NEAR EAST UNIVERSITY

Faculty of Engineering

Department of Electrical and Electronic Engineering

LIGHT ACTIVATED SWITCH

Graduation Project
EE -400

Student: Mohammad Qunj (990732)

Supervisor: Assoc. Prof. Dr. Adnan Khashman

Nicosia - 2003

ACKNOWLEDGMENT

First ofali I would like to thanksAllah {God}for guiding me through my study.

As well as I would like to thanks my parents and my family for supporting and encouraging me to accomplish my dream under their custody, and I want to handsel this project to my father because without his endless support and love for me, I would never achieve my current position. I wish my mother lives happy always and my father in the heaven be proud ofme.

Secondary I have to thanks my supervisor *Assoc. Prof. Dr. Adnan Khashman* for his prosecution and his limitless help until I complete my project.

Also I will not forget my friends in NEU, as they were with me during my study and I will never forget our nice times in Cyprus, they are really good friends and I hope to them more success in their study and their future life. Here I would like to thanks Mohammad Shuqair and Mohammad Asfoor. With their kind help, my best wishes to them in their study and their future life.

ABSTRACT

As the light is an important phenomenon in our life and it is used in a wide range of application, we are going to design and explain a light activated switch circuit by using an LOR sensor.

Before doing an eleetric circuit we have first to know the safety guidelines of doing it; to save our equipment and to make sure that the circuit will work probably without any error, the most important safety guideline is to not connect the power supply to the circuit before making sure that ali of'the components are placing in the right place and right polarities.

So by this project we can control many different real-life applications such as: alarm system, out door ilhımination, automatic control and so on. In this project we are going to make a circuit that is controlling a small fan by giving a signal (light) to the LOR sensor, we are assuming that the small fan is a drying machine, after washing our hand we are going to make it dry by putting our hand near to the machine, so our hand will be the signal which will affect to the machine to work.

TABLE OF CONTENTS

INTRODUCTION

The inquiry into the nature of light has lead us to recognize light as a small part of the Electro-magnetic spectrum on one hand and as the beam of photons on the other, forcing us to accept wave particle duality as the fundamental tenet of nature.

In this project we are going to design, build and test light activated switches, How to tum the switches on and off, using them for motor control will be presented, Suggestion into where these switches can be used will be made.

The first chapter of'this project is the background chapter, which inchıde:

1. Electronic component especially the components were used in this project (Iight activated switches) with some explanation and the characteristic of them.
2. Safety guideline when doing electronic project because of any electric component it has a guideline safety, ifyou do not know what is it you will bum, or break the component so that before doing any electric project you have to be care about this chapter,
3. Description of Iight activated switches project,

Chapter two is about switches, with some information about types of switches, how they work? How we can use them? And the contact material used for making switches.

The third chapter is about the light, what it means. What its qııality and quantity are. With some properties and characteristics of Iight, and the speed of Iight, also it has different types such as ultraviolet light.

The fourth chapter is the most important chapter, which explains the hardware project in details, how we built it, How it work, what its input and output? With the circuit diagram of light activated switches. Also the improvement of'the circuit will be included in this chapter, The aims of'this project are:

- To design and build a light activated switch.
- To gain hands-on experience in electronic hardware project.
- To modify the original circuit where possible.
- To suggest potential real-life use of switches.

CHAPTERONE
BACKGROUND

1.1 Overview

This chapter will contain information about the electronic components with some explanation about their types, characteristic, polarity and the way of measuring them (i.e, the way of measuring a resistor by readinğ its colors), Also it will shows a figures for some components spicily which are üsed in this project.

This chapter wiU •atso· explain the safety guideline when doing electronic circuits, with brief explanation about liğht activated switch circuit, how does it work.

1.2 Electronic Components

The first task problem for someone starting electronics hardware projects is that of identifying the various components used in projects. Before proceeding to the project a brief description of the used components will be given so that even a complete beginner should have no difficulty in sorting out which component is which, and connecting each eompcnent into circuit correctly.

