DESIGN AND CONSTRUCTION OF A SOUND OPERATED LIGHT SWITCH

BY

ODOFIN OMOLARA SARAH

(2003/15421EE)

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING FEDERAL UNIVERSITY OF TECHNOLOGY MINNA, NIGER-STATE.

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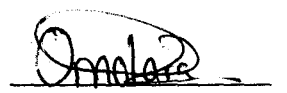
DEDICATION

This project is dedicated to the king eternal, immortal, invisible; the wise God be Hon our, Glory and praise forevermore. Father I appreciate you for your abundant grace and faithfulness throughout my stay in school, the Alpha and Omega of my Life.

I also dedicate this to my wonderful Mother Mrs. M.T Odofin for her love and total support.

DECLARATION

I hereby declare that this thesis was wholly and solely written by Odofin Omolara Sarah, under the supervision of Mr. David Michael Department of Electrical and computer Engineering, Federal University of Technology Minna.



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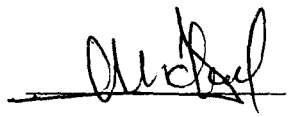
(Name of student) **Date**

Odofin O. Sarah



14/11/2008

(Name of supervisor) **Date**

Mr. David Michael

Head of Department **Date**

(H.O.D)

Prof. Y.A. Adediran

External supervisor **Date**

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The work will not be complete without mentioning and appreciating the tremendous support and encouragement from friends and colleagues;

ABSTRACT

Security is a prime concern in our day to day life. Everyone wants to be as much secure as possible; an access control for doors forms a vital link in a security chain This project is aimed at the design and construction of a security system, it involves detecting an unauthorized access of an intruder by alerting the security personnel this switch which has added to the existing strategies used in combating crime. The load i.e. the Alarm used to alert the presence of an intruder in a restricted Area and the bulb's intensity can be varied through a 10k variable resistor with the help of. After testing the device, it was discovered that the Microphone responds according to the adjustment of the sensitivity control but the Microphone is most efficient when a loud verbal command is applied. Finally, the circuit was tested and proved working.

LIST OF FIGURES

CHAPTER ONE

1.0 INTRODUCTION

In our world today, we have to use the available resources effectively for the benefit of mankind. The rate of unawareness in our society has led to unnecessary waste of time and energy in achieving little functions that ordinarily we can assign to electronic devices. So people always try to find ways to optimize human ability and not waste a bit of it if unnecessary.

Theft and criminal damage is a threat and cost to home and business. Hence there is need to protect our homes, offices and business environment. Improvement in technology by man has shown the knowledge and experience can be harmonized and refined to assist man to observe, perceive, communicate, remember, calculate reason and protect himself. Alarms as the name implies, are devices that signals and can be used to alert any situation that's a threat. There are several kinds of alarms [1] fire alarms, burglar alarms, heat and smoke detector etc.

A Sound operated light switch are increasingly being used in private homes, warehouses, stores, Strong room in Banks etc. As a matter of fact, they are fast becoming standard Security lighting equipments especially in stores; warehouses etc.These systems range from simple "do it yourself kits" which are very cheap to sophisticated a sound operated light switch that are designed by professionals. But as it turns out to be most security light switching device are actually built around the same basic design concepts.

1.1 BACKGROUND OF THE STUDY

No modern building is complete without an efficient and a consistent security system as a result of the increasing rate of which crimes particularly burgling dominates our societies today and how to protect our privates. Regard, discovered sound activated switch has added to the existing strategies used in curtailing the menace.

1.2 STATEMENT OF THE PROBLEM / EXPECTED CONSTRAINT

The total absence or lack of sufficient security systems in homes has caused a great deal of discomfort to house owners, that is landlord and tenants business sectors, store-houses, safe, restricted areas etc [2]

The 555 timer that would be operated in a monostable mode in order to trigger the delay to switch on the Alarm and light at the same time this limit the sensitivity range of sound operated light switch.

1.3 PURPOSE OF STUDY

In order to provide protection to homes and other sectors, it is necessary to provide a means of protective device or security systems in order to guarantee confidence.

In an effort to enhance the optimality of security systems, this project has added to the list of the available security systems, which among others are:-

- An anti burglary, which triggers "ON" when a beam of light is broken. This has draw back because the beam can be detect and bypassed.

- A dark room alarm, which is sensitive to light in the dark room. Alarm triggers as a result of any beam and inconvenience.
- An anti-theft car alarm, which triggers 'ON' when a thief simply touches the car. This also has the draw backs of being demobilized by the thieves before touching. [2]

With the much discussed drawbacks lead to the advent of the light, it also has the capacity of triggering video camera, tape recorder at a proper time and an electric motor.

In more recent findings, it has been discovered that this circuit/project finds it's most spectacular applications in banking industries, safe rooms, store and any restricted/prohibited Area.

1.4 OBJECTIVE OF PROJECT.

The objective of this project is to design and construct a sound operated light switch that is compact and does not require too many complex circuits because the reliability of a circuit design decreases with increase in the components used as indoor light controlled switch at homes, stores and as light controlled switch at homes, stores, offices. This purpose of the project is also serves as a security device in a security room where treasured materials, aside money are kept and the circuit is strictly mend for a security purpose to safeguard intruder from trespasses a prohibited Environment. If this circuit senses sound, it activates a relay switches on an alarm light circuit in order to alert the presence of an intruder in a Restricted/prohibited room or environment. Also, in a strong room it will call the attention of security men.

substations), nuclear plants, oil pipelines etc.

