# DESIGN AND CONSTRUCTION OF AUTOMATIC ROOM LIGHT SWITCH

*BY*

MUHAMMED JUMMAI DEDE

98/6932EE

PROJECT SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF BACHELOR OF ENGINEERING (B.ENG) DEGREE IN THE ELECTRICAL /COMPUTER DEPARTMENT OF THE FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA-NIGER STATE, NIGERIA

NOVEMBER 2004.

## DECLARATION

I hereby declare that this project (automatic room light switch) was constructed by me under the supervision of Engr. J. KOLO; a lecturer in the department of electrical/computer engineering, Federal university of technology, MINNA.

MUHAMMED JUMMAI DEDE
Student

08/12/2004
Date

ENGR. J. KOLO
Project supervisor

8/12/04
Date

## CERTIFICATION

This is to certify that this project AUTOMATIC ROOM LIGHT SWITCH was designed and constructed by Muhammed Jummai Dede for the partial fulfillment of the award of Bachelor degree in electrical/computer engineering.

8/12/04

ENGR. J. KOLO
Project supervisor

Date

8/12/2004

ENGR. M.D ABDULLAHI
Head of Department

Date

EXTERNAL EXAMINER

Date

# DEDICATION

This project work is dedicated to my parent, Mr. & Mrs. A.A Muhammad, may the Good Lord be with them. (Amen).

## ACKNOWLEDGEMENTS

I owe a debt of gratitude to those who were so generous with their time and expertise:

My profound gratitude goes to Almighty Allah, who in His infinite mercies protected, guided, directed and inspired me during this masterpiece and through out my entire stay in the University.

Special thanks go to my parent, Mr. & Mrs. A.A Muhammed for their unending support and affections.

Deep appreciation goes to my project supervisor, ENGR. J. KOLO, for making the whole task a lot easier, the head of department ENGR. M. D Abdullahi, all lecturers and other staffs of Electrical & Computer Engineering Department.

Mr. D. B Pam (gifted secondary school gwagwalada, Abuja) for his valuable advice and assistance through the design part of this work.

Thanks to my sisters and brother, Maimuna Dede, Amina Merobe, and Ahmed Muhammed for their immense support and encouragement.

I will also like to place on record the valuable help and encouragement of Adetunji Olanipekun, Mohammed Akiniran and Miss Khadijah Ibrahim.

Finally, to all my very special friends who have been supportive in a way or the other. Thank you and God bless you all (Amen).

The expertise belong to all those listed above, the errors are mine.

- Jummai

## ABSTRACT

This circuit is used to switch ON or OFF automatically the light in a room when the device is powered.

This device uses an up / down counter, two infrared transmitters and receivers, a comparator unit, an operational amplifier, a timing circuit and some logic gates.

The light in the room comes ON when a person enters a room in which the infrared beam received by the sensor placed in front of the door is broken, this then activates the up count pin of the up / down counter via the op amp, D-flip flop and other logic gates and increase the count of the up / down counter by one for every breakage of beam taking place for an interval of 10sec.

The light in the room remains ON once the output of the up / down counter is not equal to zero which is compared by the comparator, and this activates a relay through the thyristor to ON the lamp.

To OFF the light in the room, the infrared beam received by the sensor placed inside the room is broken; this activates the down count pin of the up / down counter via the op amp, D-flip flop and other logic gates and decrease the count of the up / down counter by one for every breakage of beam taking place for an interval of 10sec until it gets to zero and compares with the comparator and when it is zero the light in the room goes OFF by activating a relay through the thyristor to OFF the lamp.

This device tackles the problem of one person entering and another leaving by using two infrared sensors and an up / down counter thereby increasing its reliability.

## TABLE OF CONTENT

# CHAPTER 1

# GENERAL INTRODUCTION

## 0. INTRODUCTION

The need for automatic control systems in switching ON and OFF of light in rooms, halls, auditoriums, theatres e.t.c have made electronic systems more powerful, cheaper and easier to use.

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 system 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 circuit, represent their output as two discrete level ('I' or 'O') and could show their output in a digital display either numerically or alphabetically.

This project combined both analog and digital circuits in the realization of an automatic room light switch.

The room light controller has a lot of domestic applications and besides that power is seriously conserved when using the unit since the lights in the room is automatically switched off when nobody is inside the room.

The project uses two infrared break beam sensors positioned on inside and outside of the door to sense when someone enters or leave the room. The sensors control the mono-stable multi-vibrator whose output activates the counter and the comparator unit and switches ON the lights once there is any count, and OFF when the total count is zero (since the counter counts one place down for every person leaving the room).

## AIMS AND OBJECTIVES

1 To design and construct a control (automatic) device comprising of an

electronic circuit that controls the switching action (ON and OFF) of the room light.

2 To design and construct a device that conserves power (voltage).

3 To demonstrate how automatic room light switch can supplement the human effort of switching / turning ON and OFF the room light.

## 1.2 LITERATURE REVIEW

The 555 timers is a highly stable device for generating accurate time delay or oscillations, SIGNETIC Corporation was the first to manufacture the 555 timer in 1970 but now a number of different semiconductor manufacturers manufacture the 555 timer. The 555 timers have various applications.

This project is an application of the monostable multi-vibrator, which is working as a missing pulse detector.

This device is used to cut down the power consumption due to lighting device. The device can cut the amount of electricity we consume each day, by making less electricity to be consumed for lighting devices in the day time when the sun is out and at night when nobody is in the room, this amount may be small for each room but when added together can be very large.

Large use of energy either from lighting devices or other domestic and industrial uses has commensurately large consequences on the society, most of this energy are derived from fossil fuels principally coal and natural gas. The constant sustainability of these sources is the considerable concern also green house gas emission, deposition of precursors and smog are effect of this source. Other permanent electricity sources such as nuclear and hydroelectric power raise major environmental concerns, waste disposal in the case of nuclear power and disruptions of river ecosystem in the case of hydroelectric power.

Large consumption of energy may lead to overloading and cause frequent power outage due to load shedding. These frequent power outages are the reason for the prevalent use of standby generator in the country. These generators also have environmental disturbance such as noise and air pollution as well as economic effect since they are expensive to purchase, operate and maintain, this thereby affect the cost of goods and services produced by factories using this as a substitute in the production process.

This project is aimed at reducing the consumption of electrical energy in homes. In the average home, 25% of all the electricity we use is for lighting and small appliances such as TVs, VCRs, and stereo. A good percentage of the lighting and other appliances occur in the evening when families are home. The effort to reduce energy consumption due to lighting in buildings could lead to savings of 18% in primary energy use.

There are various researches to all power consumption (not only that due to lighting devices but other uses). This made the USA in year 2001 to set up a program controlled by a centre known as the Centre for Information Technology Research in the Interest of the Society (CITRIS) to cut down the power consumption.

Against this background, this device was constructed to save electricity consumption due to lighting device in the home. The device was modified because the circuit diagram gotten from ELECTRONIC DEVICES by FLOYD (2nd edition) has only one light sensor, which works on the principle that when a person enters a the room it gets a pulse and the light comes ON and when the person goes out the same sensor gets another pulse and the light goes OFF, this encounters the problem that when two persons enters the room one after the other, this light sensor gets two pulses and the light remain in the OFF state.

This circuit makes use of two sensors and an up/down counter to overcome this problem.

Also in the project gotten from the text book a light dependent resistor (LDR) was used for the sensor but for it being affected by ambient light condition an infrared sensor was used.

### 1.3 PROJECT OUTLINES

This project report describes in details the design and construction of an automatic room light switch.

The report comprises four chapters as outlined below,

Chapter one is a general introduction, presenting a brief insight into the main concept behind this project work, its aims and objectives, the literature review and the project outline.

Chapter two is the system design and analysis which gives a clear description of the step -by -step design of the project work with the aid of the block diagram, the principle of operation is also discussed to give a vivid layout of how the project works.

Chapter three involves the construction, testing and results, in this chapter all the techniques used in combining the different hardware components to realize the circuit is discussed, testing procedures were discussed, a summary analysis and inference of the results obtained from the hardware was discussed as well.

Chapter four includes conclusion, recommendation, and references consulted while working on the project.

