DESIGN AND CONSTRUCTION OF AN AUTOMATIC ROOM LIGHT CONTROL USING LIGHT SENSITIVE SWITCH

BY

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SUBMITTED TO

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NOVEMBER, 2010

DECLARATION

I hereby declare that this project is my original work, supervised by Mr Stephen S. Oyewobi and to the best of my knowledge has never been presented by any student in any form of award of degree, but the works of others are acknowledged.

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23/11/2010

Oyebamiji Abayomi Moses Date

2005/23272EE

CERTIFICATION

This is to certify that this project is an original work carried out by Oyebamiji Abayomi Moses. It was carried out in accordance with the rules and regulation of the Deparment of Electrical and Computer Engineering, Federal University of Technology, Minna.

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Examiner — Date

DEDICATION

I dedicate this work to God All-mighty, my parents, Pastor and Deaconess Kola Oyebamiji, for their love and support, my siblings, Mr Tayo, Dr Deji and Miss Bukky, my friends, Tolu, Dare, Kehinde, Dunke, Maria, well wishers course mates, lecturers and my supervisor for his guidance towards the success of this work.

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I wish to use this medium to thank God Almighty who has seen me throughout my stay in this great Institution.

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ABSTRACT

This study deals with the design and construction of an automatic room light control using light sensitive switch so as to use energy much more efficiently. It helps to switch on the lighting in a room when it is occupied and switches off when the room is not occupied. Testing was carried out to ascertain the efficiency of the design. The result of this testing shows that more than one person can occupy a room at a time with the light staying on until the fifth person who resets the counters. Also when a person leaves the room, the system will retain the on state of the light if there is still someone in the room or switch off the light if there is no one in the room.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 BACKGROUND TO THE STUDY

Engineering is all about making life easier through the application of science for the designing and building of machine and structure. In a bid to do this, various researches are carried out and are still being carried out to understand phenomena around us and through the application of these understanding, complex methods can be carried out through easier means and methods. An example of this is switching.

Due to not too recent field of automation, there is need to condition the factors on which a switching process depends such that the switch is self regulatory. The advantage of this is that the need for mechanically operating the switch is eliminated and it is more convenient.

It is a major task of every household, company and industry to save energy by using it more efficiently. This could benefit individuals and the country as a whole. An aspect of energy saving and efficient energy usage is examined here for implementation without disruption of any activities or putting security at risk, yet allowing persons still to feel comfortable in the new environment. Along this line, an automatic light control system for houses, offices and industry is developed.

This is an LDR (Light Dependent Resistor) based circuit. The darkness resistance of an LDR is of the order of a few Mega-ohms, while its resistance in the presence of light drops to a few Kilo-ohms. It is this inherent property of an LDR that is employed with other components to control the switching of a light unit.

In order to save energy, security lights, office lights and other lightings which are always used are – in most cases usually manually switched off in the morning and again switched on in the evening. A sensitive electronic control system is suggested that can take care of automatic light activation. It consist of photoresistor sensors and a control circuit, which can be used to switch important lighting points on or off, depending on the detection and motion of objects through the line of sight of the incident light on the photoresistor sensor. Also by using energy saver bulbs, efficiency of the system is further enhanced.

Very often lights remain unnecessarily switched on in a room or office, mainly through negligence. For this reason this control system has been designed for monitoring any activity of persons so that the desired light is maintained where required and the undesired ones are switched off. This system comprises a number of photoresistor sensors installed in a room or an office and an electronic control circuit. When the person enters the room, the sensor will automatically switch on the lights. If anyone leaves a room, a motion sensor monitoring the exit to the room sends a signal that switches off the lights.

The control systems use common electronic component, in this way simplifying and reducing the cost of the equipment. Statistically, it is estimated that energy consumption in homes and offices may be reduced by half to one third [ ] of the usual consumption by manual light control. For this reason any investment in an automatic light control system will yield quick returns. Not only does it save energy but also makes life at home or work more comfortable and efficient.

1.3 AIM AND OBJECTIVES

The energy consumed by lighting generates approximately 13 percent (13%) of a standard store's greenhouse gas emission – almost 90 percent (90%) of which is from internal lighting [ ]. Use of lighting control could reduce actual consumption further.

This project points to major potential energy savings, with relatively low payback times from investments in end-use efficiency in building. The rest points to major opportunity for saving energy and reducing the environmental and health cost of energy in Nigeria.

1.3.1 ECONOMIC IMPORTANCE

Every business needs an energy management plan. Cost savings from energy efficiency can exceed 20 percent (20%) [ ]. Energy management is good for the environment; the most effective way to reduce greenhouse gases is to reduce unnecessary energy consumption. A sound approach to energy efficiency is good for any business; energy management should be viewed as one more aspect of good management within any organisation.

There are many low-cost and no-cost ways to become more energy efficient in the work place and in the home; this project being one of such ways to achieve better energy efficiency.

1.4 JUSTIFICATION OF THE STUDY

As a context for understanding the potential to improve energy efficiency in Nigeria, it is useful to consider the overall energy intensity (energy use per unit of GDP) of Nigeria in comparison to other countries. While energy intensity is influenced not only by economic structure (how reliant the economy is on energy intensity sectors) but also on end-use efficiency [ ].

Many low-income households use less than 100kWh of electricity per month [ ], and hot water geysers and electric cooking appliances are uncommon in such households. This implies that much of the electricity use is for lighting and that energy – efficient bulbs and automatic light switches could markedly reduce electricity bills.

Efficient lighting practices include switching off lights when a room is unoccupied, fitting low power light bulbs where possible and controlling security lighting with light and movement sensors. It is estimated that incandescent lighting energy use can be reduced by 20 percent (20%) through efficient lighting practices [ ], but it is assumed that realistically achievable savings are 10 percent (10%) of the total electricity lighting energy [ ].

1.5 METHOD OF OPERATION

An ordinary automatic room power control circuit has only one light sensor. So when a person enters the room it gets one pulse and the lights come 'on'. When the person goes out it gets another pulse and the lights go 'off'. But what happens when two persons enter the room, one after the other? It gets two pulses and the lights remain in 'off' state. The circuit described here overcomes the above-mentioned problem. It has a small memory which enables it to automatically switch 'on' and switch 'off' the lights in a desired fashion. The circuit uses two LDRs which are placed one after another so that they may separately sense a person going into the room or coming out of the room. Outputs of the two LDR sensors, after processing, are used in conjunction with a bicolour LED in such a fashion that when a person gets into the room it emits green light and when a person goes out of the room it emits red light. These outputs are simultaneously applied to two counters. One of the counters will count as +1, +2, +3 etc when persons are getting into the room and the other will count as

-1, -2, -3 etc when persons are getting out of the room. The next stage comprises two logic ICs which can combine the outputs of the two counters and determine if there is any person still left in the room or not. If the results from the logic ICs suggest that there is still someone in the room, the lights will be maintained at the 'on' state, but if otherwise, a relay will be triggered to switch off the lights.

1.6 LIMITATION TO THE STUDY

The limitations of the project are as follow:

1. The circuit design is not suitable for monitoring rooms having multiple entrance and exit points. It is mostly efficient for a room possessing a single door which serves as the entrance and exit point.
2. The circuit design can only cater for a maximum of four (4) people in a room at any given time, thereby making it unsuitable for large buildings with lots of human traffic.

