DESIGN AND CONSTRUCTION OF AN AUTOMATIC SECURITY OUTDOOR LIGHTING SYSTEM

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DEDICATION

I dedicate this work to my parents; Alhaji Galadima Shehu and Hajiya Janatu Shehu, for with out their support and guidance I would not be where I am today.

DECLARATION

I Umar G. Shehu declare that this work was done by me and has never been presented anywhere for the award of a degree. I also hereby relinquish the copyright to the Federal University of Technology, Minna.

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ABSTRACT

The Project presents An Automatic Security Outdoor Lighting System. The design is to ensure a reasonable level of safety and security on buildings in the hours of the night. The availability of security lights in such places would not only stop burglars from tempering with installations in and around the areas but also would guarantee safety of householders operating within such places in the night. The operation of this device reduces the activities of mankind in the switching mechanism. It involves the natural switching OFF and ON during the day and night respectively independent on human operation, The design is precised and improved sensitivity.

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CHAPTER ONE

1.0 INTRODUCTION

Recent advances in circuit designs have led to the production of systems that control house lighting, Apart from aesthetic considerations, such systems are very useful where power economy is of great interest. Lighting control ranges from switching ON and OFF light sources, to vary the illumination level produced by the light sources. Such controls can be realized by the means of programmed or intelligent circuits or manually operated switch from where the user turns the lights ON or OFF as desired.

Automatic control system involves the use of programmed or intelligent circuits to switch the lights as appropriate. A programmed control is one in which the user specifies the time for the lighting systems to come ON or change in intensity or go OFF. In intelligent control, the system is capable of interacting with the environment to determine when to switch ON or OFF the lights or when to vary the illumination by the light sources.

Household security lights or outdoor lights are used to illuminate surroundings of a house in the night. Such lights serve a variety of purposes, ranging from security, aesthetic or decorative for indicative purposes. An outdoor light is expected to be ON in the night and OFF in the daytime.

1.1 AIMS AND OBJECTIVES

The major purpose of this project work is to realize an automatic controlled security outdoor lighting systems. The project will therefore focus on the design of the power operated switch. This form the hearting of the lighting control system in various homes, schools, or industries.

1.2 SCOPE OF THE PROJECT

The scope of this project work is limited to the application of sensor (Light Dependent Resistor) which serves as a light detector to operate an outdoor security lighting system. This is because sensor are the most effective, and efficient electronic components used to operate an automatic controlled outdoor security lighting system because of its light sensitivity surface.

1.3 LIMITATIONS

This project imposed a serious task during breadboard implementation; this is because there is a high relay. Then, I discovered that the output of 741 IC is highly amplified which led to the relay shatter. Then, this led to the modification of this project by changing the 741 Operational Amplifiers to a comparator. In this case, the comparator will compare the two input voltage signals from pin 2 and pin 3 and the difference is obtained at the output of the comparator unamplified, with this, the relay shatter was reduced drastically.

1.4 DESIGN METHODOLOGY

When the input head of the system control is connected to a 240v AC supply at a frequency of 50Hz alternating current is being fed into the input of the transformer and 12v AC supply is being obtained at the output of a step down transformer. The step down is rectified by Diodes D1 and D2 and filtered by capacitor C1 for complete dc signal(12v) and voltage regulation which was achieved by the use of one positive one negative 12v voltage regulator IC through the help of capacitor C2 whose function is to stabilize the voltage from the voltage regulator IC.

The variable resistor is used to vary the voltage supplied to the inverting input of the 741 Operational Amplifier used as a comparator. The output of the 741IC is connected to the base of the switching transistor. When a positive voltage is obtained at the output of 741 IC, it switches ON the relay that lights the bulb. When the negative voltage is obtained at the output or 741 IC, it switches OFF the transistor which in turn de-activates the relay making the bulb to go OFF.

CHAPTER TWO

LITERATURE REVIEW

2.1 HISTORICAL BACKGROUND

During the olden days people protected their lives and properties from destruction by men of the under world by the use of charms. Lighting or artificial illumination as opposed to the natural illumination of the sun or moon, was probably first furnished by camp fires and by torches made of wood. Crude stone lamps in which came from a flaming work in a pool of oil melting grease were used by pre-historic people .Candle and oil burning lamps remaining the middle of the 19th century, when kerosene lamps with flat woven wick and glass chimney came into common use. A few of these artificial sources of light are discussed below. The earliest lighting system came from firewood. Men discovered that torches dipped into animal fats lasted longer gave a stronger light. Torches were in use for several years. About the 450 AD torches were used to light the streets of Antioch. Torches light, were still in use in the middle ages. The first oil used in these early lamps came from animals. The first oil lamp was open stone dishes with wick reeds or plant fibre. These gave light used by cave men when they painted pictures deep in caves. Lamps have been in use for about 3000 B.C. Some of these early lamps were from the skull of small animals. They have a perfect shape for holding a good amount of oil for supporting a wick. The first candle was stalk was stalk filled with beeswax from beehives. The ancient Egyptians had wickless candles made of lumps of tallow rapped with rags to keep from melting apart when they are burned. The Roman used candle made with wick. Candles are made in decorative styles and colours. Some in glass containers are used for religious purposes. These are three or four inches in diameter and burns for hours. Some candles are as tall as ten feet and last for years. In the 5th century, protective cases for light lanterns were commonly used. Lanterns were designed in many different shapes. Cylindrical lantern and square types with canonical tops were popular. They were made of many materials such as woods, metals etc. Before 1859, the best lamp oil that money could buy was whale oil. Unrefined petroleum had been used in lamp for several years but a feeble and dirty flame. In that same year, a great quantity of petroleum oil was discovered in Pennsylvania. At first, kerosene burned in open lamps; the open flame flickered and was dangerous to use. Then, glass chimney was made for lamps. The flame becomes steady and gave more light. With the glass to protect it from the rain. Kerosene lamps could be used outdoors for streetlight. Kerosene lamps have flat wicks. by the turn of a small knob; the wick could be adjusted to the desired intensity. This has a great advantage over other lighting system