- Military, for detection and tracking of ships, submarine detection, to monitor enemy advancement, to detect missiles etc.

2.1 THEORY OF SOUND

The project is a light based on sound. When the sound exceeds certain intensity, the light and the alarm is triggered. Now let us look at some work on sound theory.

2.2 TYPES OF SOUND ACTIVATED/OPERATED SWITCH

As being practiced in the early times, human beings were being used as the only major form of security. But with the increase in the thinking ability of man and the advance in technology, it was found necessary to device a means so as to supplement the effort of man. The realization of such fact led to the introduction of solid state or semiconductor device on which the security systems depend. [1]

Different types of these circuits exists, though the all perform almost the same function but still carry some variations in the sense that some are expensive to achieve, no availability of components and many more draw backs.

Below are some different types of circuits;

(a) VOICES ACTIVATED SWITCH

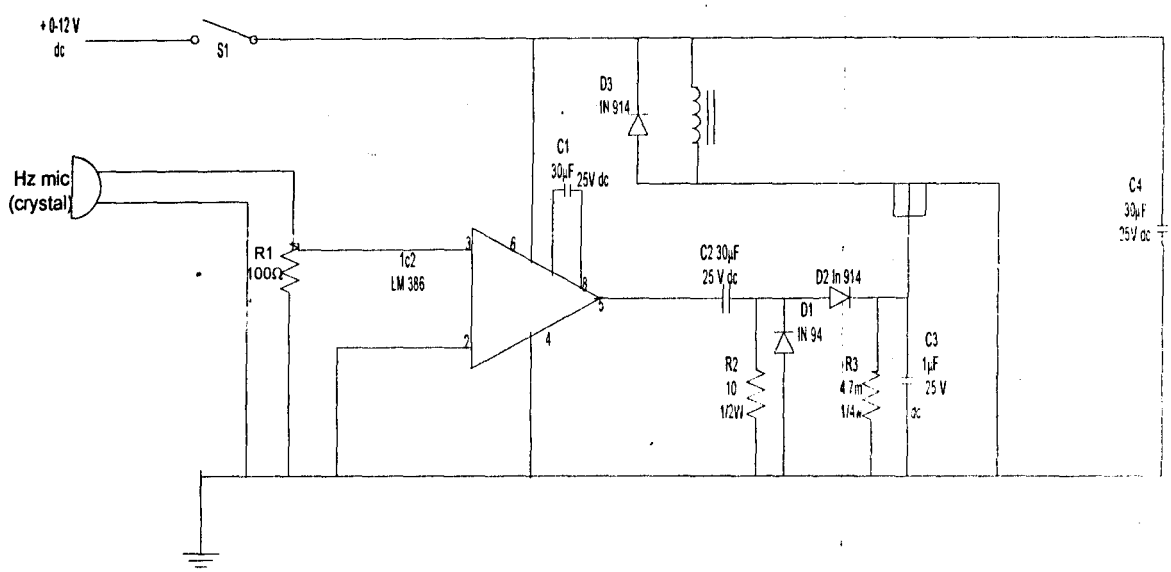


Fig.2.1 Voice Activated Switch.

A voice input is amplified and turn on Q_1, a power FET with high power impedance and considerable current drive.

When Q1 is on, it energizes RY1 (relay, 500Ω coil, 6 – 9 v.d.c, 10 – 12 mA). A bulb can be wired in series with the motor; the motor supply should be isolated from the control power supply. Such circuit is most suitable in controlling large loads. It suffers the problem of expensive and scarce components.

(B) SOUND ACTIVATED SWITCH

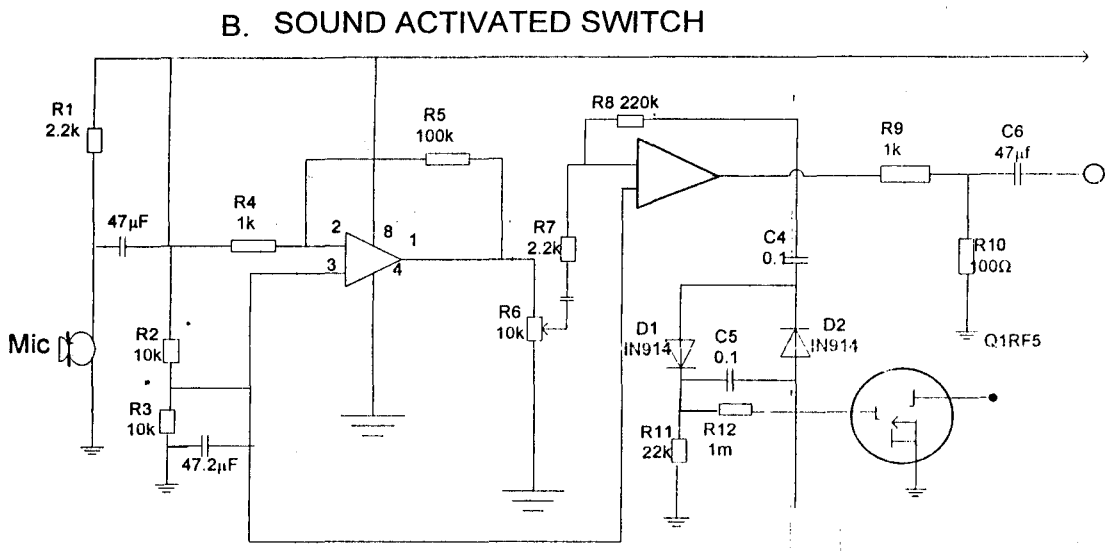


Fig.2.2 Sound Activated Switch

U_1 and U_2 = 1F353 dual.