Since LDRs are used as the sensors, care should be taken to protect them from ambient light. If this is not accomplished, there will be certain inaccuracy in response to the changes in light intensity falling on it.

CHAPTER TWO

2.0 LITERATURE REVIEW

The process of switching a lighting system ON or OFF by means of a self-regulatory circuit which depends on the response of a sensory element to a natural phenomenon is not entirely a new field. There are various sensory elements which have been used one time or the other. Specific resistance at any time changes with prevailing light condition. An LDR is very sensitive from full light intensity to extreme darkness.

2.1 THEORITICAL BACKGROUND

The entire system was broken down into sub-systems or unit blocks. Each sub-system performs a specific task. It consist various components with each working together to achieve the desired goal. By the integration of all the functional unit blocks, the automatic switching control system satisfies the overall requirement of the project.

The advantages of partitioning or breaking down a whole system into sub-systems are:

- Ease of Design
- Ease of Maintenance
- Ease of Production
- Ease of Troubleshooting
- Ease of Reliability

The sub-systems consist of four units as shown in Fig 2.1, namely:

- Power Supply Unit
- Control/Sensory Unit
- Switching/Logical Unit
- Load

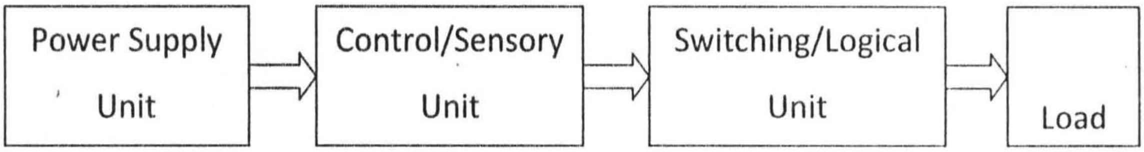


Fig 2.1: Block Diagram of The Sub-systems

2.2 Power Supply Unit

Almost, if not all electronic devices use highly stabilized and regulated D.C Power Supply to power them. Dry cells and batteries are forms of D.C sources and have the advantage of being portable and ripple free. However, they are usually not economical, convenient and dependable due to the need for frequent replacement. Hence making them expensive as compared to conventional A.C supply. It is advantageous to convert this A.C supply to DC voltage. Therefore, the requirement of this project makes use of a regulated power supply unit which will convert the available mains AC power supply (220v/50Hz) to the required form (DC power supply-9v and 5v). In spite of likely variations that may occur in the line voltage, the load current and the temperature, the output D.C must be impeccably maintained at 9v as required by the circuitry of this project.

The process of converting the A.C voltage involves voltage transformation, rectification, filtration and voltage regulation, all of which are accomplished by the use of transformer, a rectifier, a capacitor and voltage regulator circuit. The arrangement of which is shown in Fig 2.2.

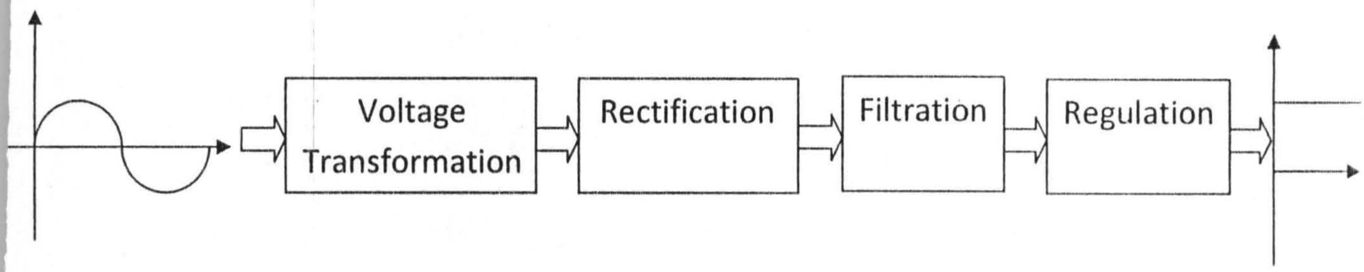


Fig 2.2: Power Unit

2.2.1 Voltage Transformation

A transformer is a static (or stationary) piece of apparatus by means of which electric power in one circuit is transferred into electric power of the same frequency in another circuit. It can raise or lower the voltage in a circuit but with a corresponding decrease or increase in current. The physical basis of a transformer is mutual induction between two circuits linked by a common magnetic flux as shown in Fig 2.3. In its simplest term, it consists of two inductive coils which are electrically separated but magnetically linked through a path of low reluctance. The two coils possess high mutual inductance. If one coil is connected to a source of alternating voltage, an alternating flux is set up in the laminated core, most of which is linked with the other coil. If the second coil is closed, a current flows in it and so electric energy is transferred (entirely magnetically) from the first coil to the second coil. The first coil, in which electric energy is fed from the A.C supply mains, is called primary winding and the other from which energy is drawn out, is called secondary winding.

An ideal transformer is one which has no losses (that is its windings have no ohmic resistance, no magnetic leakage, no I^2R and core losses. In other words, an ideal transfer consists of two purely inductive coils wound on a loss-free core. However, it is impossible to realize such a transformer in practice.

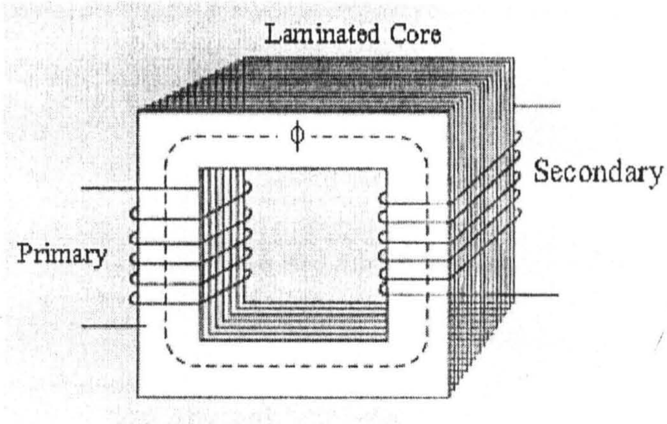


Fig 2.3: A Transformer

Let N_1 = Number of turns in primary

N_2 = Number of turns in secondary

Φm = Maximum flux in core in Webers

f = Frequency of A.C input in Hz

Flux increases from its Zero value to maximum value (Φm) in one quarter of a cycle (i.e. ¼f second)

$$Average\ rate\ of\ change\ of\ flux = \frac{\emptyset m}{1/_{4f}}$$

$$= 4f\emptyset m\ Wb/s$$

Rate of change of flux per turn means induced e.m.f in volts

$$Average\ e.m.f/turn\ = 4f\emptyset m\ volt$$

If flux Φ varies sinusoidaly, then r.m.s (Root Mean Square) value of induced e.m.f is obtained by multiplying the average value with the form factor (1.11).

$$r.m.s\ value\ of\ \ e.m.f/turn = 1.11 \times 4f\emptyset m$$

$$= 4.44f\emptyset m\ volt$$

In the primary winding, the r.m.s value will be

$$E1 = 4.44fN1\emptyset m - - - - - - - - -(i)$$

Similarly, in the secondary, the r.m.s value will be

$$E2 = 4.44fN2\emptyset m - - - - - - - - (ii)$$

From equations (i) and (ii), it can be seen that

$$E2/_{E1} = N2/_{N1} = 4.44f\emptyset m = K$$

K is known as voltage transformation ratio. If K is greater than 1 (i.e. $K > 1$) then the transformer is a step-up transformer. But if it is less than 1 (i.e. $K < 1$) then the transformer is known as a step-down transformer. Also, for an ideal transformer, input VA = output VA

2.2.2 Rectification

This is the process by which A.C voltage is converted into D.C voltage with the use of a rectifier. A rectifier is an electronic device which offers a low resistance to flow of current in the direction known as the reverse bias direction. Rectifier can be half-wave depending on the application. In this project, emphasis is laid on the full-wave bridge rectifier which is the most frequently used circuit for electronic D.C power supplies. It consist of four (4) discrete diodes incorporated together to form bridge rectifier circuit.