2.2 PRESENT DAY ELECTRIC LIGHTING

Static electricity produced by rubbing objects against fur was known to the ancient Greeks, Phoenicians parthians and mesopotamiams. Some propose that parthians and Mesopotamians may have some knowledge of electroplating, based on the discovery of the Baghdad battery, which resembles a galvanic cell. In 1600, the English scientist William Gilbert first used the new world "electric" and "electricity", in Sir Thomas Brownian pseudopodia epidemic a of 1646. In 18th century, Benjamin Franklin conducted extensive research in electricity. He had theories on the relationship between lighting and static electricity, including his famous kite-flying experiment, which was a key attached to a wet string and kite. During a lighting storm a spark struck his finger showing that lighting is electricity. It sparked interest of later scientists whose work provided the basis for electrical technology. Most notably these include Luigi Galvanic (1737-1798), Alessandro Volta (1745-1827), Michael Faraday (1791-1867), Andre-Marie Ampere (1775-1836), and George Simon Ohm (1789-1854). With the discoveries from these scientists, electric lighting has been developed in so many ways that it plays a part in nearly every activity of man. The study and practice of electric lighting has become a profession itself. The first electric lighting systems are discussed below. During the 1840, many experiments aimed at the development of a workable electric incandescent lamp were conducted. In 1879, Thomas Alva Edison, developed a carbon filament incandescent lamp. Edison passed an electric current through thin filament of carbonized thread that were tightly sealed inside a glass bulb from which all air had been evacuated by a vacuum pump. Edison invention marked the birth of electric lighting and the electric age.

Electric arc lamps consists of electrons drawn between two carbon electrodes were one of the earliest lighting device to make use of electrical energy invented around 1807[12]

Fluorescent light belong to the group of lighting devices known collectively as discharge tubes; glass tubes filled with vapour, with electrodes at both ends. Electric current that is passed between the electrodes eventually ionizes the vapour which begins to glow, producing light. Some discharge tubes emit flashes of high intensity light and are used in light houses and for directional beacon of various kinds.

With the above mentioned lighting services, lives and properties are protected due to technological advancement. Automatic security lighting system, taking the advantage of the recent development in electricity, is designed and constructed to ease human stress in switching operation.[5]

CHAPTER THREE

DESIGN, ANALYSIS, AND IMPLEMENTATION

This chapter describes the module used in the design of the automatic security lighting system using sensor. The theoretical background of each module is the block diagram of automatic security lighting system.

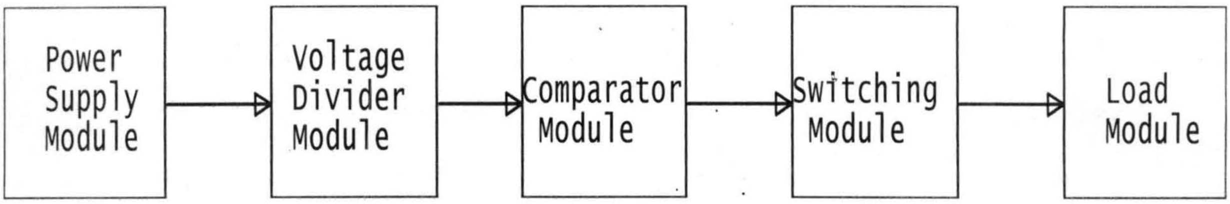

Fig 3.1 Block diagram of an automatic security outdoor lighting system.

The power system module is the power house of the entire circuit, this is a power supply section. Where the entire system gets its electrical energy. The light sensor from a voltage divider module senses the light and sends a signal to a comparator. The comparator compares the output from the sensor to a pre-determined level. Its output tells if the illumination level indicates dusk or dawn. The logic unit decides what the signal from the comparator implies and thus enables the next block in the diagram to operate.

The delay is required to ensure that the signal is not instantaneous and thus indicates a valid transition from day to night or vice-versa. If within the delay time, the logic unit confirms that the signal is valid indication of such transition, then the switching module is driven through the comparator module. Hence, the load at the output is energized

3.1 POWER SUPPLY MODULE

Power supply units are electronic circuit that provide direct current (DC) voltages and current from AC source, usually from the main supply of the electricity distribution company like PHCN in Nigeria. The output is used to operate the automatic security lighting system. This unit converts the 220-230V ac main supply to +12 v dc, which is to be constant even if there are fluctuations in the ac supply voltage. This was achieved through the following stages of operation;

(1) Transformer stage

(2) Rectification stage

(3) Filtering or smoothing stage

(4) Voltage regulation stage

3.1.1 TRANSFORMATION STAGE

A step down transformer is used to reduce 240 ac from Power Holding Company of Nigeria (PHCN) to 12ac. In this project, the two ends were used (i.e. 24v). The output current rating of the transformer used is 500mA or 0.5A.

