DESIGN AND CONSTRUCTION OF AN AUTOMATIC STREET LIGHT CONTROL PANEL

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A PROJECT REPORT SUBMITTED TO THE DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING, SCHOOL OF ENGINEERING TECHNOLOGY, MINNA, IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF BACHELOR OF ENGINEERING DEGREE (B.ENG) IN ELECTRICAL AND COMPUTER ENGINEERING.

NOVEMBER 2004

CERTIFICATION

This is to certify that this project titled "Design and Construction of an Automatic Streetlight Control Panel" was carried out by Danmallam Barnaiyi (98/6937EE) for the award of the bachelor of Engineering in Electrical and Computer Engineering, Federal University of Technology Minna ,Niger state.

7/12/04

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DATE

EXTERNAL EXAMINER

DATE

DECLARATION

I DANMALLAM, BAMAIYI hereby declare that this work was wholly presented by me under the close supervision of Engr. M.S. Ahmed during the 2003 / 2004 session. To the best of my knowledge, it has never been presented elsewhere.

SIGNATURE

07/12/04

DATE

DEDICATION

This project work is dedicated to GOD ALMIGHTY. Also to my parents, Mr..Danmallam D. Galadima and Mrs. Danmallam Maria for their financial and moral support. The work is equally dedicated to my brothers and sisters.

ACKNOWLEDGEMENT

To God the most merciful, who saw me throughout the years for His love, protection and support I give glory. My supervisor, Engr. M.S. Ahmed, thanks for your patience and good advice. May God increase and bless you; you are indeed a noble man. I appreciate the fatherly advice and concern of my H.O.D. Engr. M.D. Abdullahi. May God bless all my lecturers and class-mates for the challenges they posed to me and for their support. My sincere gratitude also goes to my parent, Danmallam D. Galadima and Danmallam Maria for their support, encouragement and parental advice; and to my brothers and sisters, Ango.Nasara, Ayuba, Kande; and my niece Esther.

Special thanks to my friends – the Council of Elders – Maxwell Igbinoba, Emeka Nlumanze, Azubike Odumodu, Nathaniel Ajagha, Femi Babatunde, Donatus Asuelinnen; and to my good friend Esse. I also appreciate deeply, the concern and encouragement of my special friend, Blessing Odia. God bless you.

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ABSTRACT

This project is to design and construct an Automatic Streetlight Control Panel. It uses a Light Dependent Resistor (LDR) which senses the change in light intensity, and transfers the change to a comparator. The comparator compares the change and sends it to a D – flip – flop which automatically transfers the data output to drive the switching transistor. Once this happens, the transistor is saturated and is energized to control an electrical contactor for the switching of the lamps.

CHAPTER ONE

GENERAL INTRODUCTION

1.1 INTRODUCTION

Electronic systems refine, extend or supplement human facilities and ability to observe, perceive, communicate, remember, calculate or reason. Electronic systems are classified as either analog or digital.

Analog systems change their signal output linearly with the input and can be represented on a scale by means of a pointer. On the other hand, digital instruments or circuits, represent their output as two discrete levels('1' or '0') and could show their output in a digital display either numerically or alphabetically.

This project involves the construction of an automatic street light module. The automatic street light control panel controls the switching of streetlights automatically. The system is designed using a LDR (light dependent resistor) as its main transducer. As light intensity across the LDR changes the voltage across it changes, and this changing or varying voltage is when compared with a fixed voltage will give two distinct voltage levels on a comparator output. The output of the comparator is later fed to the input of a switching circuit via a digital sequential logic control which switches the power to the load when there is darkness and switches it OFF when day light appears.

1.2 AIMS AND OBJECTIVES

The uses and applications cannot be over-emphasized. Among the aims and objectives are:

1. To implement an automatic switching system that can effectively switch any equipment or device to ON and OFF state.
2. To implement an automatic switching system which is flexible, reliable and user friendly due to its low cost DC power control voltage.
3. To implement an automatic switching system in place of mechanical manually operated switches.
4. To implement an automatic control system which is not bulky and is cost effective.

1.3 DESIGN METHODOLOGY

The complete system was broken down into a subsystem or unit blocks. Each subsystem performs a special task by the integration of all the subsystems. The Automatic Switch Control System satisfies the overall requirement of the project. Below is the block diagram of the system.