1.2.1 Reslstors

These are small cylindrical component having a lead out protruding from each end. The value is not marked in nımbers and letters, but is indicated by four colored bands around the body of the component. The value is in units called "ohms", and resistors often have values of many thousands of ohms, or even a few million ohms. In order to avoid constantly using very large number it is common for resistance to be specified in kilohms (K) and megohms (M). These are equal to a thousands ohms anda million ohms respectively. Thus a resistor having a value of33,000 ohms would normally be said to have a value of 33 k, anda resistor having a value of2,700,000 ohms would normally have its value given as 2.7 M. It is common these days for the units symbol to be used to indicate the decimal point as well. This sometimes further shortens a value in its written form, and there is no danger of a decimal point being overlooked due to poor quality printing or something of this nature. In our two examples given above the vahıe of 33 k would not be altered since the "K" already indicates the position of'the decimal point, but 2.7 M would be altered to 2M7.

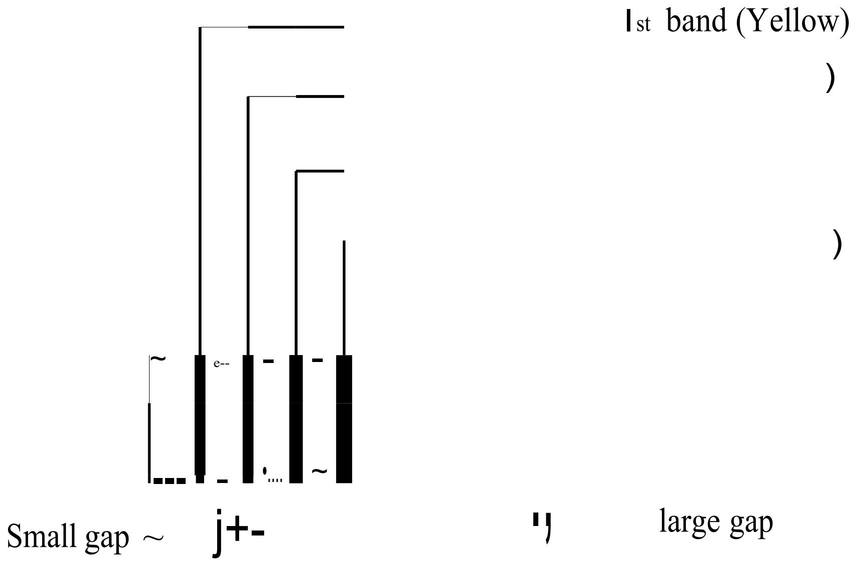
The resistor color code is detailed below [l].

Table 1.1 Resistor color code

Color	1st / 2nd Band	3rd Band	4th Band
Gold	Notused	0.1	5%
Black	0	0	Not used
Brown	1	10	1%
Red	2	100	2%
Orange	3	1,000	Notused
Yellow	4	10,000	Notused
Green	5	100,000	Notused
Blue	6	1,000,000	Notused
Violet	7	Nötused	Notused
Grey	8	used	Nofüsea
White	9	1N&tusea	Notused
Silver	Notused	.0	10%
NoBand	Not used	Notused	20%

The resistor color code is very straightforward, with the first two bands giving the first two digits of the value, the third band giving a multiplier (i.e. the first two digits are multiplied by this third figure in order to give the value of the component in ohms), and the fourth band showing the ıolerance of the component.

Thus . In the example shown in figure (1.1). The first two digits of the value are 4(Yellow) and 7(violet), giving 47 which must be multiplied by 100 (Red), giving a value of 4.700 ohms. This would normally be written at 4.7 K or 4K7. The fourth band is gold which indicates that the value of the component is within 5% of its marked value. Not that it is perfectly all right to use a component having a closer tolerance than is specified in a eomponents list (a 2% type can be used in place ofa 5% type for example), but a component having a higher tolerance than that specified (such as a 10% type instead ofa 5% type) is not acceptable [l].