Transformers make use of electromagnetic induction to transfer electrical energy from one winding called the primary winding to the secondary winding which is the second winding. An ideal transformer is one that has no losses, i.e. its winding has no ohmic resistance, there is no magnetic leakage and hence which has no I^2R Losses. It consists of two purely inductive coils wound on a loss free core. It is impossible to find an ideal transformer in practice.

$$\frac{\text{Primary ac voltage}}{\text{Secondary ac voltage}} = \frac{\text{Number of primary turns}}{\text{Number of secondary turns}} = K$$

$$\frac{V_1}{V_2} = \frac{N_1}{N_2} = K$$

Where K is a constant known as voltage transformation ratio.

N_1 is the number of turns in the primary windings

N_2 is the number of turns in the secondary windings

V_2 is the secondary ac voltage

V_1 is the primary ac voltage

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

If $N_2 < N1$ i.e. $K < 1$, then the transformer is a step up transformer.

3.1.2 RECTIFICATION STAGE

Most of the electronic devices and circuits require a dc source for their operation. This is a circuit that employs one or more diodes to convert ac voltage into pulsating dc voltage; this process is known as rectification. If one diode is used for the operation, it is called a half wave rectification, but if the diodes are more than one say two, three or four, it is called a called a full wave rectification. In this project full wave bridge rectifier was employed. This requires four diodes, which is part of an array of diodes in an integrated circuit. They are mainly found in power stage of an electrical circuit. The one used in this project has four terminals; the two terminals is connected to the AC power supply from the step down transformer which is the input while the other two terminals is the positive(+ve) and negative (-ve) output. While the positive (+ve) terminal is connected to the positive (+ve) terminal of the circuit; the negative (-ve) terminal is connected to the earth terminal as shown in the circuit diagram below; i.e. the incoming 12v ac from the step down transformer is fed into the bridge rectifier whose output is a 12v dc; it rectifiers both halves of an ac signals.

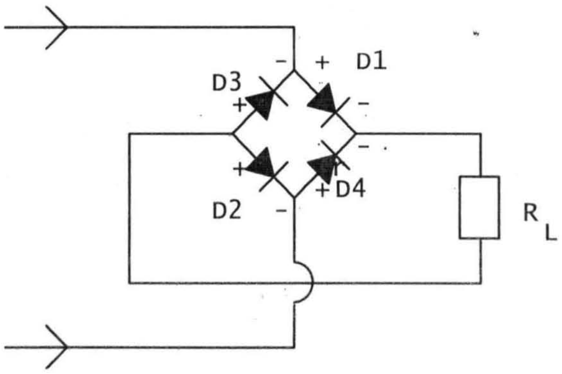

Fig 3.2 Schematic diagram of a four diode "network" (or bridge rectifier circuit)

This project adopts the use of a full wave bridge rectifier because of its ability to produce the approximate varying and reference voltage. The bridge rectifier is similar to a full wave rectifier because it produces a full-wave output voltage. Diode D_1 and D_2 conducts on the negative half cycle. As a result, the rectified load current flow during both half cycles.

During both half cycles, the load voltage has the same polarity and the load current is the same direction. The circuit has changed the ac input voltage to the pulsating dc output voltage as shown below. The advantage of this type of full wave rectification over the centre-tapped version makes it very useful for voltage rectification purpose. The entire secondary voltages are utilized.

The full wave bridge rectifier was chosen because of the following advantages. They are;

(1) Smaller transformer is needed for the operation.

(2) It is suitable for high voltage application.

(3) The bridge rectifier is cheap.

(4) It has less peak inverse voltage PIV, rating diode; i.e.2V_m compared 1.21 V_m for half wave.

(5) It has lower ripple factor compared to half wave rectifier.

3.1.3 SMOOTHING/FILTERING STAGE

There is need for the use of filter since the output from the rectifier circuit is a pulsating dc voltage. A capacitor filter is used to produce a complete dc output voltage equal to the peak value of the rectified voltage. This type of filter is the most widely used in power supplies.

And also the purpose of filtering or smoothing is to reduce the ripple component to a minimum value; the shunt capacitor filter shown in the fig 3.1.3 (a) was employed in this project. [12]