A sensitive microphone picks up the sound and feeds the signal to a two-stage amplifier, circuit, consisting of U_1 and U_2.

The amplified output of V_1 is fed to voltage doubter circuit, which comprises diodes, D_1, D_2 and capacitors (4) (5). The output of the doubter is input to the gate of Q_1.

This circuit can be used to drive a cassette/tape recorder, light etc. It is efficient and less-expenses but some components are scarce.

(c) SOUND ACTIVATED SWITCH

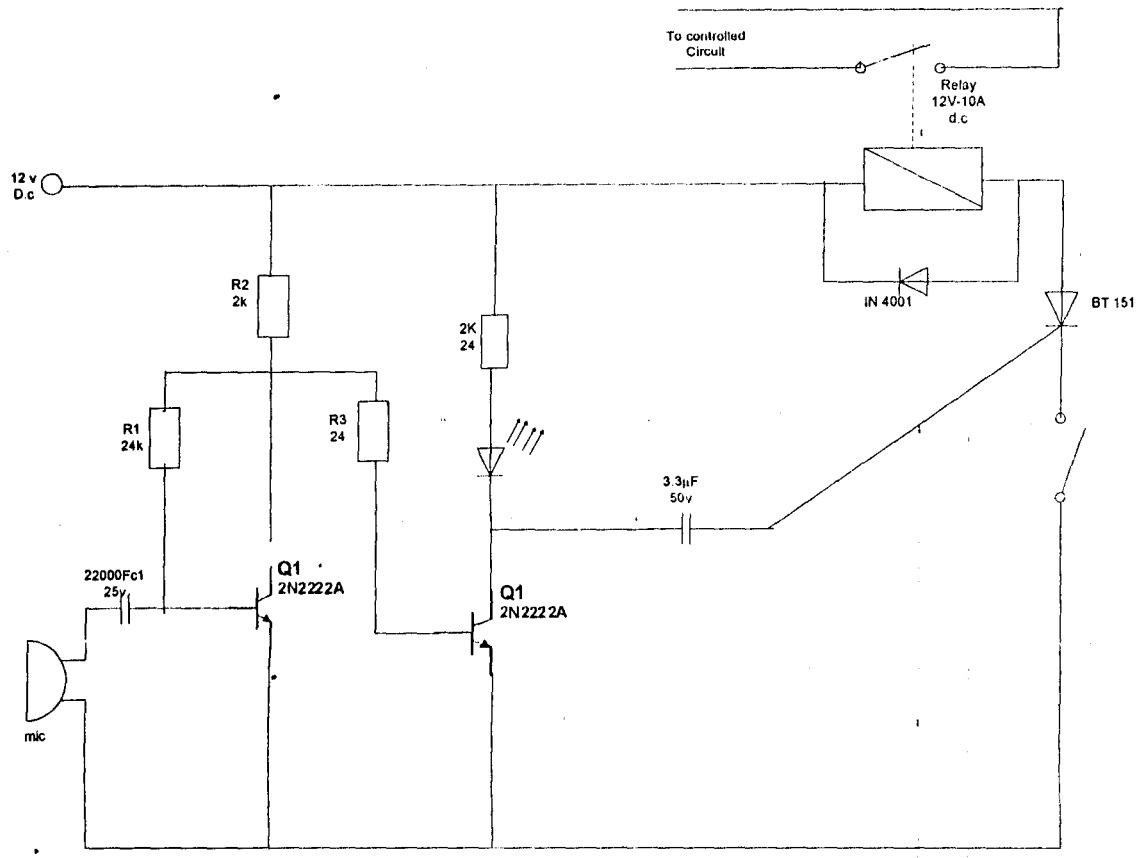


Fig.2.3 Sound Activated Switch

The security light of the system goes on when there is an external noise at the vicinity of the quiet room.[1]

The sound waves are picked up by the ceramic microphone which is converted into electrical signals. The signal voltage generated is applied to the base of the transistor Q_1 (BC 108). This transistor amplifies the signal which with the use of coupling capacitor C3 follows the second stage through Q_2.[?]

This is done, so as to achieve a high gain at the output capable of exciting the gate of the

thyristor TR1. When the thyristor is excited, current will flow and hence energies the relay which switches the light on. The relay will definitely remain on until the system is reset. The circuit can easily be reset by controlling the power supply (off-on). [13]

CHAPTER THREE

3.1 DESIGN ANALYSIS AND CALCULATION

The modular approach was used for this design. Here, the overall design was broken down into functional block diagrams. Each block diagram represents a section of the circuit that carries a specific function.

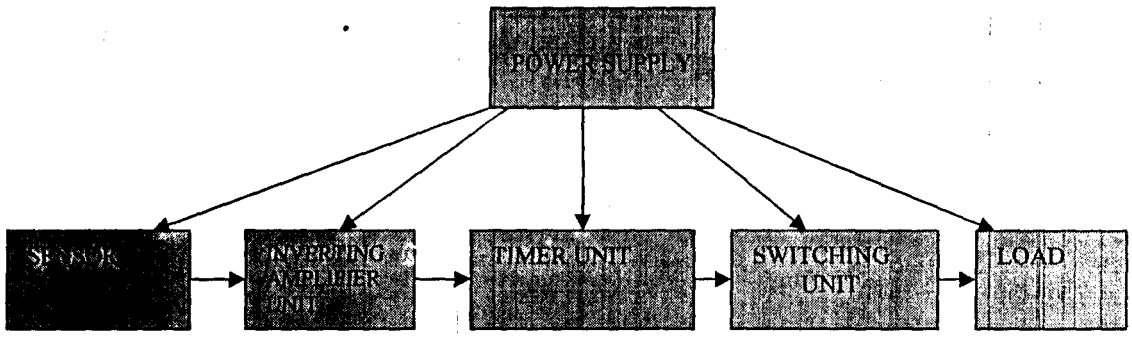


Fig. 3.1 Overall block diagram

The various modules for this project work will be explained using the overall circuit diagram of the project design, which involves the following modules.

