DESIGN AND CONSTRUCTION OF INFRARED

REMOTE CONTROLLED SWITCHING UNIT

BY

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

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DEDICATION

I dedicate this work to my parents without whose support it would not have been possible to come this far. May Allah grant them eternal joy and happiness amen.

DECLARATION

I hereby certify that this project, titled "Design and construction of an infrared remote controlled switching unit" was solely carried out by MUSA ABDULRAHMAN, under the supervision of Mr. A. S Mohammed, and submitted to the department of electrical and computer engineering, Federal University of Technology, Minna.

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(Signature and date)

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I also express my thanks to all the staff and students of the department of electrical and computer engineering, FUT Minna, some of whom are; my HOD, Engr. Musa D. Abdullahi, Mallam M.S Ahmed, my level adviser, and all other lecturers of the department.

I would also acknowledge the contribution of my supervisor, Mr. A. S Mohammed for his critical and constructive criticisms and contributions during this work, for taking the pains to read through over and over, and for making valuable corrections in making this work possible. Thank you once again.

Finally, I wish to put to record the support of all my friends, brothers, sisters, cousins, well wishers and my fellow course mate, Aboh Vincent, Kabiru, Musa Momoh, Ubong Daniel, Ahmed Abdullahi, and so many others that the whole of this page cannot contain if I want to mention, for their spiritual and moral support and assistance during the course of my stay and especially during this thesis. I thank you all. And what could have been accomplished without the will of the Omnipotent Allah? Thus my profound gratitude in no measurable terms to Him for making this work possible.

ABSTRACT

This project work, based on the design and construction of an infrared remote controlled switch, of which any remote control will trigger it provided it is pressed and held for the required time delay of approximately one second. The prototype can be used to switch on or off any electrical/ electronic equipment such as TV sets, DVD/ CD players, electric fan. The project has three sub circuits, the power supply, the switching circuit and the external circuit. Ideally, the external circuit could be any of the above mentioned loads. But as a model here, a switching lamp was chosen as the load circuit.

All remote controls generate infrared pulses of the range of 850-950nm, which is detected by an infrared module in the receiver circuit. The infrared module generate a modulated signal buffered by a pre-amplifier stage and fed into the trigger of a 555 timer connected in a mono-stable stage. The 555 timer generates a one shot pulse that clocks a D- type flip-flop, and gives a high on normally closed (NC), and the external circuit is then powered on via the relay contacts. If the relay is again pressed for the same time delay, the 555 timer gives another one shot pulse which resets the flip-flop and thus put the relay on normally open state which cuts off the power supply to the external circuit. .The whole system functions as a single channel in that it can only control one external load at a time[12]

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CHAPTER ONE

1.0 Introduction

1.1 Introduction

Infrared remote controlled appliances are so common these days that they are found in virtually every home, and are used in switching and controlling mostly electronic gadgets like TV, video sets, CD players etc, all at the user's convenience[13].

As a result of the convenience and comfort derived from having a control of most of the electronic house appliances by mere pressing of a button from a distance, it becomes a matter of interest to expand this convenience to electrical and non electrical devices, such as lighting of bedroom light, opening and closing of entrance gates, doors and windows, using infrared remote control.

This project features a single channel (on/off) switch that may be used with any infrared remote control that operates within the wavelength of 850-950mm. It can be used to turn on or off any circuit that is connected to it via a relay. Examples are night lamps, electric doors, electric gates or air conditioner that may be attached to it.

For this switch, any button of any remote control may be used to operate it. The button must be pressed and held for a seconds delay before the relay will operate. Once operated, the circuit will remain in this state (latched) until reset. To reset therefore, any button is pressed and held for the amount of time delay. For example, if a users TV set is tuned to channel 2, mere pressing and holding the TV remote control's channel 2 button for a second, that way the TV viewing will not be affected and the relay will be activated.

The relay can be connected to anything, provided the relay contacts can handle the rated voltage and current of the load [1].

1.2 Objectives:

The main objective of carrying out the design and construction of the infrared remote control switch is to develop a circuit that can be used to switch on or off any electrical appliance (connected via a relay) by means of any remote control that operates between the wavelengths of 850-950nm. This will bring so much convenience and ease in the household by saving the time and energy of users, especially the physically challenged.

1.3 Methodology:

To achieve the stated objective, the following steps were carried out;

1. Consultation was made to relevant texts, journals, magazines, internet and individuals to have a good understanding of the theories behind the principles to be employed.

2. Identification of the components that will make up the units of the entire project.

3. The data and specifications of the required components were obtained from data sheet (book) and data websites.

4. Circuit design analysis based on operational requirements was carried out.

5. Finally, the designed circuit is built, packaged and tested.

1.4 Scope of work:

The scope of this project (thesis) is as follows;

1. Building an infrared receiver that can be operated using any button of any remote control.

2. Incorporating the switch circuit to the load circuit it is desired to control.

1.5 Limitations:

Limitations in carrying out any project thesis are something that cannot be avoided. The limitation to this project is;

1. Since the circuit can be triggered by any remote control provided it reaches the delay time, it is bound to activation even if it is not desired to be activated by picking undesired signal from any infrared transmitter. As such, it should be placed at a location such that the remote control will see it only when it is desired to be operated.

CHAPTER TWO

2.0 Literature review/theoretical background

2.1 Literature review:

One of the earliest examples of remote control was developed in 1893 Nikola Tesla, and described in his patent, U.S patent 613,809, named method of an apparatus for controlling mechanism of moving vehicle or vehicles.

In 1903, Leonardo Torres Quevedo presented the Telekino at the Paris Academy of Science, accompanied by a brief, and an experimental demonstration. It constituted the World's first apparatus for radio control and was a pioneer in the field of remote control.

The first remote intended to control a television was developed by Zenith Radio Corporation in the early 1950s. The remote, unofficially called "lazy bones" was connected to the Television set by a wire. To improve on the cumbersome setup, a wireless remote control called "flashmatic" was developed in 1955, which worked by shining a beam of light onto a photo electric cell. Unfortunately, the cells did not distinguish between light from the remote and light from other sources, and the flashmatic also required that the remote control be pointed very accurately at the receiver.

In 1956, Robert Adler developed "Zenith space command" a wireless remote. It was mechanical and used ultrasound to change the channel and volume [15]. When the user pushed a button on the remote control, it clicked and struck a bar, hence the term "clicker". Each bar emitted a different frequency and the circuits in the television detected this noise. The invention of the transistor made possible cheaper electronic remotes that contained a piezoelectric crystal that was fed by an oscillating electric current at a frequency near or above the upper threshold of human hearing.

By the 1980s, Zenith engineers moved to infrared or IR remote technology. Infrared radiation is the emission of energy as electromagnetic waves in the portion of the spectrum just beyond the limit of the red portion of visible radiation [14].

The wavelengths of infrared radiation are shorter than those of radio waves and longer than those of light waves. They range between approximately 10^{-3}-10^{-6} nm. Infrared radiation may be detected as heat, and instruments such as bolometer are used to detect them [3].
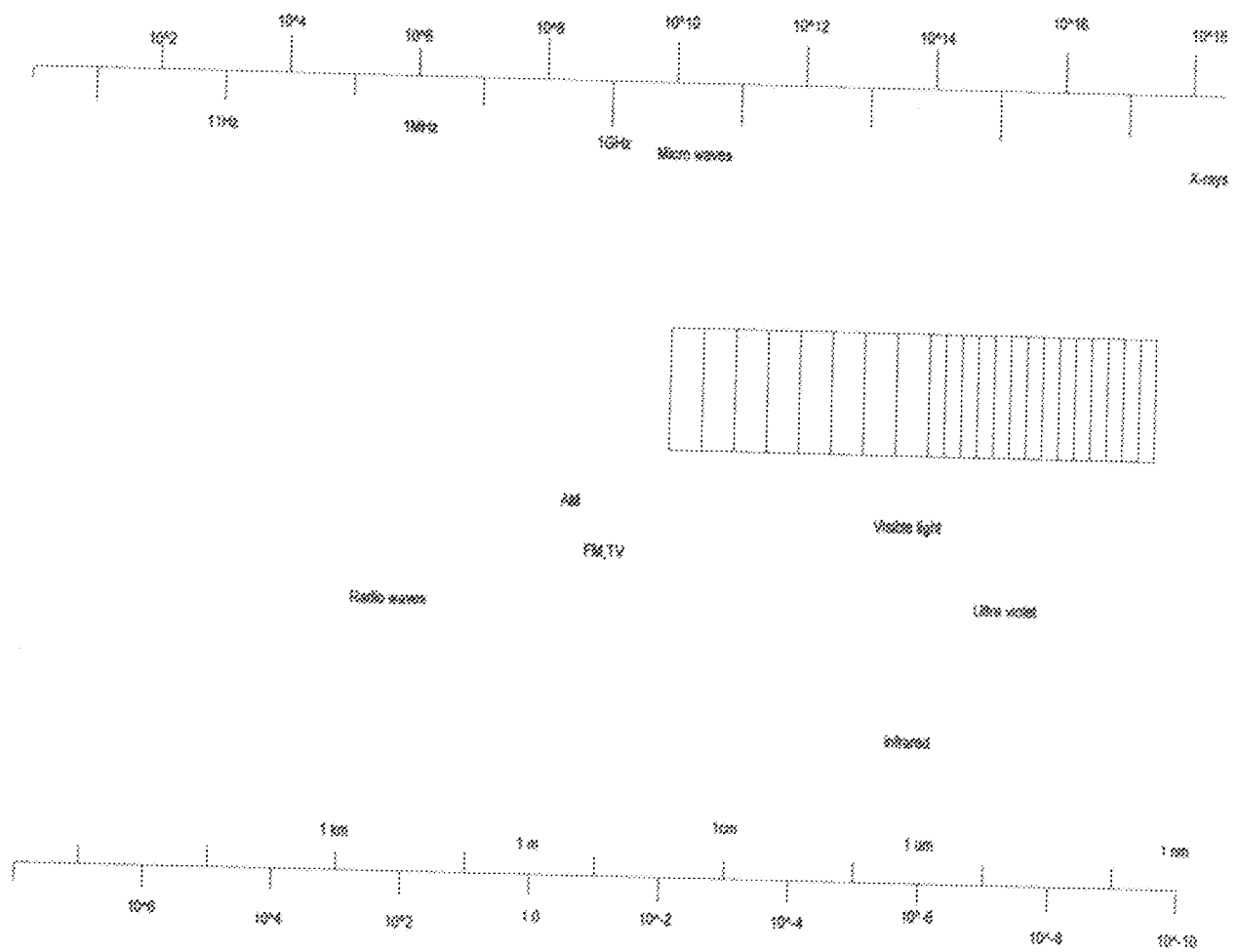
Fig 2.1 Electromagnetic spectrum showing range of IR radiation

