DESIGN AND CONSTRUCTION OF AN AUTOMATIC STREET LIGHT CONTROLLER

BY

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PROJECT REPORT
SUBMITTED TO THE DEPARTMENT OF ELECTRICAL COMPUTER ENGINEERING, SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA.
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FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA.

MARCH 2000

CERTIFICATION

I certify that this project was carried out by MR. OMEIZA ASUVA ISAAC, and that he has met the minimum standard requirement acceptable by the Department of Electrical and Computer Engineering, Federal University of Technology, Minna.

ENGR. M.S AHMED B. Eng, M.Eng.(SUPERVISOR)	4/4/2000 DATE
DR. (ENGR). Y.A ADEDIRAN (HEAD OF DEPARTMENT)	DATE
EXTERNAL EXAMINER	6/4 DATE

DECLARATION

This is to declare that this project ,Design and Construction of an Automatic Street Light Controller, was carried out by me, OMEIZA ASUVA ISAAC, at the Electrical and Computer Engineering Department of the Federal University of Technology, Minna, under the supervision of ENGR. M. S. AHMED.

OMEIZA ASUVA ISAAC (STUDENT)	2/3/2000 DATE

ACKNOWLEDGEMENT

I am most grateful to the Almighty God who has assisted me to a successful completion of my Course of study. May all praises and adoration be unto His Holy name (Amen).

My sincere appreciation goes to the entire staff of Electrical and Computer Engineering Department for the befiting training I was subjected to, more especially to my project supervisor, ENGR. M.S. AHMED, for his willingness and efforts that have accounted for the success of this project.

My gratitude to Mr Yakubu Isah Adajah for his useful suggestion and assistance that serve as an encouragement to me in the project execution. I am also very grateful to my fellow students for their constructive criticisms and useful suggestions.

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My profound gratitude goes to my dear guardian, Mr. and Mrs. Fanisi Enok, for their parental, moral and financial support. Thanks for your encouragement and sacrifices which I believe will not go un – rewarded.

DEDICATION

This project report is dedicated to my parents Late Mr. Elias Omeiza and Late Madam Nana-Awawu Omeiza, and also to the entire family of Mr. and Mrs Fanisi Enok. I also dedicate it to my beloved one, Miss Fanisi Omolara Funmilola.

ABSTRACT

This project is limited to automatic switching controller to be used for both domestic and industrial switching and more importantly as it specifically applies to street light switching automation. The basis principle of the design is based on the operation of theLight Dependent Resistor (LDR) as a sensing device and a comparator circuit using the operational amplifier (µA741) incorporated with a switching circuit (transistor and Relay to switch ON and OFF the powering source of the street light depending on whether it is dark or bright.

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CHAPTER ONE

1.1 INTRODUCTION

In the past ages, Switching and control had often been carried out manually to obtain the desired result. Considering the constant changes in technology and increase in modern civilization, the use of manually operatd switches is gradually getting phased – out thus paving way for the use of automatic switching devices in electrical installation works which has increased tremendously over the years. The yearn for automation by human race in all facets of life is only calling for easiness, comfort and efficient accomplishment of tasks that might be susceptible to inefficiency and unpredictable failures if manually done.

The use of automatic switching controllers has become more essential for domestic and industrial switching related appliances and equipment including some public utilities such as street lighting. For public utilities such as street lighting, automatic switching control is achieved by using controller operated based on the principle of the light dependent resistor (LDR) otherwise known as photocell. Thus the use of LDR which makes use of sunlight energy to generate energy has greatly reduced the involvement of mankind in the field of power switching as a result, man made errors had been considerably reduced if not totally eliminated.

Lights are controlled automatically by using an electrical circuit incorporated with a contactor or relay. This enables the natural switching of the light by the day and night phenomena, independent of human intervention. Even as the government need to ensure the security of lives and properties of her citizens, street lighting at night becomes very important. Moreso that individuals likewise would want lighting system at night for their premises in order to enhance visibility.

