage to 12v using a step down transformer .the output current rating of the transformer used is 6A.

Transformers make use of electromagnetic induction to transfer electrical energy from one winding called the primary winding to the second winding called the secondary winding. this transformation process encounter some form of losses, though it is impossible to find an ideal transformer in practice , that is a transformer that has no losses, its windings have no ohmic resistance, there is no magnetic leakage and hence has no I^2R losses.

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

$$\frac{Vac1}{Vac2} = \frac{N1}{N2} = K$$

Where:

V_{ac1} = primary ac voltage

V_{ac2} = secondary ac voltage

N_1 = primary numbers of turns

N_2 = secondary numbers of turns

K = constant (voltage transformation ratio)

From above equation of transformer, $N_1/N_2 = K$

If $N_2 > N_1$ i.e. $K<1$, the transformer is a step up type and

If $N_2 < N_1$ i.e. $K>1$, the transformer is a step down type.

For the one used in this work

$V_{ac1} = 230v$

$V_{ac2} = 12v$

N_1 =?

N_2 =?

But $$k = \frac{Vac1}{Vac2} = \frac{230}{12} \approx 20$$

Then $\frac{N1}{N2} = \frac{20}{1}$

Since N2 < N1, it means that it is a step down transformer

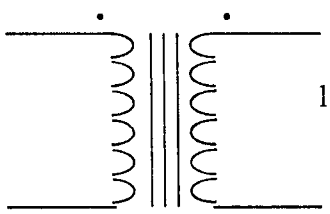


Fig 3.3 A step down transformer

When V_{ac1} = 230v is applied to the primary winding, and the turns ratio =20:1

Then $$\frac{N1}{N2} = \frac{V1}{V2} = 20$$

Therefore $$\frac{V2}{V1} = \frac{1}{20}$$

$$V2 = \frac{V1}{20}$$

And $Vac2 = \frac{230}{20} \approx 12v$ will appear at the secondary winding as output thus transformation of $230v_{ac}$ to $12v_{ac}$ is completed.

3.4.2 RECTIFICATION

This is a circuit that employs one or more diode to convert ac voltage to dc voltage (pulse). In this project full wave bridge rectifier circuit was employed, this requires four diodes arranged in such a way that current flow through the load in one direction in each half cycle of the AC voltage.

The 1N4007 diodes were used, for they are low voltage and current diodes but are very fast which makes then ideal for use with very high frequency circuits. These diodes are widely used in rectification and timing circuits

Components: the following components are used for rectification-

Table 3.1 component for rectification

Name	Components Used	Description	Number of components required
TRANSFORMER	TRANSFORMER	Transformer	1
RES	RC05	Resistor	1
DIODE	1N4007	Diode	4
VGEN	VGEN	Ac voltage source	1
GND		Ground	1

Theory: -

The Bridge rectifier is a circuit, which converts an ac voltage to dc voltage using both half cycles of the input ac voltage. The Bridge rectifier circuit is shown in the figure below. The circuit has four diodes connected to form a bridge. The ac input voltage is applied to the diagonally opposite ends of the bridge. The load resistance is connected between the other two ends of the bridge.

For the positive half cycle of the input ac voltage, diodes D1 and D3 conduct, whereas diodes D2 and D4 remain in the OFF state. The conducting diodes will be in series with the load resistance R_L and hence the load current flows through R_L.

For the negative half cycle of the input ac voltage, diodes D2 and D4 conduct whereas, D1 and D3 remain OFF. The conducting diodes D2 and D4 will be in series with the load resistance R_L and hence the current flows through R_L in the same direction as in the previous half cycle. Thus a bi-directional wave is converted into a unidirectional wave.

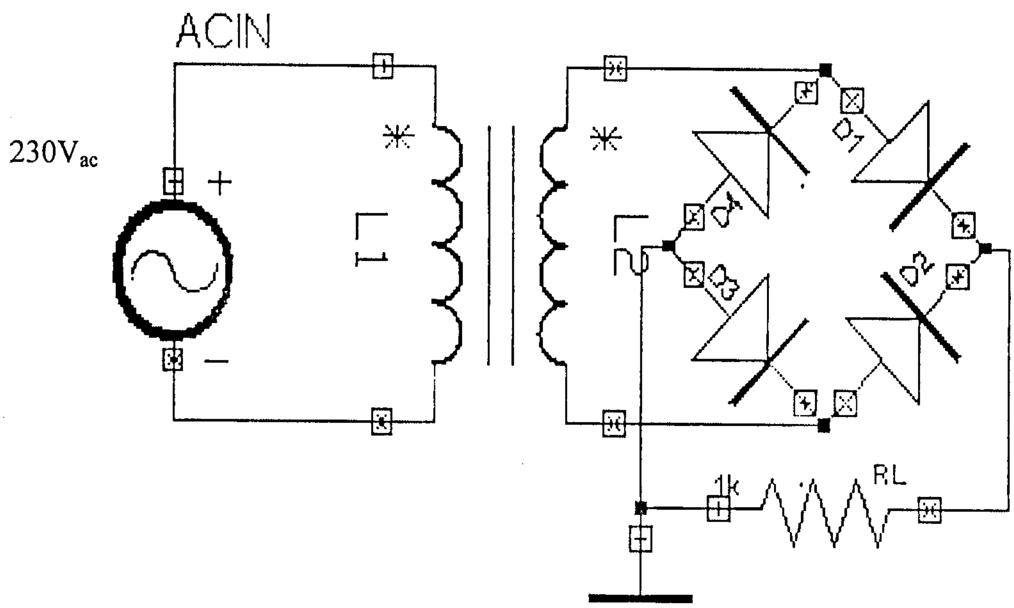


Fig 3.4 rectification circuit diagram

Peak Inverse Voltage

Peak inverse voltage represents the maximum voltage that the non- conducting diode must withstand. At the instance the secondary voltage reaches its positive peak value, V_m the diodes D1 and D3 are conducting, where as D2 and D4 are reverse biased and are non-conducting. The conducting diodes D1 and D3 have almost zero resistance. Thus the entire voltage V_m appears across the load resistor R_L. The reverse voltage across the non-conducting diodes (D2 and D4) is also V_m. Thus for a Bridge rectifier the peak inverse voltage is given by $P_{iv} = v_m$