## CHAPTER 2

## SYSTEM ANALYSIS AND DESIGN

### 2.0 INTRODUCTION

The sole goal of this project work is that the practical work undertaken should work in conformity with the design specifications. For the purpose of analysis, this project design is described in details with the aid of block diagram as presented below.

The project has commercial and industrial application as well. The generalized diagram is shown in Fig. 2.0.0

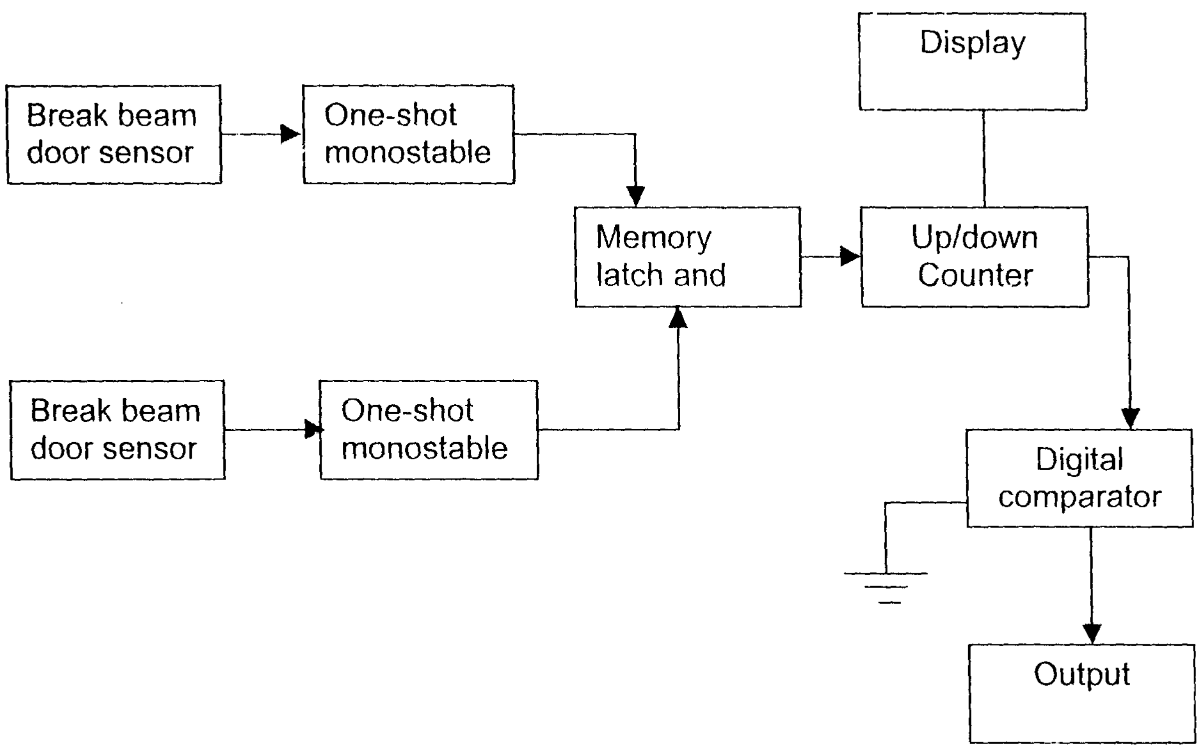



**FIG 2.0.0 GENERALIZED BLOCK DIAGRAM OF AUTOMATIC ROOM LIGHT SWITCH.**

### 2.0.1 DESIGN SPECIFICATION

| | | |
|---|---|---|
| Input Voltage | : | 220VAC Mains |
| Supply Voltage | : | +5v & +12VDC |
| Infrared Detection Range | : | 1 Meter |

Max counts : 09(i.e. maximum no of people to enter room)

The block diagram consists of basic units / components presented below:-

**Power supply unit:** This is the source of electrical energy or power to the entire system and its indispensability can be appreciated from the fact that, without it, the system will not be able to perform any work. The unit provides a 12v and 5v (d.c) with a common ground.

**One shot monostable multi vibrator:** This unit mainly comprises of a 555 timer (cmos I.C) and other discrete components such as resistors and capacitors whose output activates the counter and comparator unit. The entire system comprise of two monostable stages as shown in fig 2.0.0 above.

**Break beam door sensor unit**: This unit consists of an infrared emitter and receiver (photo diode) positioned on inside and outside of the door to sense when someone enters or leave the room. It also consists of a comparator and passive components such as resistors. The break beam door sensor controls the monostable multi-vibrator. The entire system comprise of two break beam door sensor stages as shown in fig 2.0.0 above.

**Memory latch and logic control unit:** The Memory latch and logic control is more or less a decision making circuit, the decision whether the counter should count or not and when to stop counting is made here. This unit comprises of a D flip-flop, OR gates (7432), and Schmitt trigger oscillators (40106).

**Up/down counter:** this consist of flip flops joined in cascade to count the required number of bits, this up/down counter can count up (increasing in value) or down (decreasing in value) depending on the input pulse applied to the two different pins (count up or count down pins). A HIGH on the count up pin allows the counter to increment by one on its initial value and a HIGH on the count down pin allows the counter to decrement by one on its initial value. A LOW on any of the two pins will not activate the counter to count. The counter used in this project is 74192.

**Display unit:** The display unit consists of the BCD-to-seven segment decoder (7447) and the seven-segment display unit. The decoder converts the four BCD input from the up/down counters to seven output to light the seven LEDs that form the seven segment display. This depends on the different combination of the output to display the decimal equivalent of the output of the up/down counter.

**Digital comparator unit:** This is a 7485 comparator. It compares the output of the up/ down counter with a reference value which is a 4 LOW bits (0000) and outputs a value HIGH if they are the same, otherwise a LOW.

**Output unit:** The output unit consists of the load which is the 4 filament bulbs, a thyristor and 5v /12v relay; here the thyristor was used to switch the light circuit via the relay.

**2.1 POWER SUPPLY STAGE**

All stages in this project uses +5V.The power supply stage is a linear power supply type and involves a step down transformer, filter capacitor, and voltage regulators, to give the various voltage levels. The power supply circuit diagram is shown in fig. 2.1.0

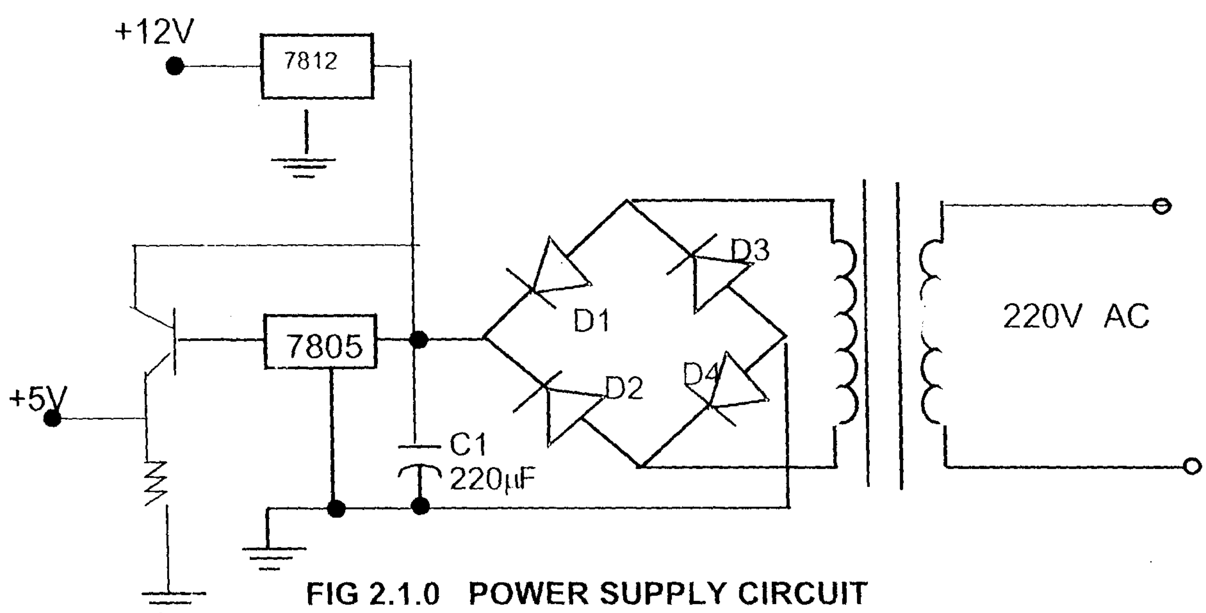



**FIG 2.1.0 POWER SUPPLY CIRCUIT**

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.