Thus this project is aimed at designing and construction of an automatic street light controller, which is an illumination controlled system that switches itself ON whenever the levels of light in its surrounding drops to a certain level and also switches itself OFF when the sunlight level exceeds a predetermined level without any human intervention.

1.2 AIMS AND OBJECTIVES

The primary objectives of this project is to design and construct an automatic street Light controller system. The system is designed to be automated by switching ON and OFF. The aims to achieve includes:

(i) The control system should be such that easily interfaced with wider variety of security systems.

(ii) The project should be relatively inexpensive.

(iii) It should be easily set up and relatively cheap to maintain.

Hence, the desire to design a system that maintains and provide a required control for a street lighting and also to be used with minimum cost of maintenance motivated me to embark on this project.

1.3 LITERATURE REVIEW

One of the early references to electrical lighting was in 1858, in the south fire land light on the Kent coast, using a carbon arc lamp. This was followed in 1862, by the installation of arc lamp at the Dungeness light, also in Kent. In 1879 Brush Charles Francis demonstrated the first street lighting in Cleveland and 1882 Brush light had spread over large part of U.S.A. and England. Since then the technology of security lighting, which is often referred to as road, public or street lighting has gone through considerably improvement over the years, Including the lighting of pedestrian ways, sub ways and buildings.

The first controller to put security light ON and OFF was the lamp lighter which have went around lighting gas lamps. Since then there have been many methods of control devised to switch light ON and OFF either individually or a group of them. Solar – dial time switch has been the most reliable and cheapest means of switching for many years. This is a clock driven by a synchronous electric motor, and this is set compensating and allows for the daily variation in switching ON and OFF which relates directly to sunrise and sunset.

Because of the need to reset the solar dial, time switch after every power cut, the automatic switching of the solar dial, which is based on average daylight condition, was found to be inadequate. As a result, there was a serious desire for a switching devise controlled by ambient day light condition, which would for example, switch light ON when there is fog or when it gets dark early because of an overcast sky. The modem photoelectric cell fulfils this requirement and is being used extensively for modem lighting control. A photoelectric cell can be seen generally on the top of a lamp controlling an individual lamp, but it is often wired to a relay which in turns serve as a switch to many light stands.

1.4 PROJECT OUTLINE

The entire project report is divided into four chapters;

Chapter one entails the general introduction of the work. It also clearly states out the

Objectives and aims of the project. The chapter was concluded with the literature review.

Chapter two basically treat the system design, stating the steps and calculation involvement that leads to the selection of components used. At the end of the chapter, the principle of operation of the system was briefly outlined.

Chapter three entails the construction of the system to ascertain whether design goals are met or not.

Chapter four includes the conclusion, recommendation and references.

CHAPTER TWO

SYSTEM DESIGN

The Project design process is basically divided into three stages i.e.

1. The control unit
2. The switching unit
3. Power supply unit

2.1 THE CONTROL UNIT

The control unit of this project comprises of basically an operational Amplifier serving as voltage comparator, a Light depended Resistor (LDR) and a variable resistor for presetting.

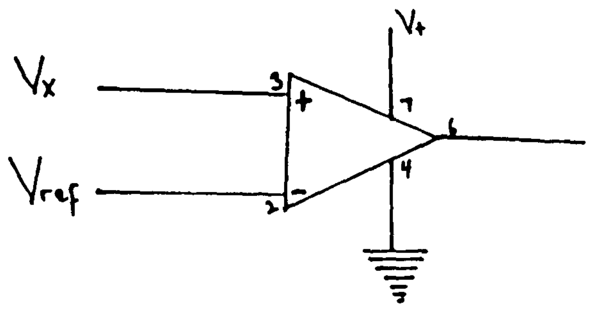
2.1.1 THE VOLTAGE COMPARATOR

The differential operational amplifier in this project was used as a voltage comparator. It is type 741 with an off-set voltage of about 2.0 volt. The comparator compares the registered voltage V_x at the non – inverting input with the already established reference voltage V_{ref} in order for it to decide the output of the comparator. If V_x is greater than the V_{ref} i.e. in dark situation the output signal of the comparator will be HIGH, while the output of the comparator is LOW if V_x is less than V_{ref}, i.e. in bright situation.