Ripple Factor

The ripple factor for a Full Wave Rectifier is given by

$$\gamma = \sqrt{\left(\frac{V_{rms}}{V_{dc}}\right)^2 - 1}$$

The average voltage or the dc voltage available across the load resistance is

$$V_{dc} = \frac{1}{\pi}\int_0^{\pi} V_m \sin \omega t \, d(\omega t)$$

$$= \frac{V_m}{\pi}\left[-\cos \omega t\right]_0^{\pi} = \frac{2V_m}{\pi}$$

$$I_{dc} = \frac{V_{dc}}{R_L} = \frac{2V_m}{\pi R_L} = \frac{2I_m}{\pi} \quad and \quad I_{rms} = \frac{I_m}{\sqrt{2}}$$

RMS value of the voltage at the load resistance is

$$V_{rms} = \left[\frac{1}{\pi}\int_0^{\pi} V_m^2 \sin^2 \omega t \, d(\omega t)\right]^{1/2} = \frac{V_m}{\sqrt{2}}$$

$$\therefore \gamma = \sqrt{\left(\frac{V_m/2}{2V_m/\pi}\right)^2 - 1} = \sqrt{\left(\frac{\pi}{8}\right)^2 - 1} = \underline{\underline{0.482}}$$

__Efficiency__

Efficiency, is the ratio of the dc output power to ac input power

$$\eta = \frac{dc\,output\,power}{ac\,input\,power} = \frac{P_{dc}}{P_{ac}}$$

$$\frac{V_{dc}^2/R_L}{V_{rms}^2/R_L} = \frac{\left[2V_m/\pi\right]^2}{\left[V_m/\sqrt{2}\right]^2} = 8/\pi^2 = 0.812 = \underline{\underline{81.2\%}}$$

The maximum efficiency of a Full Wave Rectifier is 81.2%.

The output wave forms are shown below

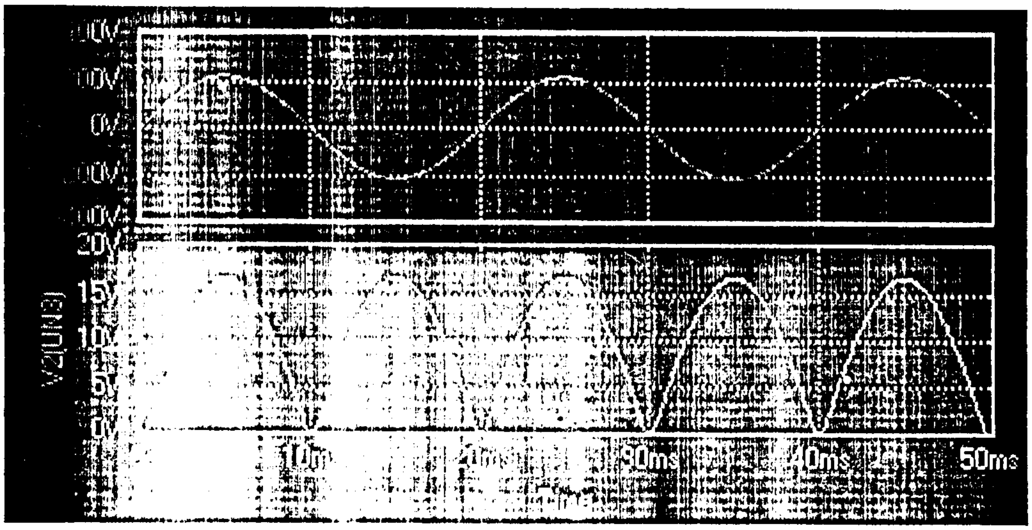


Fig 3.5 output wave forms for rectification

4.3 FILTERING OR SMOOTHING

The output of the rectifier consists of two components:

1. The DC component
2. The AC or ripple component.

The purpose of filtering or smoothing is to reduce the ripple component to a minimum value.

A bridge rectifier makes use of four diodes in a bridge arrangement to achieve full-wave rectification. This is a widely used configuration, both with individual diodes wired as shown and with single component bridges where the diode bridge is wired internally. the RC filter that is a shunt capacitor filter shown in figure 3.1.3 (a) was employed in this project to filter the ac ripple shown above in fig.

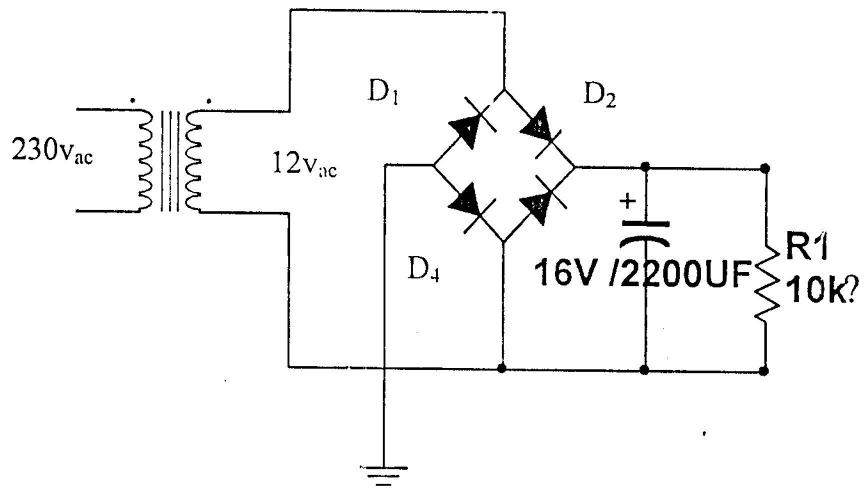


Fig 3.6 RC filter circuit for rectification

In the above circuit, a 2200uf capacitor was connected across the rectifier and in parallel with the load RL to achieve filtering action. This filter circuit depends (for its operation) on the property of a capacitor, it charged up and discharges during half non conducting cycle. A capacitor opposes any changes in voltages when connected across a pulsating dc voltage it tend to oppose the changes and thus smoothen out or filter out the pulsation (or ripple).