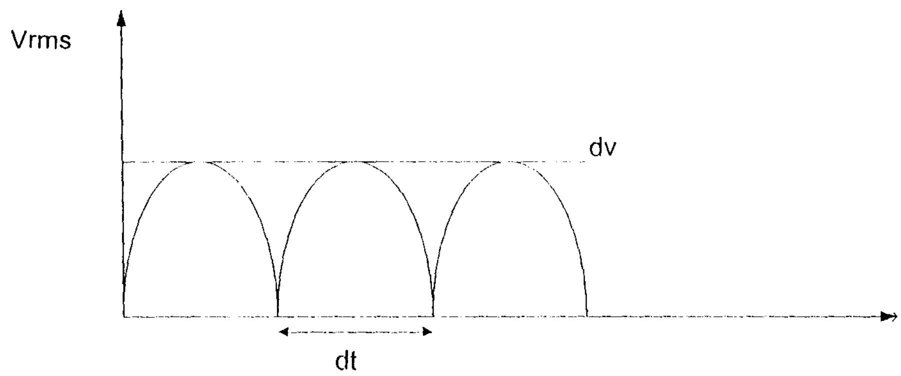



**Fig. 2.1.1 shows the ripple gradient**

Where,

dv is the ripple voltage for time dt,

dt is dependent on power supply frequency.

For an rms voltage of 12volts (from transformer)

Vpeak = 12 x √2 (i.e., rms x √2)

= 16.97V

Hence letting a ripple voltage of 25% makes dv = 4.24

But 1/C = dv / dt

C = dt / dv

= 10ms / 4.24V (where dt = 10ms for 50Hz)

= 2358.5μF

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

A 7806 Regulator was used for +5V supply. The transistor TIP41 that is used to buffer the output drops by 0.7V ($V_{BE}$) to reduce the +6 to 5.3V, which is approx. +5V and a 7812 regulator was used for the 12V supply generation.

## 2.2 BREAK BEAM DOOR SENSOR (IN AND OUT):

### 2.2.0 OPTO-DEVICES

Opto-devices convert light energy from one form to another. They are used for transmission of infrared rays, emission of light in different colors (i.e. LED's), sensing of light rays of different intensity (LDRs, photo diodes and phototransistors), and for the conversion of light to different electrical quantities like current, voltage and frequency. For this project, two infrared emitters were used and two receivers known as photo diodes.

### 2.2.1 OP-AMPS & COMPARATORS

An operational amplifier is a differential amplifier with an extremely high open voltage gain. Negative feedback circuits are employed in op-amps to control the gain when precise gain values are needed. The comparator an operational amplifier without a feedback. Hence, it is controlled by the open loop voltage gain.

The op-amp was originally developed for use with analog computers but now they found place in almost all aspect of electronics. The op-amp has the following ideal characteristics; Infinite voltage gain, Infinite input impedance, Infinite bandwidth.

In practice however there are deviations from ideal conditions due to manufacturing processes and other physical conditions the various components might be subjected to which make up the op-amps. Below shows the actual characteristics of μA741 op-amp.

Voltage gain - 106dB (numerical gain = 2000000.0)

Input impedance - 1MΩ

Output impedance - 7500Ω

Bandwidth - up to 1MHz

The voltage gain and bandwidth are two parameters that must be critically looked at, for successful application of this device. More information about the parameters could be gotten from IC data sheets

$V_{out} = A_0 V_{in}$

Where,

$A_0$ = open loop voltage gain and

$V_{in} = V^+ - V^-$

Due to the very high $A_0$, $V_{out}$ will tend to saturate upon any difference in input. Other op-amp circuits include, inverting and non - inverters amplifiers, summing amplifiers, unity gain buffers etc.

### 2.3 ONE SHOT MONOSTABLE:

#### 2.3.0 IC TIMERS.

The emanation of IC timers eliminated a wide range of mechanical and electromechanical timing devices .It also helped in the generation of clock and oscillator circuits.

Timing circuits are those, which will provide an output change after a predetermined time interval. This is, of course, the action of the monostable multi-vibrator, which will give time delay after a fraction of a second to several minutes quite accurately. The most popular of the present IC, which is available in an eight pin, dual in line package in both bipolar and CMOS form. The 555 timers is a relatively stable IC capable of being operated as an accurate bistable, monostable or astable multi-vibrators. The timer comprises of 23 transistors, 2diodes and 16 resistors in its internal circuitry. Its functional diagram is shown below in fig 2.3.0

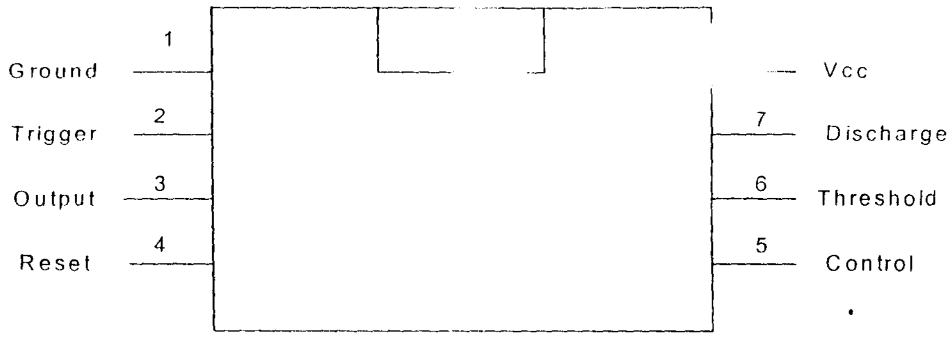



**FIG. 2.3.0 555 timer pin orientations**

The functional diagram consists of two comparators, a flip-flop, two control transistors and a high current output stage. The two comparators are actually operational amplifiers that compare input voltage to internal reference voltages which are generated by internal voltage divider of three 5K resistors.

The reference voltage provided is one third and two third of Vcc. When the input voltage to either of the comparators is higher than the reference voltage for the comparator, the amplifier goes to saturation and produces an output signal to trigger the flip-flop. The output of the flip-flop controls the output stage of the timer. The 555 timer chip works from a d. c. supply between 3-15V and can source or sink up to 200mA at its output.

The operation of the 555 timers is further explained by defining the functions of each of the pins and stating details regarding connection to be made to pins as follows.

Pin 1: This is the ground pin and should be connected to the negative side of the supply voltage.

Pin 2: This is the trigger input. A negative going voltage pulse applied to this pin when falling below 1/3Vcc causes the comparator output to change state. The output level then switches from LOW to HIGH. The trigger pulse must be of shorter duration than the time interval set by the external CR network other wise the output remains high until trigger input is driven high again.

Pin 3: This is the output pin and is capable of sinking or sourcing a load requiring up to 200mV and can drive TTl .cuits. The output voltage available is approximately -1.7V.

Pin 4: This is the reset pin and is used to reset the flip-flop that controls the state of output pin 3. Reset is activated with a voltage level of between 0V and 0.4V and forces the out put low regardless of the state of the other flip-flop inputs. If reset is not required, then pin 4 should be connected to same point as pin 8 to prevent accidental resetting.

Pin 5: This is the control voltage input. A voltage applied to this pin allows the timing variations independently of the external timing network. Control voltage may be varied from between 45 to 90 of the Vcc value in monostable mode. In astable mode the variation is from 1.7 to the full value of supply voltage. This pin is connected to the internal voltage divider so that the voltage measurement from here to ground should read 2/3 of the voltage applied to pin 8. If this pin is not used it should be bypassed to ground, typically use a 10nF capacitor. This helps to maintain immunity from noise. The CMOS ICs for most applications will not require the controlled voltage to be decoupled and it should be left unconnected.

Pin 6: This is the threshold input. It resets the flip-flop and hence drives the output low if the applied voltage rises above two-third of the voltage applied to pin 8. Additionally a current of minimum value 0.1 A must be supplied to this pin since this determines the maximum value of resistance that can be connected between the positive side of the supply and this pin. For a 15V supply the maximum value of resistance is 20M.