Resistor R_2 = R_3 =15K. They both function to establish a reference voltage. V_{ref} = 6 volts across the inverting input.

When $V_x > V_{ref} \Rightarrow V_{out}$ =HIGH(+ve)

$V_x < V_{ref} \Rightarrow V_{out}$ =LOW(ground) ⇒O



(a) OPERATIONAL AMPLIFIER AS COMPARATOR

(b) THE FREQUENCY COMPENSATED OP – AMP 8 – PIN CAN SHOWING THE CONNECTING PINS

1. THE FREQUENCY COMPENSATED OP – AMP 8 – PIN CAN SHOWING THE CONNECTING PINS

Pin 1 Offset null

2. Inverting input

3. Non – inverting input

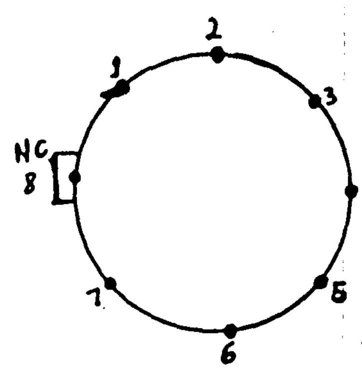
4. Connected to case – v.

5. Offset null

6. Output

7. +V

8. NC



2.1.2 THE VARIABLE RESISTOR

The resistor Rv whose resistance can be varied up to a maximum value of about 10 kΩ was used in this project. It is being used to preset or varies the resistance which thus lead to the variation in the voltage across the Non – inverting input of the operational amplifier. Thus the variable resistor is serving as a voltage divider. A 1.5 kilo ohm resistor was connected in series with the variable resistor, serving as a shield to protect the variable resistor from being damaged.

2.1.1 THE LIGHT DEPENDENT RESISTOR (LDR)

The LDR is often referred to as the eye of the project (i.e. the sensor). It sense the Darkness or brightness the environment that leads to the changes in the resistance builds up accordingly. Based on the resistance across the LDR in conjunction with that of the preset value of the variable resistor, a voltage is registered at the non – inverting input of the comparator.

From experimental observation, It is known that in a dark situation the resistance by the LDR is about 10 mega ohms, and the resistance falls with increasing illumination. For a typical LDR, Figure 2 illustrates the variation in cell resistance with illumination.