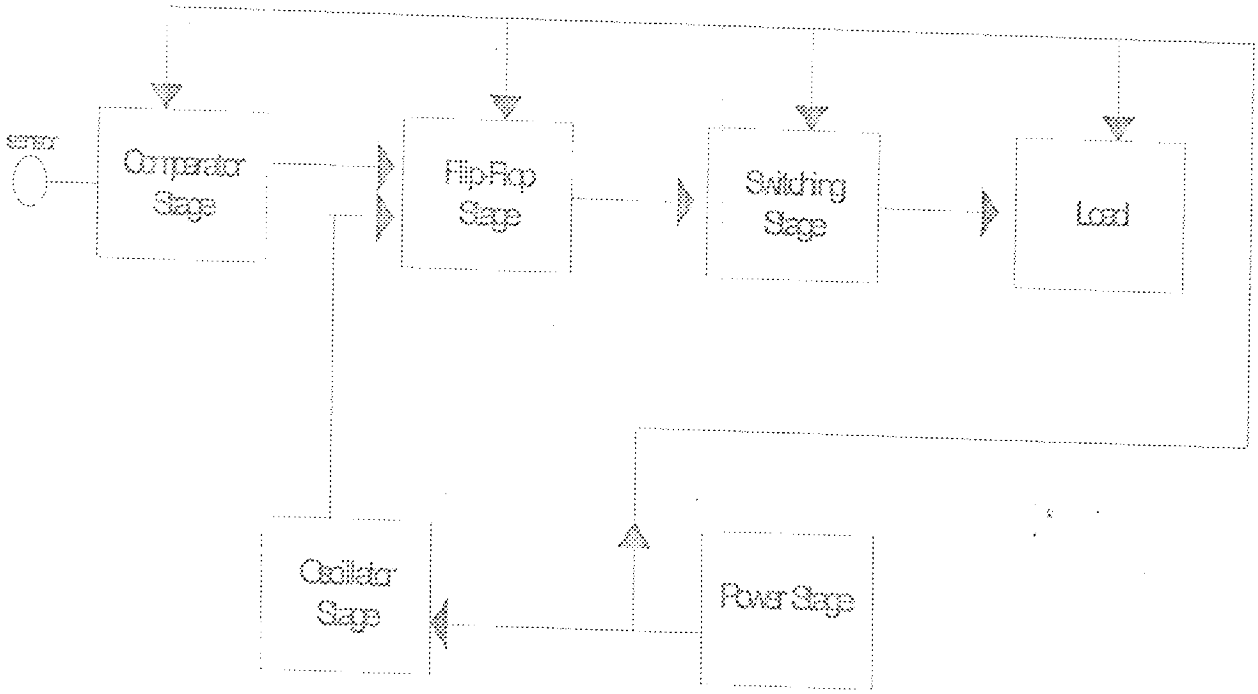


FIG 1.1: GENERALIZED BLOCK DIAGRAM.

1.3.1 DESIGN SPECIFICATIONS

Power Supply	5VDC and 12VDC
Mains Input	200-240VAC
SENSITIVITY	Adjustable from a variable resistor.
Power output	5000watts (i.e. load).

1.4 LITERATURE REVIEW

Automatic switching systems are electronic circuits that do switching based on electrical input commands that are influenced by conditions of environment which could be natural or artificial. Transducers therefore, are always integral parts of these systems. The Automatic Streetlight Control Panel is based on this principle. The evolution of automatic switches is linked to the quest by man to have his surrounding conditions control his devices so that life is made much easier.

By the end of the 1870s, developments in electric lighting and generation had produced the ability for electricity to compete with gas for lighting of streets and public areas. But most of he switching was done manually to switch the lamps ON and OFF. Development on automatic switches for this purpose started around this time and its rate has been rapid since then.

The commonest application of a switch is to switch a device ON and OFF. It is used as a safety device to switch OFF power in cases of an accident. It is used for economic reasons when conserving electrical power.

1.5 PROJECT OUTLINE

The project outline contained chapter by chapter is stated below.

Chapter One: This chapter gives an overview of the project, introducing its functional units and applications. The Literature Review is contained here. It reviews the earlier research, the basic concepts and alternatives. The chapter also contains the Aims and Objectives, and the Design Methodology.

Chapter Two: This chapter contains the overall system design and analysis. Each subsystem is treated elaborately.

Chapter Three: This chapter contains the construction, testing and results. It gives details of how the project was constructed.

Chapter Four: This is the last chapter of the project and it involves the Summary, Recommendation and Conclusion.