- Power Supply Unit
- Sensor Unit
- Amplification Unit
- Timing Unit
- Switching Unit
- Load

3.1.1 POWER SUPPLY UNIT

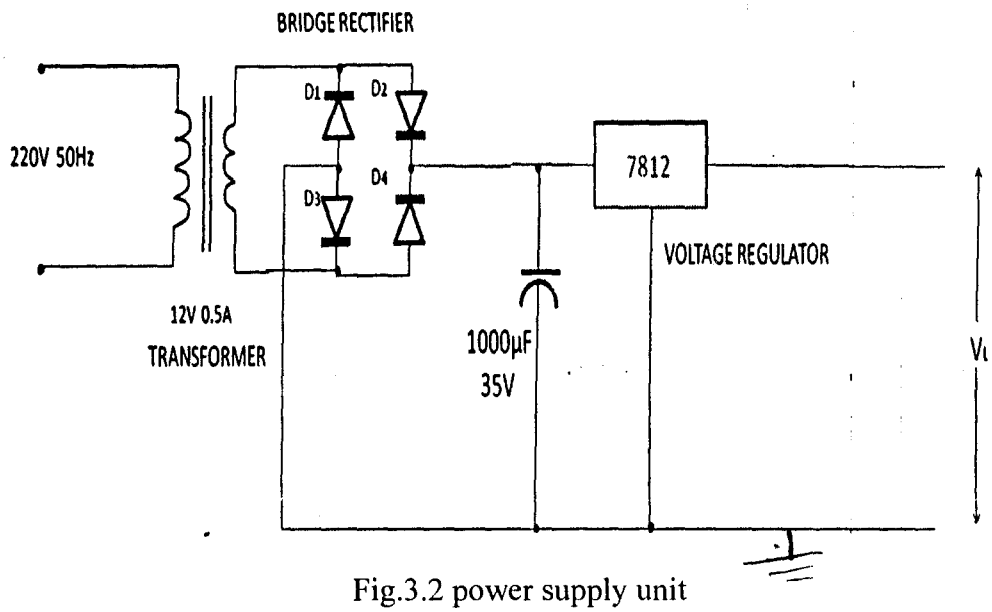


Fig.3.2 power supply unit

This project is designed to be powered from a wall outlet. The ac supply available at the ordinary wall outlet is 220V, 50 Hertz (Hz) (line to neutral).

The voltage from the a.c mains supply is stepped down to 12V using a step down transformer and converted to d.c using the bridge system rectification. The bridge rectifier's system output still has a lot of ripples and has to be smoothed out in order to generate genuine d.c. Capacitors resist changes of voltages across them; hence they are used to provide the desired smoothing action [9]. The ripple voltage is calculated thus;

- The load resistance, R_L, is given as;

$$R_L = \frac{V_{out}}{I_{out}} \quad [9]$$

Where V_{out} = output voltage = 12V

I_{out} = current output =0.5A

$$R_L = \frac{12V}{0.5A} = 24\Omega$$

The transformer's voltage input is $220V_{rms}$ which was stepped down to 12V and this means that the 220V was reduced by

$$\frac{220V}{12V} = 18.3times$$

The maximum voltage, E_m, is given as;

$E_m = 12_{rms} \times \sqrt{2} = 12_{rms} \times 1.4142 = 16.9V$

$E_m \approx 17\ V_{pk}$

The smoothing is performed by a large value electrolytic capacitor. The capacitor used is 1000μF. To determine the ripple voltage in the power unit. [10]

Where F = frequency of a.c supply = 50 H, C = capacitance = 1000μF

But the full wave rectifier consist of a waveform with doubled original a.c supply frequency

Therefore, the ripple voltage is 0.2V

Hence the d.c voltage after the smoothing action by the capacitor

The power supply unit consists of a 220/12V Transformer.