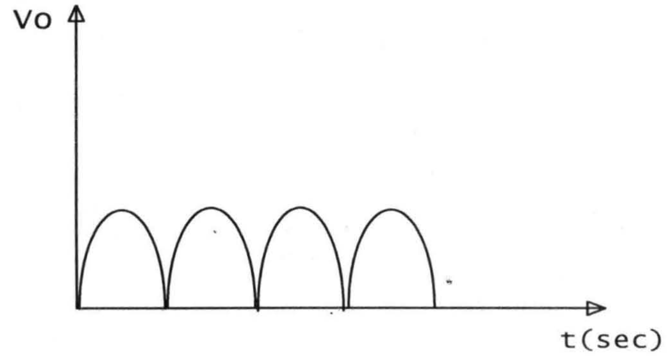

Fig 3.3 A Pulsating dc voltage

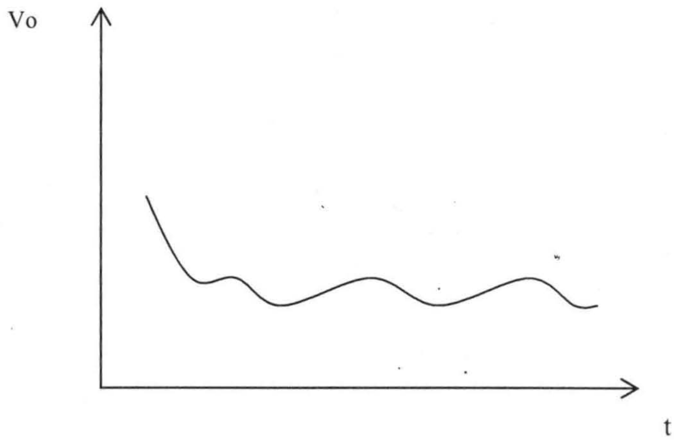

Fig 3.4 Graphical representation of a filtered dc voltage

In this circuit a suitable capacitor C_1 is connected across the rectifier and in parallel with the load R_L to achieve filtering action. This filter circuit depends for its operation on the property of a capacitor to charge up (i.e. store energy) during conducting half-cycle and to discharge (i.e. deliver energy) during non-conducting half cycle. A capacitor opposes any changes in voltages. When connected across a pulsating dc voltage, it tends to smoothen out or filter out the pulsation (or ripples).[9]

Increasing the filter capacitance that is using a bigger capacitor tends to reduce the ripple magnitude. It has been found that bigger capacitance has the following advantages;