Theoretical background:

This project features a single channel (on/off) switch that may be used with any infrared remote control that operates within the wavelength of 850-950nm. It can be used to turn on, or turn off any circuit that is attached to it through the relay. It can be

used to turn on night lamps, electric doors, air conditioners, electric windows and virtually any household electric appliance.

Any remote control may be used to work the switch. Just press a button for a second's delay for the relay to operate. Once operated, the circuit will remain in this state (latched) until reset. To reset it therefore, any button is again pressed and held for the same time delay. The relay can be connected to anything provided the relay contact can handle the rated voltage and current of the load [4].
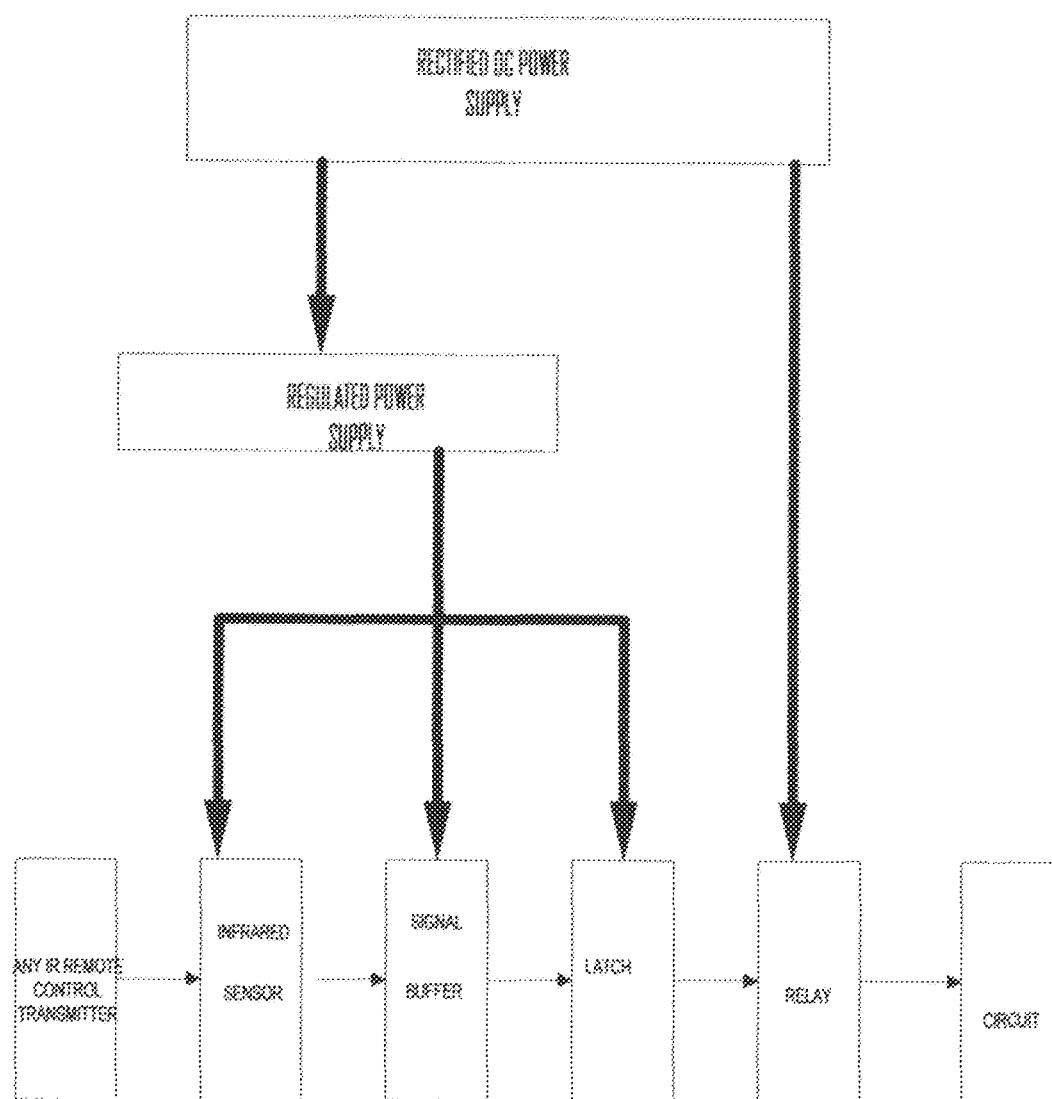
Fig. 2.2 Functional block diagram of the remote control switch.

2.2.1 Remote control system concepts:

Infrared beam systems can easily be designed to give very effective single or multi channel remote control operation. Fig 2.3 illustrates the basic principle. Here, the hand held control unit transmits a coded waveform via a broad infrared beam, and

this signal is detected and decoded in the remotely placed receiver, and thence used to activate external devices via the receiver.
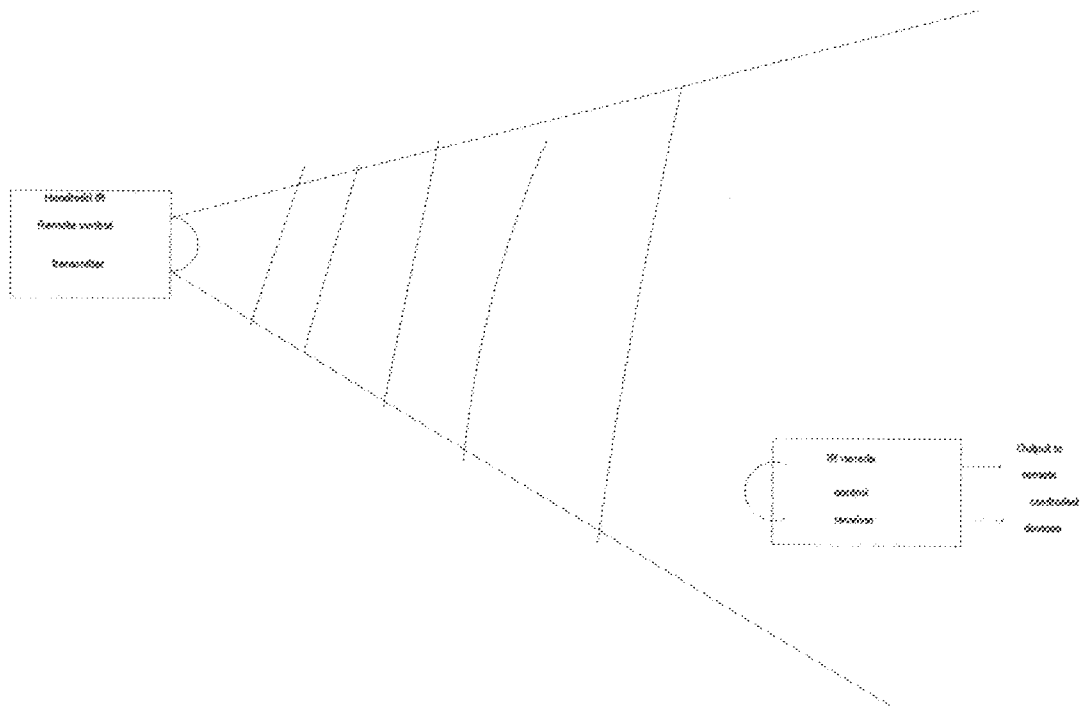

Fig. 2.3 Basic IR remote control system

Note from the figure that the transmitter can remote –control a receiver placed anywhere within the active area of the IR beam.