Pin 7: This is the discharge pin .It is connected to the collector of an npn transistor while the emitter is grounded. Thus, the transistor is turned on pin 7 is effectively grounded. Usually the external timing capacitor is connected between pin 7 and ground and is thus discharged when the transistor goes on.

Pin 8: This is the power supply pin and is connected to the positive of the supply. The voltage applied may vary from 4.5V to 16V although devices, which operate up to 18V, are available.

For this work, the 555 timer is used as a monostable multi-vibrator. It has one absolutely stable (stand by) state and one quasi-stable state. It can be switched to the quasi-stable by an external trigger pulse but it returns to the stable condition after a time delay determined by the values of the circuit components. It supplies a single output pulse of a desired duration for every input trigger pulse. It has one energy-storing element i.e. capacitor.

## 2.4 MEMORY LATCH AND LOGIC CONTROL UNIT:

### 2.4.0 FLIP FLOPS AND LATCHES.

Latches and flip-flops fall under memory latch and logic control circuits. The flip-flop may be defined as a 1 - bit memory element (or latch) having two outputs, which take up complementary states 0 i.e.0 and 1 when signal are applied to the input. The output condition would then be retained until another input signal combination causes the output stage to change.

Flip-flops generally formed the building block for IC Latches. Some of the widely used flip-flops are the SR (sit reset), JK, D and T-type flip-flops but the JK flip-flop is the most versatile of the various types of flip-flops since it can be used as a basic element to generate all the other types. Most flip-flops are designed using combinational logic circuits (i.e. logic gates etc) but in situations where large numbers of bits are involved, commercially available flip-flops become handy.

Examples of commercially available flip-flops are, 7474, 7473, and 7427, 74373, 74374...

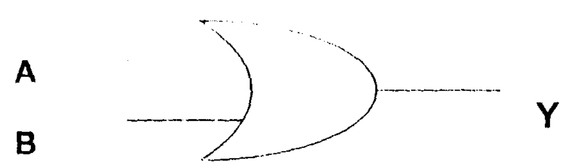
The 74374 are an 8-bit edge triggered register coupled to eight tri state output buffers. The two sections of the device are controlled independently by an external clock pulse (CP), and output enables OE to the gates.

The register is fully edge triggered and the state of each D (data) input one setup time before a low to high clock transition is transferred to the corresponding Q output of the flip-flop. The clock buffer has about 400mv of hysterisis built in to help minimize problems that signal and ground noise can cause in clocking operation.

A 7474 D flip flop was used in this circuit.

### 2.4.1 OR GATES (7432)

It has two or more inputs and one output. The output is HIGH when at least one of the inputs is HIGH and it is LOW when all its inputs are LOW. For a 2-input OR gate, the output is HIGH when either or both inputs are HIGH and LOW when both inputs are LOW The logic symbol and the truth table for a 2-input OR gate is shown fig 2.4.1below.




| A | B | Y |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 1 |

**Fig 2.4.1 Logic symbol and the truth table for a 2-input OR gate.**

OR gate have any number of inputs but the standard package usually contains four 2-input OR gate, three 3-input OR gate, and two 4-input OR gate.

### 2.4.2 SCHMITT TRIGGER OSCILLATORS (40106)

This is a monolithic complementary Metal Oxide Semiconductor (CMOS) IC, constructed with N and P-channel enhancement transistor. The positive and negative-going threshold voltages show lo riation with respect to temperature. Its features include Wide supply voltage range: 3V to 15V, High noise immunity, Low power TTL compatibility, Hysteresis, Equivalent to MM74C14 or MC14584B

## 2.5 UP/DOWN COUNTER

### 2.5.0 UP/DOWN COUNTER (74192)

A counter is a device, which stores (and sometimes displays) the number of times a particular events or process has occurred, often in relationship to a clock. The counter is a very important digital system. There are many types of counters, but their purpose is to count either in binary or binary coded decimal (BCD) the changing levels or pulses. The simplest and most common method of counting is by means of binary sequence of codes, e.g. for a three bits, the sequence 000, 001, 010, 011, 100, 101, 110, 111, then again 000, 001, ... and so on. A circuit, which follows the sequence in this order, is called an **up counter. A down counter** works with the reverse sequence 111, 110, 101, etc.

To count, the counter must remember the present number so that it can go to the next proper number sequence; therefore storage capability is an important characteristic of all counter and flip flops are normally used to implement them. The flip flops are connected together to perform counting operations and the number of flip flops used and the way in which they are connected determines the number of states as well as the specific sequence of states that the counter goes through during each complete cycle.

Counters are classified into two according to the way they are clocked. There are asynchronous counter and synchronous counter. in asynchronous counters, the first flip flop is clocked by the external clock pulse and then each successive flip flop is clocked by the output of the preceding flip flop. In synchronous counter, the external clock pulse is applied to all the flip flops so that they are clocked simultaneously.

Within each of these two categories, counters can be classified by the number of states, or the number of flip flops that makes up the counter. The MOD-10 counter is a decade counter; it is any counter that has ten distinct states, no matter what the sequence. A BCD counter is a decade counter which counts in sequence from 0000 (decimal zero) through 10001 (decimal nine) and it uses ten BCD code groups.

## 2.6 DISPLAY UNIT

### 2.6.0 BCD-TO-SEVEN SEGMENT DECODER (7442)

A decoder is a combinational circuit, which generates at its output all the $2^n$ canonical product terms of the n-signal connected to its inputs. The basic function of a decoder is to detect the presence of a specified combination of bits (code) on its inputs and to indicate the presence of that code by a specific output level. One and only one output of the decoder is selected for any combination of input signals. The decoder converts coded information such as the binary numbers into a non-coded form such as the decimal form.

The 7442 is used in this device to convert a 4-bit binary code into the appropriate decimal digits. It is a BCD-to-7 segment latch/decoder/driver, which is constructed with CMOS enhancement mode device. The decoder accepts the BCD code (4 binary numbers) on its input and provides output to drive seven-segment display device to produce a decimal readout. The four inputs to the 7442 is gotten from the output of the up/down counter 74192. The output of the decoder is fed to the seven-segment display, which indicates the decimal equivalent of the binary input. It helps in the decoding of the 4-bit BCD code into the seven outputs that are required to light the segments of the seven segment LED chip to produce a decimal readout.

produces a decimal readout.

### 2.6.1 SEVEN SEGMENT DISPLAY

Many electrical calculators, clocks, cash register and measuring instruments have seven segments red or green LED displays as numerical indicators, each segment is a LED and depending on which segments is energized. The display lights up the numbers 0 to 9.it is usually designed to work on 5v supply, each segment requires a separate current limiting resistor and all the cathode are joined together to form a common connection, its characteristics include small size, reliability, long life, small current requirement and high operating speed.

## 2.7 DIGITAL COMPARATOR

### 2.7.0 DIGITAL COMPARATOR (7485)

The 7485 is a high speed magnitude comparator that uses silicon-gate CMOS technology to achieve operating speeds similar to LSTTL with the low power consumption of standard CMOS integrated circuits. It is a four-bit magnitude comparator, which will perform comparison of straight binary or BCD codes. The circuit consist of either comparing input (Ao,A1,A2,A3,Bo,B1,B2,B3) three cascading input (A>B,A<B, and A=B)and three output(A>B,A<Band A=B).the device are expandable with external gathering in both serial and parallel fashion.

This device compares two four-bit words A and B, and determines whether they are equal for this project. One of the four-bit word is coming from the output of the up/down counter and the other is the reference ground voltage. When the input to the comparator from the up/down counter is zero that means the two inputs to the comparator are equal and the lamp goes off otherwise the lamp is on.

## 2.8 OUTPUT

### 2.8.0 FOUR FILAMENT BULBS

These refer to the room light bulbs that were used to indicate person's entrance and exit to and from the room, it consist of four 10 watt bulbs housed and connected to the automatic light switch.

### 2.8.1 RELAY

A relay is a switch operated by an electromagnet; it is useful if we want a small current in one circuit to control another circuit containing a device such as a lamp or electric motor which requires a large current, or if we wish several different switch contacts to be operated simultaneously. In this project, a relay was used to control the switching effect of the bulbs used. The diagram below, fig 2.8.1 shows the symbol of a relay. The current needed to operate a relay is called the pull-in current and the dropout current is the current in the coil when the relay just stops working.