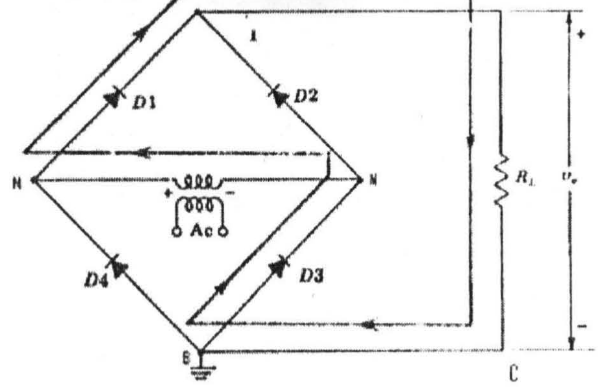


Fig 2.4: Full wave bridge rectifier

When input A.C supply is switched on as shown in Fig 2.4, the ends M and N of the transformer secondary become +ve and –ve alternatively. During the positive half-cycle of the AC input, terminal M is +ve, C is at Zero potential and N is at –ve potential. Hence, being forward-biased, diode D_1 and D_3 conducts (but not D_2 and D_4 which is reverse-biased) and current flows along MACBN. As a result, positive half-cycle of the voltage appears across R_2.

During the negative half-cycle, when terminal N becomes +ve, then D_2 and D_4 conducts (but not D_1 and D_4) and current flows along NACBM. So, we find that current keeps on flowing through Rc in the same direction (i.e. from A to B) in both half-cycles of AC input.

The average and RMS values of voltage and current as given as:

$$V_L = V_{LM}/\sqrt{2} = 0.707\ V_{LM}$$

$$V_{L(dc)} = 2\,V_{LM}/\pi = 0.636V$$

$$V_{L(ac)} = \sqrt{({V_L}^2 - {V_{L(dc)}}^2)}$$

$$I_{LM} = \frac{V_{LM}}{R_L} \quad ; \quad I_L = \frac{I_{LM}}{\sqrt{2}} = 0.707 I_{LM}$$

$$I_{L(dc)} = \frac{2 I_{LM}}{\pi} = 0.636 I_{LM}$$

$$I_{L(ac)} = \sqrt{I_L^{\,2} - I_{L(dc)}^{\,2}}$$

But, incidentally $I_{L(ac)}$ is the same thing as $I_{r(rms)}$. Hence the ripple factor can be written as:

$$\gamma = \frac{V_{L(ac)}}{V_{L(dc)}} = \frac{V_{r(rms)}}{V_{L(rms)}}$$

Similarly,

$$I_{L(ac)} = I_{r(rms)} = \sqrt{I_{L1}^{\,2} - I_{L2}^{\,2}} = 0.305 I_{LM}$$

Therefore,

$$\gamma = \frac{0.305 V_{LM}}{0.636 V_{LM}} = 0.482$$

The efficiency is also given as:

$$\%\eta = \frac{81.2}{1 + 2r_d/R_L}$$

2.2.3 Filtration

The main function of a filter circuit is to minimize the ripple content in the rectifier output. As seen, output of various rectifier circuits is pulsating. It has a d.c value and some a.c components called ripples. This type of output is not useful for driving sophisticated electronic circuits or devices. In fact these circuits require a very steady dc output that approaches the smoothness of a battery output.

When positive half-cycle of the AC input is applied, the diode is forward-biased and hence is turned ON. This allows C (capacitor) to quickly charge up to peak value of input voltage because charging time constant is almost zero. After being fully charged, the capacitor holds the charge till output AC supply to the rectifier goes negative. During the negative half-cycle, the capacitor attempts to discharge. However, it cannot discharge through diode which, being now reversed (OFF). Hence, it discharges through R_L from point b to c. During the next positive half-cycle, the process starts again with C being charged quickly.

2.2.4 Regulation

Regulated power supply can be obtained by using a voltage regulator circuit. A regulator is an electronic control circuit which is capable of providing a nearly constant dc output voltage even when there are variations in load or input voltage.

$$\%Regulation = \frac{V_{max} - V_{min}}{V_{max}} \times 100$$

In an ideal or perfectly regulated DC power supply, the percentage voltage regulation is zero. The voltage regulation is also called Load Regulation.

2.3 Control/Sensory Unit

The control sub-system is comprised of the following components which together can detect physical changes in the environment and as a result trigger the remaining circuit blocks. They are:

- Stable light source(s)
- Photo Resistors
- Timer ICs
- Transistors

- Diodes
- Resistors
- Capacitors

2.3.1 Stable Light Source

Light is an electromagnetic radiation of a wavelength that is visible to the human eye (in a range from about 380 or 400 nm to about 760 or 78nm). In physics, the term light sometimes refers to electromagnetic radiation of any wavelength, whether visible or not. Five primary properties of light are intensity, frequency or wavelength, polarization, phase and orbital angular momentum. Light which exists in tiny packets called photons, exhibits properties of both waves and particles. This property is referred to as the wave-particle duality. The speed of light in a vacuum is presently defined to be exactly 299,792,458m/s (approximately 186,282 miles per second). The fixed value of the speed of light in SI units results from the fact that the meter is now defined in terms of the speed of light.

Generally, EM radiation is classified by wavelength into radio, microwave, infrared, the visible region we perceive as light, ultraviolet, X-rays and gamma rays. The behaviour of EM radiation depends on its wavelength. Higher frequencies have shorter wavelengths, and lower frequencies have longer wavelengths. When EM radiation interacts with single atoms and molecules, its behaviour depends on the amount of energy per quantum it carries.

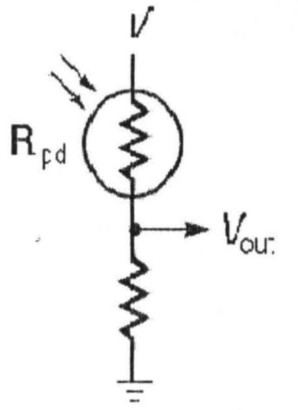
There are many sources of light. The most common light sources are thermal: a body at a given temperature emits a characteristics spectrum of black-body radiation. Examples include sunlight (the radiation emitted by the chromospheres of the sun at around 6,000K peaks in the visible region of the electromagnetic spectrum when plotted in wavelength units and roughly 40% of sunlight is visible), incandescent light bulbs (which emits only around 10% of their energy as visible light and the remainder as infrared).