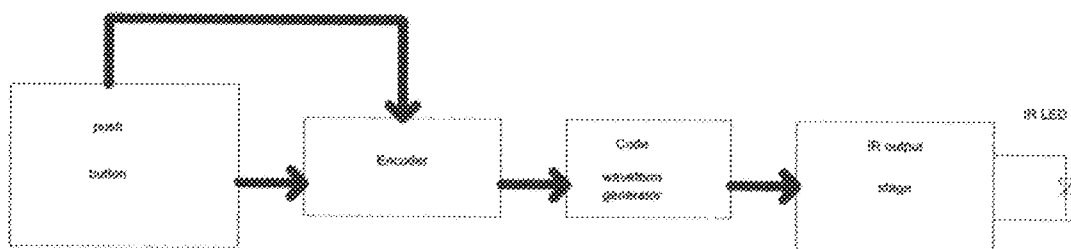## 2.2.2 IR remote control transmitter:

Fig 2.4 Typical IR remote control transmitter block diagram

Fig. 2.4 shows the typical block diagram of an IR remote control transmitter. This unit is usually fitted with a functional push button, which has its output repeatedly scanned via an encoder circuit that controls the input to a code waveform generator system. This latter unit generates the carrier wave signal plus synchronizing pulse frame waveform, which is then passed onto a standard infrared transmitter output stage.
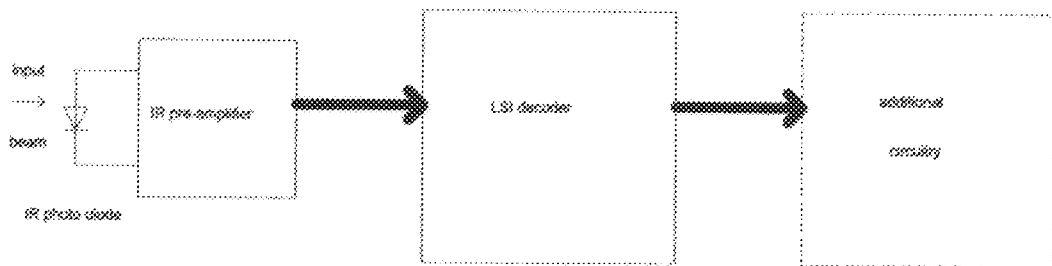
2.2.3 IR remote control receiver:

Fig. 2.5 shows the typical IR remote control receiver block diagram. In the receiver circuit, the detected IR signal is first fed to a fairly sophisticated pre-amplifier stage which provides very high gain for long-range operation, but does not saturate if the transmitter is used near the receiver. The pre-amplifier output is fed to an LSI decoder, which modulates the infrared signal into a wave train of modulated electrical signal.

2.2.4 IR Sensor Unit:

This consists of the infrared module which is the transducer that receives the infrared the infrared signal from the transmitter, and modulates it into a wave train of modulated electrical signal. Pin diode and pre-amplifier are assembled on lead frame, the epoxy package being designed as an infrared filter. The

demodulated output signal can directly be decoded by a microprocessor. TSOP12 is the standard infrared remote control receiver series supporting all major transmission codes [5].

2.2.5 Signal buffer unit.

This consists of a time delay circuit and a 555 timer connected in a mono-stable stable state which processes the modulated signal and sends a one shot output that is needed to trigger the latch (which is a D-type flip-flop).

The LM555 is a highly stable device for generating accurate time delays or oscillations. Additional terminals are provided for triggering or resetting if desired. In the time delay mode of operation, the time is precisely controlled by one external resistor and capacitor [6].

In the mono-stable mode of operation, the timer functions as a one –shot. The external capacitor is initially held discharged by a transistor inside the timer. Upon application of a pulse of less than 1/3 Vcc to pin 2, the flip-flop is set which both releases the short circuit across the capacitor and drives the output high [6].
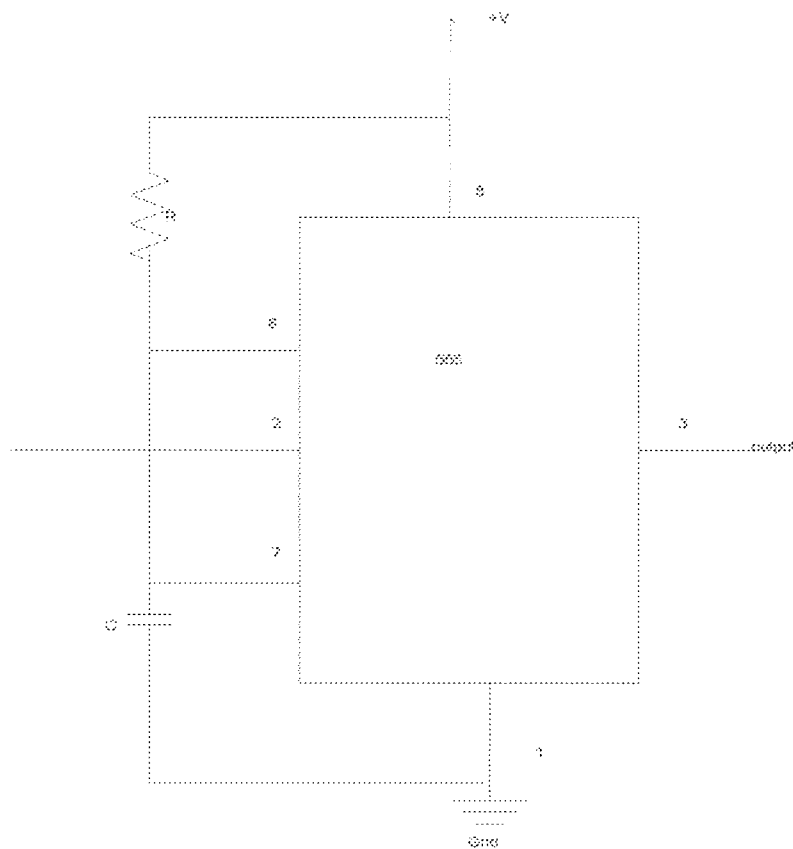
Fig. 2.6 a 555 timer connected in a mono-stable state

During the timing cycle when the output is high, the further application of a trigger pulse will not affect the circuit so long as the trigger input is returned high at least 10 micro seconds before the end of the timing interval. However, the circuit can be reset during this time by the application of a negative pulse to the reset terminal (pin 4). The output will then remain in the low state until a trigger pulse is again applied. When the reset function is not in use, it is recommended that it be connected to Vcc to avoid any possibility of false triggering [8].

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2.2.6 The latch unit:

The latch, according to Microsoft e-dictionary, is a device for keeping doors shut, a device for holding a door, gate or other opening/closing consisting of a movable bar that drops into a hole or notch. Latches are registers used to hold a set of bits. That is, their output follows the input when enabled, and holds the last value when disabled. Example of a latch is the d-type flip-flop.

The latch is introduced in this circuit in order to serve as a one way switch which holds the relay on/active permanently when triggered, and would not off it until it receives another cycle of clocked signal.

The CD4013 dual edge- triggered flip-flop utilizes schottky TTL circuitry to produce high speed D-type flip-flops [10]. Each flip-flop has individual clear and set inputs, and also complementary Q and $\overline{Q}$ outputs. Information at D is transferred to the Q output on the positive going edge of the clock pulse. Clock triggering occurs at a voltage level of the clock pulse and is not directly related to the transition time of the positive-going pulse. When the clock input is at either the HIGH or LOW level, the D input signal has no effect.
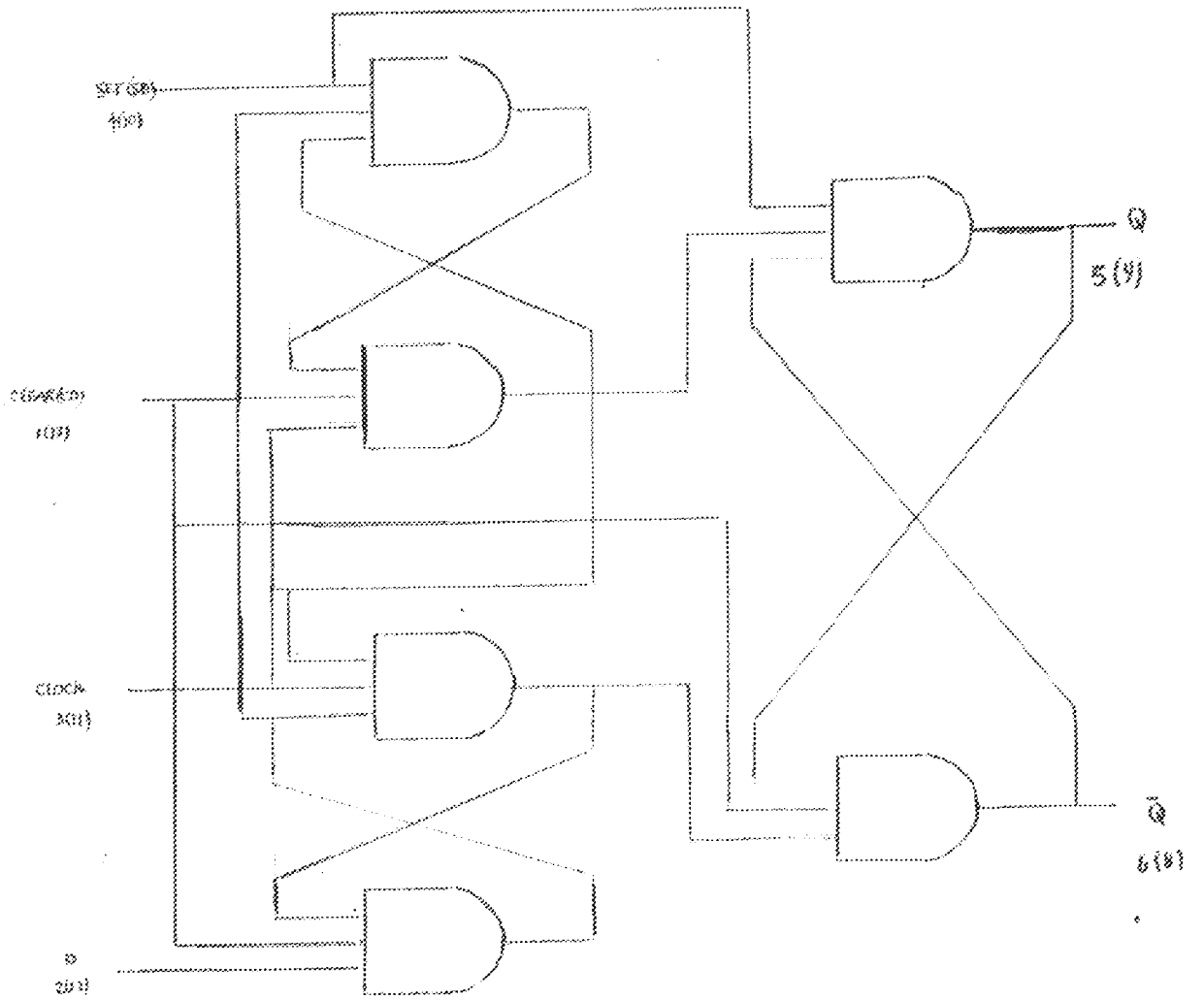
Fig 2 logic diagram of the D-type flip-flop