47 * 100=4700 ohms, 4,7 K, or 4K7

Tolerance-is 5%

Figurel.1 the value ofthe resistor using color code

Resistors also have a power rati:ng, and this is not usually marked on the component (except in the case of high power types where the value and wattage may both be written on the component, no color codes being used), For the circuit in this book ordinary miniature 1/ 8, 1/ 4, or 1/3 watt resistors are satlsfactory since the power Ievels involved are very low. Higher power resistors are not really suitable, and this is due to their physical rather than electrical characteristics. Higher wattage resistors are physically quite large and would be difficult to fit into the available space, and some have very thick lead out wires, which will not fit easily into solder less breadboards.

1.2.2 Capacitors

Most capacitors used to look much the same as resistors but were normally a little larger and had the value written on their body rather than marked using a color code, Modern capacitors are still generally somewhat larger than resistors, but they often have both lead out wires coming from the same end of the component as this makes them more convenient for use with printed circuit boards. Also, they eften have rect-angular rather than tubular bodies.

An important point to bear in mind with electrolytic capacitors is that they are polarized, and must be connected to the circuit the right way round (resistors, and most other types of capacitor can be connected either way round), the lead out wires are identified by "+" and "-" signs on the bodies of'the components,

Additionally, axial types usually have an indentation around one end of the components body, and this indicates the end of the component from which the positive (+) lead out wire emerges. One of the capacitors used in a few projects is a tantalum bead type, and like an electrolytic capacitor this is a polarized component. Tantalum capacitors are normally small, bead shaped components (which are sometimes called tantalum bead capacitors), which have both lead out wires coming from the same end of the body. The appropriate signmarked on the body of the component should,

Identify the positive lead out wire. Be carefiıl to connect the tantalum capacitor the right way round as capacitor of'this type is easily damaged by voltage of'the wrong polarity.

The value of the capacitors might be given as 332, to indicate a value of 3.3nF. The first two nuınbers give .the first two digits of the value, and the third number indicates the number of zeros to be added to give the value in picofarads. Thus 332 indicates a vahıe of3,300 pF, and as 1,000-pF equals one nanofarad (1 nf'), 3,300 pF equals 3.3 nF. Incidentally, larger capacitance value is usually given in microfarads (μF); **1 μF being equal to 1,000 nF or** 1,000,000 pF [l].

1.2.1 Dledes

One type of diode is used in the proiect, the 1N4148 silicon type. The main point to note about diodes is that they are polarized components and must be connected into circuit the right way round if the circuit is to function properly. The cathode (+) lead of a diode is normally marked by a band around the appropriate end of the component's body, and this band is shown on the component layout diagrams in order to indicate diode polarity.

Therefore, if a circuit that uses diodes fails to work we should check the diodes with some sort of component tester if this is possible, Another minor complication is that some diodes have a number of bands marked around their body, and in such cases the manufacturer uses these bands to indicate the diode type number rather than simply marking the type number on the component. In such cases the bands are normally offset towards the end of the component :from which the cathode (+) lead out wire emanates. Figure (1.2) should help to clarify this point [1].

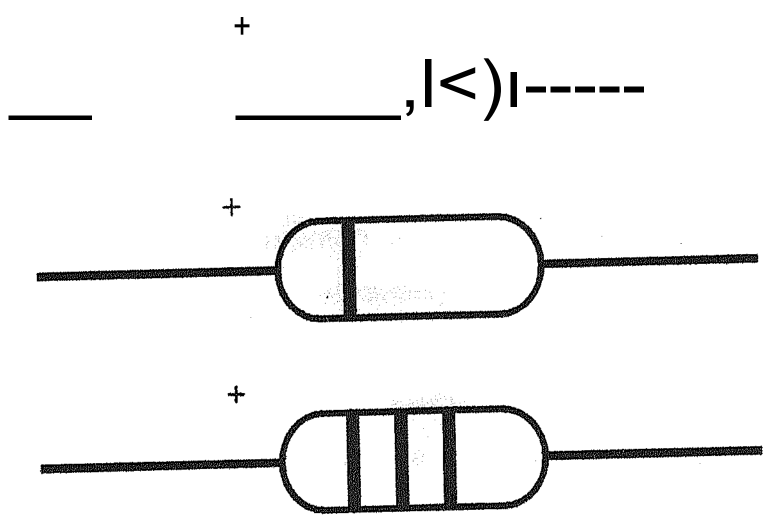


Figure 1.2 Diode polarity is shown by a barıd (or bands)

One light-emitting diode (LED) is used in this project. There are various ways used to show which LED lead out wire is the anode and which is the cathode, one of the most common being to have one lead out shorter than the other as shown in fig (1.3). usually the shorter \ Iead out wire is the cathode one] 1].