Atoms emit and absorb light at characteristic energies. This produces emission lines in the spectrum of each atom. Emission can be spontaneous as in light-emitting diodes (LEDs), gas discharge lamps and flames. Emissions can also be stimulated, as in a laser or a microwave maser. For this design, the spontaneous light - emitting diode (LED) is used. LED is a forward-biased P-N junction which emits visible light when energized. Typically the maximum forward voltage for LED is between 1.2V and 3.2V depending on the device. Reverse breakdown voltage for an LED is of the order of 3V to 10V. It is evident from the figure above that amount of power output translated into light is directly proportional to the forward current. The greater the forward current, the greater the light output.

2.3.2 Photo Resistors

It is a semiconductor device whose resistance varies inversely with the intensity of light that falls upon it. It is also known as photoresistive cell because it operates on the principle of photoresistivity. The resistivity and hence resistance of a semiconductor depends on the number of free charge carriers available in it. When the semiconductor is not illuminated, the number of charge carriers is small and, hence, resistivity is high. But when light in the form of photons strikes the semiconductor, each photon delivers energy to it. If the photon energy is greater than the energy band gap of the semiconductor, free mobile charge carriers are liberated and as a result, resistivity of the semiconductor is decreased.

Photoresistive cells are generally made of cadmium compounds such as Cadmium Sulphide (Cds) and Cadmium Selenide (CdSe). Spectral response of Cds cell is similar to the human eye. Hence such cells are often used to simulate the human eye. That is why they find use in light metering circuits in photographic cameras.



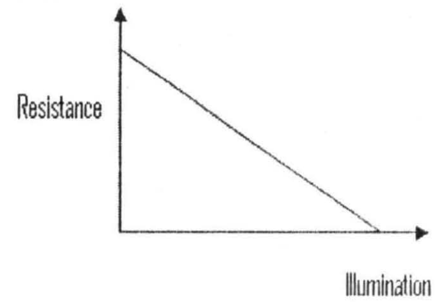


Fig 2.5a: Typical Interface Circuit

Fig 2.5b: Terminal Characteristics

A thin layer of photosensitive semiconductor material is deposited in the form of a long strip zigzagged across a disc-shaped ceramic base with protective sides. For added protection a glass lens or plastic cover is used. The two ends of the strips are brought out to connecting pins below the base.

The figures above show the terminal characteristic of a photoresistive cell. It depicts how the resistance of the cell varies with light intensity. Typically, the dark resistance of the cell is 1MΩ or larger. Under illumination, the cell resistance drops to a value between 1 and 100KΩ depending on surface illumination. The photoresistive cell is an inexpensive and simple detector which is widely used in OFF/ON circuits, light-measurement and light-detecting circuits.

2.3.3 555 Timer ICs

Integrated timer circuits represent one of the interesting developments in IC design. The circuit consists of a number of high-quality functional blocks that are combined in one IC but that are interconnected externally. This one IC can be used for many different functions. A good example is the 555 timer used in this design. It can be used as a monostable multivibrator (an oscillator), as a linear voltage ramp generator, as a missing pulse detector, and as a pulse width modulation. But for the purpose of this project design, the monostable mode of trigger for a 555 timer is given a closer look.

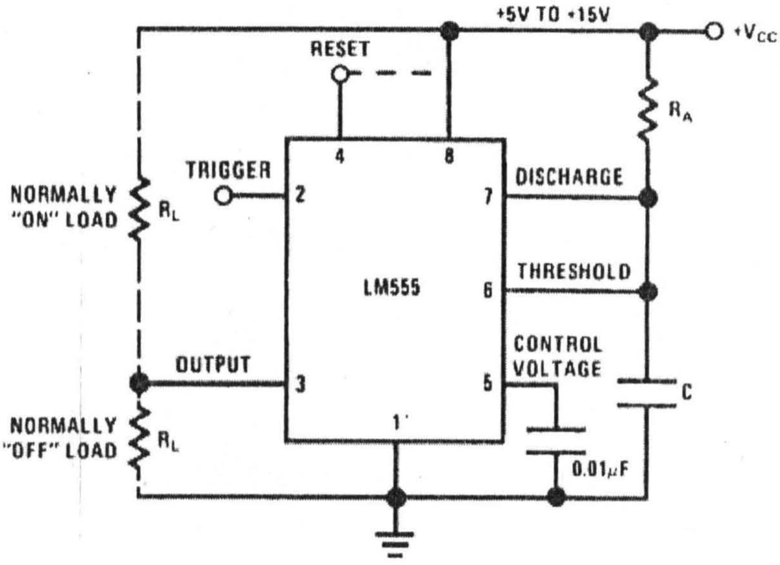


Fig 2.6: Monostable Configuration

In the monostable configuration shown in the figure above, a capacitor and a single resistor are used for the timing network. Both the threshold terminal and the discharge transistor terminal are connected together when the input voltage to the trigger comparator falls below 13Vcc, the comparator output triggers the flip flop so that its output sets low. This turns the capacitor discharge transistor "off" and drives the digital output to the high state. This condition allows the capacitor to charge at an exponential rate which is set by the RC time constant. When the capacitor voltage reaches 23Vcc, the threshold comparator resets the flip flop. This action discharges the timing capacitor and returns the digital output to the low state. Once the flip flop has been triggered by an input signal, it cannot be retriggered until the present timing period has been completed. The time that the output is high is given by the equation $t = 1.1R_AC$.

A reset pin is provided to discharge the capacitor, thus interrupting the timing cycle. As long as the reset pin is low, the capacitor discharge transistor is turned "on" and prevents the capacitor from charging. While the reset voltage is applied, the digital output will remain the same. The reset pin should be tied to the supply voltage when not in use.

2.3.4 Diodes

It is a two-terminal device consisting of a P-N junction formed either in a Ge (Germanium) or Si (Silicon) crystal. It is a one-way device offering low resistance when forward-biased and behaving almost as an insulator when reverse-biased as shown in Fig 2.8. Hence, such diodes are mostly used as rectifiers.

Fig 2.7: Schematic Diagram Of A Diode

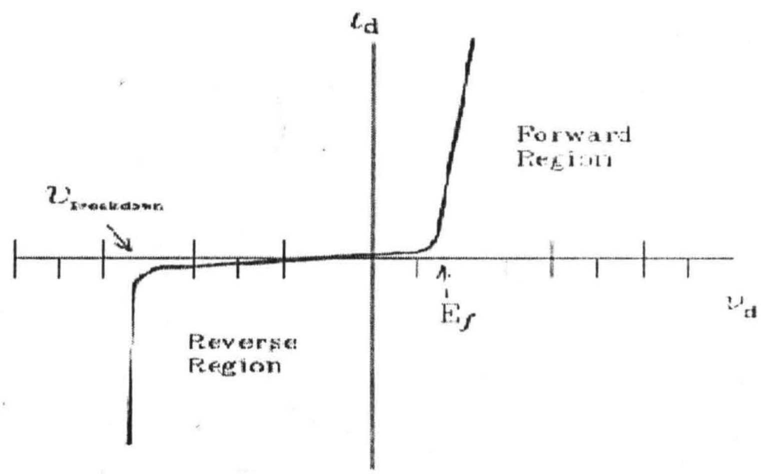


Fig 2.8: Typical V-I Characteristic Of A Diode

When the diode is forward-biased and the applied voltage is increased from Zero, hardly any current flows through the device in the beginning. It is so because the external voltage is being opposed by the internal barrier voltage whose value is 0.7v for Si 0.3v for Ge. As soon as the barrier voltage is neutralized, current through the diode increases rapidly with increasing applied battery voltage. It is found that as little a voltage as 1.0v produces a forward current of about 50mA. A burnout is likely to occur if forward voltage is increased beyond a certain safe limit.