(1) It increases V_{dc} towards the limiting value V_p

(2) It reduces the magnitude of ripple voltage

(3) It reduces the time of current pulse through the diodes

(4) It increase the peak current in the diodes

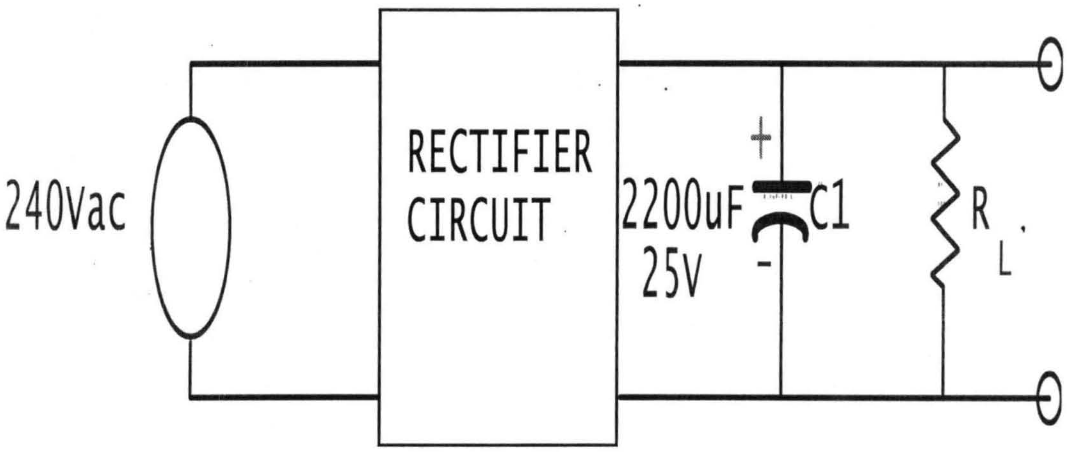

Fig 3.5 :(c) Shunt capacitor filter

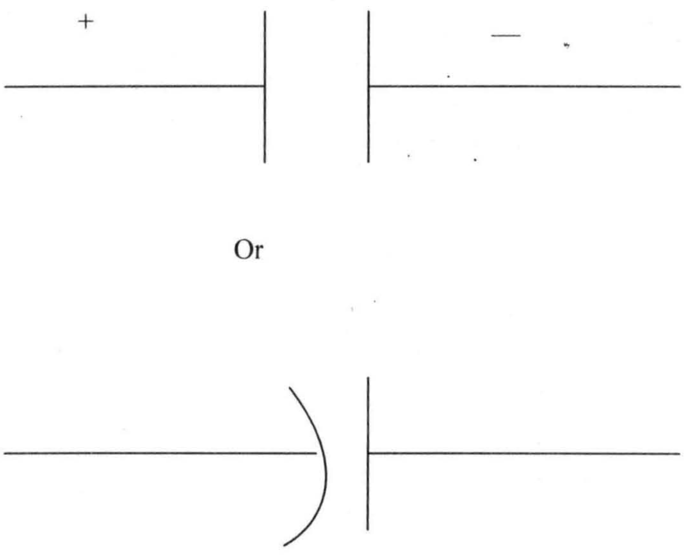

Figure 3.6 a circuit symbol of a capacitor

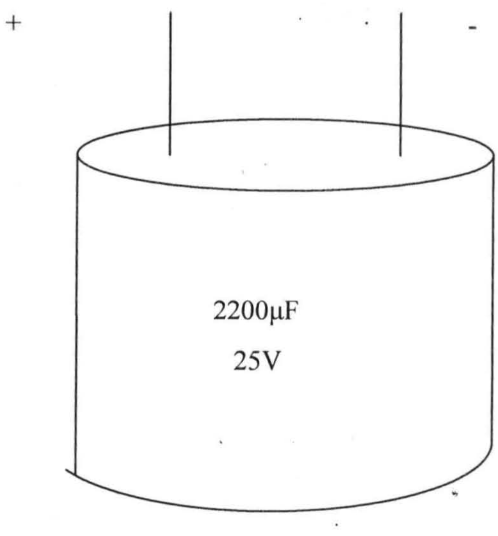

Fig 3.7 a diagram of a capacitor

3.1.4 VOLTAGE REGULATION STAGE

In an unregulated power supply, the output voltage changes whenever input supply voltage or load resistance changes i.e. 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 zero or, at least, to a minimum possible value with the help of capacitor C_2 which is a regulation/stabilizing capacitor whose function is to maintain a steady or stable supply of voltage to avoid voltage drop when load is applied to it; it is acting as backup to the voltage regulator IC.[11]

Two main types of regulator are available in integrated circuit form. In linear regulator, the transistor operates somewhere between saturation and cut-off. It is always ON and dissipates power. Hence, its efficiency (output/input power) is 50% or less. In switching regulators, the transistor operates like a switch i.e. it is either saturated or cut-off. Hence, its power efficiency is 90% or more.

The linear regulators may be in form of series regulator or shunt regulator, and switching regulator can be of two basic types; i.e. step down or inverting type. One linear regulator was used in this project. They are negative and positive 9v linear regulators. The percentage regulation or, simply regulation of a power supply is given as percentage regulation.[8]

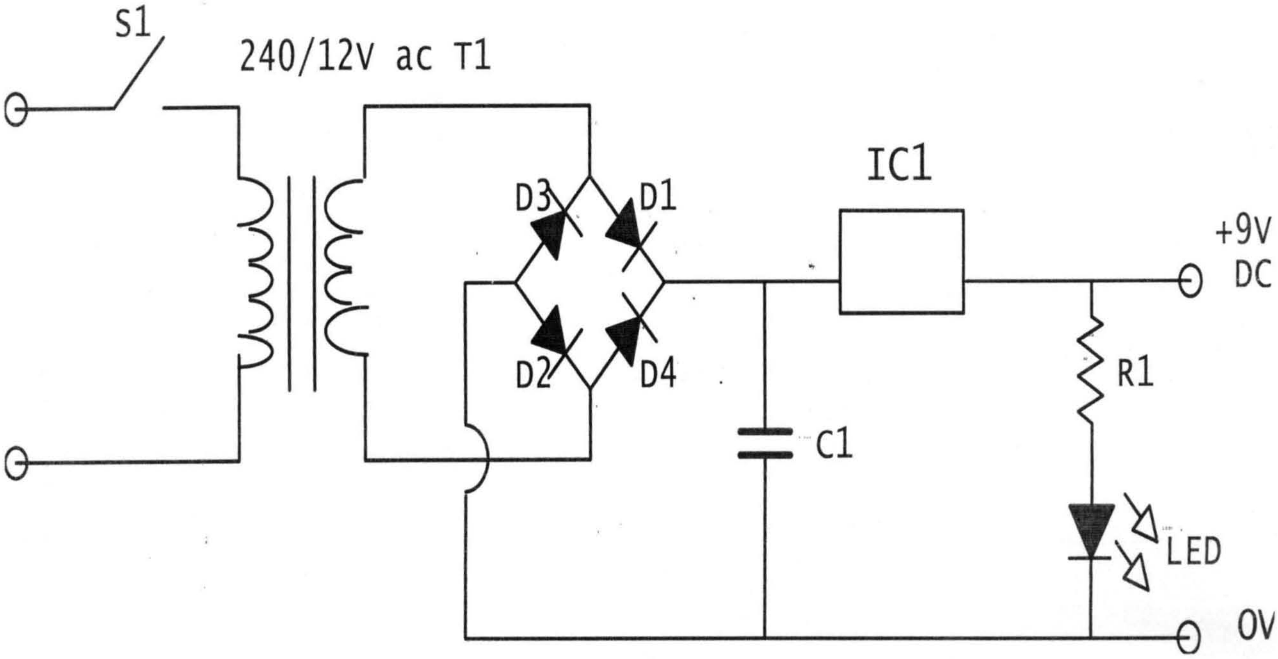

Fig 3.8 A complete power supply module

Diodes D_1, D_2, D_3, and D_4 form the bridge rectifier. The selections of these diodes are based on its peak inverse voltage (PIV) and forward current ratings. For this design, root mean square voltage of transformer is 12volts.

$$\text{Peak voltage} = 12 \times \sqrt{2} = 16.97 \approx 17\text{Volts}$$

This shows that any rectifier diode with peak inverse voltage (PIV) greater than 17volt and capable of passing a forward current of $0.5 \times \sqrt{2} = 0.7$A would be recommended.

Here IN0067 diode with PIV of 700v was chosen.