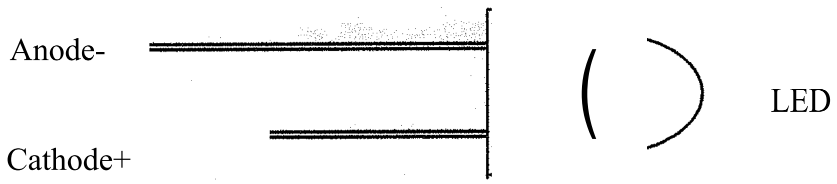


Figure 1.3LED polarity

1.2.4 Photocell

The photocell used in this project (light activated switches) is an RPY58A which is a small cadmium sulphide photo-resistor, and physically is flat, about 5 mm square, and has the two Iead out wires comingfrom one edge. It Iooks very much Iike a small ceramic plate capacitor.

Like an ordinary resistor, a cadmium sulphide photocell is not a polarized component and can be connected into circuit either way round. The Iight sensitive surface of the component is the one having a gold pattemed surface, and not the one to which the two lead out wires can be clearly seen to connect[1 J.

1.2.5 Transistor

The transistor is an arran.getnent···of semiconductors materials that share -common physical boundaries. Materials most commonly used are silicon, gallium arsenide, and germanium, into which a process called "dopinğ'ahas introduced impurities. In *n* -type semiconductors the impurities or dopants result in an excess of electrons, or negative charges; in *p* -type semiconductors the dopants lead to a deficiency of electrons and therefore an excess of positive charge carriers or "holes.

The *n-p-n* junction transistor, which is used in this project, consists of two *n* -type semiconductors (called the emitter and collector) separated by a thin layer of *p* -type semiconductor (called the base). The transistor action is such that if the electric potentials on the segments are properly determined, a small current between the baseand emitter connections results in a large current between the emitter and collector connections, tbus producing current amplification. Some circuits are designed to use the transistor as a switching device; current in the base-emitter junction creates a low-resistance patlı between the collector and emitter.

The *p-n-p* junction transistor, consisting of a thin layer of *n* -type semiconductor lying between two *p* -type semiconductors, works in the same manner, except that ali polarities are reversed [1].

1.2.6 Switches

There are many different types of switch available to the designer. Which type of switch is used depends largely on what they control. To set something in the on or off position a normal on/off switch is used. An on/off switch stays in the off position until·it is switehed on (it will also stay in the on position until it is switched oft).

A switch, which stays in the set position until it is reset, is ealled a latched switch. A simple on/off switch is called a single-pole, single-throw switch (SPST). The poles-are the number of circuits that the switch makes or breaks. The throws are the number of positions to which each pole is switched. There is other type of switches which is not operating manually as (SPST),it is operate via an electromagnet; which called (RELAY). There are many types of RELAY, one of these is used in this project, which is having an operating coil with a resistance of 185 ohm or more, and 12 volt operating supply. There make sure that the voltage and current rating of the RELAY are sufficient to control the equipment concerned. RELAY s do not have lead out wires.

1.3 Safety Guideline

The most important thing before working on any electric circuit, to have a good knowledge about the (SAFETY GUIDELINE), which is save your electronics component, so we have to mak.e surethat each component is connected at the correct place with correct polarity of, it, there are some components which when connected in wrong polarity the circuit fails and this might destroy the components themselves, so that before using any electronic component we have to know its polarity.

Another important thing is that do not connect the power supply without making sure that ali the components are connected on the circuit by the correct connection, for that purposes some times (fuses) are used. Even we are doing our circuit with a small voltage that is not dangerous for a humanIife we have to take care about the safety guideline.

Also we have to take care about the measurement instruments, when we are going to measure the voltage and the current at any point in the circuit, the following precaution should be observed when using a voltmeter or an ammeter:

(a) Observe the correct polarity. Wrong polarity causes the meter to deflect against the mechanical stop and this may damage the pointer.