particular supply voltage. In each case, the coil will draw the right pull-in and holding current when connected to that supply voltage.
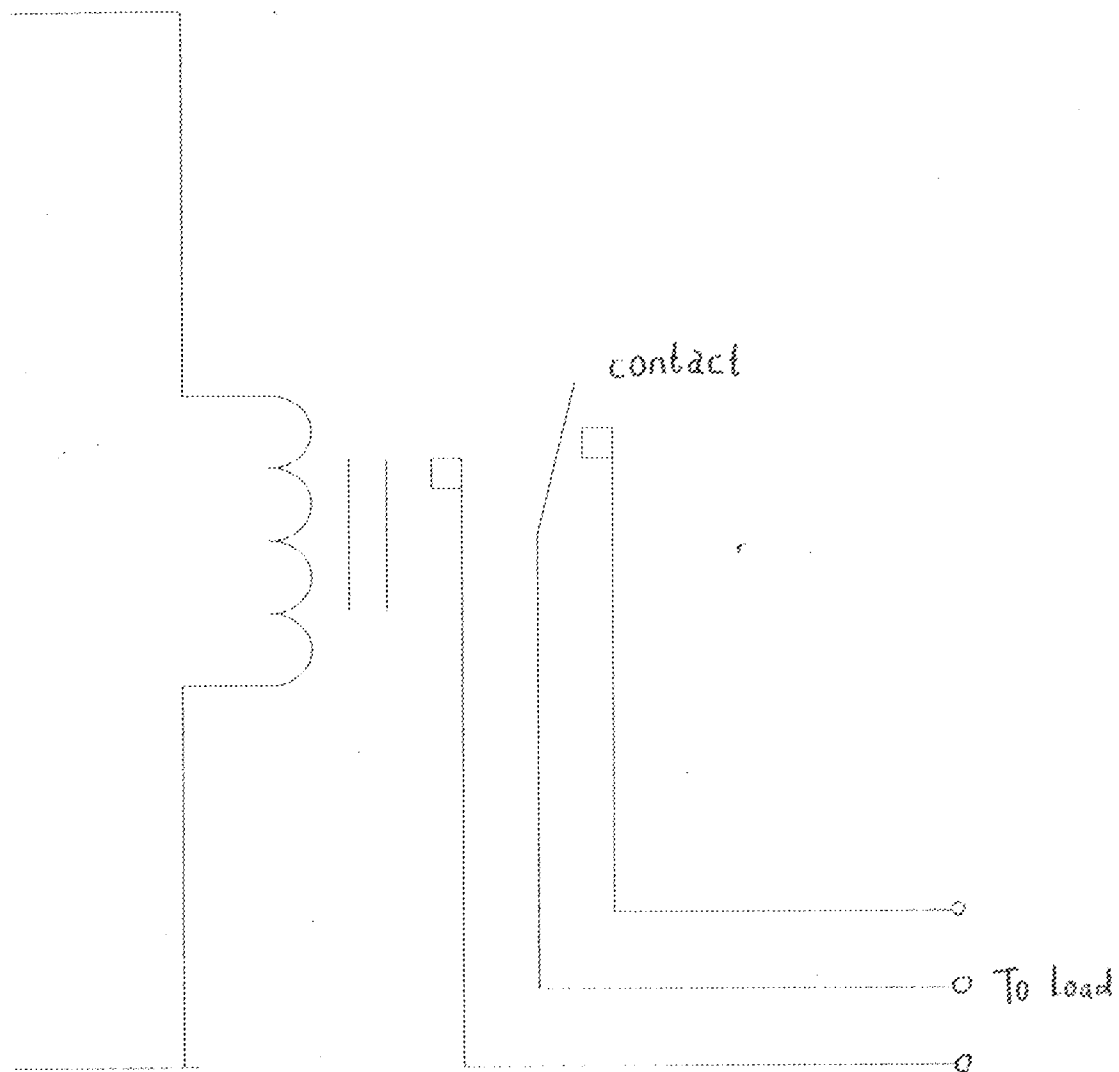
contact

To load

Fig 2.8 diagram of a relay

CHAPTER THREE

DESIGN AND IMPLEMENTATION

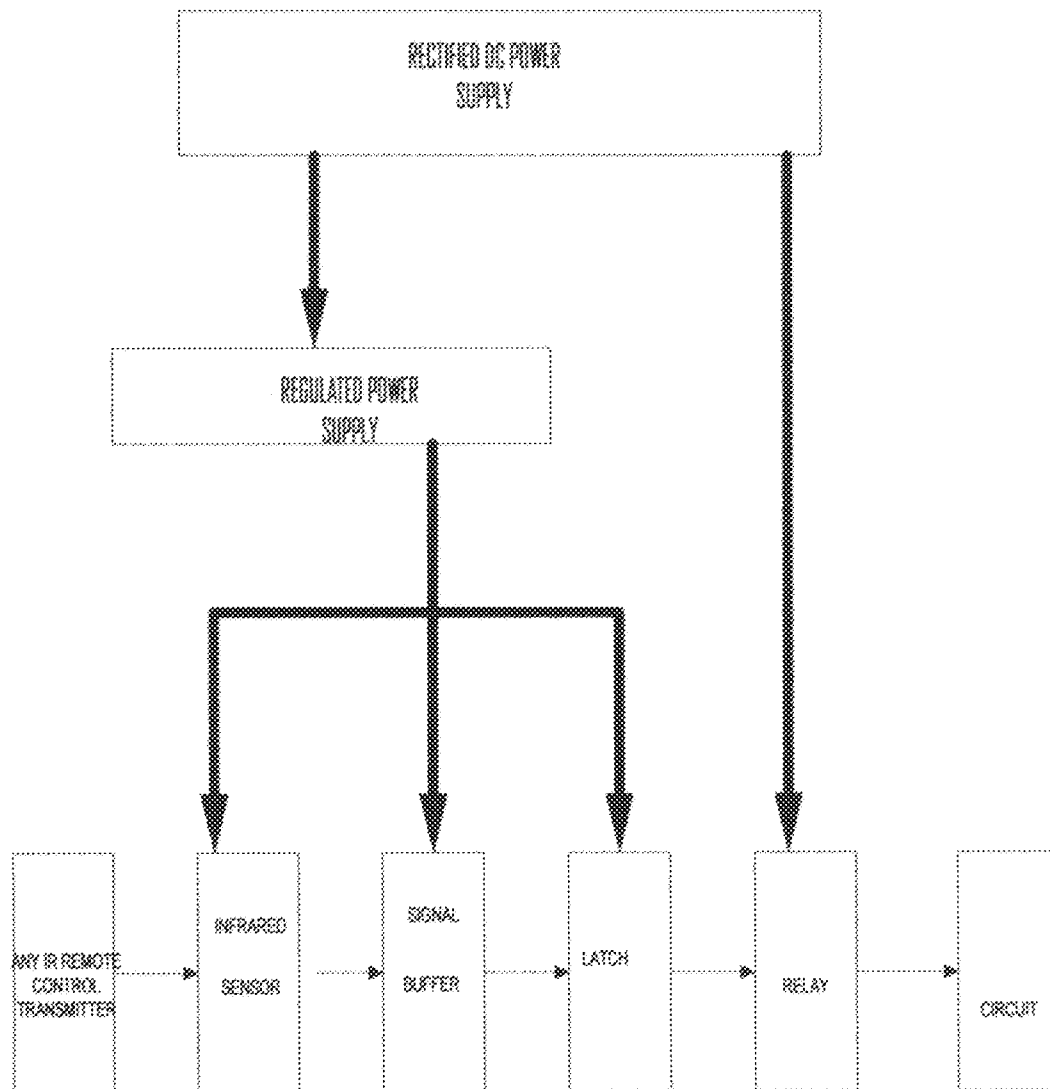## 3.1 Functional block diagram of the design work:

Fig 3.1

The infrared control system comprises the functional blocks listed below;