If the coil resistance of a relay is R and its operating voltage is V, then, the pull-in current $I = V/R$

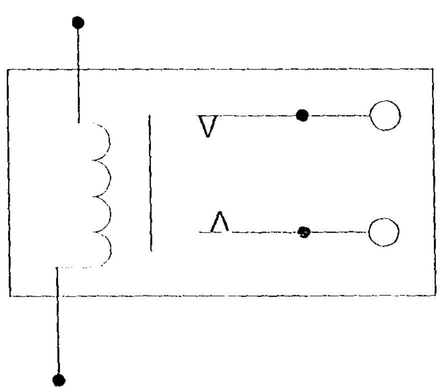


**Fig. 2.8.1 relay**

### 2.8.2 THYRISTOR.

A thyristor is a four- layer, three -terminal semi conducting device, it used to be called a silicon controlled rectifier (SCR) because it is a rectifier which can control the power supply to a load and in a way that wastes very little energy.

When forward biased, a thyristor does not conduct until a positive voltage is applied to the gate. Conduction continues when the gate voltage is removed and stops only if the supply voltage is switched off, or reversed or the anode current falls below a certain value.

For this device, the process of making the room light goes off when nobody is in the room was achieved by using a thyristor to switch the relay.

## 2.9 OTHER PASSIVE COMPONENTS

Passive components are components, which cannot amplify power and require an external power source to operate. They include resistors, capacitors, diode, indicators, and transformers etc. their application range from potential dividers to control of current (as in resistors), filtration of ripples voltages and blocking of unwanted D.C voltages (as in capacitors). They form the elements of the network circuit oscillator stages and are also used generally for signal conditioning in circuits. Their schematic diagrams and symbols are shown in fig 2.9.0 below.

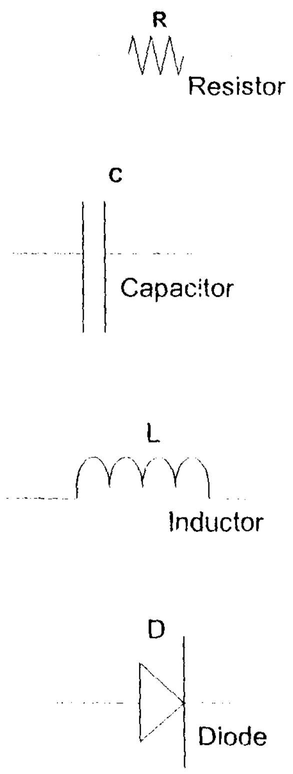



**Fig. 2.9.0 schematic representation for passive components.**

## 2.10 PRINCIPLE OF OPERATION

This project works on the principle of breaking and making of an Infrared beam of light. It consists of two transmitting, two receiving and two one-shot monostable stages. The first one is for someone coming in while the second is for going out of the room. The comparators give a LOW when the beam is being broken and a HIGH when transmitting normally. The LOW output of the comparator is used to trigger the one-shot monostable multi-vibrator, which is also connected to a D flip-flop, the logic gates, up/down counter and the output. The light will be ON if the output of the up/down counter is not equal to zero and OFF if the output of the up/down counter gets back to zero by last person leaving the room.

Explaining this operation using the circuit diagram:

There are two sensors; sensor (A) in front of the door and sensor (B) behind the door. Someone entering the house will break sensor (A) first and triggers IC4 monostable. When this happens, IC2 is inhibited so that when the person enters the door sensor (B) will not trigger the counter. IC4 also trigger a flip-flop in set mode, which keeps Q at 1 and $\overline{Q}$ at zero. Q at 1 goes to IC11, which is an OR gate hence irrespective of the other input, the output will be HIGH. This is because the up down counter (IC 9) has two clock inputs (one for count up and the other for count down and the un-used clock input must be HIGH for count up or down to take place). Hence IC11 when high keeps the count down clock input high and IC12 does the checking.

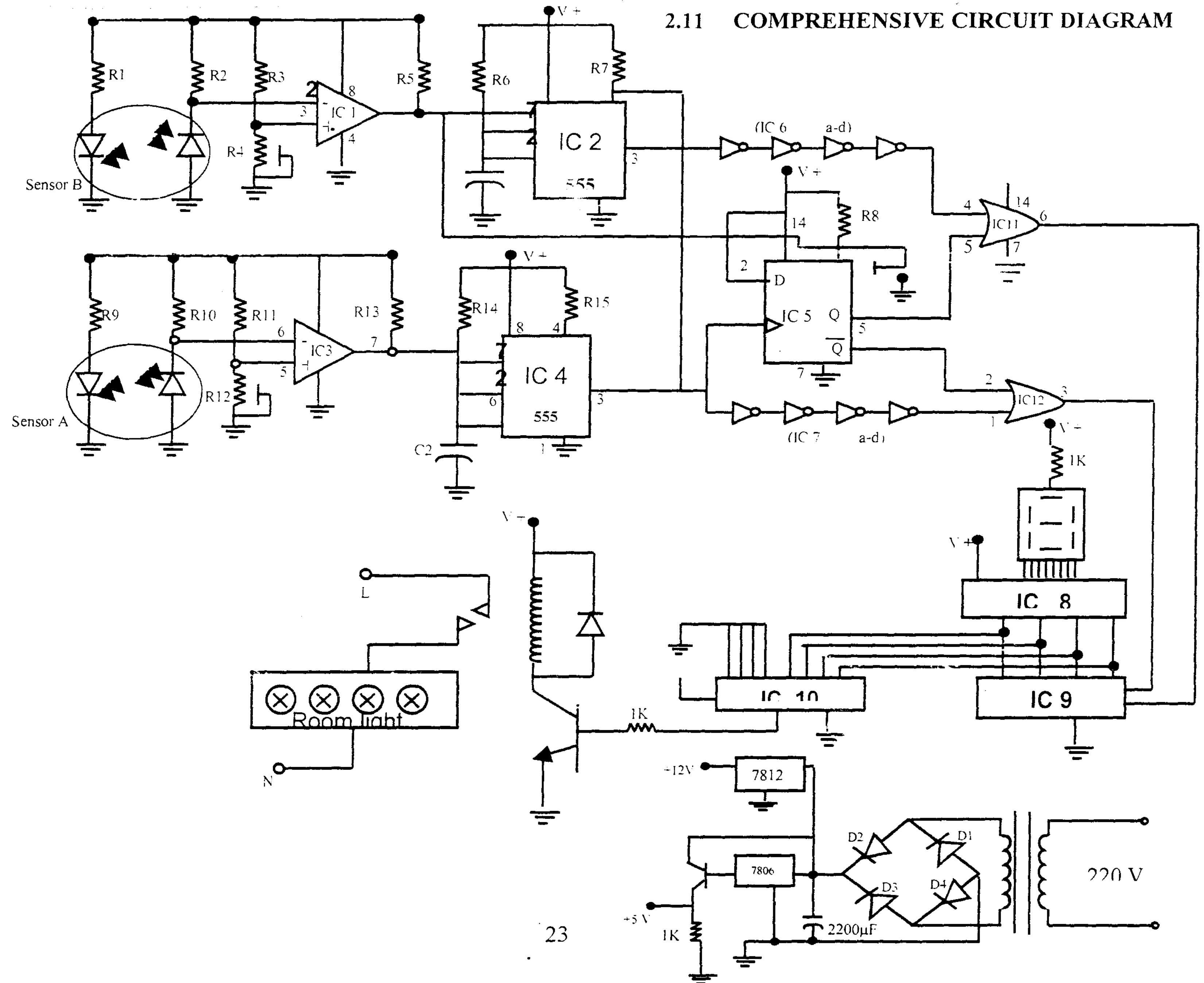
Once clocked the counter counts up; clocking takes place each time somebody enters or leaves the room.

Once there is any count the comparator compares the counter output (i.e IC9) with zero, and once there is any count the comparator output is zero and that lights come on.

In a situation where 4 people enter the room, the counter counts 4. The first person entering already triggered the lights ON. If two people out of the four leaves the room the counter would count down to two, which means there are still people inside the room. If the remaining two people leave, the count will reduce to zero and switch OFF the lights.

In summary each person entering the room triggers an UP counter and each person coming out triggers a DOWN counter. The lights go off only when the not count is zero (i.e. when there is nobody in the room).