(b) Connect the voltmeter in parallel and the ammeter in series with the load.

(c) When using a multirange voltmeter or ammeter, always use the highest rang .ofvoltage or current and then decreases the range until a good up-scale reading is obtained.

As an engineer one has to be accurate when you are doing such an electronic circuit to avoid any faults in the circuit and to save electronics components are used in the circuit [2].

1.4 Light-Activated Switeh

Light-activated switches have application in field s such as burglar-alarm systems and automatic control systems. This project is for a switch of the type that activates a relay when the light level received by the Iight sensor rises above a certain threshold level, and switched off again when the light level falls back below the threshold level. The relay coil is driven from the collector of Transistor is switched on by a suitable base current and voltage. The voltage and current available at the base of the Transistor is dependent on two main factors: the resistance provided by PCCl, and the setting of variable resistor. If variable resistor is set a maximum value PCC1 needs to have a resistance of about 100 K or less in order to bias the transistor into conduction and activate the relay. In total darkness PCC1 has a resistance of 200 K or more, but only a very low light level is sufficient to reduce it resistance sufficient to switch on the transistor and the relay,

1.5Summary

In this cha.pter we have seen different types of electronic components and the safety way of using them in any electric circuit, also we leamed how to measure them without expecting an error, the operaıioıröf the circuit (LIGHT ACTIVATED SWITCH) was described.

In second chaptef we will talk about different types of switches, the materials are used for making switches, vvifh some figures showing the operation of them.

CHAPTERTWO

SWITCHES

2.1 Overview

This chapter will present information about switches, what they mean? Where we can use them? And the types of switches, contact materials, applying switches in hostile environment, and switch terminology have all been inchıded, with some circuit parameters that affect the switch life-time. .In addition, this chapter will explain the effect of acceleration (shock and vibration).

2.2 Introduction to Switches

Switches are devices used to allow electric current to flow when closed, and when opened, they prevent current flow. This is a generic high-level search form that includes options for ali switch types. There are many different types of switch available to the designer, Which type of switch is used depends largely on what you are trying to control,

These days, using a computer to do just about anything is easy - providing you can manipulate .a keyboard anda mouse. For many young Iearners with complex physical and/or communication disabilities, the whole experience of education through the use of technology can be a closed book. However, the use of altemative access devices like switches can often transform "I can't do" into0I can do". With switches, we can control anything from a simple toy to a sophisticatedspeech output device, record school work and have access to recreational software. This article gives an overview of what can be possible through the use of switches, and how to facilitate that possibility. However, at the outset it is vital to remember that the successfiıl use of switch access to technology is dependent on the careful undertaking of assessment and trial, monitoring and progression.

Switches come in all shapes, sizes and types and must be carefully matched to the needs of the user. The process of switch selection cannot be separated from the needs of individual students. The following suggestions are offered to help us begin our switch assessment planning. We wilI need to choose switches using the following criteria.

(a) Switch type

Button, wobble, string, platform, tongue, finger, sound, grip, suck, blow, head there are many types of switch available, and the one(s) chosen should be dependent on a combination of the factors discussed in this resource.

(b) Target area

How big does the surface area of'the switch need to be for the user to operate it-successfully? For example, the Able Net *Big Red* switch (13cm diameter), provides a large target to hit, but also increases the risk of being knocked accidentally. A small switch, for example the Able Net *Specs* switch (3 .Scm diameter), may be too small a target for a child with only gross arm movements.

(c) Feedback

Does the user need to hear a click to help them understand that they have activated the switch? Does this click draw attention away from the activity being accessed?

(d) Sensitivity

How much pressure is the user able to use to activate the switch? Some switches need a greater amount of'pressure than others. The *TashMicro light* and Able Net *String* switches, for example, are very sensitive, while the QED *Platform* switch requires greater pressure. Some switches, like the Able Net *Large Adjustable Pressure Switch,* can be adjusted to operate at various Ievels of'pressure from Iight to heavy.