CHAPTER TWO

SYSTEM DESIGN AND ANALYSIS

2.1 CIRCUIT ANALYSIS

The light dependent resistor effectively operates when there is change in light intensity, the non-inverting pin of the IC1(LM393) goes low below the reference inverting pin, when light falls on the LDR .And hence gives a low output to supply the D-input which is low to the switching transistor(BC546).The transistor is switched off in this mode

IC_2 which is a 555 timer connected in astable as used to supply constant time clock to the D-flip-flop at 1KHz. When the light intensity drop, for instance during the night, the resistance of the light dependent – resistor goes high thereby increasing the voltage at non-inverting of IC_1 above the referenced – voltage of the inverting IC_1. The output of the comparator (IC1) thus goes high and the output is supplied to the D-input of the D-flipflop together with the clock of the IC_2 (555 timer). The output of the flip-flop is high, thereby switching the transistor and the relay is connected to allow the load (Bulb) to light.

A single supply of 5VDC is generated to supply all the functioning stages.

2.2 POWER SUPPLY STAGE

The power supply stage is a linear power supply type and involves a step down transformer, filter capacitor, and a voltage regulator to give the 5V. The power supply circuit diagram is shown in fig. 3.4

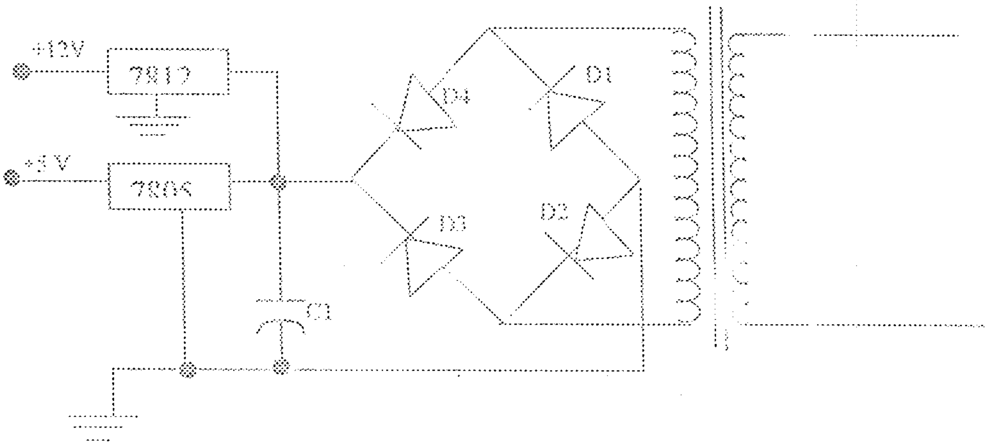


FIG 2.1: POWER SUPPLY CIRCUIT

The rectifier is designed with four diodes to form a full wave bridge network. C_1 is the filter capacitor and C_1 is inversely proportional to the ripple gradient of the power supply. Fig.2.1b shows the ripple gradient

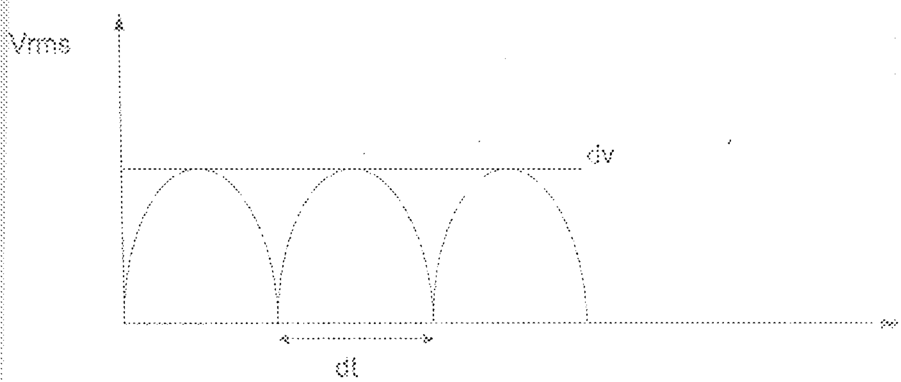


Fig. 2.1b: Ripple Gradient of Power Supply Stage.

Where dv is the ripple voltage for time dt, where dt is a dependent in power supply frequency.

For an rms voltage of 18volts (from transformer)

Vpeak $= 18 \times \sqrt{2}$ (i.e., rms x $\sqrt{2}$

$= 25.46$ V

Hence letting a ripple voltage of 15% makes dv = 3.82

But $I/C = \frac{dv}{dt}$

$C = \frac{dt}{dv}$

$= \frac{10ms}{3.82}$ (where dt = 10ms for 50Hz)

$= 2620\mu F$

A preferred value of 2200μF was employed for the power supply stage.

A 7812 regulator was used for the power supply stage.