## 2.11 COMPREHENSIVE CIRCUIT DIAGRAM



### 2.11.1 COMPONENTS LIST

D1 = TSUS 5400 Infrared Transmitter

D1 = BPW 41 - Photo diode

| | | |
|---|---|---|
| R1, R9 | - | 33Ω |
| R2, R10 | - | 1M |
| R3, R11 | - | 1K |
| R4, R12 | - | 2.2K |
| R5, R13 | - | 1K |
| R6, R14 | - | 100K |
| R7, R15 | - | 1K |
| C1, C2 | - | 10μF |
| IC1, IC3 | - | LM393 |
| IC2, IC4, | - | NE555 timer |
| IC5 | - | 7474 (D flip flop) |
| IC6, IC7 | - | 40106 (Schmitt trigger) |
| IC8 | - | 7447(BCD to seven segment decoder) |
| IC9 | - | 74192 (up/down counter) |
| IC10 | - | 7485 (magnitude components) |
| IC11A, IC11B | - | 7432(quad OR gate) |
| C4 | - | 3300μF 50V |

## 2.12 DESIGN CALCULATIONS

### 2.12.0 TRANSMITTER STAGE

The transmitter stage is not too complex since no coding is involved. The infrared diode is forward biased to meet the electrical conditions, which it operates. The transmitter is as shown in Fig. 2.12.0 below

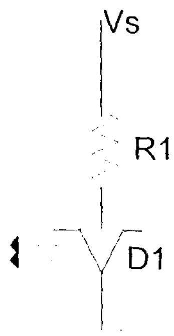



**Fig. 2.12.0 The Transmitter Stage**

D 1 is the opto device (infrared diode) while

R1 is the limiting resistor.

V+ is gotten from the power supply and is +5V

For the diode to be forward biased, the maximum forward voltage,

$V_F$ = 1.7V and maximum forward current, $I_F$ = 150mA

The resistor R will therefore be,

$$R_1 = \frac{(V+) - (V_F)}{I_F}$$

$$R_1 = \frac{5-1.7}{150mA}$$

$= 22\Omega$

A preferred of 33 is used for $R_1$ as well as $R_2$.

Once forward biased the transmitter emits infrared rays projected at an angle of about $60^0$ from its current surface.

**2.12.1 RECEIVER / AMPLIFIER STAGE**

The receiver is shown in Fig. 2.12.1(a) below. The circuit employs the use of a photodiode receiver and amplifiers to enable its output drive other stages.

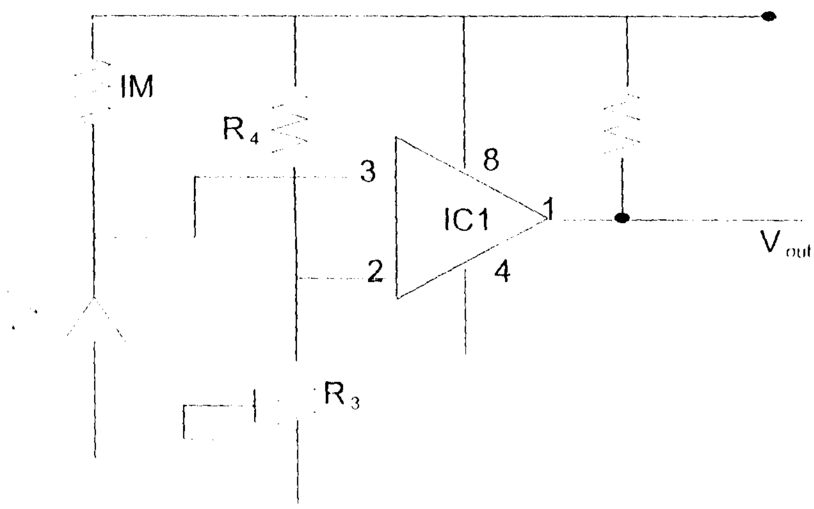



**Fig. 2.12.1(a) The Receiver or Amplifier Stage**

The photo diode was used as the main opto sensor due to its ability to resist day light interference better than the other optical devices mentioned.

The photodiode is operated in reverse biased condition. In darkness the photodiode has a high resistance hence a low forward current.

The change in resistance causes a change in the drop across R2, which is fed to the input of the comparator ICl.

The resistance measured from the photodiode when there is no transmission is approximately 1MΩ. Fig 2.12.1(b) shows the potential divider network formed using the photodiode and the resistor $R_1$ and $R_2$.

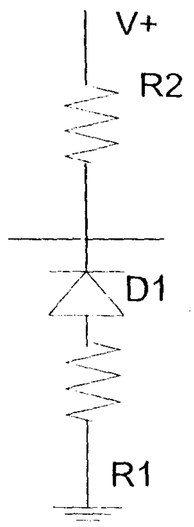



**Fig.2.12.1(b). Potential Divider**

$R_2$ is set at 1MΩ (to allow in appreciable drop)

At V+ =5V,

the drop across $R_2$ will be (R2 * V+)/($R_1$ + $R_2$)

if $VR_2$ is the drop across R2

$$\Rightarrow VR2 = \frac{1M\Omega \times 5V}{1M\Omega + 1M\Omega}$$

= 2.5V

### 2.12.2 ONE SHOT MONOSTABLE STAGE.

The one-shot monostable stage generates one shot of clock pulse each time the sensor detects somebody entering the door. The one-shot monostable is triggered from the output of a comparator, which senses the breaking of the beam and sends it clock to the input of a counter to show the count. Fig 2.12.2 shows the one shot monostable.

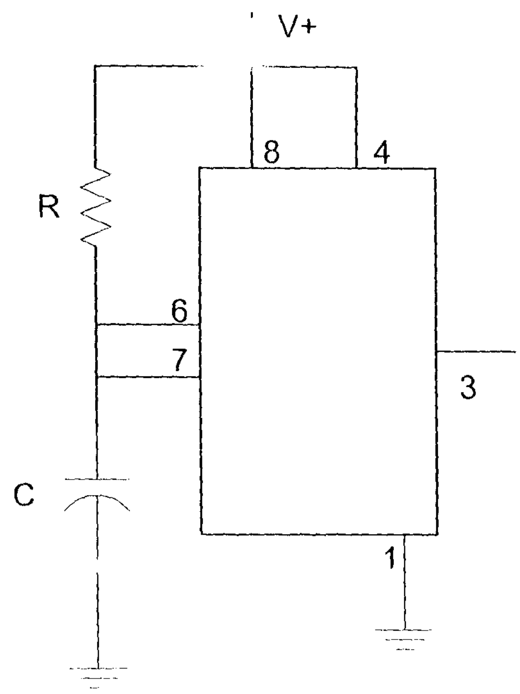



**Fig.2.12.2 one-shot monostable.**

Since T = 1.1RC, and the time duration of the monostable is 10s.

(To allow for fast triggering of the counter).

Letting C=100uF,

Gives R = 10/ 1.1x100uf

= 90.9K

A preferred value of100K was used for $R_6$.

### 2.12.3 COUNTER CALIBRATOR

The counter calibrator generates the sequence and this fed to the counter. The counter calibrator is an astable 555 timers. The counter calibrator circuit is shown in fig. 2.12.3.