For the filter capacitance value

3.2 SENSING CIRCUIT

The sensing circuit consists of the voltage divider module and the comparator module. R_2 and R_3 form the voltage divider, holding the reference voltage at half the supply voltage. Its values are chosen to be10k for this project while the reference voltage is calculated thus

$$V_{ref} = \frac{R_2}{R_2 \times R_3} = \frac{10}{10+10} \times 9 = \frac{90}{20} = 4.5Volt$$

The reference voltage at the inverting pin (pin 2) of the operational amplifier is 4.5volt, see the circuit at the overleaf.

The comparator module in this case is the 741 Operational Amplifier (Op-Amp) configured as a voltage comparator compares the magnitude of two input signals between the inverting and the non-inverting input. Its output is high as soon as the voltage as the voltage at the non-inverting terminal (pin 3) is slightly greater than the voltage at the inverting terminal (pin2) which holds the reference voltage.[7]

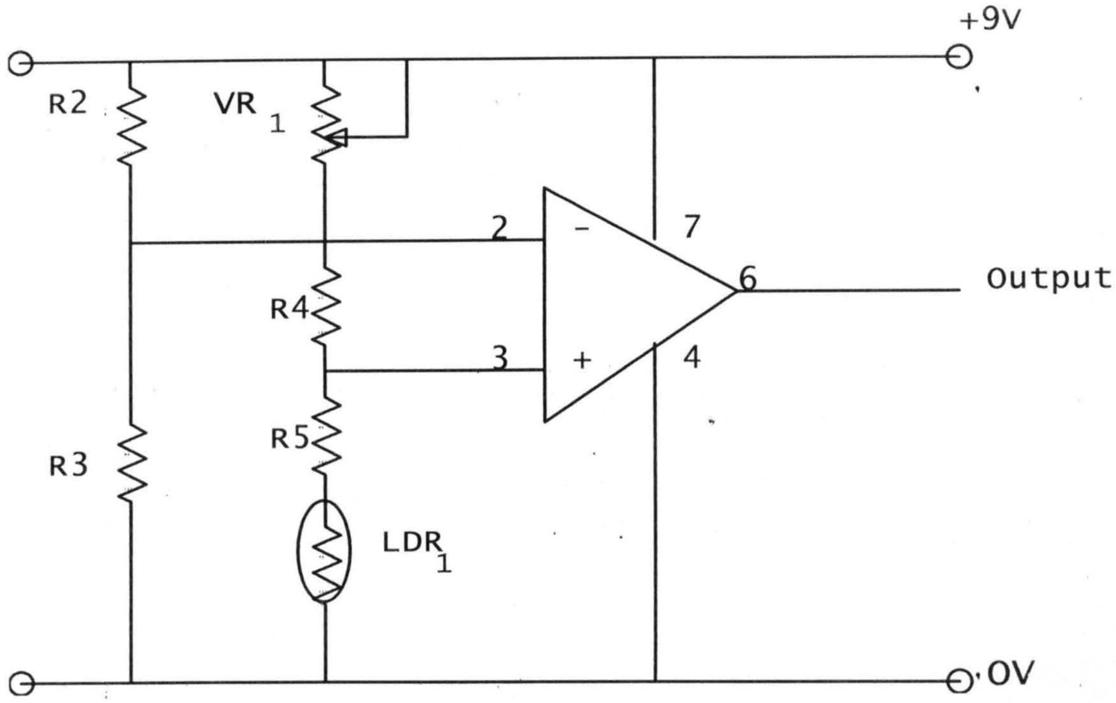

Fig 3.9 Schematic diagram of the sensing circuit

3.3 SWITCHING MODULE

Switching means timing ON or OFF directing an electric current or redirecting an electric current. The switching modules interface the entire system with the load. Without this module, the aim of this project will not be activated.[2]

For this design, a transistor and relay where used for the switching module. The choice of the transistor was based on its reliability, durability, responsiveness and its snap action. Thus, with the aid of the transistor switch, a relay can turn ON and OFF by small signal in the cut off region (open) where as the transistor operates in the saturation region and create a short circuit.[10]

An NPN high speed switching transistor (MPS 2222) silicon type was used and was connected in common emitter configuration with its collector output connected to the relay coil. The small signal from the logic unit (comparator module) will produce a higher switched output required to drive the relay coil, this in turn energizes the load at the socket outlet. Below shows the switching circuit.