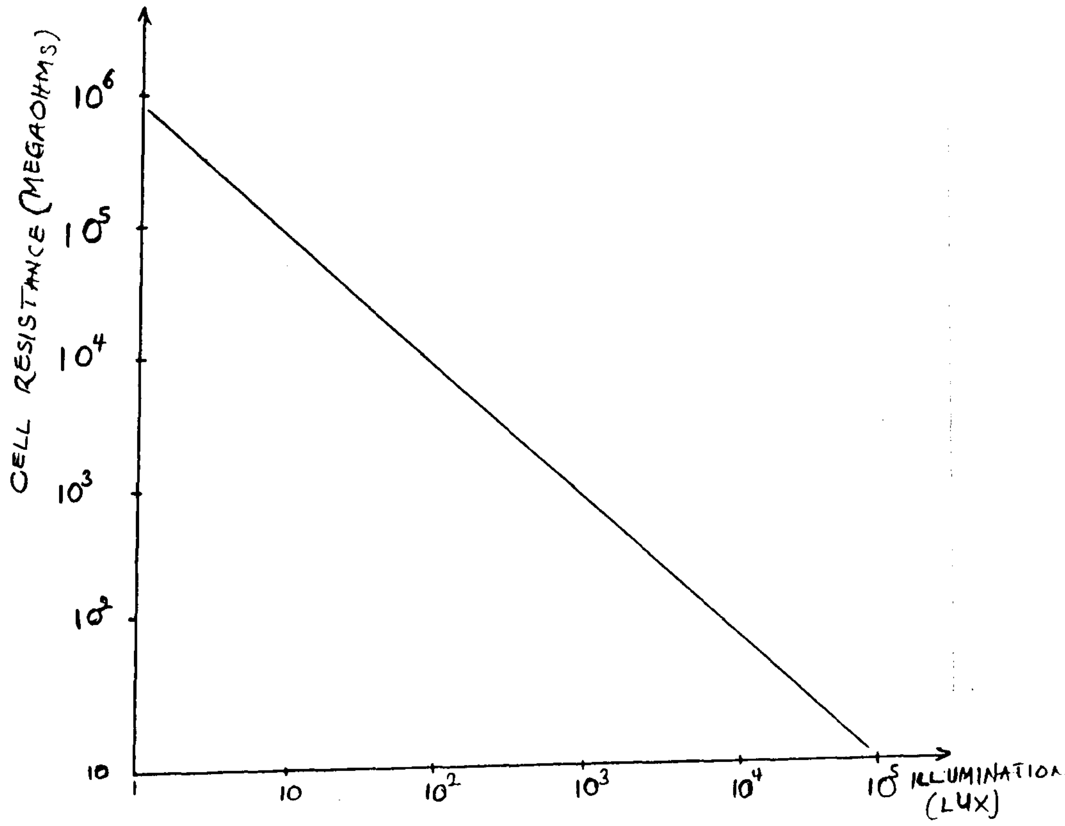


FIGURE 2: VARIATION IN CELL RESISTANCE WITH ILLUMINATION FOR A TYPICAL LDR

In OFF situation, the offset voltage of the comparator is about 2.0.V. Thus the resistor R_B helps to drop this value which is sufficiently large enough to bias the transistor. It also serves to protect the transistor.

During the ON situation, the relay coil which is also an inductor stores energy it will discharge in OFF situation. Thus a free will diode is connected in parallel to it so that it could discharge through it. The 1k resistor serves to protect the LED indicator from being damaged.

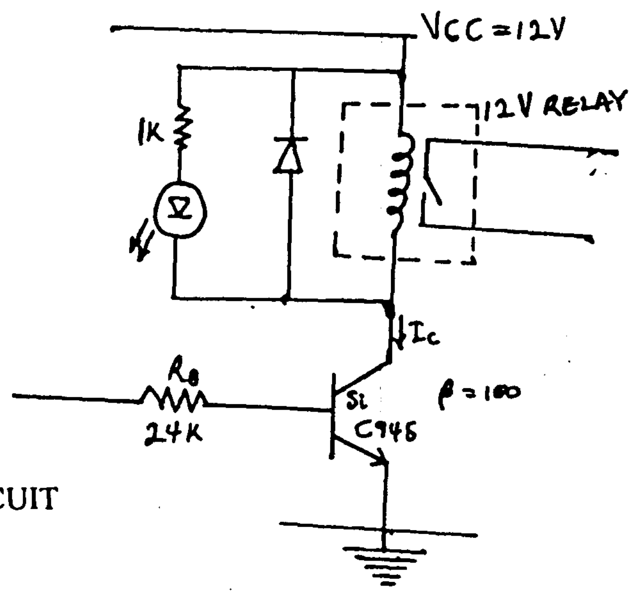


FIGURE 4: THE SWITCHING CIRCUIT

2.3 POWER SUPPLY UNIT

In present day, electric power has been generated, transmitted and distributed in the form of an alternating current (A.C) and voltages. This is due to the fact that A.C posses relatively simpler engineering and economic problems if compares to the direct more appropriate or advantageous such that it becomes more preferable to A.C, most especially in control and protective works in most electrical and electronic equipment and appliances.

The power supply unit design had been divided into four distinct stages for convenience sake.i.e.

(1) Transformer stage

(2) Rectifying stage

(3) Filtering stage

(4) Voltage regulation.

3.1 SELECTION OF TRANSFORMER.

In most power supply units, a transformer is often used to step down an A.C. mains to the required voltage level that is most appropriate for our needs.