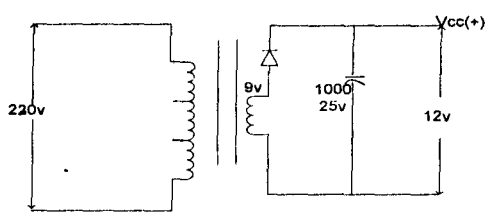


Fig. 3.3 power supply unit

3.1.2 **SENSOR UNIT**

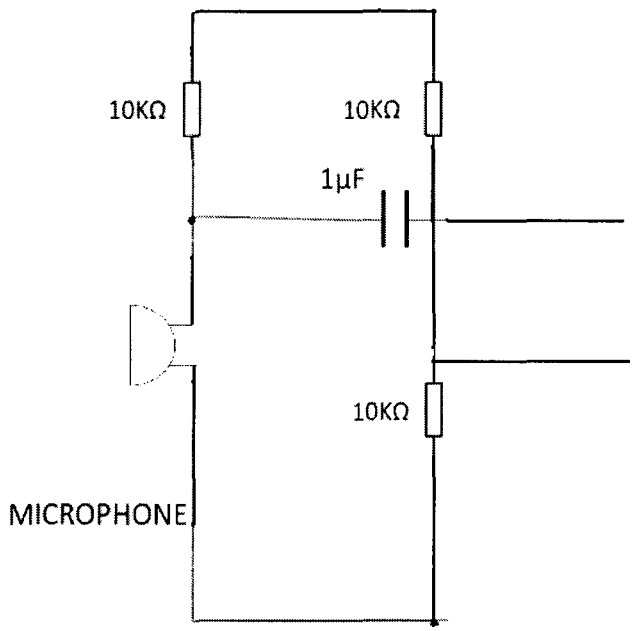


Fig.3.4 Sensor unit

This is purely made up of an electrets microphone .The reason for this choice is because of its high sensitivity. This transducer is capacitive in nature where charges are on the plate, however any sound pressure tends to disturb the charges thereby producing an output signal. Usually in mV.

To Calculate current flowing through this unit

$$I_C = \frac{V_{IN}}{R_1} = \frac{12}{10} \approx 1.2A$$

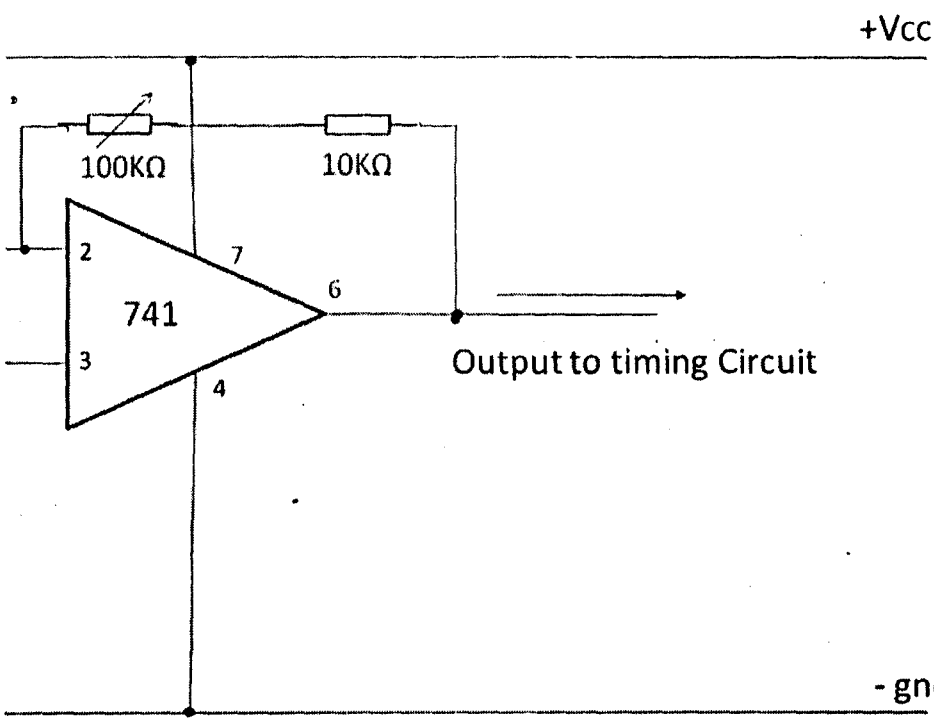


Fig.3.5 Amplification stage

The first operational amplifier is a negative feedback operational amplifier (inverting op-amp). The voltage gain is given as;

3.1.4 Design Calculations

From Fig. 3.5, R_1 and R_2 form a potential divider, to reduce the unregulated voltage to a low voltage of less than V. At 220V ac input let VR2 = 1.5V

Where V^+=Vcc

Where VR2 is a assumed value of the variable resistor i.e. the adjusted value of variable resistor.

But, $VR_1 = \frac{R_1 V^+}{R_1 + R_2}$ ----------1

Where VR_2 is the drop across R_2 and V^+ is the unregulated voltage. it can be seen that $V^+ = 12V$ at 220VAC input.

Let $R_1 = 10k\Omega$

$R_2 = 10\ k$

$= 10k$ Preferred value

$R_1 = 10k\Omega, R_2 = 10k\Omega$

R_3 and R_4 form another potential divider for the reference. Letting a maximum adjustable reference of 6V and setting $R_3 = 10k\Omega$

$$VR_4 = \frac{R_2 V^+}{R_1 + 10k} \quad \ldots\ldots\ldots\ldots 2$$

$$VR_4 = \frac{10 \times 12}{10 + 10}$$

$R_4 = 6V$

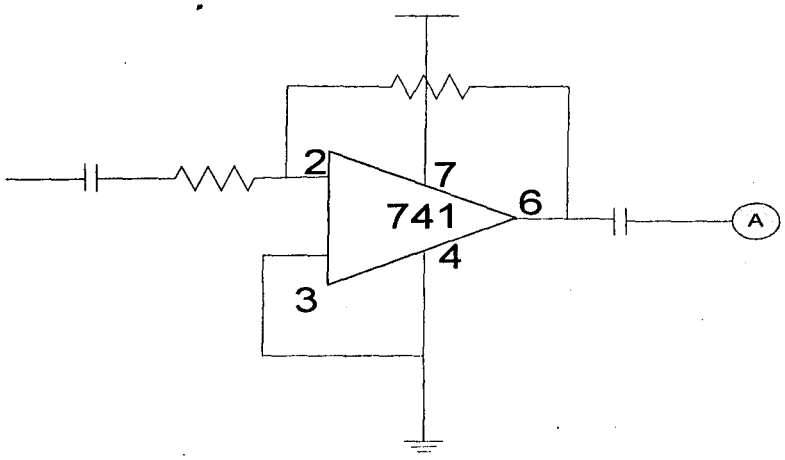
$=$ 6V preset (preferred value)

$R_3 = 1.5V$ and $R_4 = 6V$ preset.