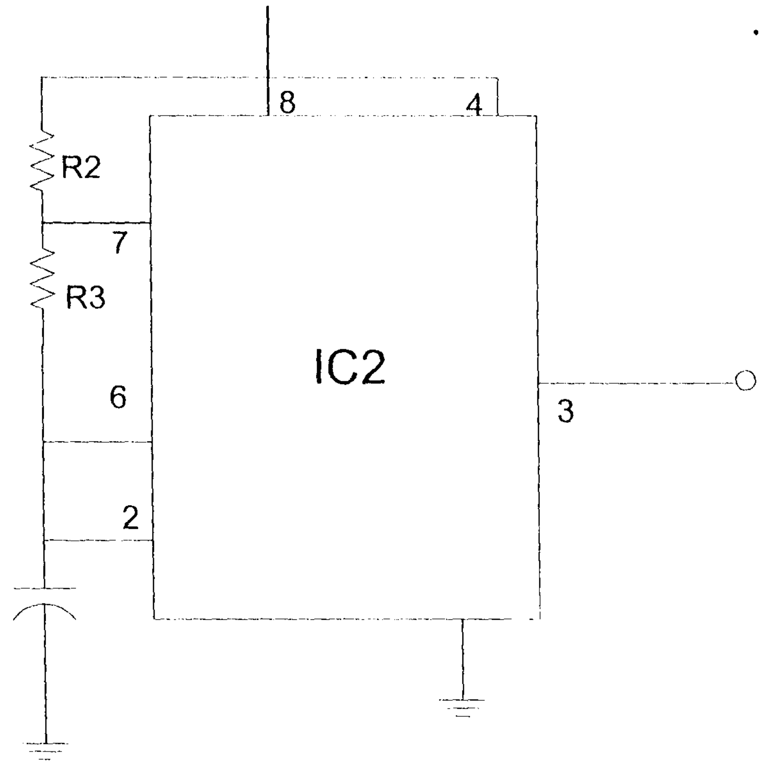



**FIG. 2.12.3 COUNTER CALIBRATOR**

Since VCO center frequency is 500Hz, at maximum voltage input frequency count should be 1 KHz.

For the frequency counter to display the appropriate frequency, the counter must count for duration of 1s.

For T=1s,

F=1/T

=1Hz.

Given that,

F= 1.44/ (R1 + 2R2) C.

For duty cycle of the output waveform to be symmetrical, $R_B$ (= $R_3$) must be > $R_a$ (= $R_2$), hence letting

$R_2$ = 1k and C = 10μF, implies that

$$R_B = \frac{1.44}{FC} - R_A$$

$$= \frac{(1.44 - 1K)}{(1 \times 10\mu F)} /2$$

$$= 71.5K\Omega$$

a preset resistor of 100KΩ was used.

Hence $R_2$ = 1k, $R_3$ = 100k (preset) and C = 10μF.

### 2.12.4 MEMORY LATCH AND LOGIC CONTROL

This stage comprises of a D-type flop-flop (7474) and an AND gate (74LS32).

Since the data input is HIGH and the Reset input is receiving a high from the second comparator (IClb) data (D - input) is moved to output when clock pulses arrives at the flip-flop input.

This data is held at the output (and fed to the input of IC5 to enable it) until the person passes through the second sensor. At this point, the reset input gets a low and resetting action takes place.

The operation of the flip-flop can best be described in table 2.12.4

| | INPUTS | | | OUTPUTS | |
|---|---|---|---|---|---|
| OPERATION MODE | CK | D | Rs | Q | |
| SET | | 1 | 1 | 1 | 0 |
| RESET | | O | 1 | 1 | 0 |
| ASSYCHRONOUS SET | X | X | 0 | 0 | 1 |
| ASSYCHRONOUS RESET | X | X | 0 | 0 | 1 |

**Table 2.12.4 Truth Table for D-Type Flip-Flop**

The system is set to operate set and asynchronous set modes.

## 2.12.5 SWITCHING TRANSISTOR STAGE FOR RELAY.

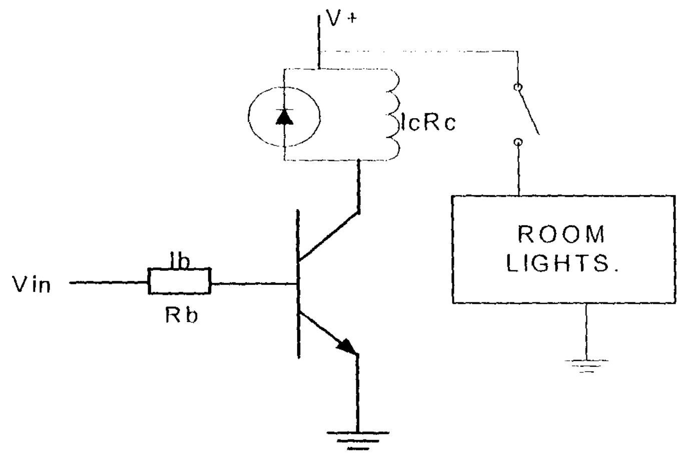



**Fig. 2.12.5: Switching Transistor for Relay**

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 battery)

Vbe = 0.6V (sillicon)

Vce = 0V (when transistor is switched)

Vin = 10.3V (from the timer output)

Hfe = 300 ( from data sheet for BC337)

since,

$V_{+} = I_c R_c + V_{CE}$ .....................(1.0)

$V_{in} = I_B R_B + V_{BE}$ ---------------(2.0)

$$\frac{I_C}{I_B} = h_{fe} \qquad \text{---------------(3.0)}$$

$$R_b = \frac{V_{in} - V_{BE}}{I_B} \qquad \text{-----------------(4.0)}$$

Where,

$I_C$ = collector current

$I_B$ = base current

$V_{in}$ = input voltage

$V_t$ = supply voltage

$V_{CE}$ = collector-emitter voltage

$H_{fe}$ = current gain.

From 1.0, $12 = IcRc + Vce$

$12 = Ic(400) + 0$ and,

$Ic = 30mA$

From 3.0 . $I_B = 30mA/300$

$= 100uA$

From 2.0, $10.3 = 100uAR_B + 0.6$

$R_B = 9.7/100uA$

$= 97K\Omega$

$R_B = 100K\Omega$ (Preferred value)

## CHAPTER 3

## CONSTRUCTION, TESTING AND RESULTS.

### 3.0 CONSTRUCTION

The construction of this project was done in two different stages: the soldering of the circuits and the coupling of the entire project to the casing.

The power supply stage was first soldered before the infrared transmitter, receiver stage and other stages were soldered. The soldering of the circuit was done on a Vero board. The second phase of the project construction is the casing of the project. This project was coupled to a metal casing. The casing material being stainless steel designed with special perforation and vents to ensure the system is not overheating and to give ecstatic value.