When the diode is reverse-biased, majority carriers are blocked and only a small current (due to minority carriers) flows through the diode. As the reverse voltage is increased from Zero, the reverse current very quickly reaches its maximum or saturation value which is known as leakage current. It is of the order to nanoamperes (nA) for Si and Microamperes (mA) for Ge. The value of the leakage current is independent of the applied reverse voltage but depends on: (a) Temperature (b) Degree of doping (c) Physical size of junction when reverse voltage exceeds a certain value called break-down voltage, the leakage current suddenly and sharply increases. Any further increase in voltage is likely to produce burnout unless protected by a current-limiting resistor.

These characteristics can be described by the analytical equation called Boltzmann diode equation. Given as:

$$I = I_o \frac{eV}{(e^{KT} - 1)} ampere$$

Where Io = diode reverse saturation current

V = Voltage across junction

K = Boltman constant = 1.38×10^{-23}

T = Crystal temperature in ^{O}K

$\eta = 1$ - for germanium

$= 2$ - for silicon

2.3.5 Transistor

A transistor is a semiconductor device used to amplify and switch electronic signals. It is made of a solid piece of semiconductor material, with at least three terminals for connecting to an external circuit. A voltage or current applied to one pair of the transistor terminals changes the current flowing through another pair of terminals. Because the controlled (output) power can be much more than the controlling (input) power, the transistor provides amplification of a signal.

Today, some transistors are packaged individually, but many more are found embedded in integrated circuits. The transistor is the fundamental building block of modern electronic devices and is ubiquitous in modern electronic systems. Following its release in the early 1950s the transistor revolutionized the field of electronics, and paved the way for smaller and cheaper radios, calculators, and computers, amongst other things. The transistor's low cost, flexibility, and reliability have made it a ubiquitous device.

The essential usefulness of a transistor comes from its ability to use a small signal applied between one pair of its terminals to control a much larger signal at another pair of terminals. This property is called gain. A transistor can control its output in proportion to the input signal; that is, it can act as an amplifier. Alternatively, the transistor can be used to turn current on or off in a circuit as an electrically controlled switch, when the amount of current is determined by other circuit elements.

The two types of transistors have slight differences in how they are used in a circuit. A bipolar transistor (BJT) has terminals called base, collector, and emitter. A small current at the base terminal (that is, flowing from the base to the emitter) can control or switch a much larger current between the collector and emitter terminals. For a field-effect transistor (FET), the terminals are labelled gate, source, and drain, and a voltage at the gate can control a current between source and drain.

2.3.6 Resistors

Resistance may be defined as the property of a substance due to which it opposes (or restricts) the flow of electricity (that is flow of electrons) through it, the practical unit of resistance is ohm. When some conductors having resistance R_1, R_2 and R_3 etc, are joined end-on-end as shown in Fig 2.9, they are said to be connected in series. Here, current is the same through all the three conductors, but voltage drop across each is different due to it different resistance and the sum of the three voltage drops is equal to the voltage applied.

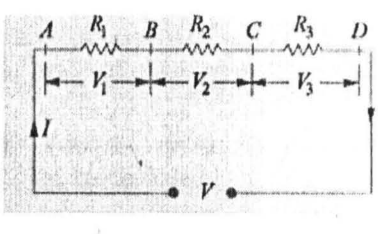


Fig 2.9: Resistors In series

$$R = R_1 + R_2 + R_3$$

When three resistances are joined as in Fig 2.10, they are said to be connected in parallel. Here, current in each resistor is different, potential difference across all resistances is the same and the total current is the sum of the three separate currents.

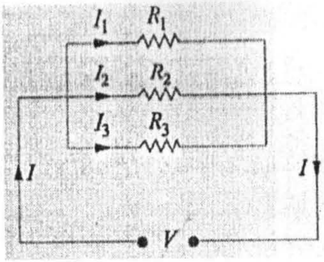


Fig 2.10: Resistors in parallel

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

2.3.7 Capacitor

A capacitor essentially consists of two conducting surfaces separated by a layer of an insulating medium called dielectric. The purpose of a capacitor is to store electrical energy by electrostatic stress in the dielectric.

$$C = \frac{Q}{V} = \frac{Charge}{Potential\ Difference}$$

When capacitors are connected end-to-end as shown in Fig 2.11, they are said to be in a series connection. Here, the charge on all capacitors is the same but potential difference across each is different.

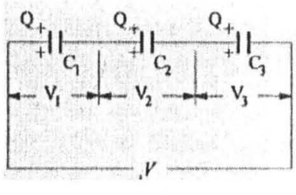


Fig 2.11: Capacitors In Series

$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

When they are connected as shown in Fig 2.12, they are said to be in a parallel combination. Here, the potential difference on each is different.

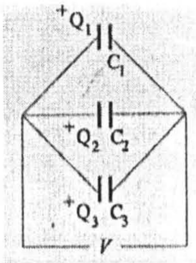


Fig 2.12: Capacitors In Parallel

$$C = C_1 + C_2 + C_3$$

2.4 Switching/Logical Unit

The switching sub-system consists of the following components which together, can receive an input from the control unit to either switch on or off the connected load.

They are:

- Counter
- Inverter IC
- AND IC
- Relay

2.4.1 Counter

In digital logic and computing, a counter is a device which stores (and sometimes displays) the number of times a particular event or process has occurred, often in relationship to a clock signal. In practice there are two types of counters.

- Up counters, which increases in value

- Down counters, which decreases in value

In electronics, counters can be implemented quite easily using register-type circuits such as flip-flop and a wide variety of designs exist, examples are:

- Asynchronous (ripple) counter
- Synchronous counter
- Decade counter
- Up-down counter
- Ring counter
- Johnson counter
- Cascaded counter

For this project design the decade counter is used. A decade counter is one that counts in decimal digits, rather than binary. A decade counter may have each digit binary encoded (as the 7490 integrated circuit) or other binary encodings (as the bi-quinary encoding of the 7490 integrated circuit). Alternatively, it may have a "fully decoded" or one-hot output code in which each output goes high in turn; the 4017 is such a circuit. The latter type of circuit finds application in multiplexers and demultiplexers, or wherever a scanning type of behavior is useful.

The 4017 IC is a 16-pin CMOS decade counter from the 4000 series. It takes clock pulses from the clock input and makes one of the ten outputs come on in sequence each time a clock pulse arrives.

2.4.2 Relay

The electromechanical relay (EMR) is a device that uses an electromagnet to provide the force to close (or open) switch contacts, in other words, an electrically power switch. When the electromagnet, called the coil, is energized, it pulls down on the spring-loaded armature. Relay contacts are described as being one of two kinds, normally open contacts (NO), which are open in the unenergized state and normally closed (NC).

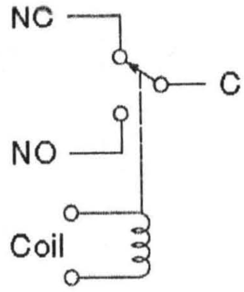


Fig 2.13: A common schematic symbol of relay

The coil voltage and resistance can be used to calculate the steady-state coil current. Actually, it takes more voltage and current to pull in the relay contacts than it does to hold them there because the armature must be pulled in across an air gap. Hence these quantities are called, respectively, pull-in voltage and pull-in current. This is to guarantee that the relay will pull-in quickly and reliably when operated at the rated voltage.