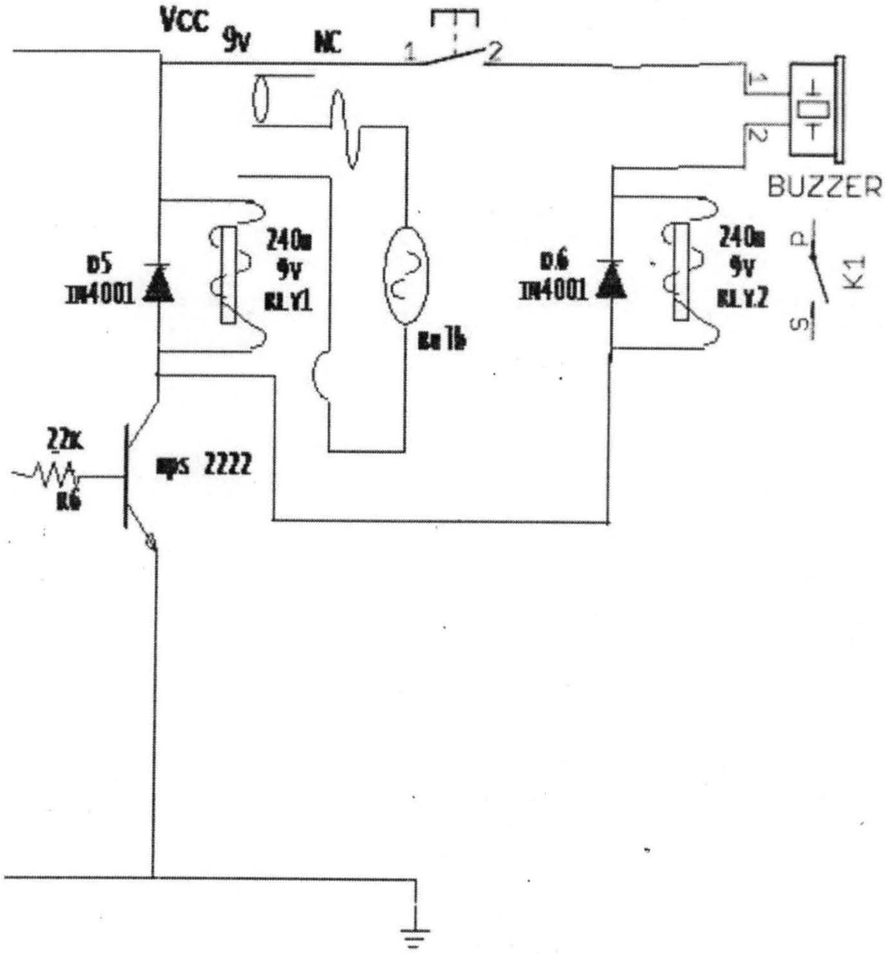

Fig 3.10 Schematic diagram of the switching module

NPN = Si General Purpose

$V_{CBO} = 75V$

$V_{CEO} = 40V$

$V_{EB} = 0.6V$

$I_c = 0.6A$

$H_{fe} = 200TYP$

Power = 0.5W

Frequency = 300MHZ

The load resistance is resistance $240\,\Omega$ i.e.R_6 which is the resistance of the relay coil. To operate a transistor as a switch it has to be driven into saturation.

$$I_C\,(sat) = \frac{V_{CC}}{R_C} = \frac{9}{240} = 37.5\times10^{-3}\,A$$

For $\beta = 200$

$$I_6 = I_b = \frac{I_C}{\beta} = \frac{37\times10^{-3}}{200} = 187.5A$$

Therefore

$$R_6 = base\ resistor = \frac{V_{CC} - V_{BE}}{I_b} = R_B$$

$$R_6 = \frac{9-0.6}{187.5\times10^{-6}} = 44800\Omega = 44.8K$$

This value was halved so as to over drive the transistor by twice the required current to guarantee saturation and to take care of β tolerance

$$R_b = \frac{44800}{2} = 22400 = 22.4k.$$

But the standard value of 22k was chosen.

D_5 is a free wheeling diode to prevent damage to the transistor due to back electromotive force (e.m.f) from the relay coil. IN 4007 diode was chosen with peak inverse voltage (PIV) of 700volt.[5]