2.3 PHOTOCONDUCTING CELL

The LDRs are also known as Photoconducting cells. They show a pronounced decrease in resistance with increasing illumination. As light intensity across the LDR changes, the voltage across it changes, and this changing or varying voltage when compared with a fixed voltage will give two distinct voltages. The project uses the LDR as its main transducer.

2.4 COMPARATOR CIRCUIT STAGE

The function of the comparator is to compare two voltages and give an output, which tell if they are equal or unequal. The comparator stage in this circuit is used to sense when the light falls or not on the LDR. A reference voltage of 3.0V is applied to the inverting input of the comparator(but this could be reduced to increase the sensitivity).

When the light intensity drops,the voltage drop across the LDR increases and once the intensity drops to a level where it increases above the reference(i.e the inverting input) the comparator output goes high to satisfy the data condition for set mode operation of the D- flip flop. Also when the intensity increases(i.e day time), the drop across the LDR, reduces and when it reduces below the reference, the comparator output goes 'LOW, which satisfies the reset data condition of the flip flop and switches the relay OFF.

The comparator stage is shown in fig.3.2

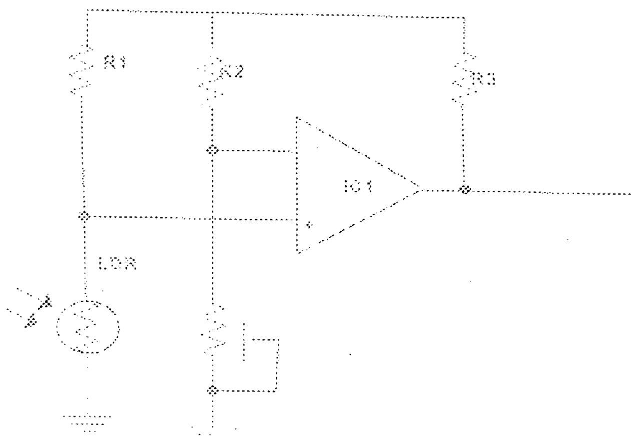


FIG 2.2: COMPARATOR CIRCUIT.

Vout = A_0 Vin

Where A_0 = open loop voltage gain.

And Vin = $V^+ - V^-$

Vout will drop to V+ for the slightest positive difference in voltage since A0 is often very large (in order of 20000).

As the light intensity drops, the voltage across LDR tends to increase to 4.48V with respect to the inverting input voltage (3.08V)

Since Vout = 1 when $V^+ > V^-$

2.5 FLIP-FLOP STAGE / OSCILLATOR STAGE

The logic control is built around a D- type flip-flop. It is the flip-flop that tells the system when to start and stop the lighting process. The operation of the system is described in the truth table below.

Mode	D input	Ck	Q	$\bar{Q}$
Set	1	↑	1	0
Reset	0	↑	0	1
Hold	X	X	0	1

X ...... Don't care

↑ ... Rising edge

Q and Q ...... Outputs

D ...... Data input

The logic control circuit operates in its set and reset mode. When the Astable multivibrator sends clock signal, the flip-flop shifts data from the data input to the Q output to switch the relay ; in order words if there is no input to the flip-flop , the Q output will be low. The diagram of the flip-flop stage is show in fig. 2.2 below.