CHAPTER THREE

3.0 DESIGN METHODOLOGY

The entire system was broken down into subsystem or unit blocks. Each subsystem performs a special task. By the integration of all the functional unit blocks, the automatic switching control system satisfies the overall requirement of the project. They are:

- ➢ Power Supply Unit
- - Transformation unit
- - Rectification unit
- - Filtration unit
- - Regulation unit
- ➢ Control Unit
- - Entry photoconductor unit
- - Exit photoconductor unit
- ➢ Switching Unit
- - Counter (Positive and Negative) unit
- - Logical unit
- - Relay
- ➢ Load

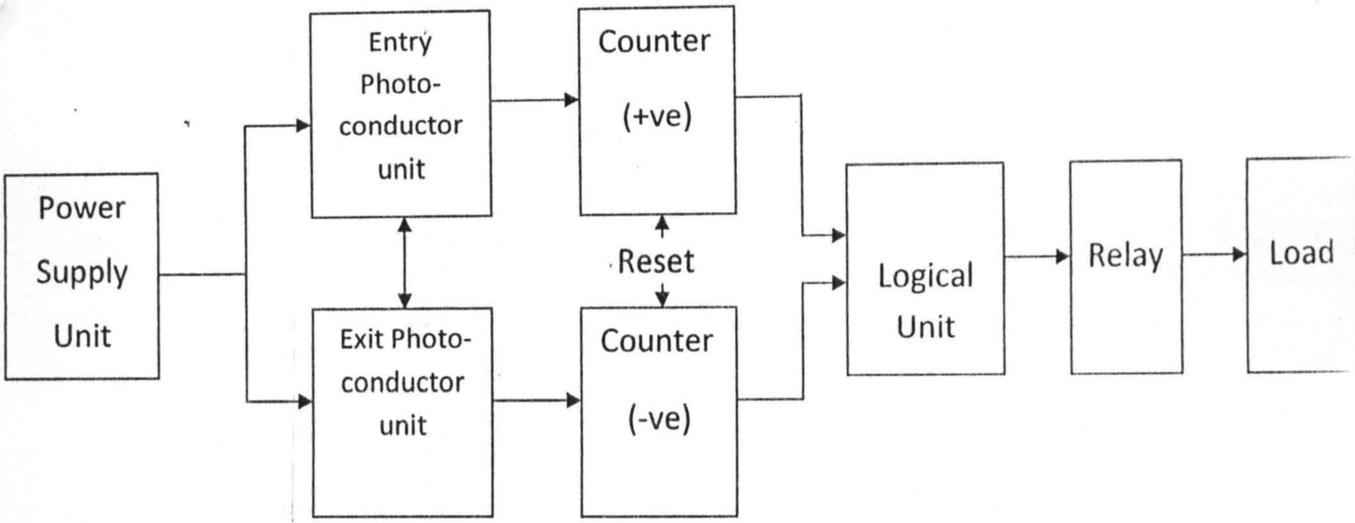


Fig 3.1: Block Diagram an automatic light switch

3.1.1 Transformer Selection

The insulated iron core transformer used to transform the input voltage to the circuit was chosen from the following transformers as stated in the manufacturer data sheet:

- 415/2400v transformer
- 220-240/12v transformer
- 224-240/9v transformer
- 240/24v transformer

Table 3.1: Current calculation

Components	Quantity	Maximum Current (A)	Total Maximum (A)
LDR	2	0.45	0.9
Relay	1	9.0	9.0
LED	2	0.011	0.022

Total Maximum Current = 9.922 A

Given 10% allowance to total current = 0.992 A

Expected Maximum Current = 9.922+ 0.922 = 10.844 A

This implies that a worst case maximum, expected current is approximately 10.844. If a 220-240/12v, 50Hz transformer is chosen, the power rating of the assuming unity power factor is:

$$P = VI = 12 \times 10.844 = 130.128\,VA$$

Specification is as follows

- Primary voltage – 240v
- Secondary voltage – 12v
- Power rating – 130.128 VA
- Current rating – 500mA
-

3.1.2 Rectifier Selection

The four (4) diode bridge rectifiers used have the following rating

- Maximum voltage = 25v
- Maximum forward current 1.5A
- Peak value of full wave signal = Vp

$$V_P = \sqrt{2} \times V_{rms}\ ;\ but\ V_{rms} = 12$$

Therefore, $V_p = \sqrt{2} \times 12 = 16.97$

Hence N4001 was chosen with peak inverse voltage of 25v.

3.1.3 Capacitor Selection

The capacitor used for filtering the transformer dc output was selected by carefully calculating its specification as:

$$C = \frac{V_{dc}/V_r}{2fR_L}$$

Where C= Capacitor, F = Frequency, V_{dc} = dc voltage from the transformer, V_r = Ripple voltage, R_L = Load resistance

If 2% ripple is assumed, $\quad {V_{dc}}/{V_r} = 50$

Hence,

$$C = \frac{V_{dc}/V_r}{2fR_L} = \frac{50}{2 \times 50 \times 400} = 1250\mu F$$

It should also be noted that the larger capacitor, the more electrons stored and the less the ripple. So, 2200μf 25v was used.

3.1.4 Regulator Selection

The 3 terminals fixed voltage regulator used to regulate the input voltage to the circuit was chosen from the following serves as spelt out in manufacture specification sheet.

- 109 series regulator for 0.3 – 5v range
- 7809 series regulator for 5 – 25v range
- 7900 series regulator for (-5) – (-25v) range

Hence 7809 and 7805 regulator was chosen to handle the 9V control circuit and the 5v switching circuit respectively.

3.1.5 Photoconductor Selection

The light Dependent Resistor (LDR) is light sensitive variable resistor made from Cadmium Sulphide (CdS) whose resistance is high with little or no illumination and vice versa. The technical specification of typical ORP12 (LDR) is shown below.

- Peak spectral response – 610nm
- Cell resistance (i) at 50 lux – 2.4km

  (ii) at 100 lux – 130n
- Dark resistance 10MΩ
- Max voltage is 110v (ac or dc)
- Max power dissipation at 25^0C – 200mW

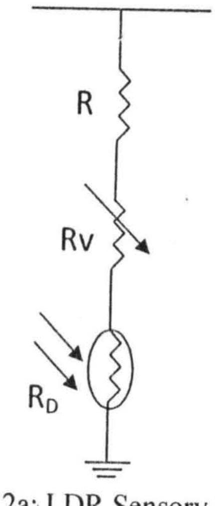


Fig 3.2a: LDR Sensory Circuit

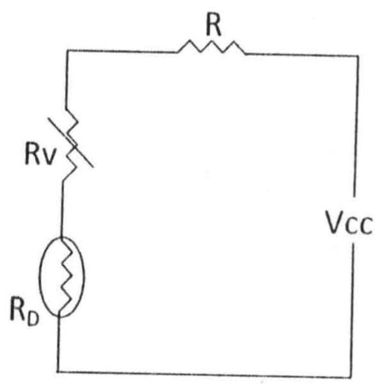


Fig 3.2b: Equivalent Circuit

If the resistance of the LDR is given as R_D, then the equivalent circuit of the section will be:

$$V_{RD} = \left[\frac{R_D}{R + R_D + R_V}\right] V_{CC}$$

3.1.6 Counter Selection

The 4017 IC is a 16-pin CMOS decade counter from the 4000 series. It takes clock pulses from the clock input, and makes one of the ten outputs come on in sequence each time a clock pulse arrives. The function of each pin is as given in the data book.