1. Power supply

2. infrared sensor

3. signal buffer

4. flip-flop

5. load power switch

3.2 Design of the power supply unit:

A system power supply of 9V was utilized for the system operation. It was derived from a step down transformer and a bridge rectifier network as shown below;
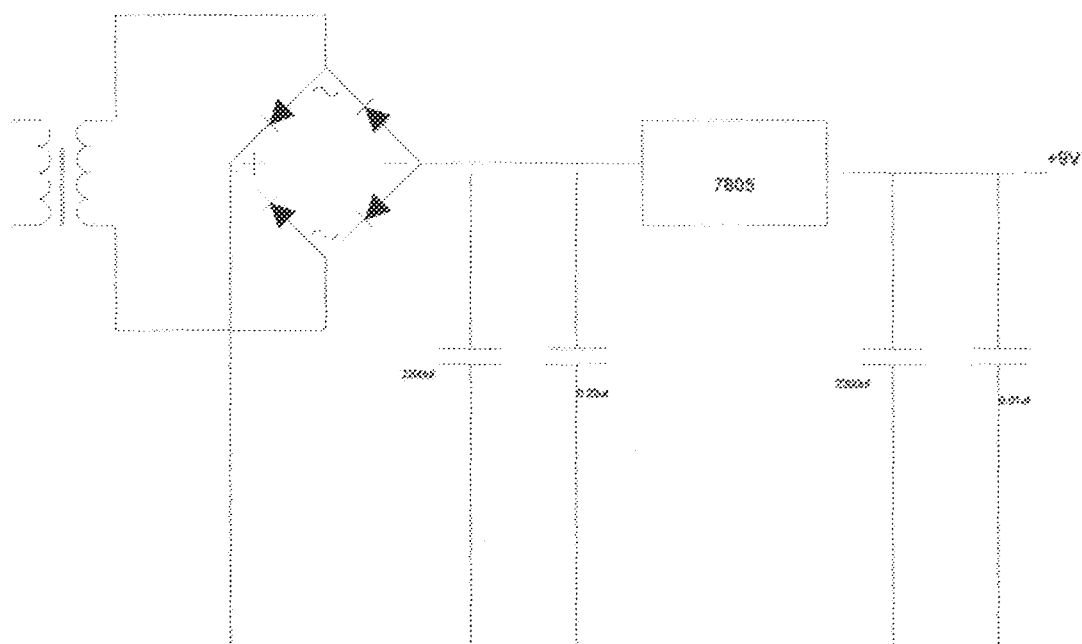

Fig 3.2 complete power supply unit

3.2.1 Design of the transformer:

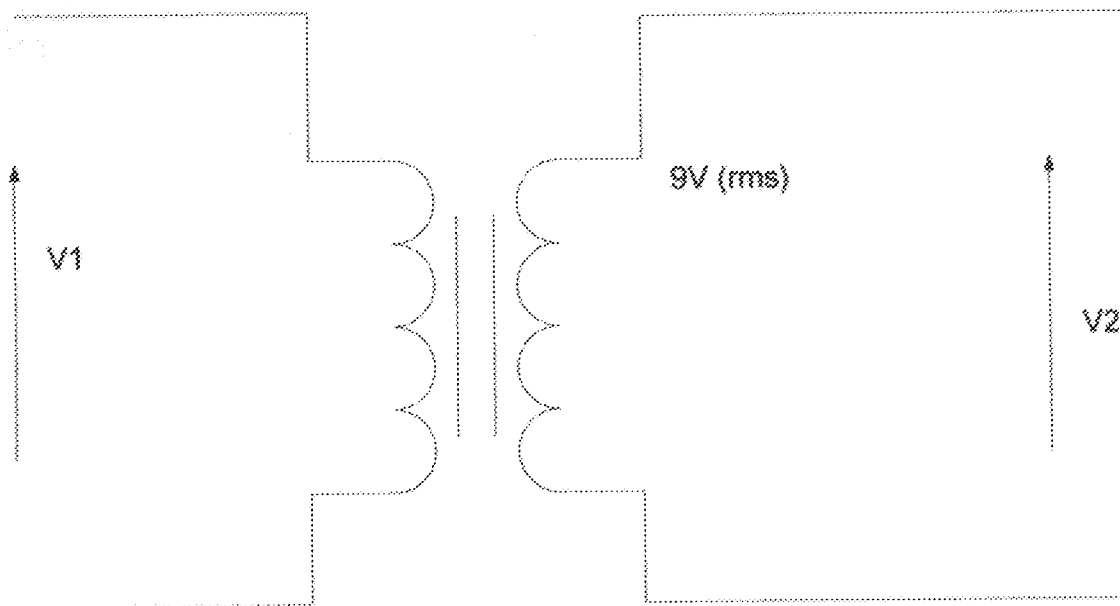A standard transformer of 220V to 9V was chosen for convenience.

Fig 3.3 diagram of a transformer

3.2.2 Design of the rectifier:

A bridge rectifier was chosen to provide a full wave rectification. IN4002 rectifiers were chosen.

3.2.3 The voltage regulator:

A regulator, 7805 series, having a 1-5 voltage output was used.

3.3.0 The infrared sensor and indicator unit:

3.3.1 The infrared sensor:

A TSOP 1738 38 KHz infrared sensor was used in the receiving unit to detect the generated infrared from the transmitting device (any IR remote control). The sensor interface is as shown below;

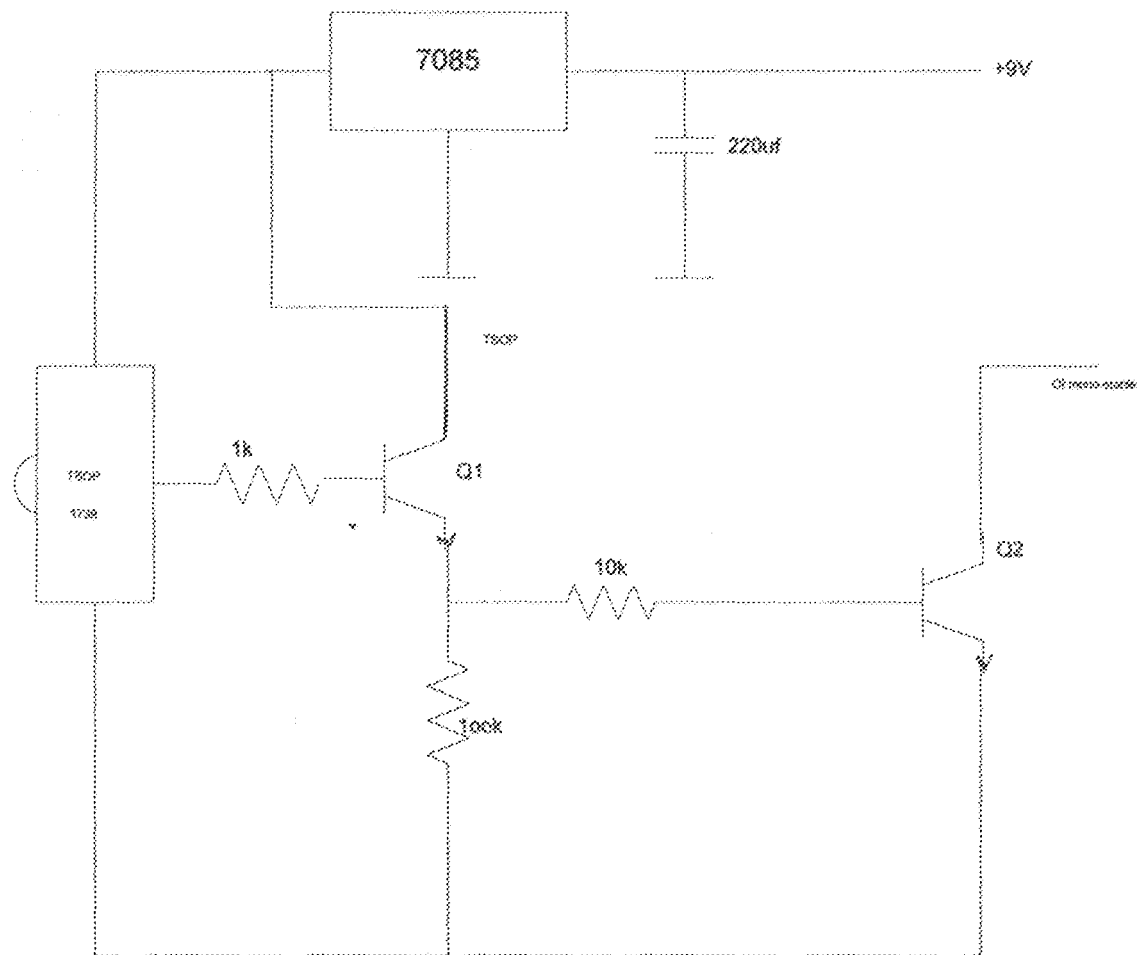Fig 3.4 infrared sensor unit

The TSOP11738 sensor to a two-two transistor level shifter network. The sensors output is high in the absence of any transmitted infrared beam. When a 38KHz input is detected, the sensor switches low, forward biasing transistor Q1, which also biases transistor Q2 in the forward direction.