Design calculation

Since ripples increase with increase in the load current (output current) according to the formulae.

$$ripple\ factor = \frac{1}{4\sqrt{3}FCR} = \frac{I}{4\sqrt{3}FCV} = \gamma$$

Where:

$\gamma = ripple\ factor$

F = frequency

C =capacitance value of the capacitor

R_L = load resistance

V_p = peak rectifier output voltage = $12\sqrt{3}$ V

I_{dc} = output current = 6A

But the ripple factor was = 0.482

F = 50Hz

$$R_L = \frac{Vp}{Idc} = \frac{20}{6} = 3.3k\Omega$$

$$\text{Then } C = \frac{1}{4\sqrt{3} * 50 * 3.3 * 0.482} = 2397\mu F$$

The choice of 2200uf was made based on the load current ,it was found large enough to reduce the ripple ,increasing the filter capacitance, that is using a higher magnitude of capacitor tend to reduce the ripple magnitude, it has been found that bigger capacitance has the following advantages:

1. it reduce the magnitude of ripple voltage more
2. it increase V_{dc} toward the limiting value V_p
3. It reduces the time of current pulse through the diodes.
4. It increase the peak current in the diode.

.4.4 VOLTAGE REGULATION

In an unregulated power supply, the output voltage changes when ever input supply voltage or load resistance changes, that is, it is never constant. The change in voltage from no load to full load condition is called voltage regulation. The aim of a voltage regulation circuit is to reduce these variations to a minimum possible value if not zero.

A linear regulator was employed in this project work, in a linear regulator, the transistor operate somewhere between saturation and cut-off, it is always ON and dissipate power hence it efficiency is always 50% or less. The efficiency was obtained by the formulae

$$\frac{Vn - Vf}{Vn} * 100\%$$

Since $$Vf = \frac{1}{2}Vn$$

$$efficiency = \frac{Vn - \frac{1}{2}Vn}{Vn} * 100$$

Therefore, $$= \frac{1}{2} * 100$$
$$= 50\%$$

Where:

V_n = no load or open circuit terminal voltage of the supply

V_f= full load terminal voltage of the supply. .

3.5 SENSOR UNIT

The sensor unit consists of a light dependent resistor (LDR) and fixed resistor connected as voltage divider to give two different dc voltages. One voltage is obtained by connecting a fixed resistor and LDR, making the vóltage to vary depending on the amount of illumination on the LDR, while the second voltage is obtained by connecting two fixed resistors in such a way that the voltage remains constant and it is used as a reference voltage.

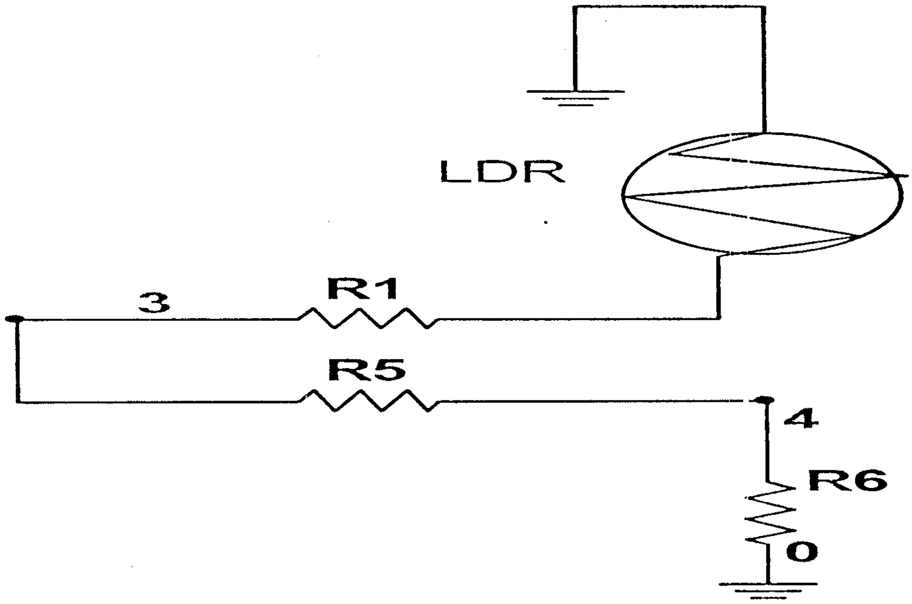


Fig 3.7 circuit showing resistor arrangement

LIGHT DEPENDENT RESISTOR (LDR)

The light dependent resistor or photo resistor is a two terminal semi conductor device whose terminal resistance will vary with the intensity of the incident light. It is a transducer (sensor), which convert light to resistance. It is made from cadmium sulphide (CdS) or cadmium selenide (CSe) and resistance decrease as the brightness falling on it increase .the resistivity of a conductor depend on the number of free charge carriers available in it [14].