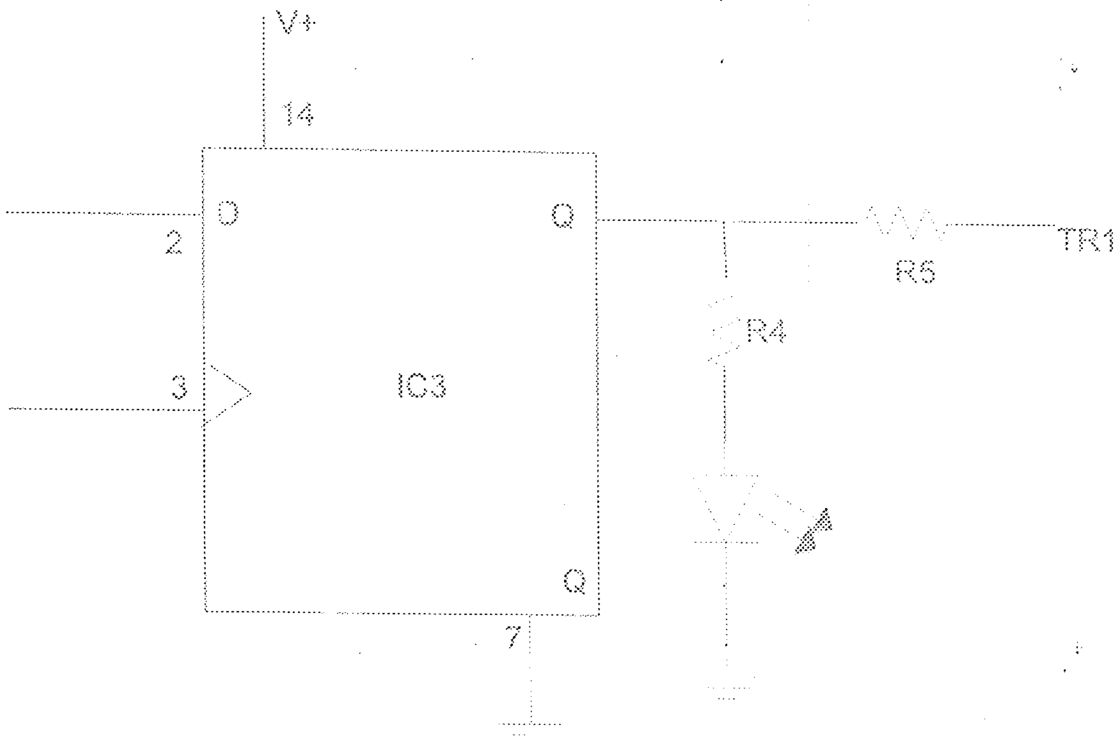


FIG 2.3 D- TYPE FLIP- FLOP.

The oscillator is an astable oscillator stage. a 1kHz freq was used for the astable oscillator stage. the 1 KHz was selected to enable fast transfer of data f rom D input to Q output.

Fig. 2.4 below shows the astable clock stage.

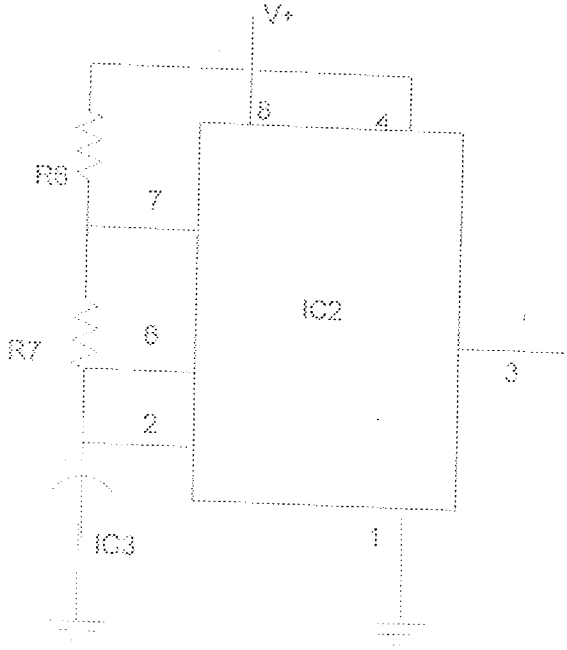


FIG 2.4: ASTABLE CLOCK STAGE

For the astable timer frequency,

$$F = \frac{1.44}{(R_A + 2R_B)C}$$

Letting C = 100nF for F = 1KHz, and setting R_A = 1K

$$R_B = \frac{(1.44/FC - R_A)}{2}$$

$$R_B = \frac{((1.44/1KHz \times 100nF) - 1K)}{2}$$

R_B =R7 = 6.7K (6.8k is the preferred value)

Ra = R6 = 1k

2.6 SWITCHING STAGE.

The –D-flip-flop switches a relay circuit which turns on the bulb when the D- flip-flop output is high , and off when the D-flip-flop output is low. Fig. 2.5 below, shows the switching circuit.