(e) Travel

How much active movement does the user have? Some switches are designed for Iarge sweeping movements (e.g. the Able Net *Handy Switch)* while others will activate with a very small movement (e.g. the Able Net *Jellybean* switch)

(t) Design

Most switches are made of hard material such as plastic. Some users hit their switches with some force and may appreciate a softer surface, for example the Taslı *SofiSwitch [9].*

2.3 Switeh Types

1. Normally open and normally closed
2. Rockerswitches
3. Pusbbutton switches
4. Tact switches
5. DIP switches (Dual In-Line Package)
6. Snap-Action switches
7. Slide switches
8. Rotary switches
9. Key lock switches
10. Leaf switch
11. Detector switches
12. Toggle switches

2.4 Switch Terminology

All switches, regardless of how they Iook or the size or what part of the body is used to control it, operate in the same manner. A switch is a mechanical device used to open and close a circuit, Opening a circuit (usually tums a device OFF) is achieved by breaking a connection in the circuit. This stops current flow in the circuit. Closing the circuit (usually tums a device ON) allows the current to flow again. These are some terminologies associated with switches.

NormaUy Open (N.O.): Without activating the switch, the contact is open.

NormaHy Cfosed (N.C.): Without activating the switch, the contectis closed.

Single Pole Single Throw (SPST): Activating the switch opens/closes one circuit, Single Pole Double Throw (SPDT): Activating the switch opens/closes the connection of one circuit to one of two.

Double Pole Single Throw (DPST): Activating the switch opens/closes the connection of two circuits to one.

Double Pole Double Throw (DPDT): Activating the switch opens/closes two circuits,

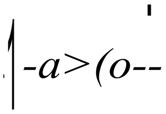
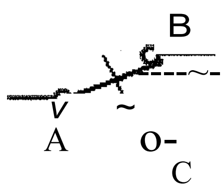
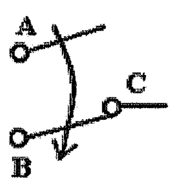
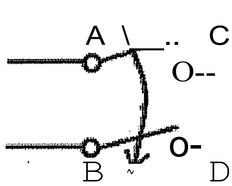
Momentary: The switch is closed/open only when the switch is activated.

Lateh: The switeh remains closed/open until the switch is activated again,

Feedback: The switch indicates that it has been activated:

For example: visual (light), audio (click) [9].

Table 2.1 contact forms

	Open (N.O)	[illegible] activating the switch, the contaci
	Eorinally Closed (N C.)	~~~'.:.activating the switch, the contact
	Single Pole Single Throw (SPST)	Activating the switch opens/closes one circuit,
	Single Pole Double Throw (SPOT)	Activat~g the swit~h o~ens/closes the connection ofone circuit(A) to one oftwo (B orC).
	Double :P?l~ Single Throw (DPST)	Activat~g the switc~ opens/closes the connection of two cireuits (A and B) to one (C).
	Double Pole Double Throw (DPDT)	Activating the switch opens/closes two circuits (A to C) and (B to D).

2.5 Contaet Materials

The most universal contact material is silver. It combines the chemical, electrical, thermal, and mechanical properties that usually ate needed for best contact performance in a wide range of applications. If silver contacts are clean, there is no lower limit to the voltage and current thatthey will control reliably.

This applies, for e:x:aınple, to a switch that is sealed sufficiently to keep out contaminates. Silver has definite drawback and that is its tendency to tarnish in the presence of H2S and moisture. This characteristic encourages the use of gold contacts in some applications. If silver contacts are ex.posed to sulfides and moisture for a long enough time and in sufficient concentration, the<côl'itacts will tarnish, This seldom effects performance of the switch. Nearly always, the côrrlfünation of mechanical force and movement of'the contacts, and the circuit voltage, rupture< the tarnish film and reestablish good electrical continuity. Occasionally, however{ srrlall amounts of silver sulfide may collect at the contact interface and increase the resistahce of the closed switch enough to constitute an open circuit. Generally such a malfürıction clears up on the next switch closure, but it may not.

The likelihood that silvef contacts will experience this kind of problem depends upon the voltage, current, inductive characteristic of the circuit, the temperature, humidity, and purity of the environment;the degree of sealing of the switch enclosure; the mechanical forces and movement of the switch>contacts; the exposure time and number of switch operation; and the amount of switch resistru:ıce that constitutes an effectively open circuit.