When there is no light or little light falls on the LDR, the number of charge carrier is small, and hence resistivity (resistance) is high, but when light in form of photons strike the LDR, each photons delivers energy to it, if the photo energy is greater than the energy band gap of the LDR, free mobile charge carrier are liberated and as a result, resistivity (resistance) of the LDR decreases.

The sensor unit is based on the fact that the resistance of LDR decreases in the presence of light and increases when darkness covered it. This gives varied voltages at day time and night, the possible voltage divider connection of LDR with fixed resistor, the first one is to connect the fix resistor to the ground and the LDR to the source, and the second method is to connect the LDR to the ground and the fix resistor to the source. the second method was choosen for this project due it protective advantage that the positive voltage is always resisted by the fixed (Rf) resistor instead of causing damage to the LDR.

Design calculation

Since the input voltage is 8V and the current measured was approximately 0.8mA, the resistance value that can withstand the current will be:

Using ohms equation

R = V/I

R = 8/0.8mA

R= 10KΩ

But when two 10KΩ are connected in parallel

From voltage divider theorem

$$Vout = \frac{R1}{R1 + R2} * Vin$$

$$Vout = \frac{10k\Omega}{10k\Omega + 10k\Omega} * 8V$$

$V_{out} = 4V$

It was observed that the LDR start conducting at the range of 50kΩ-100kΩ averagely.

From $Vout = \frac{Rldr}{Rf + Rldr} * Vin$

Where

V_{in}=8v

R_{ldr} = 50KΩ (taken)

R_f=?

V_{out} = 4v

If R_{ldr} is taken to be 50kΩ, for V_{out} to be 4v, Rf must be 50kΩ too. But for $V_{out} \geq$ 4v, Rf must be less than 50k therefore it was halfed to about 22k which is more close to 25k to obtain V_{out}> 4v since voltage due to the fixed resistors = 4v as shown above

Then voltage due to LDR will be:

$$Vout = \frac{Rldr}{Rf + Rldr} * Vin$$

$$Vout = \frac{50k\Omega}{22k\Omega + 50k\Omega} * 8V$$

V_{out} = 5.55 i.e. > 4V

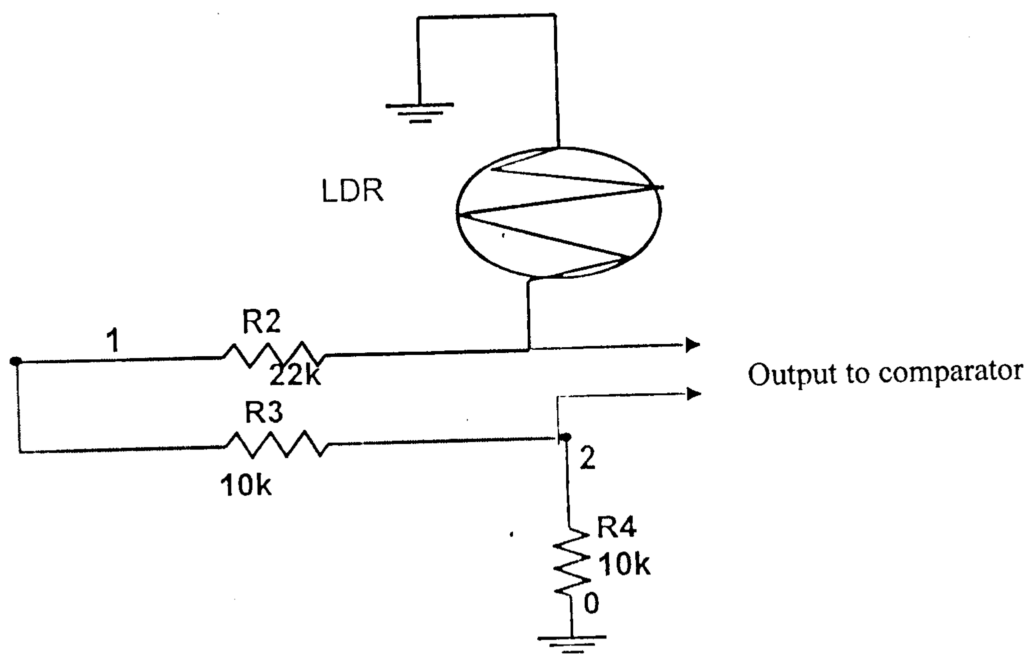


Fig 3.8 circuit arrangement of sensor unit

COMPARATOR UNIT

This unit is required to compare two voltages V1 and V2 and then produce their difference as output.

The LM339 is a very common comparator integrated circuit. It is designed for use in level detection, low level sensing and memory application in consumer, automotive and industrial electronic applications. It possesses four comparators in built. Each unit operates independently. The integrated circuits comparators unit works the same way as conventional types.

Calculation

In the evening the resistance of the LDR falls between 50KΩ-100KΩ

The reference will be obtained by

$$Vout = \frac{R1}{R1 + R2} * Vin$$

Where R_1 and R_2 are two fixed resistors of 10KΩ each

$$Vout = \frac{10k}{10k + 10k} * 8v$$

V_{out} = 4V this will be fed to the inverting input of the comparator

The non-inverting input value depend on the value of the resistance of the LDR

If the value is 50K then

$$Vout = \frac{Rldr}{Rf + Rldr} * Vin$$

$$Vout = \frac{50k}{22k + 50k} * 8v$$

$V_{out} = 5.55$

Therefore the comparator output is given by

$V=V_2-V_1$

From above V= 5.55-4 =1.55

In this case the comparator gives logic 1 as output

But if the resistance of the LDR is less than 50K then the V2 will be less than the V1 and V will give negative value and the comparator will produce logic 0 as output.