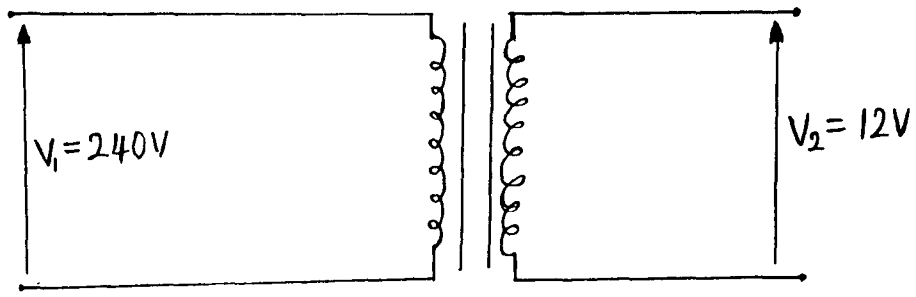


FIGURE 5: TRANSFORMER.

Let V_1= Primary Voltage

V_2 = Secondary Voltage

N_1 = Number of turns in primary coil

$$Thus, \frac{V_1}{V_2} = \frac{N_1}{N_2}$$
$$but, V_1 = 240V, V_2 = 12V$$
$$\frac{240}{12} = \frac{N_1}{N_2}$$
$$\frac{20}{1} = \frac{N_1}{N_2}$$

N_2 = Number of turns in primary coil

Therefore, for the purpose of this project, a 240V/12V step – down transformer with turns ratio N1:N2 = 20:1 was chosen.

2.3.2 RECTIFYING STAGE.

In rectification, a rectifying circuit employs one or more diodes to convert A.C. voltage into a pulsating D.C. voltage. For this project, the full – wave bridge rectification was used. The full – wave bridge rectifier consists of four diodes which produces a ripple frequency twice that of a fundamental frequency. It is most frequently used circuit for electronic D.C. power supply.

Selection of diodes:PIV = Peak inverse voltage > 2Vm

$$Vm = \sqrt{2Vrms}$$

Where Vm = Peak to peak Voltage

$V_{rms} = V_{ac} = 12V$

$$Vm = \sqrt{2 \times 12}$$

=16.97V

Since PIV>2Vm

>33.94V

Therefore, diode 1N4001 with peak inverse voltage of 50V was chosen for the design.

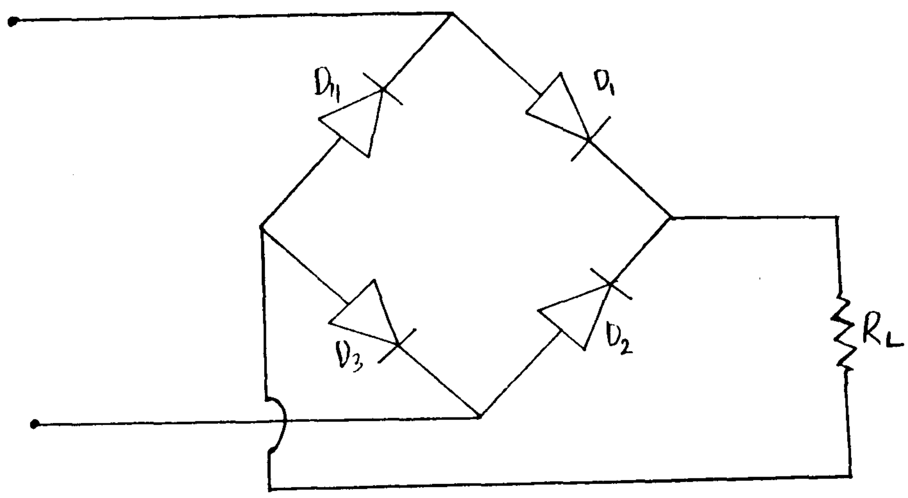


FIGURE 6: THE RECTIFIER CIRCUIT.