3.3.2 Delay circuit:

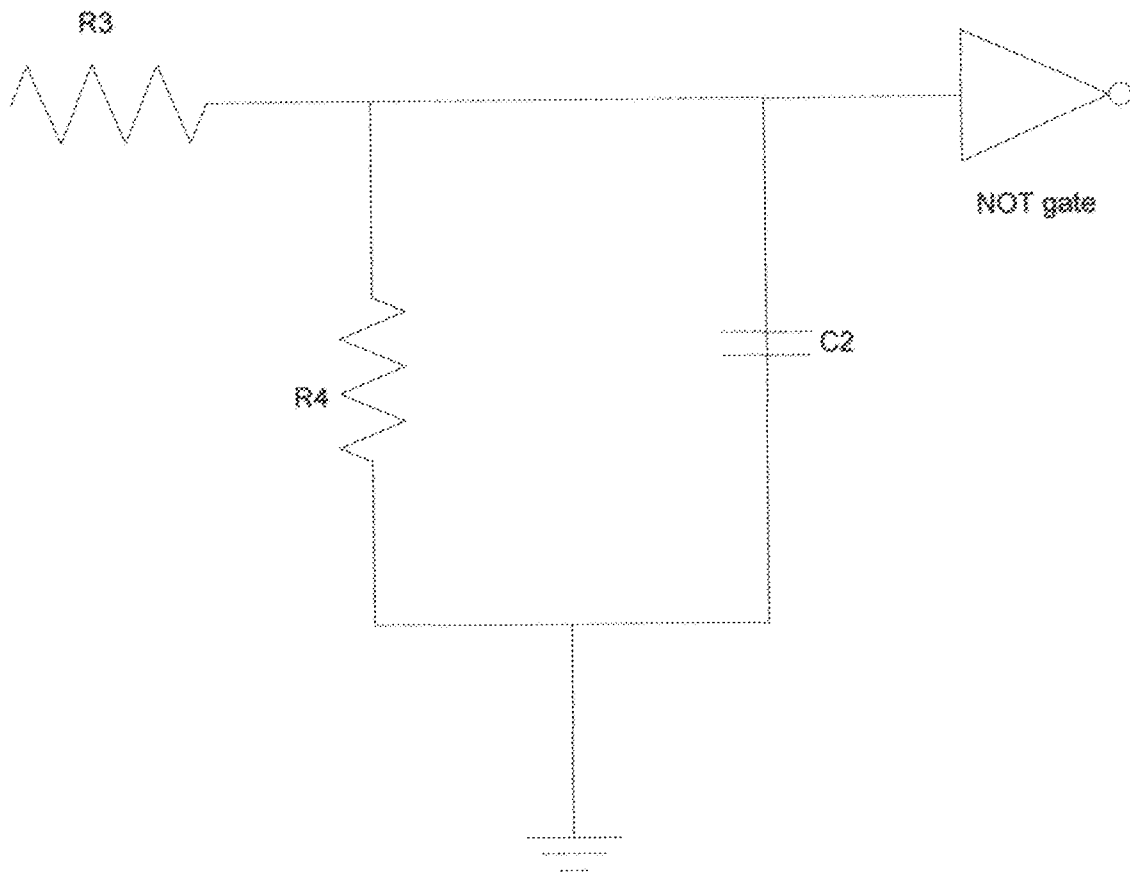The delay comprises of R3, C2,R4 and D1 as shown below;

Fig 3.5 diagram of the delay circuit

C2 charges via R3 and discharges via R4, D1 prevents quick discharge via the low output impedance of the CMOS buffer. The time taken to charge a capacitor is the product of resistance and capacitance, more commonly known as RC time constant. At one RC, a capacitor will only charge to 63% of the supply voltage. It takes 5 RCs for a capacitor to reach 99% charge. In this circuit, the capacitor charge has to reach the logic threshold of the CMOS inverter. Once the capacitor is charged, the inverter triggers the 555 timer which is connected in a mono-stable state with a time delay of a second.

3.3.3 The mono-stable 555 timer:

The collector of transistor Q2 was connected to the trigger input of an
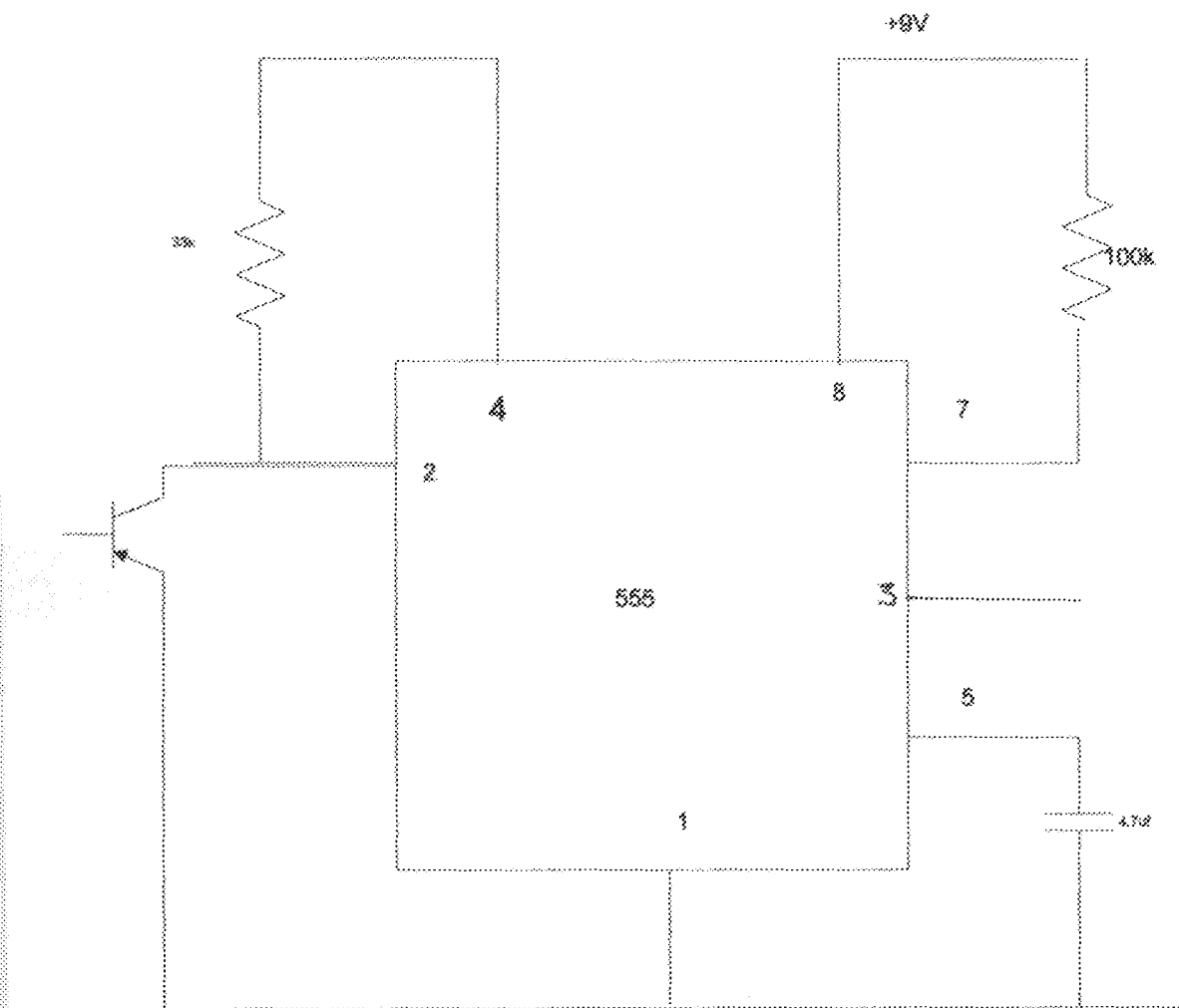NE555 mono-stable timer wired as shown below

Fig 3.6 mono-stable clock generator

When the transistor switches on, the trigger input is pulled low, causing the mono-stable to switch its pin 3 high for a period of time determined by the value of the timing components.

The mono-stable was needed to generate a clock pulse from the detected infrared carrier. The clock pulse is then used to clock a toggle flip-flop (a D-latch) which controls the relay. When the mono-stable is triggered, pin3 goes high for:

$$T = 1.1RC \text{ seconds}$$

$$T = 1.1 * 100 * 10^3 * 4.7 * 10^{-6}$$

$$= 0.517.$$

A one second delayed output was produced from the mono-stable as a clock pulse for the toggle flip-flop.

3.4.0 The latch unit:

A D- type toggle flip-flop (CD4013 IC) was used to change the system state. The input is applied to the clock pin, the inverted output fed back to the data input and clear and preset lines tied to Vcc. For every pulse, the relay will operate and latch. That is if the unit is initially ON, a received infrared pulse switches it OFF and vice-versa.

Fig 3.7 D-type toggle flip-flop

The truth table for the toggle flip-flop is shown below;

D	CLK	Q	$\bar{Q}$
0	0	Qn	$\bar{Q}$n
0	1	0	1
1	1	1	0
X	0	Qn	$\bar{Q}$n

Table 3.1

A received clock pulse changes the state of the output.