For the comparator,

$V_{OUT} = A_0 V_{in}$ 3

$$A_o = \frac{V_{out}}{V_{in}} = \frac{6}{12} = 0.5$$



The amplifiers help in signal amplification, thereby increasing the voltage gain.

The coupling capacitor 741 operational amplifier (Inverting Amplifier) was

Used for this stage.

The 741 op-Amplifier is the basis of all operational amplifiers. It has 8 pins.

For this purpose, it is used in the inverting mode, since the inverted signal will be use for triggering inverting mode, the next stage which could be used latter. The stage receives weak signal from the transducer through a coupling capacitor. The coupling capacitor helps in passing only A.C signals and blocking D.C. The signal is amplified by the gain factor which is determined by the resistors. Shown in the diagram that it can be represented mathematically as;

$A = {}^{R_2}\!/_{R_1}$ Where A= gain factor

Therefore, $V_{out} = V_{in} \times A$

$= V_{in} \times R_2 / R_1$

3.1.5 IC 741 (COMPARATOR)

Most op-amp is of different input type. The device is operated via a dual power supply with a common ground, thus enabling the op-amp output to swing either positive or negative with respect to ground.

The 741 op-amp is a greatly improved third generation version of the 709 op-amp. It is immune to input latch up, has a short circuit proof output, and has a build in frequency compensation and it is prone to instability when used in linear mode.

3.16 CHOICE OF OP-AMP (741)

The 8-PIN 741 op-amp is used in the design of this project and its choice was based on the information obtained in the data book. Listed are the parameter within which the 741 can operate.

external RC network is connected between the supply voltage and ground. The junction of the resistor and capacitor connected to the threshold input. An input trigger pulse is applied to the trigger input, which is the input to the lower comparator.

The multivibrator i.e. the Ic 555 is wired in a monostable mode and it's reset Pin 4 at high level when there is no light. Transistor T_1 conducts to trigger 555 timer.

Whenever a trigger pulse is applied to the input, the 555 will generate its single duration output pulse. Depending on the values of external resistance and capacitance used, the output timing pulse may be adjusted from approximately 1 millisecond to as high as one hundred seconds. IC timers are normally used where long output pulses are required. In this application, the duration of the output pulse in seconds is approximately equal to:

$$T = 1.1RC \text{ (second)}$$

The output pulse width is define by the above formula and with relatively few restriction, timing components R(t) and c(t) can have a wide range of values.

In the design R = 100k, c = 10μf

$T = 1.1 \times 10 \times 10^{-6} \times 100 \times 10^{3} = 1.1$ seconds

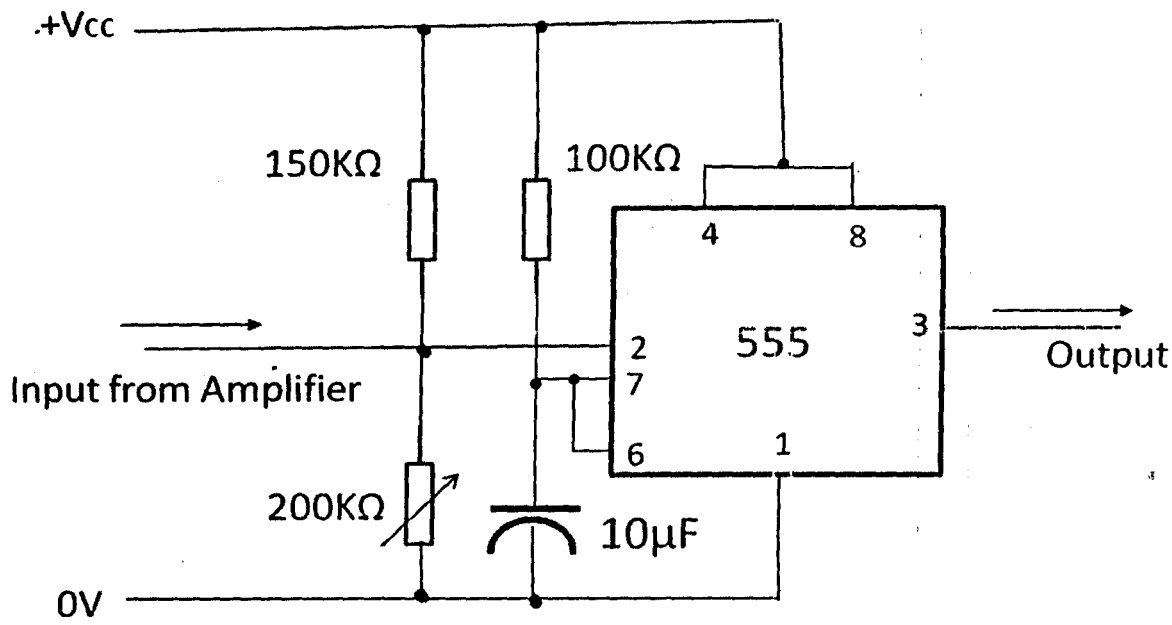


Fig.3.8 Timing unit

3.1.8 SWITCHING UNIT

The switching unit comprises a relay driver which triggers the load. A Relay is an electromagnetic device or switch with a movable armature mounted above the core is powered or energized, the armature is altered and the contact point change position, this relay is in a normally open stage when current passed through it, it then closed in order to allow passage of current which triggers the load. When the relay is closed, the circuit in now closed and the timing module becomes active. R_1 and R_2 form the voltage divider. Current flows from emitter to the base of the transistor. As current flows, C_1 starts to charge. When fully charged, they become positive the current in the relay switch on the load