The figure below shows a typical comparator circuit diagram

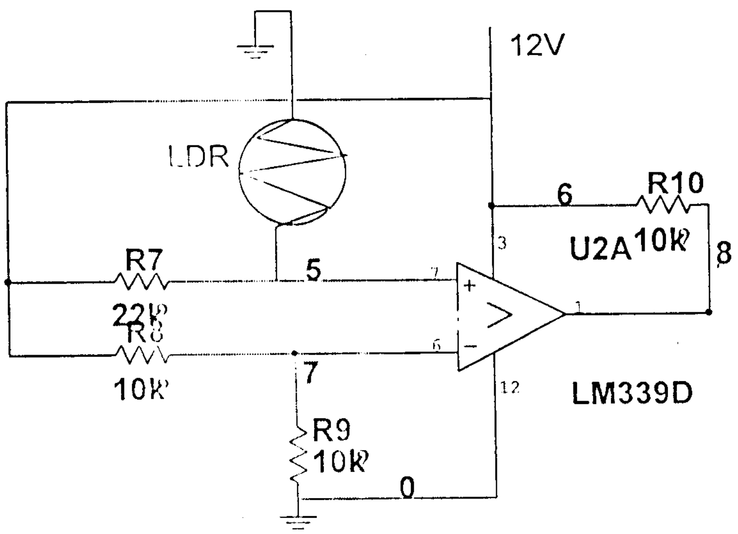


Fig 3.9 A typical comparator circuit diagram.

The comparator usually holds two analogue inputs and produce a single digital output. The two inputs are the non-inverting(positive) and inverting(negative) terminals the digital output is either logic 1 or 0 depending on the inputs situation when the voltage at non-inverting input(V_{in}(+))is greater than that of the inverting (V_{out}(-)),the output is always logic 1,(high). But when the inverting is greater than the non-inverting inputs the output condition is always low (logic 0) [19].

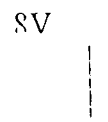
i.e. if $V_{in}(+) > V_{in}(-)$ output is logical 1

$V_{in}(+) < V_{in}(-)$ output is logical 0

In this project V_1=Vin (-) was made the reference point and V_2=Vin (+) the varying input, this is made so in order for the output to respond in a particular manner.The IC is a 14 pin configuration. Pins 1,2,13 and14 are output which requires a resistor to V_{cc}. A typical resistance value is 10kΩ, it is encourage by the manufacturers' data sheet. Only one of the comparator was used in this design.

.7 PULSE GENERATION (LOGIC UNIT)

The logic unit consists of 555 timer, shunt capacitor and resistor which serve as current limiters. The 555 timer is configured in monostable mode, the circuit produces a single output pulse when triggered. it take track of the comparator current send it to the transistor which act as switch, this current depend on light intensity that fall on the LDR, if the light has less intensity than the sunlight it might not be sufficient to charge up the capacitor and also trigger the transistor, this unit control is the decider which decide base on light intensity, so even if a car passes and flash some light on the LDR the light might not be sufficient to switch off the transistor.



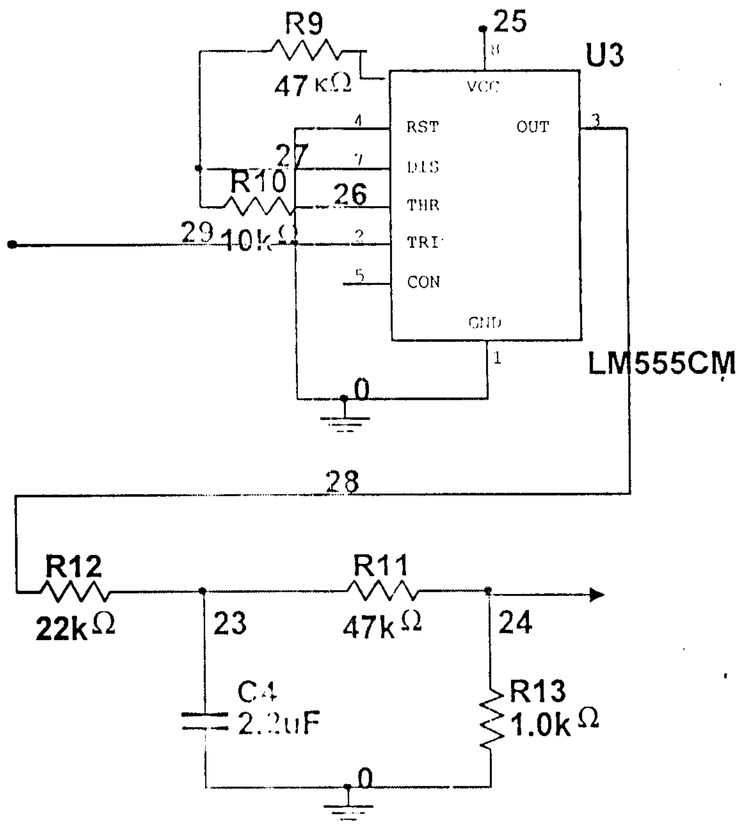


Fig. 3.10 Logic unit circuit diagram

The duration of the pulse(time period) T is determined by the formulae

T=1.1RC

The timing period is triggered when the trigger inputis less than 1/3Vs

For the comparator output of 1.55V and 0.3mA

R= V/I = 1.55/0.3mA =47KΩ

Choosen an average period of 180 seconds

$$C = \frac{180}{1.1 * 47k\Omega} = 2.5\mu F$$

2.2uF close to 2.5uF was choosen since the capacitor charges to 2/3 its capacity=67%

Therefore the time period becomes

T=1.1 *47KΩ *2.2uF =1.9minuite

And the frequency $F = \frac{1}{T} = \frac{1}{1.9} = 0.5Hz$

SWITCHING UNIT

In concept, the transistor in the circuit function as a current controlled switch, it closes whenever an impulse signal is fired at its terminal to pass and thus activate the relay, until the signal reaches zero value, at which point the device opens again and await another impulse signal to close it terminal connection. The most commonly used transistor switch is the NPN variety. The secret to making a transistor switch work properly is to get the transistor in a saturation state. For this to happen we need to know the maximum load current for the device to be turned on and the minimum HFE of the transistor., it was estimated for a load that requires 100mA of current and a transistor with a minimum HFE of 100, we can then calculate the minimum base current required to saturate the transistor as follows:

$$\max imum\ base\ current = \frac{100mA}{100} = 1mA$$

In actual practice, it is best to calculate about 30% more current than will needed to guarantee our transistor switch always saturated. In this case, we will use 1.3 mA. We must also select our supply voltage, so, for this work 8volts was used.