Fig 3.0.1 Components layout on Vero board 1

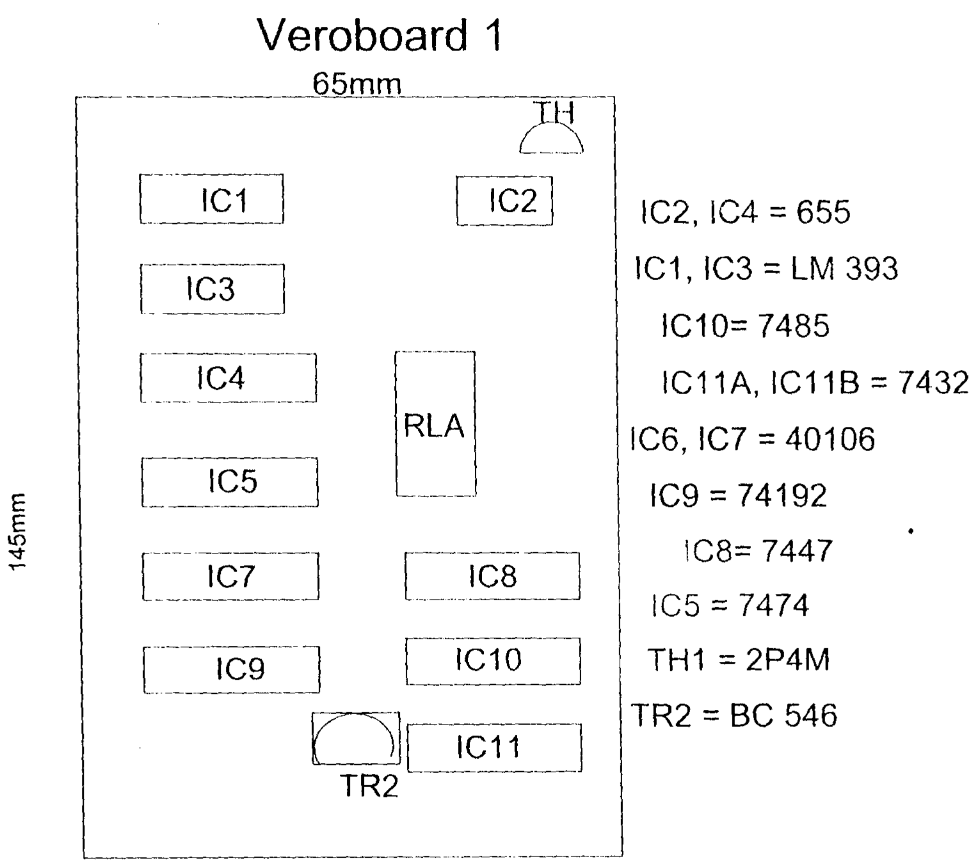



**Fig 3.0.1Components layout on Vero board 1**

## Veroboard 2 Power Circuit

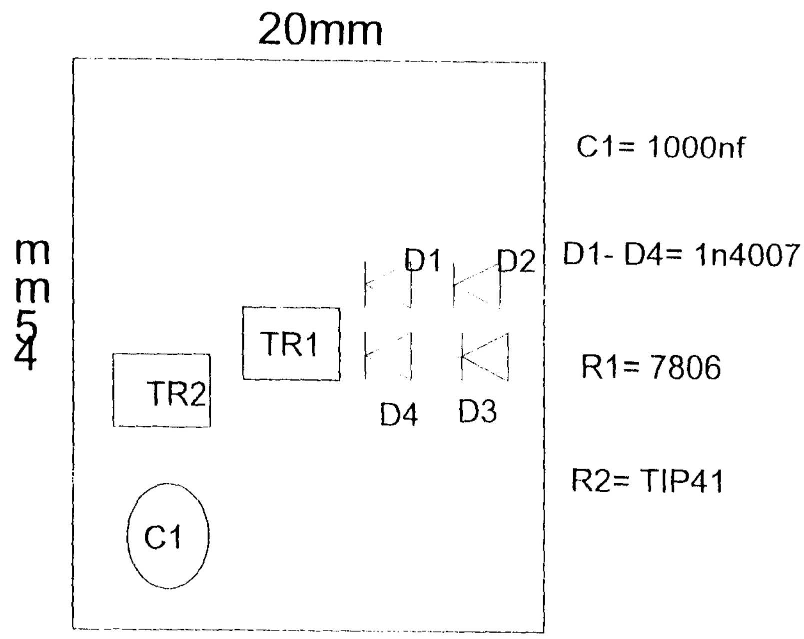



**Fig 3.0.2 Components layout on Vero board 2**

## Casing

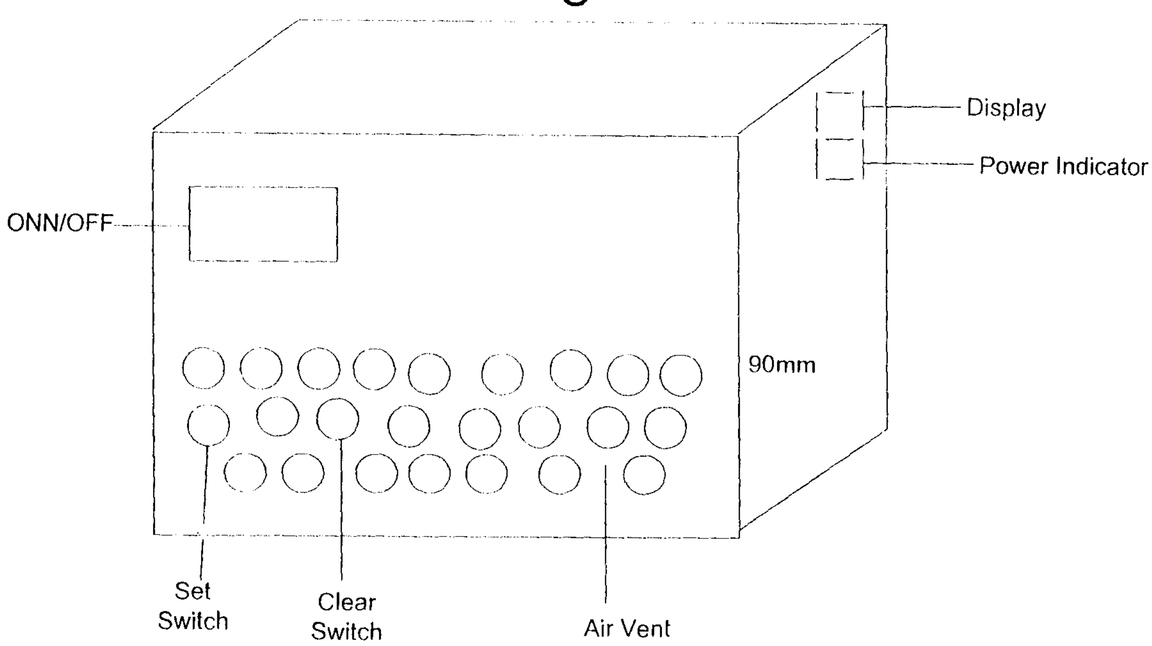



**Fig 4.2 isometric view of finished project.**

## 3.1 TESTING

The physical realization of this project is very vital. This is where the fantasy of the whole idea meets reality: I e work is not only realized 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 various circuits and stages were soldered to meet desired workability of the project.

Connecting the plug to the main power supply turned on the device then the device was tested as follows

1. When an object broke the infrared radiation received by sensor A to show that one person has entered the room.
2. When the infra - red radiation received by sensor B was broken to show that the person inside the room is out.
3. When the infra - red radiation received by sensor A was broken twice with an interval of 10sec.
4. When the up/down counter is reset and the infra - red radiation received by sensor A was broken twice with an interval less than 10sec.
5. The infra - red radiation received by sensor A was broken ten times with interval greater than 10sec for the ten different breaks.

## 3.2 RESULTS

The following results were gotten for the processes being tested as stated above.

1. When the infra - red radiation received by sensor A was broken, the

seven segment display showed 1, and the bulb goes on.

2. When the infra - red radiation received by sensor B was broken, the seven segment display showed 0, and the bulb goes off.

3. With this test, the seven segment display showed 2 and the bulbs remained on.

4. With this test, the seven-segment display showed 1, which implies that only one person was inside the room; this shows that the device cannot be used for interval less than 10sec.

5. With this test, after the ninth breakage of the infra - red radiation received by sensor A, the seven segment display showed 9 and the bulbs were still on. On the tenth breakage, the seven-segment display showed 0 (zero), and the bulb goes off. This shows that the device cannot be used for more than nine people.

# CHAPTER FOUR

# CONCLUSION AND RECOMMENDATIONS

## 4.0 CONCLUSION

This project, which is the design and construction of an Automatic room light switch has been successfully designed and constructed. The performance of the project after test met design specifications; therefore the aim has been achieved. 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.

All components were soldered on one Vero board, which makes troubleshooting easy.

The design and construction of this project was done considering some factors such as economy, availability of components and research materials, efficiency, compatibility, portability and durability. The general operation of the project and performance is dependent on the presence of the person entering the door and how close he is to the door. The light is meant to switch on automatically.

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, more knowledge and understanding on 555 timers ICs, logic control circuits, relays and opto-devices (e.g. photodiode, photo cells etc) has been acquired.

However, like every aspect of engineering there is still room for improvement and further research on the project as suggested in the recommendations below.

## 4.1 RECOMMENDATIONS.

1. I would recommend that this project work be used in homes, halls, auditoriums, etc. if possible work be done on it to reduce the size so it can be handy and can easily be commercialized.
2. A backup power supply be designed since the system cannot work without constant supply just like any other automatic system (e.g. an inverter, ups or a standby generator)
3. A software model of the design should be done to enable further research and improve the performance of the system.
4. The department should acquire more research-oriented books in the departmental library, to make enough materials available for students to use.

## REFERENCE

1 B.L. THERAJA and A.K. THERAJA (1999); A TEXT BOOK OF ELECTRICAL TECHNOLOGY (general references) Published by S.CHAND & COMPANY LTD.

2 D.I. CRECRAFT, D.A. GORHAM &. J.J. SPARES (1993): ELECTRONICS (pp 276-280, counters, pp 227-228, and seven segment display) by NELSON THORNES LTD.

3 EYITEMI FELIX (2003); "LIGHT DIMMER WITH AUTOMATIC SEQUENTIAL LIGHT INTENSITY CONTROL" (final year project, FUT MINNA -general references)

4 TOM DUNCAN (2001); SUCCESS IN ELECTRONICS (pp 44-75, other passive components, pp107-119, op-to devices and transducers, pp 121-122, relays, pp115-116, seven segment display, pp 369 thyristor). Published by LONGMAN