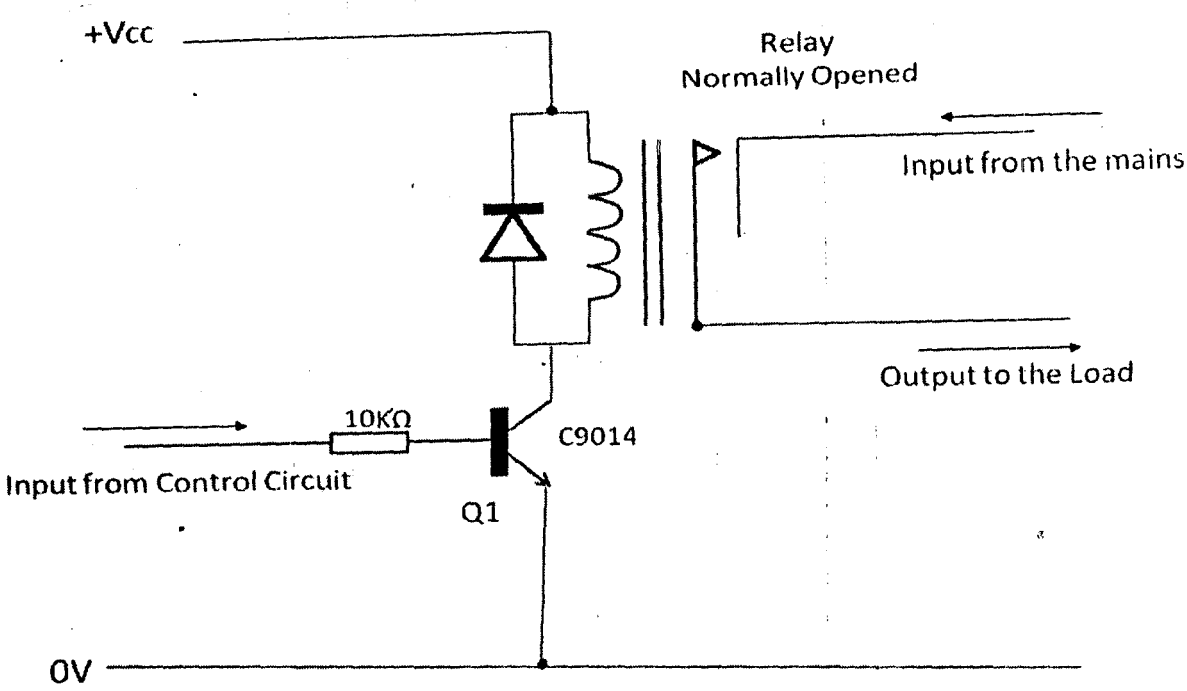


Fig.3.9 Switching unit

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 stage)

VBE = 0.7V (silicon)

VCE = V (when transistor is switched)

Vin = 12V (from switching stage)

$h_{fe} = 300$ (from data sheet for BC108) since,

$V^{+} = IC\,RC + VC$.....x

$$Ic = \frac{V^{+} - Vc}{Rc} = \frac{12-6}{400}$$

Ic= 0.015A

$Vin = IB\,RB + VBE$.....xx

$$I_B = \frac{V_{in-V_{BE}}}{R_B}$$

$$I_B = \frac{12-0.7}{10} = 1.13A$$

$V\,R_4 = \underline{Vin --- VBE}$ xxx

IB

$$VR_4 = \frac{12-0.7}{1.13} = 10k$$

$$I_c = \frac{V^{+} - V_c}{R_C}$$

Where $V_c = \frac{1}{2} V_{CC}$

$$I_C = \frac{12 - 6}{400} = 0.015A$$

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.*

From Equation I_C = 15mA

From Equation $I_{B} = 113uA$

From Equation $R_{B.}$ = 10k

= 10KΩ (preferred value)

3.19 LOAD

A 220v, 60W lamp filament bulb was used for the purpose of this project and the Alarm which aid the Relay and comes on together with the bulb.