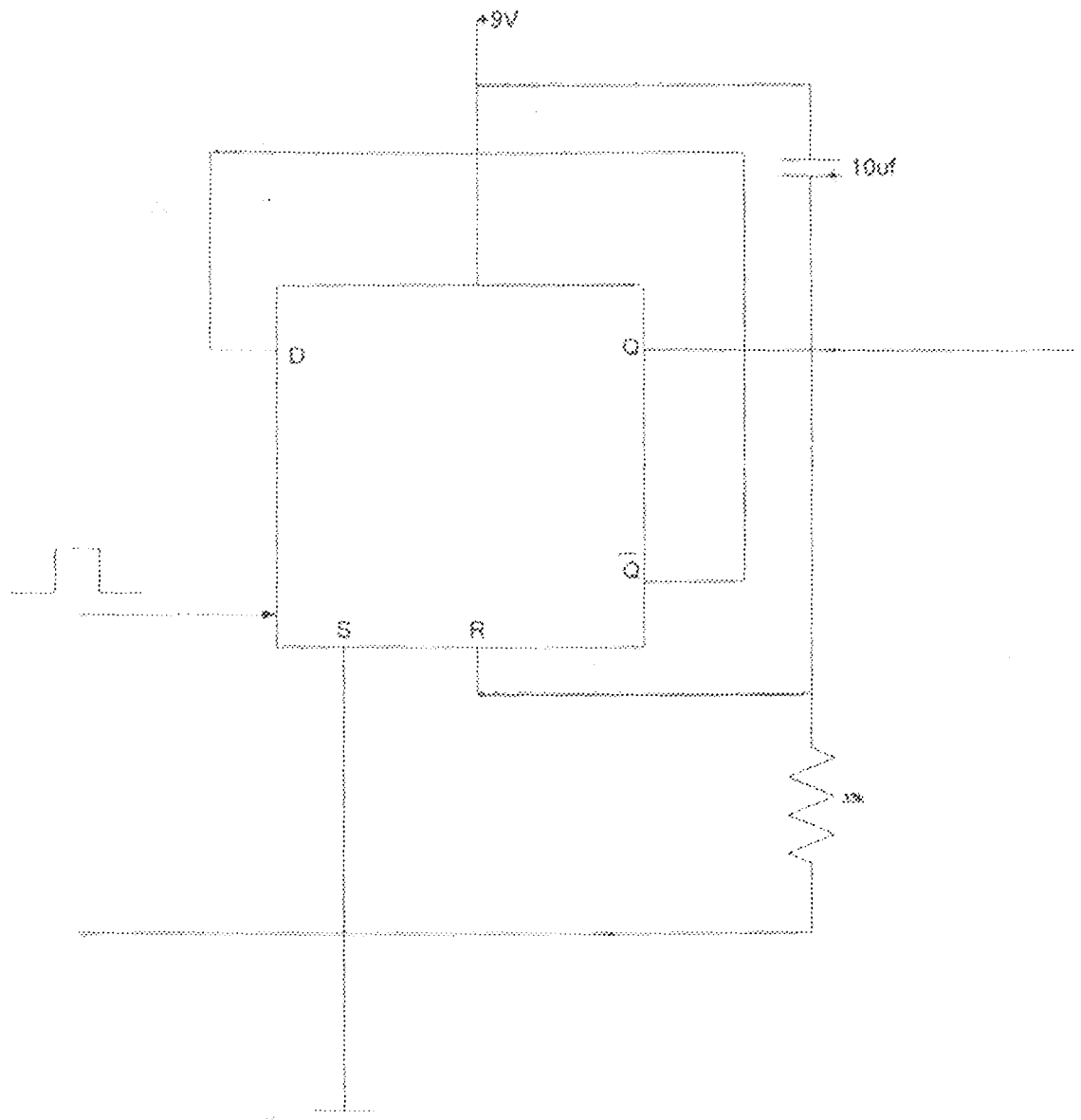A CD4013 flip-flop was configured as the toggle flip-flop as shown below;

Fig 3.8 configuration of the flip-flop

The 10UF capacitor and 33k ohm resistor form a power- on reset circuitry

that forces Q low at power up, putting the device in a known state.

3.4   Relay drive circuit:

The relay drive circuit is made up of a current limiting resistor, transistor switch and s relay as shown below;
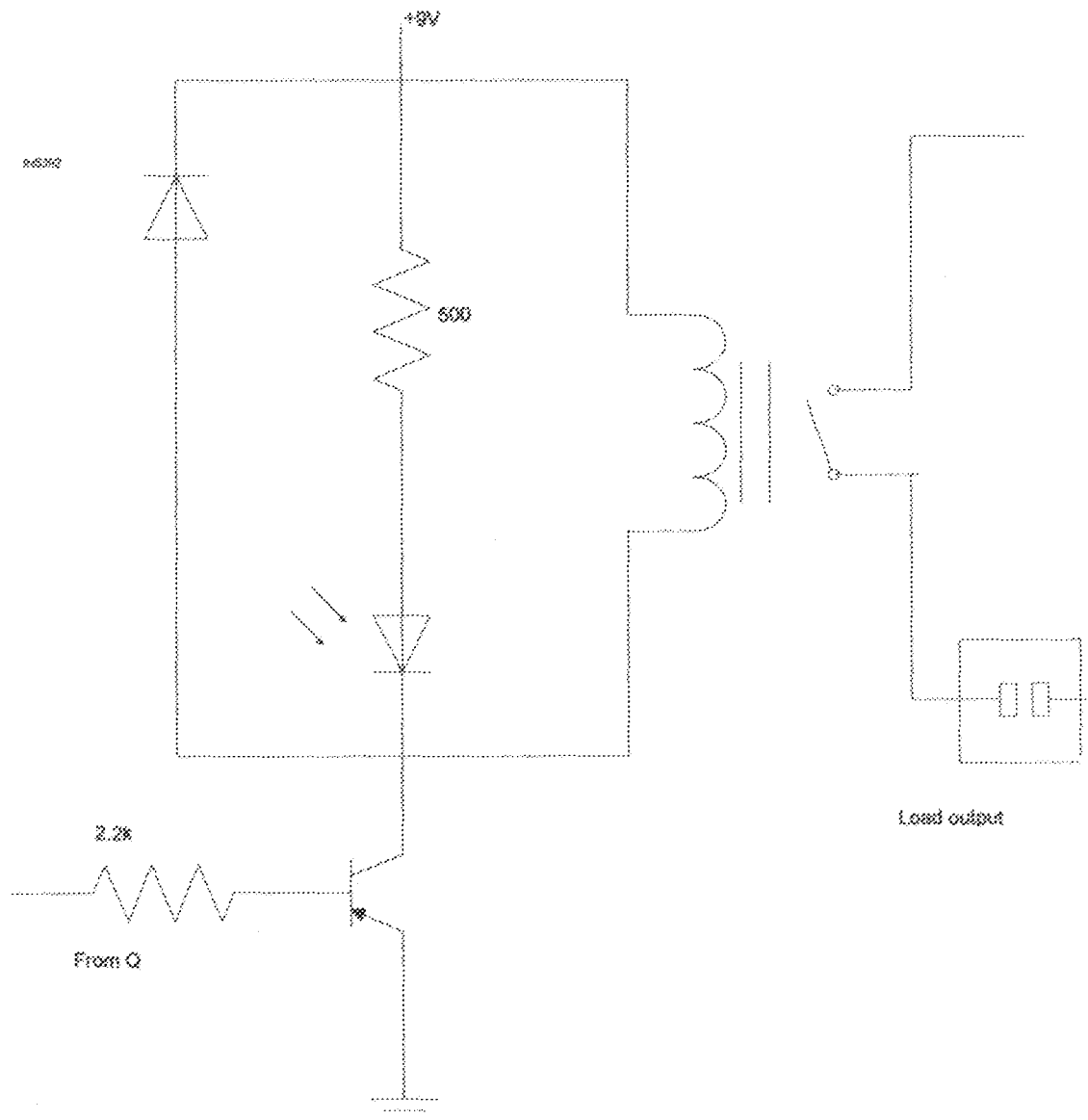

Fig 3.9 relay switch

The Q output of the latching unit was fed into the base-emitter junction of an NPN transistor whose collector load is the 9V relay. For a relay of coil resistance of 400 ohm, at 9V, the relay coil current Ic is calculated thus;

$$Ic = 9/400$$

$$= 0.0225A$$

$$= 22.5 \ mA$$

using the value of 100 for beta;

to calculate for Rb we have that;

$$Ib = Ic/B, \text{ where } B = 100$$

$$\text{Therefore, } Ib = 0.0225/100$$

$$= 0.0000225$$

$$\text{from } R = V/I = (Vh - Vbe)/Ib$$

$$\text{where Vh for CMOS} = Vdd$$

$$Rb = (9 - 0.7)/0.0000225$$

$$= 8.3/2.25 * 10^5$$

from which Rb = $3.2 * 10^5$ ohms.

A value of 2.2K ohms was used for Rb.