$\max imum\ current = 100mA$

Supply Voltage = 8 Volts

The diagram is shown below.

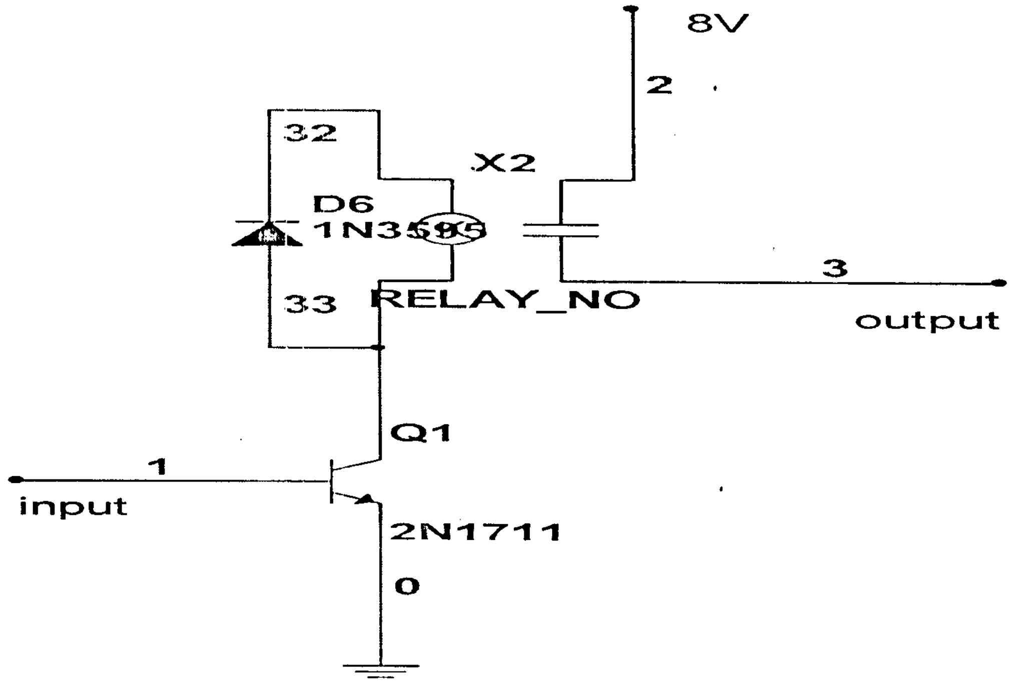


Fig 3.11 switch unit circuit diagram

Transistor switches are used for a wide variety of applications. Transistor switches are commonly used to turn on transmitter circuits, LED's, cooling fans and even relays as seen above. However, when using a transistor to turn on a relay coil, it is very important to use a 1N4001 diode reversed biased in parallel with the relay coil as in Figure above. This is to prevent the kickback voltage in the reverse polarity from destroying the transistor. This reverse voltage occurs momentarily when the normal current stops flowing through the coil. It is good practice to always use a diode when turning on any inductive load. Transistor switches are often used to take the low-level output from logic circuits to turn on or turn off the relay

3.9 BACKUP POWER SUPPLY

Solar power was choosen to charge up a battery for back up power of the system .the was choosen because it is most abundant and easily accessible and it can be kept close to a device in which it is powering.

This unit consists of solar panel connected directly to battery as shown below in fig 3.6

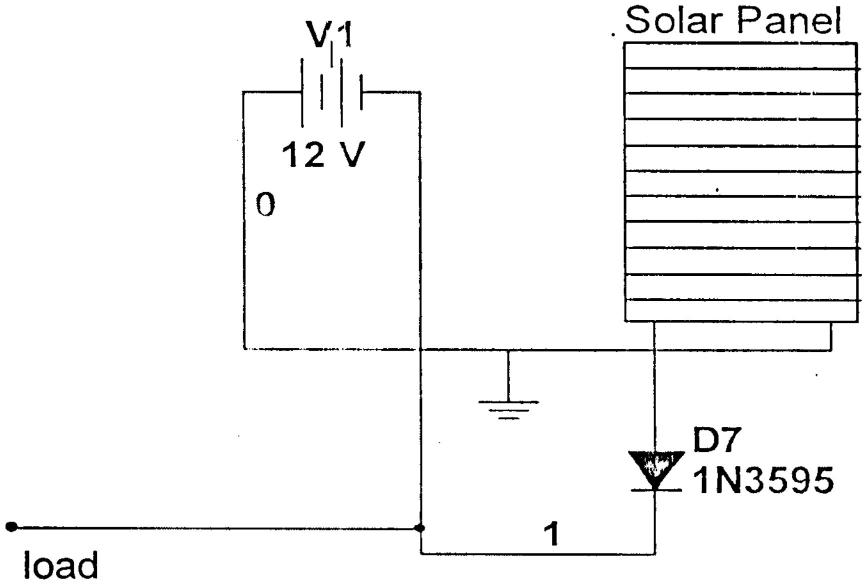


Fig 3.12 Back –up unit circuit diagram

The solar panel charges the battery during the day time, since the battery does not discharge at that time, at night when there is main supply, the battery does not conduct neither does it charge because at night the solar panel produce as low as 0.2v which is negligible compared to maximum voltage of 5v. But when the mains fail the battery take over and start to discharge. The diode at the solar terminal prevent back E.M.F from the battery to the panel.