2.3.3 FILTERING STAGE.

The rectifier generally provides pulsating D.C. voltage at the output. The filter circuit is applied to considerably reduce the ripple present in the output. For most purposes, this ripple must be reduced even if it cannot be completely eliminated.

The filtering is achieved by the use of a simple low – pass filter. The simple low – pass filter is a capacitor often connected across the output of the rectifier.

Selection of the filter capacitor:

$$Capacitance\,C = \frac{I_{dc}}{2f\Delta v}$$

Where

I_{dc} = maximum load current

F =frequency of the main supply

C = capacitance of the filter capacitor

ΔV = peak to peak ripple voltage = 5% of V peak

$$since\,V_m = \sqrt{2} x V_{rms}$$
$$= 16.97V$$
$$Therefore, \Delta V = \frac{5}{100} x 16.97$$
$$= 0.8485$$
$$let\,I_{dc} = 150mA$$
$$\Delta V = 0.8485$$
$$F = 50HZ$$
$$Hence, C = \frac{150 \times 10^{-3}}{2 \times 50 \times 0.8485}$$
$$= \frac{150 \times 10^{-6}}{2 \times 50 \times 0.8485}$$
$$= 1{,}767.8\mu F$$

For the purpose of this project, 2,200 μF, filter capacitor was chosen for the design.

2.3.4 VOLTAGE REGULATION

Because of the fact that the output voltage of any practical power supply falls a certain amount when a load current is drawn, the need for voltage regulation becomes a thing of importance. The aim of voltage regulation is to keep the terminal voltage of the D.C. supply constant even when either

(i) A.C input voltage to the transformer varies or

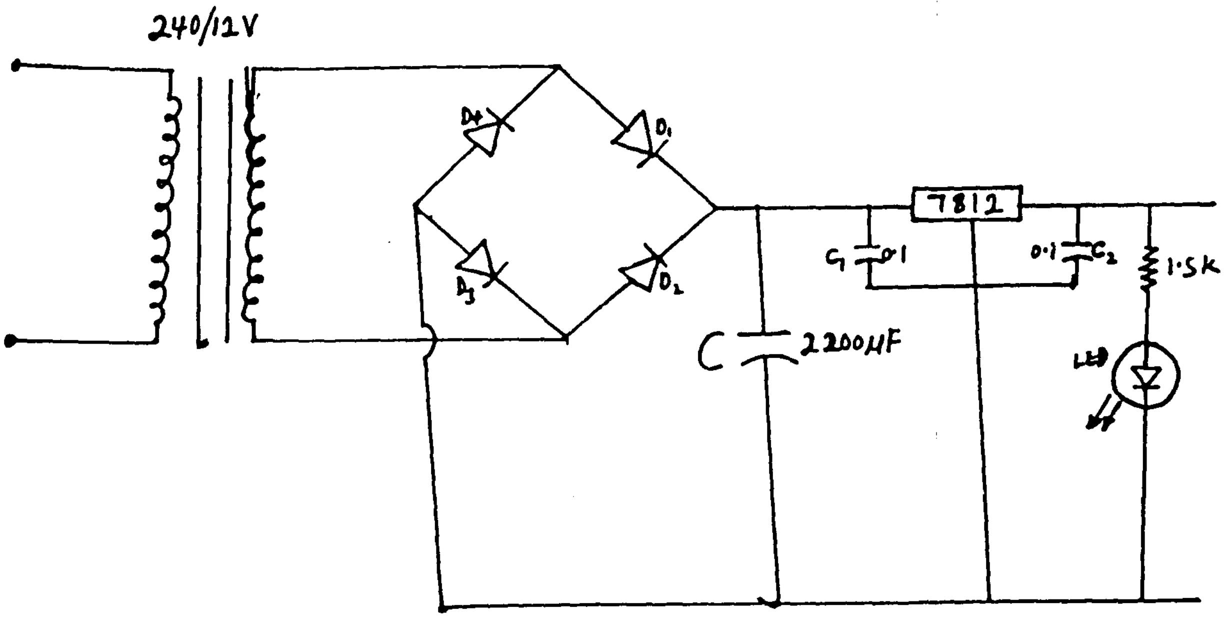


FIGURE 8: THE COMPETE CIRCUIT OF POWER SUPPLY

2.4 A BRIEF OUTLINE OF THE OPERATION.

Referring to the circuit in fig. 10 the output of the regulated power supply is applied to both the control and the switching units.