Gold is nearly inert cherrlically and does not form sulfides of oxides in normal switching environment. It has some impôrtant Iimitations as a contacts material. It expensive, it is soft and ductile, and it is usefulness is very limited where an electric arc is present, It does, however, prevent sulfide tarnishing if properly applied. To reduce cost and to make the contacts more nearly üniversal, silver contacts are sometimes plated with gold. Accordingly; the theory goes, if the voltage and current are Iow enough to make gold contacts desirable, they are low enough that they will not disturb the gold plate. If voltage and eurrent are too high for gold contacts, they will bum the plate off and expose the silver, which is suitable for higher loads. However, there are some practical limitations. If gold is plate directly on silver contacts, sulfur atoms in the presence of moisture can penetrate the pores in the gold plate and react with the silver base metal, forming silver sulfide. The sulfide then migrates rapidly over the surface of the gold plate as a spongy deposit that can cause more trouble than would sulfide tarnish on an unprotected silver contact. The usual procedure is to use a nickel barrier plate between the silver base metal and the gold plate. This stops the sulfide problem but adds to the cost and sometimes is incompatible with some of the switch manufacturer' s production processes.

Cost aside, the answer would seem to be a solid gold contact, but gold is very ductile and may experience plastic flow under the influence of contact force on closure. This can be remedied by alloying other elements with the gold to harden it. Sometimes it is possible to alloy a high enough percentage of other elements with the gold that the cost of the contact can be significantly reduced. But this introduces other considerations, for example, polymer formation. Gold and gold alloy contacts can generate polymers at the contact interface when organic contaminants are present in the atmosphere. Silver does not form polymers.

The type of polymer usually formed on pure gold contacts does not increase switch resistance, but the same is not always true for gold alloys, If the atmosphere around gold or gold alloy contacts is clean, no polymer will be formed, but then under such conditions silver contacts will not form sulfides and are considerably less expensive, In short, the choice of contact material involves a number of consideration and often a trade-off decision.

Other contact materials sometimes are used for applications of this kind. the most common materials are platinum, palladium, and their alloys, Although these materials are sometimes used as pure metal, they tend to have poor wear properties and are very sofi: hence the use of alloys, which preserve some of the desirable properties of the elemental materials and improve hardness and wear resistance. The ruthenium, osmium, and rhodium. Others are silver, copper, and nickel. Most of the platinum and palladium alloys can form polymers that increase switch resistance.

In summary, although no universal rules can be laid down, the **following practices usually are** followed:

- If the switch is sealed, sulfides can not enter and silver contacts can be used.
- if the switch is not sealed, the electrical load should be considered .if there is **an arc, silver** contacts can be used.
- if there is no arc, the environment is a controlling factor. if panicle comamination is likely to reach the contacts, gold is no help. Use a sealed switch or bifurcated constants.
- if a completely alien film contaminant such as paint spray or oil mist can reach the constants , gold does not help, so choose a sealed switch.
- if the environment of an unsealed switch" contains significant amounts of moisture and H2S (from sources such as decaying organic matter or vulcanized rubber),gold contacts can be a real help [11].

2.6 Applying Switehes in Hostile Envlrenment

In their simplest forms, elecrromechanical, electromagnetic, and solid-state control devices are designed for environments which may be called friendly, i.e., clean factory areas{offi.ces, and other surroundings that are typical of room conditions. However, these devices eften are needed for use in the presence of dust, dirt, metal particles, oil, corrosive agents, or very high or low temperatures.

For extreme environment such components usually are made fromspecial rriaterials, provide with protective enclosuress of. changed •İn /Other ways to alter tneirrimedfateiafea· öf control enable the device to surviveand perförınsatisfactory.