3.10 PRECAUTIONS

1. Each integrated circuit chip used was protected with a particular IC socket to prevent them from heat destruction attributed to soldering iron.

2. the circuit was properly checked for short circuit before been powered
3. Some sensitive wires were glued to the board to prevent unwanted removal.
4. during soldering ,components were well spaced on the board to prevent short circuit and wrong connection
5. data sheets of every used component were consulted before they were incorporated into the circuit

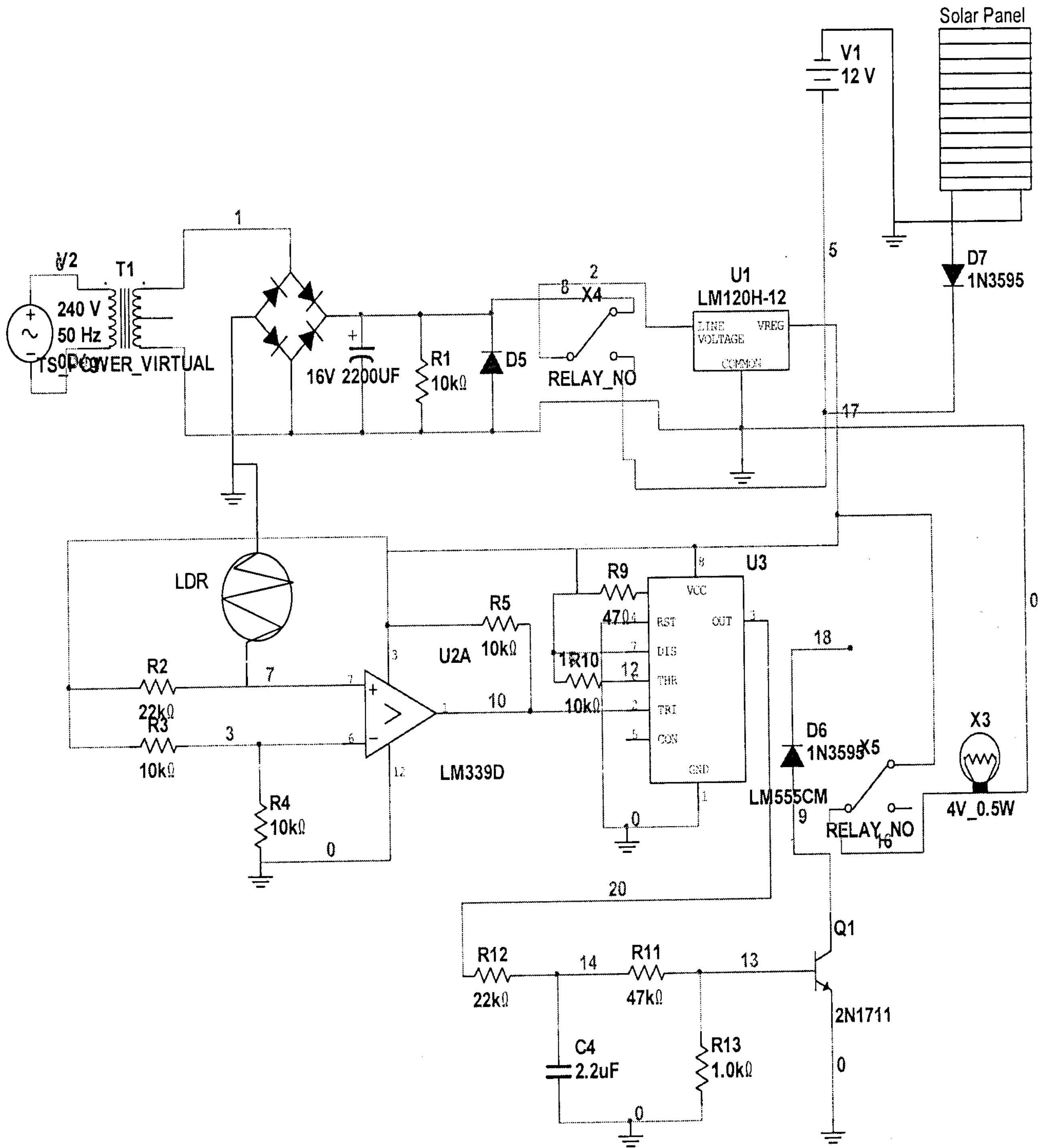


Fig 3.13 MAIN CIRCUIT DIAGRAM

CHAPTER FOUR

TEST, RESULT AND DISCUSSION

In line with the objective of this project work, after an in depth analysis of how the circuit is supposed to function, the next step is the physical construction of the circuit on a proto type electronics Vero board and powering the circuit to see if it will operate as expected .but before construction of the circuit, a number of factors were considered such as:

1. type of Vero board to be used
2. size of board due to casing
3. nature of connection to be made on the board
4. Supply line to the circuit.

4.1 CONSTRUCTION

The circuit was first implemented on a breadboard for preliminary testing ,if the proto type was built without this preliminary stage there is the possibility that some component may need to be removed or added and this might lead to problems like damaged terminal, damaged component, short circuit, open circuit among others.

The construction was started on Vero board after the acquisition of the components. the Vero board was cut to a size that should accommodate the complete circuit diagram and fit into the casing as well. The circuit was implemented bit by bit from one stage to the other .each sub-circuit was solely completed and then connected together. Short circuit and any wrong connection from the circuit diagram were properly checked to avoid damage to the components. When the circuit was completed, it was then powered and tested to see if it was working properly.