Based on the established voltage V_x due to the variation in the situation of the day, the voltage comparator compares the value of V_x to V_{ref} in order for it to determine the output.

If $V_x > V_{ref}$ i.e. in the dark situation, the output of comparator will go HIGH, thus biasing the transistor operating in its switching mode; as a result the 12V D.C. flows across the relay coil which invariably energized the relay and causes it to close contact. The output of the relay which is connected to the contactor cause the contactor to be energized, thus making the contactor to close. Immediately the contact closes, the street light goes ON.

If on the other hand $V_x < V_{ref}$ i.e. in bright day situation, the comparator output will be LOW and hence cannot bias the transistor. Therefore the street light or the load remain in the OFF situation in the bright day time.

Below is a block diagram illustrating the operation

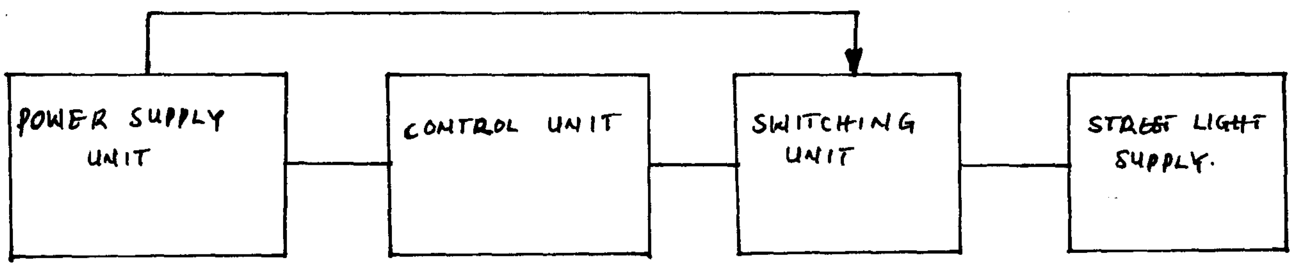


FIGURE 9: BLOCK DIAGRAM ILLUSTRAING THE OPERATION OF THE SYSTEM.