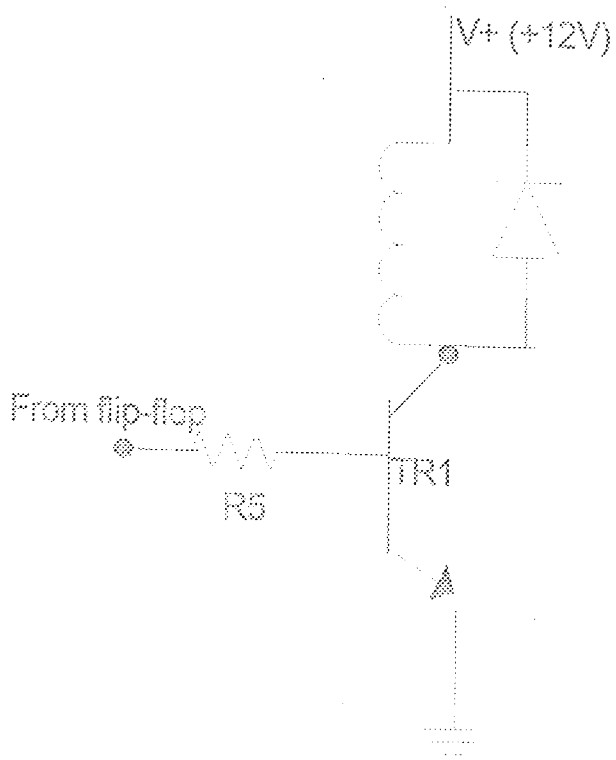


FIG 2.5: SWITCHING TRANSISTOR.

The switching transistor switches the relay which powers the bulb. The transistor as a switch operates in class A mode. The relay is switched on when the D Flip-flop gives a HIGH output. A base resistor is required to ensure perfect switching of the transistor in saturation. Diode D5 protects the transistor from back emf that might be generated since the relay coil presents an inductive load.

In this case Rc, which is the collector resistance, is the resistance of the relay coil, which is 400Ω for the relay type used in this project.

Hence, given that Rc = 400Ω (Relay coil resistance)

V^{+} = 12V (regulated voltage from the power supply)

Vbe = 0.6V (sillicon)

Vce = 0V (when transistor is switched)

Vin = 5V (from the D flip-flop)

Hfe = 300 (from data sheet for BC546)

since,

$$V_{+} = I_c R_c + V_{CE} \quad \text{------------(2.1)}$$

$$V_{in} = I_B R_B + V_{BE} \quad \text{------------(2.2)}$$

$$\frac{I_C}{I_B} = h_{fe} \quad \text{------------(2.3)}$$

$$R_B = \frac{V_{in} - V_{BE}}{I_B} \quad \text{------------(2.4)}$$

Where,

I_C = collector current

I_B = base current

V_{in} = input voltage

V_{+} = supply voltage

V_{CE} = collector-emitter voltage

H_{fe} = current gain.

m (2.1), 12 = IcRc + Vce

12 = Ic(400) + 0

nd,   Ic = 30mA

rom (2.3) , I_B = 30mA/300

= 100μA

From (2.2),   5 = 100μAR_B + 0.6

R_B = 4.5/100A

= 44K

R5 = 47K (Preferred value)

CHAPTER THREE

TESTING AND CONSRUCTION

3.1 TESTING

The physical realization of the project is very vital. This is where the fantasy of the whole idea meets reality. The designer will see his or her work not just on paper but also as a finished hardware.

After carrying out all the paper design and analysis, the project was implemented and tested to ensure its working ability, and was finally constructed to meet desired specifications. The process of testing and implementation involved the use of some equipment stated below.

(i) BENCH POWER SUPPLY: This was used to supply voltage to the various stages of the circuit during the breadboard test before the power supply in the circuit was built. Also during the soldering of the project the power supply was still used to test various stages before the d.c power supply used in the project was finally constructed.

(ii) CILLOSCOPE: The oscilloscope was used to observe the ripples in the power supply waveform and to ensure that all waveforms were correct and their frequencies were accurate. The waveform of the clock circuit feeding the D-flip-flop was also checked using the oscilloscope

3.1.1 DIGITAL MULTIMETER:

The digital multimeter basically measures voltage, resistance, continuity, current, frequency, temperature and transistor hfe. The process of implementation of the design on the board required the measurement of parameters like, voltage, continuity, resistance values of the components and in some cases frequency measurement. The digital multimeter was used to check the various voltage drops at the various stages, and also to check the switching of the output relay.

3.2 IMPLEMENTATION

The implementation of this project was done on the breadboard. The power supply was first derived from a bench power supply in the school electronics lab. (To confirm the workability of the circuits before the power supply stage was soldered).

Stage by stage testing was done according to the block representation on the breadboard, before soldering of circuit commenced on Vero board. The various circuits and stages were soldered in tandem to meet desired workability of the project.

For proper understanding of how the system operates and allow for troubleshooting, the pin configuration of the Ics and other active components used are shown below. Fig 4.1a shows the pin out of the NE555 which was used as clock for the synchronous operation of the flip-flop.