3.1.7 Transistor Selection

The characteristic properties of the transistors used in this design are as specified in the data book.

3.1.8 Relay Selection

Manufacturer's specification sheet

V = 9 Vdc

I = 5A

R = 400Ω

3.1.9 Logical unit

The logical unit consists of two integrated circuits (ICs), which are:

- 74LS04 and
- 74LS08 or 4081

The characteristics of these ICs are as given in the data book

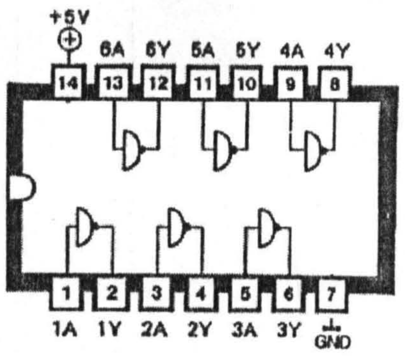


Fig 3.3: 7404- 6 inverters

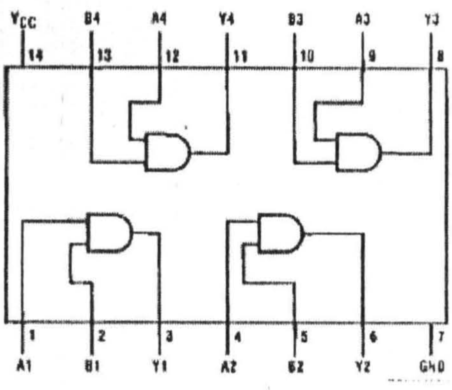


Fig 3.4: 7408 – 4 AND gates

3.2 CIRCUIT OPERATION

When a person enters the room, first he would obstruct the light falling on LDR1, followed by that falling on LDR2. When a person leaves the room, it will be the other way round. In the normal case light keeps falling on both the LDRs, and as such their resistance is low (about 5 kilo-ohms). As a result, pin 2 of both timers (IC1 and IC2), which have been configured as monostable flip-flops, are held near the supply voltage (+9V). When the light falling on the LDRs is obstructed, their resistance becomes very high and pin 2 voltages drop to near ground potential, thereby triggering the flip-flops. Capacitors across pin 2 and ground have been added to avoid false triggering due to electrical noise.

When a person enters the room, LDR1 is triggered first and it results in triggering of monostable IC1. The short output pulse immediately charges up capacitor C5, forward biasing transistor pair T1-T2. But at this instant, the collectors of transistors T1 and T2 are in high impedance state as IC2 pin 3 is at low potential and diode D4 is not conducting. But when the same person passes LDR2, IC2 monostable flip-flop is triggered. Its pin 3 goes high and this potential is coupled to transistor pair T1-T2 via diode D4. As a result transistor pair T1-T2 conducts because capacitor C5 retains the charge for some time as its discharge time is controlled by resistor R5 (and R7 to an extent). Thus green LED is lit momentarily. The same output is also coupled to IC3 for which it acts as a clock. With entry of each person IC3 output (high state) keeps advancing. At this stage transistor pair T3-T4 cannot conduct because output pin 3 of IC1 is no longer positive as its output pulse duration is quite short and hence transistor collectors are in high impedance state.

When persons leave the room, LDR2 is triggered first followed by LDR1. Since the bottom half portion of circuit is identical to top half, this time with the departure of each person red LED is lit momentarily and output of IC4 advances in the same fashion as in case of IC3. The outputs of IC3 and those of IC4 (after inversion by inverter gates N1 through N4) are ANDed by AND gates (A1 through A4) are then wire ORed (using diodes D5 through D8). The net effect is that when persons are entering, the output of at least one of the AND gates is high, causing transistor T5 to conduct and energize relay RL1. The bulb connected to the supply via N/O contact of relay RL1 also lights up. When persons are leaving the room, and till all the persons who entered the room have left, the wired OR output continues to remain high, (that is the bulb continues to remains 'ON') until all persons who entered the room have left.