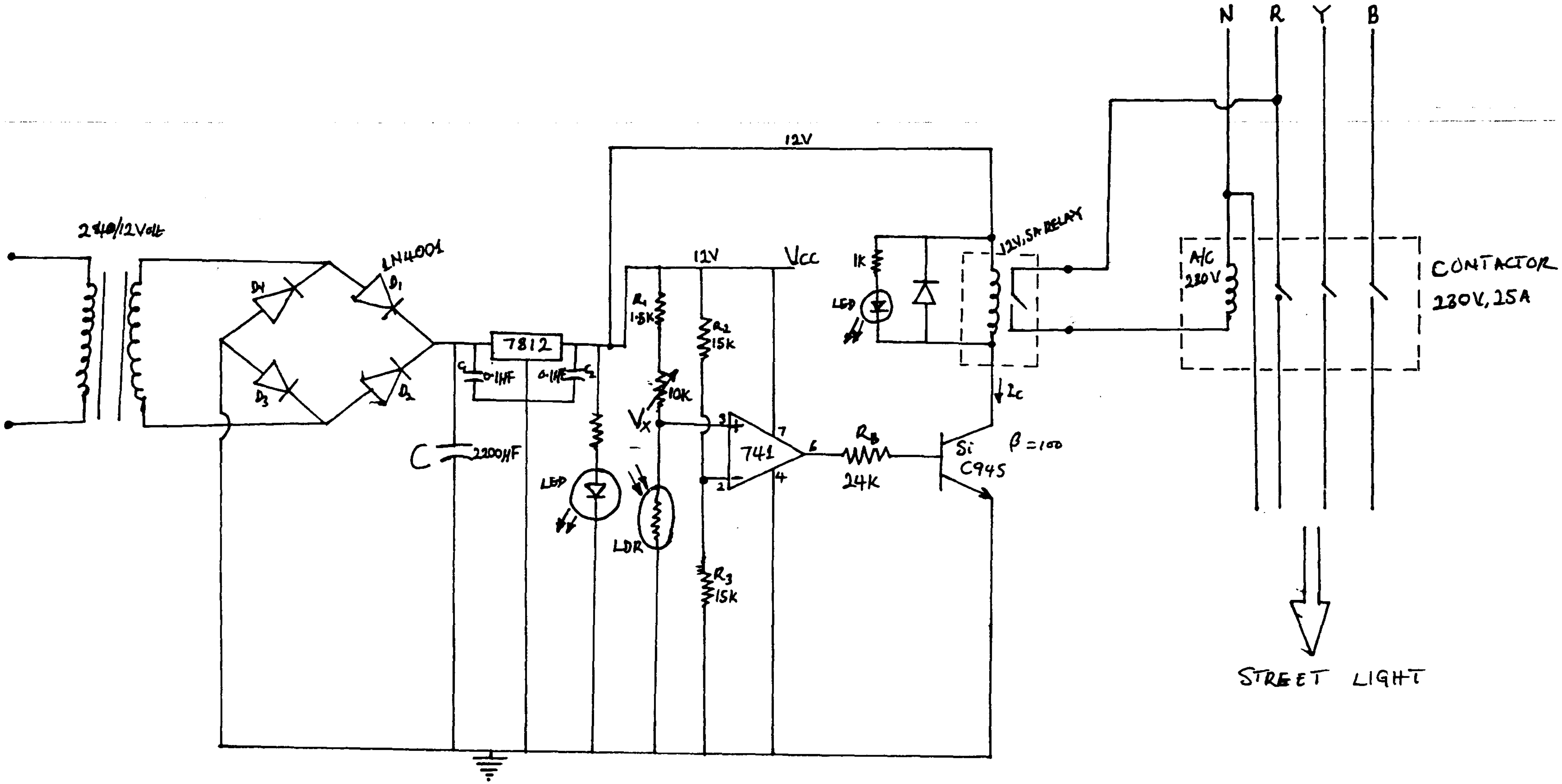


FIGURE 10: THE COMPLETE CIRCUIT OF AN AUTHOMATIC STREET LIGHT CONTROLER

CHAPTER THREE

CONSTRUCTION, TESTING AND ASSEBLING

3.1 CONSTRUCTION:

In the process of realising this project, the construction was initially carried out on a breadboard to allow for checking and to ascertain that it is functioning effectively. All irregularities were checked and then tested and found to have a satisfactory output.

The component were then removed and transferred to a vero board strip and soldered into place and all discontinuous point were cut out to avoid short – circuiting.

3.2 TESTING

With the knowledge of the system of operation as briefly out line in section 2.4, the system was tested at the relay output. The load was connected across its normally open terminal and its common terminal.

The light intensity on the LDR was reduced by covering the top of the LDR with a dark material indicating a dark situation. The relay thus gets energized and close the contact, thereby switching ON the load. Immediately the material used in covering the LDR is removed, light rays fall on the LDR, thereby de – energizing the relay and in turn switching OFF the load.

Testing was carried out by connecting a 60 watts electric bulb as the final load for illustration. Further tests was carried out at dusk and dawn without covering the top of the LDR to ensure that it is functioning effectively. The effectiveness of the controller circuit had been tested for several times and was found to be effective and reliable.

3.3 ASSEMBLING

The whole system was packed in a small wooden box and provision was made for the LDR to sense light from the outside. Also, LED indicators which glow Red and Green respectively was mounted with the red indicating that there is power in the circuit, while the green indicates that the load or the street light as applicable in this project is ON.

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