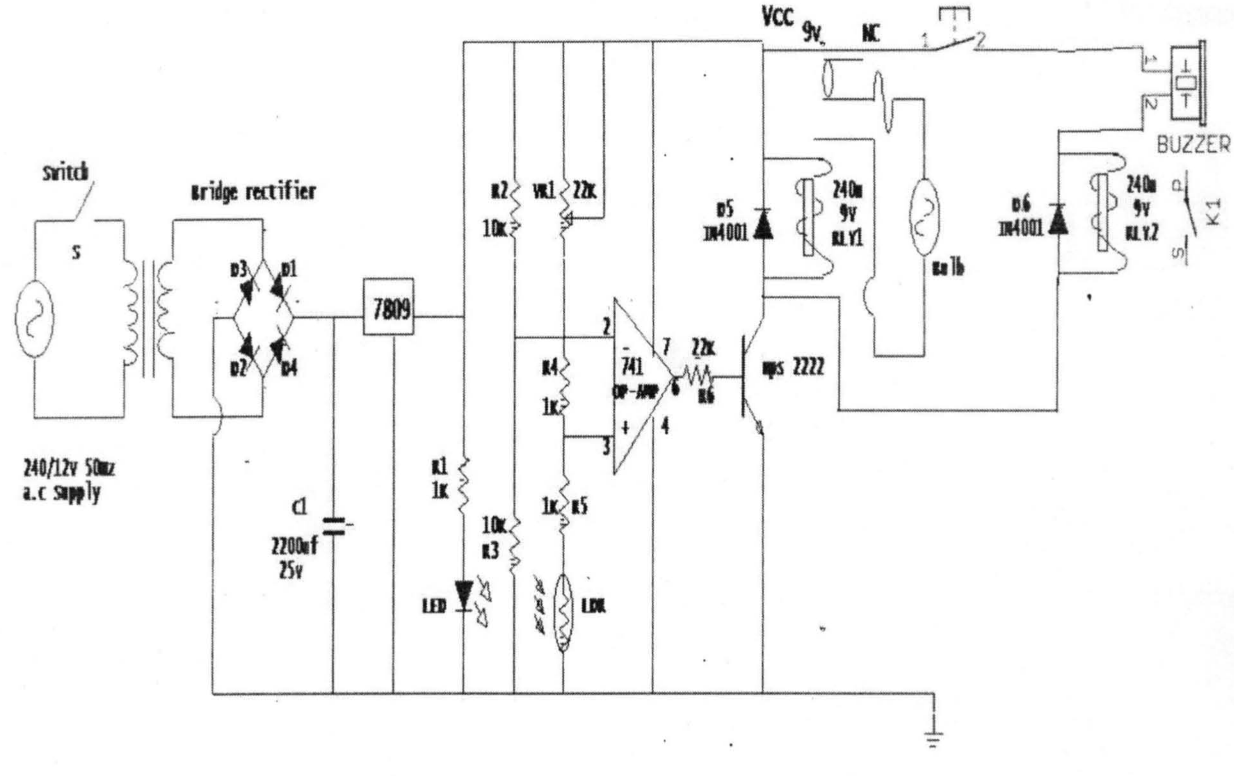

Fig 3.11 A Complete Circuit Diagram of an Automatic Controlled Security Outdoor Lighting System

CHAPTER FOUR

CONSTRUCTION, TESTING AND RESULTS.

The following are the tools used for construction: screw driver, tester, needle, side, precision set, digital meter and some of the component used are vero board(Electronic board) , connecting wires, one lamp holder, Electronic bulb, relays, capacitors, transistor, transformer, voltage regulator of 9V, cable of 1.5mm diameter.[6]

4.1 CONSTRUCTION DETAILS

Prototyping of this project is necessary at the initial stage of the project; implementation of the hardware circuit was done on a bread board otherwise known as a socket board. The function of this board is solely for prototyping purposes, as it allows components to be added and remove with ease without soldering.

Initially the circuit was implemented on a bread board. The problem encountered when bread board was used is that, connection on the board is temporal; noise from the board is noticeable by just powering the circuit. Obtaining a uniform result with the bread board circuit, prove to be very difficult so the next best solution before developing a full PCB was to use a vero board.[3]

A vero board requires soldering and has copper interconnection tracks making it less prove to noise. With the vero board, the size of the circuit was reduced significantly and the entire unit was arranged in a casing. This makes the circuit about three times as small as compared to using the bread board. As for the noise issue, using the vero board eliminates majority of the noise.

The first component fixed on the vero board was the step down transformer of 240/12V. A positive voltage regulator of 9V was then used after rectification by rectifiers and filtering capacitor to stabilize the d.c voltage at 12V so used to activate the relays. The regulator was used in building the power supply to allow for easy adjustment and self protection against short circuits. The mounting of the electronic push switch circuit was done in good manner.

4.2 PREVENTIVE MEASURES TAKEN

i. The entire individual components were independently tested before use, to ensure that they are all in good working order.

ii. Polarities of the components (where applicable) were considered before connecting them to prevent demand and ensure proper sequence of operation.

iii. The normally open and normally close of the relay were identified with the aid of a digital meter to avoid wrong connection of the relay contacts.

iv. Necessary portions of the electronic board (Vero board) were isolated to avoid continuity which may result in short circuit.

v. Badly soldered joints were avoided by applying a little soldering lead into the joints.

vi. Water and moisture were prevented from coming in contact with the circuit constructed.

4.3 TESTING AND RESULT

The whole circuit was traced to ensure that there is no short or open circuit, when all the soldering has been done on the vero board. The output of the project work was found to switch the load (220Vbulb) ON and OFF as designed. When dark covered the LDR, the load switched ON which indicate that an intrude wants to open the door, and when the LDR is uncovered, the load switch OFF which signifies that there is somebody at the door

4.4 PROJECT CASING

A container was used to protect prototype project on the vero board and make it safe for use. The casing unit of the project constructed is made of PVC of rectangular shape box having the dimension of 15cm x 10cm x 6cm. The PVC were joined together with Super Glue.

4.5 PROBLEM ENCOUNTERED

The problem encountered when using the bread board was in the connections on the board is temporal. Initially, the voltage across the regulator was not up to the required 9V when measured, until the circuit was troubleshooted. Also when powered in the first instance, some of the relays coils got burnt and could not change contacts. This was as a result of some points along the vero board not properly isolated to prevent short circuiting. This was later corrected and the circuit attains normal.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

After the design and construction, various tests were carried out and the results obtained demonstrate that the Automatic Security Outdoor Lighting System achieved its aims. The system worked accordingly to specification and quite satisfactory. The Automatic Security Outdoor Lighting System is relatively affordable and reliable. It is easy to operate.

5.2 RECOMMENDATIONS

The following are the recommendation for further improvement:

1. Higher current capacity relays should be employed.
2. Timing circuitry could be incorporated into the design to allow different delay in switching.
3. A microprocessor could act as a replacement of integrated circuit improved flexibility and performance.
4. Alarm should be added to the circuit in future.

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