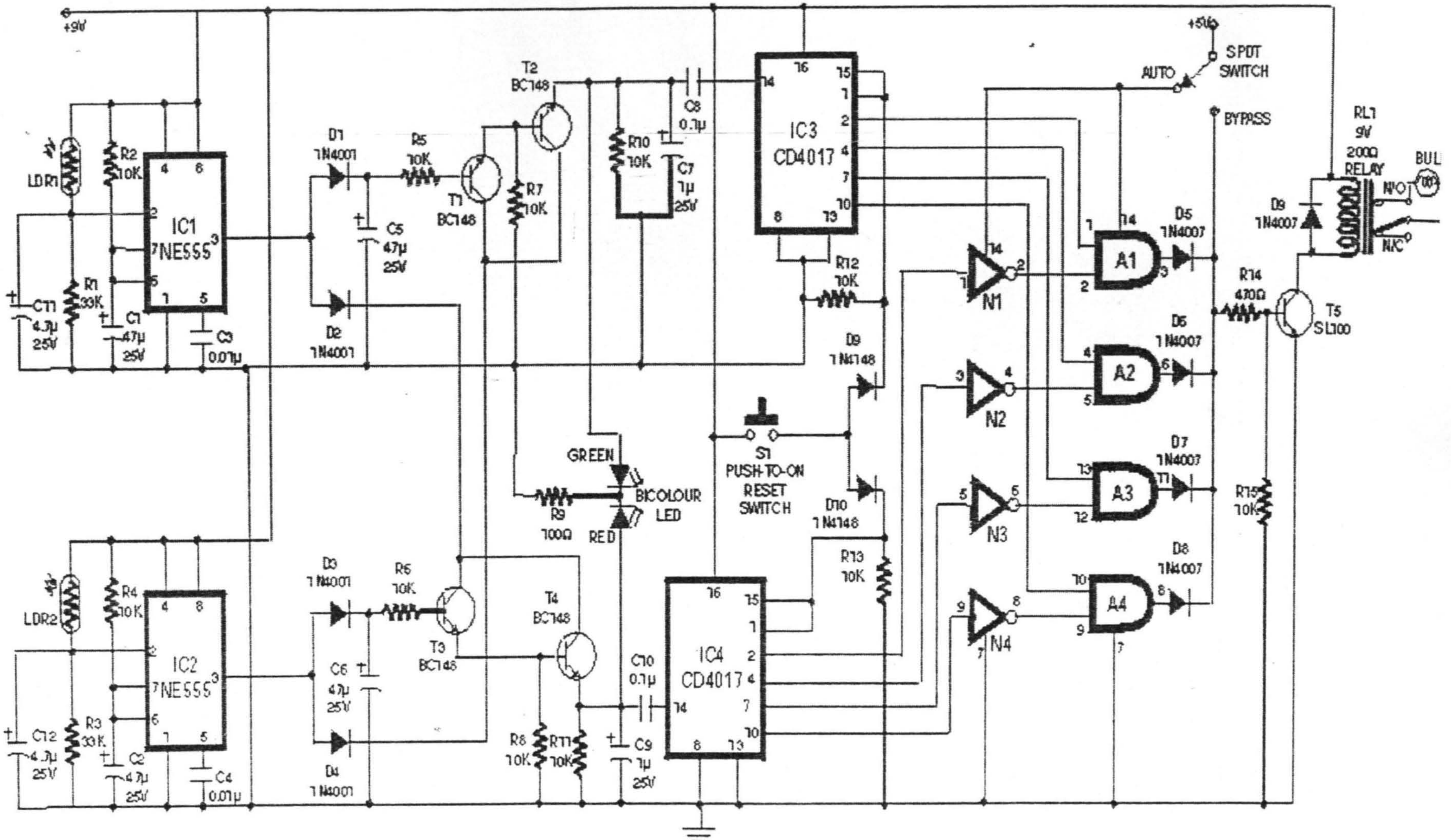


Fig 3.5: Circuit diagram of an automatic light switch

CHAPTER FOUR

4.0 IMPLEMENTATION AND RESULT

On completion of the design stage of the system, it was first implemented on a breadboard to be sure it worked as desired. Various aspects of the system were then modified to obtain desired working and stable circuit before it was constructed permanently on a veroboard.

4.1.1 CONSTRUCTION

The following materials were used in the construction and implementation of the design. They are:

i. Soldering iron
ii. Soldering lead
iii. Solder sucker
iv. Long nose pliers
v. Cutter/ Razor blade
vi. Screw drivers (flat end)
vii. Digital multimeter
viii. Connecting wires
ix. Vero board

4.1.2 CONSTRUCTION STEPS

The following steps were taken to ensure a neat and desired construction. They are:

i. The circuit was first tested on a bread board. A few adjustments and modifications were made on the circuit.

ii. The layout plan for the component position on the vero board was made. Unnecessary distances between components were avoided to reduce the length of wire used and hence reduce overall circuit capacitance and resistance.

iii. The copper strips on the veroboard were disengaged appropriately to avoid unwanted connections.

iv. The discrete components- resistors, capacitors and transistors were soldered directly to the board.

v. Adequate heat sinks were used.

vi. Installed components were then connected to one another using wires in accordance with the design.

vii. A digital multimeter was then used to check the contacts for continuity where necessary.

4.1.3 SOLDERING

The following steps were used while soldering:

i. Using little but enough solder for any joint to ensure proper contact.

ii. Heat sinks were used to conduct heat away from the active component during soldering.

iii. Preventing damage that could result from overheating by making sure that the temperature of the soldering iron does not get too high.

4.1.4 TESTING AND RESULTS

Though the testing was first done on the breadboard, the circuit was found to yield an interesting and desired result. The output was found to turn ON and OFF in response to a person crossing the device in and out respectively, with high sensitivity (that is the response of the LDR to luminous intensity was high). This was done by covering LDR_1 and LDR_2 sequentially (or in turn) from the incident ray of a straight light source to signify an entrance and covering LDR_2 and LDR_1 sequentially from the incident ray of a straight light source to signify an exit.

Since the design of the circuit can only accommodate four persons in a room at a time as a fifth person will make the counters to reset, the truth table for the theoretical logical outputs for switching ON on entry and switching OFF on exit are given below:

Table 4.1: Truth Table on ENTRY

Entry counter	**Exit counter**	**Inverted exit Counter**	**Output (AND)**
1	0	1	1
1	0	1	1
1	0	1	1
1	0	1	1

Table 4.2: Truth Table on EXIT

Entry counter	**Exit counter**	**Inverted exit Counter**	**Output (AND)**
0	1	0	0
0	1	0	0
0	1	0	0
0	1	0	0

Table 4.3: Overall Truth Table for Triggering Load

Entry output (AND)	**Exit output (AND)**	**Overall output**
1	0	1 (ON)
1	0	1 (ON)
1	0	1 (ON)
1	0	0 (OFF)

4.2 SWITCHING TIME DELAY

The total delay time before the load (bulb) lights up is due to switching delay that is attributed to the relay, transistors and capacitors.

Relay delay time = 160 ms

Capacitor delay time =70 ms

Transistor delay time = 0.7 ms

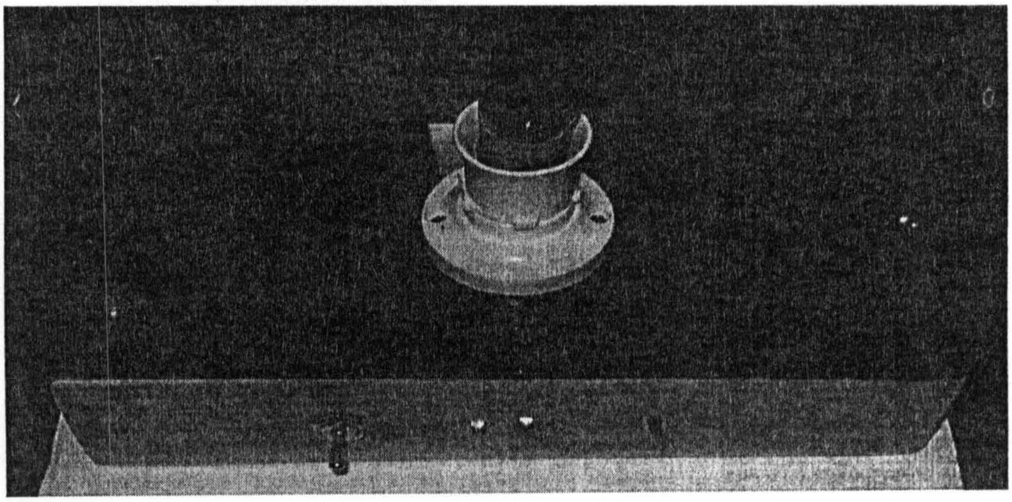
Total delay time = Relay delay time + Capacitor delay time + Transistor delay time

= 160 + 70 + 0.7

= 230.7 ms

4.3 CASING

A wooden casing of convenient size was used to case the components. Robustness was taken into account to allow for easy heat dissipation. Different parts were placed in appropriate position based on ventilation, available space and ease of access and maintainability.



CHAPTER FIVE

5.1 CONCLUSION

The efficiency of power systems is that the amount of energy produced by the generation station is almost equal to the amount of energy consumed by the consumer. But in a case where the amount of energy produced is in no way equal to the amount of useful energy consumed, something should be done to remedy the wastage in the system which is the sole aim of this project.

In conclusion, an ordinary automatic room power control circuit has only one light sensor. So when a person enters the room it gets one pulse and the lights come 'ON'. When the person goes out it gets another pulse and the lights go 'OFF'. But what happens when two persons enter the room, one after the other? It gets two pulses and the lights remain in 'OFF' state. The design of the circuit described overcomes the above-mentioned problem as was seen from the result obtained that more than one person can occupy a room at a time with the light remaining in the ON state.

5.2 RECOMMENDATION

The maximum number of persons that this circuit can handle is limited to four since on receipt of fifth clock pulse the counters are reset. The capacity of the circuit can be easily extended for up to nine persons by removing the connection of pin 1 from reset pin (15) and utilizing Q1 to Q9 outputs of CD4017 counters. Additional inverters, AND gates and diodes will, however, be required. Also, since in this circuit LDRs have been used, care should be taken to protect them from ambient light. If desired, one may use readily available IR sensor modules to replace the LDRs.

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