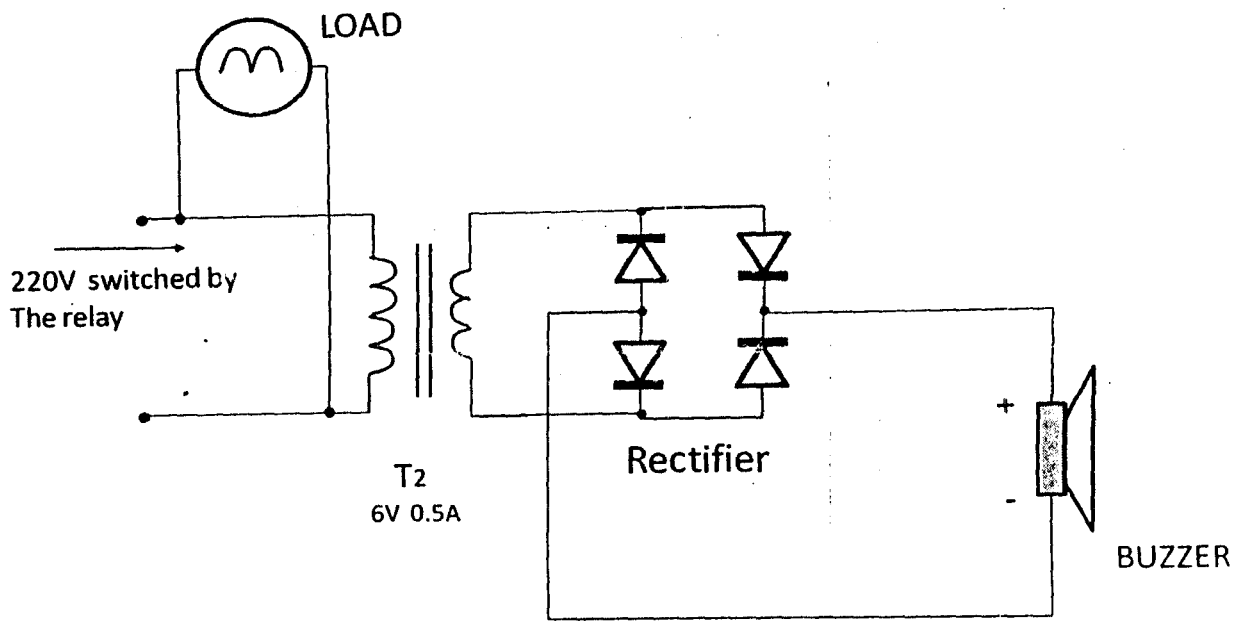


Fig.3.10 Load

3.20 Choice of Components

The choice of components in many engineering designs is considered as one of the major factors in carrying out an engineering design. The circuit is attributed to low power, simple and economical design.

In designing the power unit, three items are taken into consideration: transformer, rectifier and filter [9]. The choice of the transformer used is a step down transformer, so as to step down the input voltage from the main power source. Next is the choice of rectification; there are three types of rectifier systems available for use in power supplies: half-wave, full wave and bridge [12]. The bridge rectifier system was chosen for a.c to d.c conversion for the following reasons:

I. The four diode rectifier provides a greater d.c output voltage than the centre

tapped full wave rectifier circuit [13].

II. The four diode rectifier provides a greater d.c output voltage than the centre tapped full wave rectifier circuit [13].

III. The need for centre tapped transformer is eliminated

IV. The full wave bridge rectifier utilizes both half-cycles of the input a.c voltage to produce the d.c output.

The major components of the design are as follows:

- Electret's Microphone
- LM 741 (operational amplifier)
- passive components
- Relay driver
- 555 timer

Other Passive Components

Passive components are components which cannot amplify power and require an external source to operate. They include resistors, capacitors, inductors etc. Their application ranges from current control (resistors), filtering of ripples voltages and blocking unwanted d.c voltages (as in capacitors). They form the elements of the circuit stages and are generally used for signal conditioning in circuits.

CHAPTER FOUR

4.0 CONSTRUCTION AND TESTING

This chapter is based on testing, performance evaluation and assembling of components on Vero board in relation to the design circuit. Each individual component was tested and each of the 6 subunits was built on bread board and monitored before finally transferring to the Vero board. The result of the performance evaluation of the 6 subunits was observed and the wave shape was monitored on the oscilloscope.

4.1 CIRCUIT CONSTRUCTION

The circuit's construction involves making the circuit diagram on paper a reality. The system was first built on bread board. This was done in order to ascertain its workability and to logically arrange the entire circuit according to the design specification.

After this was successfully carried out, the construction was transferred on the Vero board. The IC was fixed on IC socket so as to ensure easy replacement. The individual components were held firm on the Vero board with the aid of soldering.

The sub-unit constructed include:- the power supply unit, the sensor unit, the Amplification stage, Timing unit Switching unit and finally the load stage which is the output.

4.1.1 TESTING

Various test were carried out before, during and after the construction has been completed. The multi-meter was extensively used. It was ensured that each of the subunit was tested and confirmed efficient.

4.1.2 CONTINUITY TEST

The multimeter was used to check open circuit in the circuit, as part of this test short circuit test was also conducted. Partial contact was throughout checked.

4.1.3 COMPONENT STATUS TEST

The theoretical specification of components and their appropriate characteristics was tested and was observed to be efficient.

4.1.4 CASING

The whole system is cased in a metallic case, which was designed before the construction was carried out. It has a dimension of 25 x 35cm and a height of 7cm. The case also provides a space of ventilation.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATION

5.1 SUMMARY

The sound operated light switch is a switch, which is activated by sound. For the design, electrets microphone is used to pick up audio signals; this is converted into electric signals and amplified by IC741 used as a comparator. The construction of this project is designed to detect the presence of a person in a restricted area, and the light comes on to signify that there is an intrusion inside a building. The relay is to the trigger the load – i.e. the bulb and the alarm.

5.2 CONCLUSION

Having designed this project, constructed, tested and packaged it. It can be seen that the aim of this project is achieved.

At this time of insecure society this project is recommended as a measure for security in homes, offices, Banks, Jewelry Stores that needs to know when there is an intruder to unauthorized places.

The project was designed considering some factors such as economic application, design economy, availability of components and research materials, portability and durability. The performance of the project after test met design specifications.

5.3 RECOMMENDATION

I hereby recommend that upcoming student should improve on this project design. Provision for backup power (battery) can be included to solve the perennial problem of power outage from the mains.

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OVERALL CIRCUIT DIAGRAM