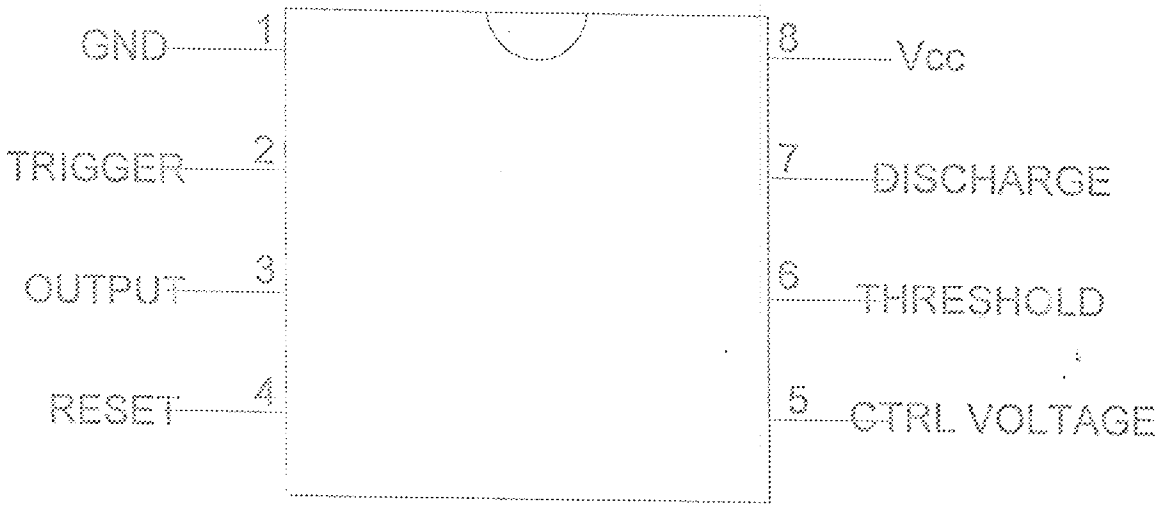


Fig. 3.1a: NE555 pin configuration.

The 7474 Dual D-type flip-flop was used in SET, RESET mode.

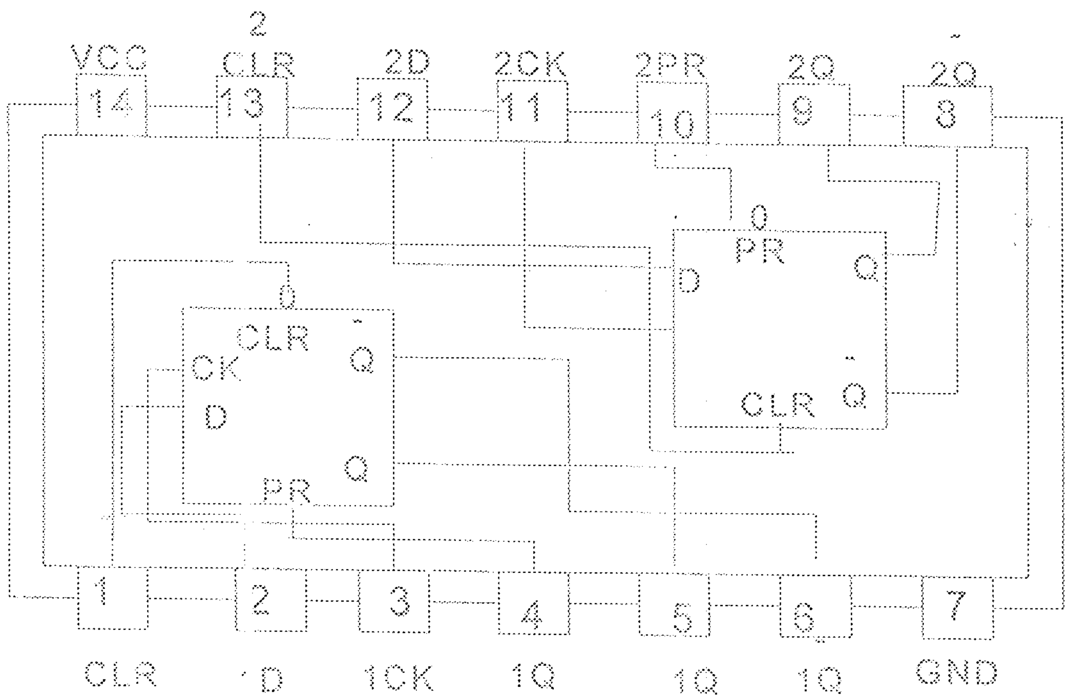
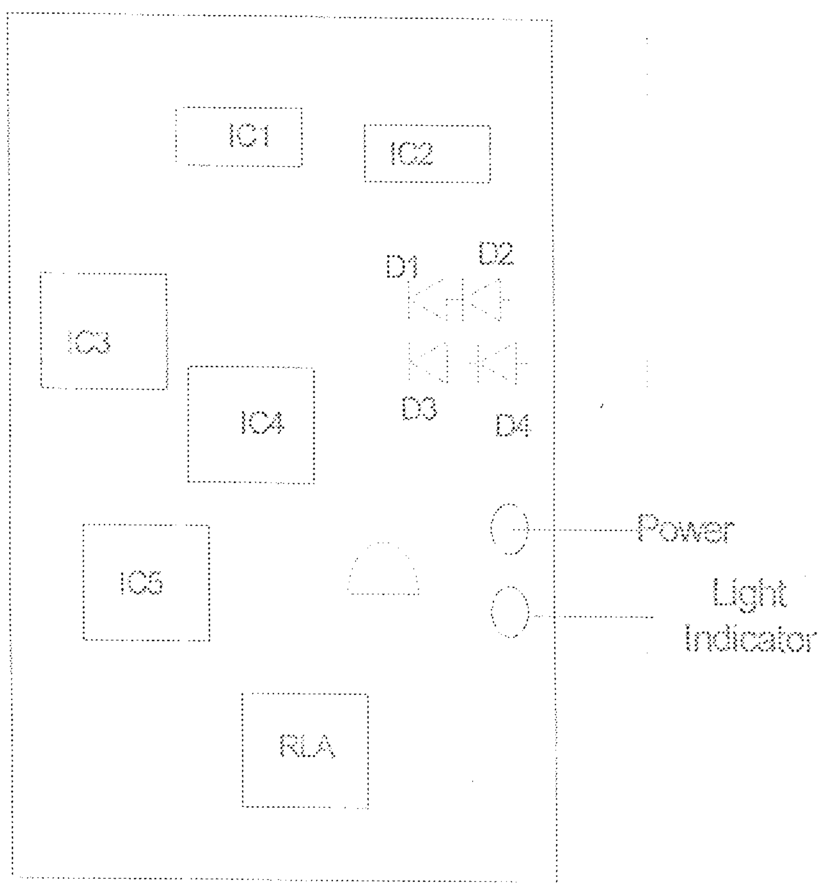