The AC output to the load was routed through the relay via the relay contact
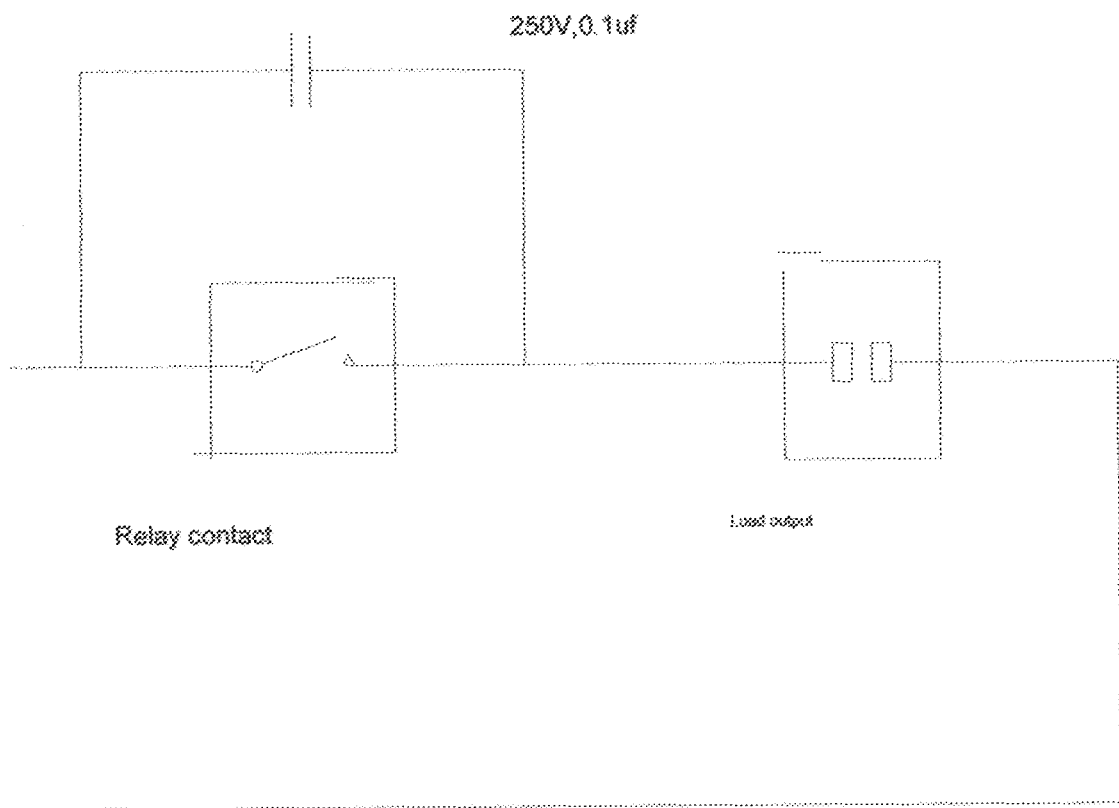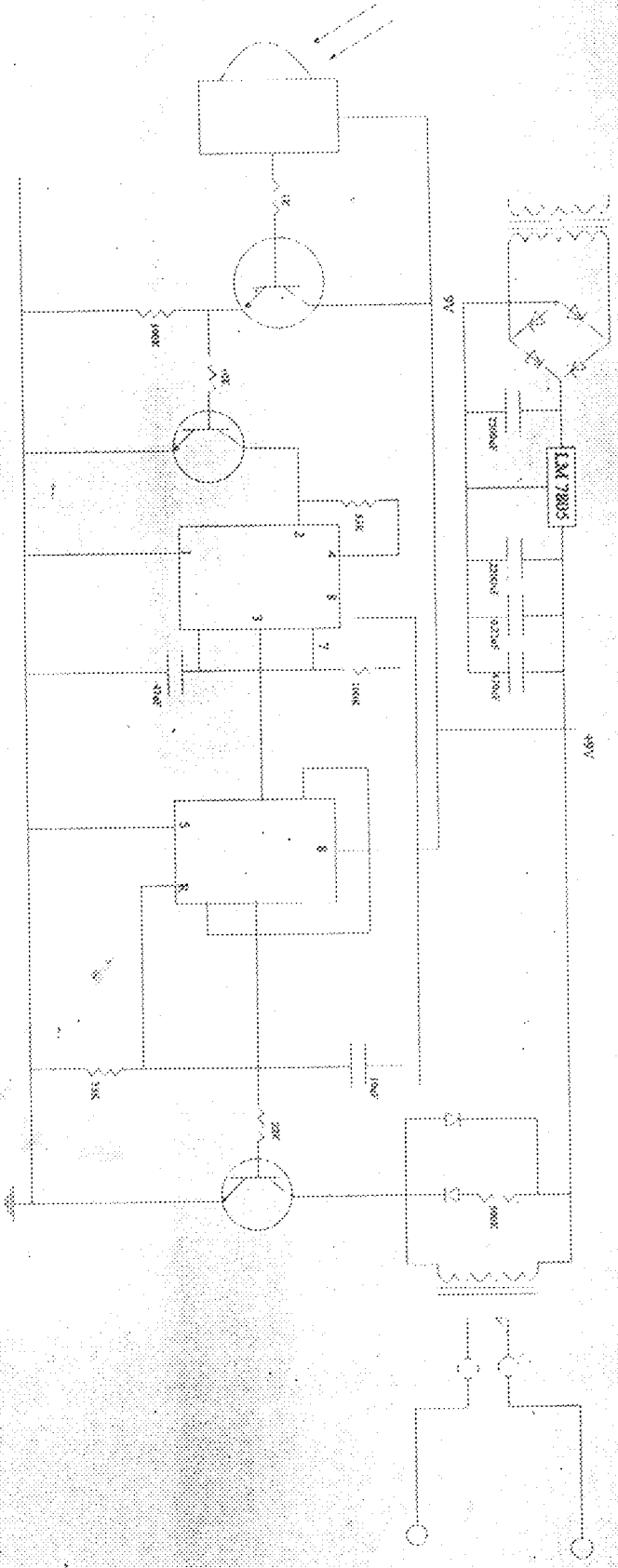
250V,0.1uf

Relay contact

Load output

Fig 3.10   load power switch.

Fig 3.11 Complete Circuit Diagram

CHAPTER FOUR

4.0 Construction and discussion

4.1.0 Construction, testing and results:

This chapter brings focus on the construction procedures and techniques used to produce the system, the testing and the result obtained.

To ease the construction procedures, the circuitry was segmented into functional blocks. A component layout plan was thus drawn to ease construction.

The construction included a prototype located on a bread board followed by the final construction located on a veroboard.

4.1.1 Component layout:

The layout plan for the electronic components location on a vero-board was drawn out on a sheet of graph paper to ensure the following:

1. Economy of space used on the vero board.

2. That the best connection routes for the component were used.

An interconnection plan was developed for the connection between the two ICs. The functional blocks of the projects circuitry was broken into the following:

1. Infrared transmitter.

2. Infrared sensor.

3. The signal buffer.

4. Data latch

5. Relay.

6. External circuitry.

4.2 Hardware construction

The initial construction and components connection was done on a bread board. Each block was tested and the results obtained before the components were permanently soldered on the vero board.

4.3 Soldering:

A soldering iron, a plastic suction tube and soldering lead were used during the soldering process. The precautions taken during soldering include;

1. Adequate amount of soldering lead was used.

2. IC sockets were used so that the intense heat generated during the soldering may not destroy the ICs.

3. Ensured that the soldering of each component was done in a quick but efficient manner to avoid overheating and hence possible destruction.

4.4 Testing and analysis:

On completion of the construction, a thorough test and assessment of the component connection was carried out. The following steps were carried out:

1. The continuity and connectivity of the jumper wires and links were taken using a multi-meter while the circuit was not powered.

2. The construction was tested block by block.

3. The measurement of capacitance, current, resistances and voltage were taken and compared with design values.

To operate the system, a button is held down from any IR remote control transmitter while being pointed at the receiver.

CHAPTER FIVE

5.0 CONCLUSION

The aim of the design and construction of the infrared remote control switch unit has been achieved with a great deal of patience and good reasoning during the construction of the prototype.

The objective of which is to turn on or turn off an appliance from a considerable distance using infrared radiation as a medium. Though the external circuit employed here was a model, any household appliance like television, radio, table lamp etc can be controlled using the same circuit, all that is needed is to connect the positive line of the appliance through the secondary part of the relay.

Also, the device was seen to have a degree of sensitivity with considerable distance (3-4 meters) away provided that the line of sight is maintained between the transmitter and receiver. The device is also portable.

Yet for the achievement to be made, many problems were encountered. The problems encountered were;

1   At the early stage of construction, the output was erratic and inconsistent due to undesired infrared radiation picked up from fluorescent lamp in the room.

2   After all the assembly were made, the circuit did not respond . this was due to wrong connection of some of the pins to the integrated circuit which was corrected by consulting data sheets.

4. Most of the connections were later discovered to be falsely leaded as a result of an insulating coating on the vero board from the manufacturer, so a razor blade was used to remove the coating before it was used.

5.1 Recommendations

Based on the and limitations recorded by this project work, the following recommendations should be considered:

    i.   The system can be modified can be modified (by software program) so that only a specific remote control can operate it.

    ii.   As this project involves the switching of only one channel, the project can be modified into driving multi channel i.e. to control many appliances.

    iii.   Also, the power supply can use a battery to make it more portable.

    iv.   The use of more compact electronic components can also make it more portable.

References:

1. AndyCollinson, Harrison electronics publications (www. Harrisonelectronics.com), electronic circuit diagrams

2. Digital Fundamentals Eighth edition by Thomas L. Floyd, 2003, pg 398 and 428

3. Encarta world reference library 2006, electromagnetic spectrum.

4. www.harrisonelectronics.com/datasheet/relay, relay units

5. www.vishay.com/datasheets.

6. www.howstuffworks.com/555timertutorials.htm, connection and operation of 555 timers.

7. Forrest M. Mims III, 555 timer IC circuits, Engineer's mini Notebook. Radio shack pg 367

8. www.alldatasheet.com/lm555.

9. Paul Horowitz, the Art of Electronics, Cambridge University press, pg 508.

10. www.oseni.com, CD4013 as a D-type flip-flop.

11. Emmanuel Nandet, Design and construction of sound activated switch, Elect/Elect Engineering, ATBU Bauchi, Nov. 1993, pg 14

12. en.wikipedia.org/wiki, abstract

13. John Young, electronic sensor devices, third edition, Princeton publications, New Jersey, 1995, page 28.

14. www.remotecontrols.com/history, history of remote controls.

15. Kraus/ Fleich, electromagnetic with applications, fifth edition WCB/McGraw-Hill publications page 477

MANUAL OF OPERATION FOR THE INFRARED REMOTE CONTROL SWITCH

The device prototype is operated following the simple procedures;

1. Connect the device to power supply.

2. Connect the load circuit to power supply.

3. Cross check to make sure the load voltage rating does not exceed rated voltage of the prototype.

4. Press any button of any remote control to turn on the load circuit.

5. Press any button of any remote control to turn off load circuit.

6. Disconnect completely from power supply.

PRECAUTIONS

1. Keep away from moist environment.

2. Avoid connection of device to high power supply

3. Isolate completely from power supply when not in use.