4.2 TESTING

The testing was aimed at checking the complete function of the circuit. The testing involved the solar panel, LDR, and finally the while circuit functionality.

During the test, the following tools were used:

1. Digital multimeter-the digital multimeter basically measures voltages, resistances, continuity, current e.t.c. the process of implementation of the design on the Vero board requires measurement of parameters.
2. Bench power supply-this was used to supply voltages to the various stages of the circuit during the construction.

The test was carried out in stages: First, the output from the LDR was observed and measured at various times of the day for several days. This was to determine it resistivity output variation at different period with different intensity of light.

Secondly, the output from the solar panel was measured at various times and intervals, it was also to determine it output voltages at different periods of time to ensure appropriate current level for battery charging.

The next was to measure the output voltage from the main rectifier circuit using digital multimeter to ensure safety of the circuit components. The outputs of the various blocks were also measured, up to the final stage of lighting the bulb.

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RESULT

The various result obtained during the test were shown below

Table 4.1 Light Dependent Resistor (LDR) result

	Day	Sunset/Sunrise	Dusk/Early Morning	Night	Pitch Black
Photocell Response(Ω)	<50K	50K-100K	101K-474K	475K-1.6M	>1.6M
% Maximum Voltage Output	0	68	80	90	100

The above table shows that if the LDR response is >= 50K, it will work effectively by switching ON he bulb and if it <=50K it will switch OFF the bulb, therefore it is only during the day time that the bulb will go OFF.

Table 4.2 solar panel results

Time Intervals	Average Voltage Output From Panel
9-12am	4.6V
12-3pm	5.0V
3-5pm	4.4V

The table above shows the output from the solar panel at different time intervals of the day. it produce maximum voltage between 12 noon and 3pm, finally, the bulb comes ON a power is being supplied to the circuit and the LDR is covered, when the LDR is uncovered th bulb goes OFF, which gives the desired result of the work.

4 DISCUSSION

Having designed this circuit following its theories of operation, the construction was a success and testing carried out. the results were really evident in nature, as the main aims of darkness activated switch and automatic power change over were achieved.

Covering the light sensor automatically trigger ON the streetlight, the light remain ON until it is uncovered. When it is covered and the mains power cable is removed, the battery takes over power supply and when the cable is replaced it switches back to the mains supply.

Moreover, a fully charged battery put the lamp on for roughly 4 Hours. Also, the charging section of the circuit was designed to be able to charge a complete uncharged battery within a reasonably short period of time. A 5v solar panel was choosen to slowly charge the battery since it is not always used. Choosing a higher value may lead to over charging of the battery and lead to damage of the battery of its short life.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

The darkness activated streetlight with solar power back up system has been successfully designed, constructed and tested. the device constructed achieved its desired objectives, with regard to its functionality and cost effectiveness. However, it should be stated here that the device is prototype and that a larger sale implementation would cost relatively less. The unit responded well to changes in light level and also to power sources available.

5.2 RECCOMENDATION

Project work forms a vital part of the university education and is of many benefit to the students since it is of more effective and has more impact directly on student. I hereby make the following recommendations for the improvement on this project:

- the circuit could use a small size battery of equivalent power to increase compactness
- Some features in form of entertainment or sound could be incorporated into the system to entertain passersby with either messages or just sound.
- Microcontrollers could be used to control light intensity instead of a capacitor, since programming can control hardware more efficiently than ordinary component which can fail at any time.

Finally, I am therefore calling on engineers to keep following the technological evolution and make use of available materials to achieve the most sophisticated modern design aimed at simplicity, compatibility, reliability, availability and flexibility. Further more the automatic darkness activated streetlight system with solar back-up can now be used in many streets with or without power supply problem.

REFERENCE

[1] A. Criswell,"Streetlights Leaves Student in the Darkness," The Digital Collegial, September 2001, Http //Www.Collegian.Psu.Edu/Archive/2001/09/09-20-01tdc/09-20dnews-10.Asp.(25/09/08)

[2] Tork Turn-Lock, Mounting Photo controls, Http://Www.Tork.Com/Main5n2.Htm, December 2003.(20/09/08)

[3] D. Neamen. Electronic Circuit Design And Analysis. Mcgraw-Hill, 2001.

[4] Solar Cell History.Pdf,Www.Itebookhome.Com (20/09/08)

[5] J. Labella, "Glasgow Evaluates Scada For Streetlight," Public Power Magazine, November 2003. Pp 70.

[6] D. Maycock And Edward N.Stirewalt,"A Guide To Photovoltaic Evolution" Sunlight To Electricity In One Step. By Rodule Press, Emmaus, Pa,1985.

[7] B.L Theraja And A.K Theraja, A Text Book Of Electrical Technology,22nd Edition, S.Chad And Company Ltd. New Delhi, 1999, Pp924-926, 1676-1677, 1682, 1709, 1712-1715, 1735, 2003-2004.

[8] R.Dorf And J.Svoboda, "Introduction To Electrical Circuit", Wiley And Son,2001.

[9] "Transformers And Power Supply," Http://Www.Stancor.Com/Pdfs/Quiksel/Pdf.

[10] G.Sapkota,"Transformers And Their Uses In Robotics" Http://Www.Itsansar.Com/Arficles.Htm#2, 2003.

[11] M.Marcus, "Switching Circuits For Engineers", Prentice-Hall, 1967,Http://Www.Switches.Com.Htm.

[12] B. Oliver And J. Cage. Electronic Measurements And Instrumentation.Mcgraw-Hill,1971,Http://Www.Instrument/Measure/Arficle.Htm.

[13] Bello S.A. "Design and Construction of Automatic Streetlight Controller",(Under Graduate Thesis),2003. Department Of Electrical And Computer Engineering, Federal University Of Technology, Minna.