Fig 3.1b: 7474 Pin Out line.

3.3 CONSTRUCTION

The construction of the project was done in two different stages: the soldering of the circuits and the coupling of the entire project to the casing. The components arranged on the veroboard is as follows:

Fig. 3.2: Component Arrangement on Veroboard



3.4 PROBLEMS ENCOUNTERED

1. There was hysterics in the comparator stage at the transition from darkness to light and vice-versa but the noise immunity of the D-flip-flop solved the problem

2. There was feedback from the light (i.e. lamps) to the sensor, which made the circuit to start oscillating, although this is really not a problem since the positioning of the sensor would be such that feedback would not occur.

CHAPTER FOUR

CONCLUSION AND RECOMMENDATIONS

4.1 CONCLUSION

The project which is the design and construction of an AUTOMATIC STREET LIGHT CONTROL PANEL was designed considering some factors such as economy, availability of components and research materials, efficiency, compatibility and portability and also durability. The performance of the project after test met design specifications. The general operation of the project and performance is dependent on the user who is prone to human error such as wrongly positioning the sensor or poor calibration of the sensor.

Also the project is dependent on how well the soldering is done, and the positioning of the components on the Vero-board. The ICs and the logic components were not soldered near the power supply to prevent overheating which might occur and affect the performance of the entire system.

The construction was done in such a way that it makes maintenance and repairs an easy task and affordable for the user should there be any system breakdown.

The project has really exposed me to digital electronics and practical electronics generally which is one of the major challenges I shall meet in my field now and in future. The design of the AUTOMATIC STREET LIGHT CONTROL PANEL involved research in both digital and analog electronics. Intensive work was done on op-amps, comparator and also interface circuits using relays and contactors and other electronic circuitsThe project was quite challenging, and tedious but eventually was a success.

4.2 RECOMMENDATIONS.

1) The department should acquire more research-oriented books in the departmental library, to make enough materials available for students to use.

2) A software version of this project be designed to enable interfacing with the PC and to increase the variables of the coding system and decrease the chances of breaking the code

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APPENDIX

COMPONENTS LIST

R1, R2		1K
R3	-	2.2K
R4	-	1K
R5	-	4.7K
R6	-	470Ω
R7, R8		10K
IC1	-	LM393
IC2	-	7474
IC3	-	NE555
IC4	-	7805
D1-D5		IN4007
C1	-	1uF
TR1	-	BC546
IC2	-	NE555
IC3	-	7474
IC4	-	7805
TR1	-	BC546