Switches control circait: safely and reliablyin millions of applications. As the link between the mechanical and< electrical parts of a system, a switch must perform well, both mechanicelly and eleetrically. It usually does, despite the complication effects temperature, humidity, and other environmental factors. Stili, there are environments that reduce the reliability of switches and can even caııse premature failure. High temperature can reduce contact life; a partial vacuum can encourage electrical breakdown to ground; oil can deteriorate plastic can disable the switch; ice can jam the actuating mechanism; the electric arc in an unsealed switch can detonate an explosive atmosphere,

The effects of environments on switches are not always obvious, and it is possible for a system design to be well advanced before a potential switch problem is recognized, Familiarity with the effects of environment on switch performance eften can improve the design and save considerable time. This section discusses the factors to consider when applying switches in hostile environments.

Any specific environment consists of a unique combination of temperature, pressure, humidity, contamination, and the like, and these conditions sometimes conspire to cause switch problems, The environment in which a switch must operate is determined not only by the geographical location but also by the equipment and circumstances in which it is to be used. The table (2.2) illustrates some types of hostile envy. To which some switches may exposed. The switch should be tested by exposing it to simulated condition of end use (electrical, mechanical, and environmental) and evaluating it to be sure it performs as required [4}.

2.7 Effects of Acceleration, Shock and Vib.ration

When the switch is accelerating any direction, the common contact experiences an apparent force in the opposite direction. This may act to keep closed contacts closed and open contacts open, in which case there is no problem. The force may be directed perpendicular to the Iine of movement of the common contact, and have no significant effect. However, if the force acts to separate closed contact or to closed open contacts, there is the possibility that the switch may experience a malfunction. During the launching of a high-velocity missile, switches on the missile are subjected to high Iinear scceleration. Switches used in the hub of the propeller of in a spinning projectile have a component of acceleration toward the center of rotaıion. The movable contact, as a passenger in the switch, may be forced in an unfavorable direction [5].

Table 2.2 A Partial List of Typical Hostile Environments Encountered by Switches{4].

High temperatureı Industrial and household furnaces, pasteurizing equipment, steam Cleaning offood processing machinery, foundries, rolling mills, surfaces high performance aircraft, jet engine afterburners, missile launchers.

Low temperature : Commercial refrigeration, military and commercial equipment in arctic regions, Aircraft flying above 35,000 ft, cryosurgical, liquid oxygen, and other cryogenic equipment.

Temperature shock: Transfer of equipment to and from heated shelters in arctic regions, airdrops of military supplies, spacecratt reentry.

Vaeuum; Aircraft and spacecraft, aerial cameras and weather instruments, industrial Vacuum processes.

High pressure : Undersea equipment, oil drilling instrumentation.

Humidity: Laıındry machinery, dairy and meat packing equipment, textile plants, hothouses, carrier-based aircraft, pharmaceuıical manufacture.

Liquid splash or shallow immersion: Sump pumps, aircraft landing gear, shipbôarddeck mounted equipment, gasofüıe pu.rnps/hydraülic produetion machinecy.

Ieeı Snow removal machinery, ski lifts, refrigeration control, aircfaft, arcticinstallatiöns.

Corrosion: Marine and seaboerd applications, platingdepartıneıılts, battery ınanu.facture.

Sand er dust: Earth movingınachiıııecy, desertvehicles, air conditiônefs, foundries, cement mills, concrete hlock.hıaıııufacture, textile manııfacture, flour mills.

Fungus: Tropical military gear, geôfogical an.dınetrological in.stı:uınent.

Explosion: Starch packaging, coal mines, petroleum refining, grain elevators, flour mills, coke mamıfacture, surgical operating rooms, machining operations producing aluminum or magnesium dust.

2.7.1 Shock

When a device containing a switch is struck, dropped, or otherwise subjected to a disturbance, it under-goes a pulse of acceleration known as a shock. In its simplest form, this transient acceleration is ali in one direction, but its magnitude varies with time. A graph of the acceleration versus time may be a simple half-sine wave, or it may have any of wide variety of shapes and dimensions.. Although ordinarily mechanical shock has little or no effect upon switch petformance, a shock pulse having high acceleration and relatively long duration can causeia .c;Iosed switch to open momentarily or an open switch to close momentarily. If acc.elerationis .very high, in the thousands of gravity units, some switches may be permanentlyi(fiunagedby the shock.

To judge the effeot ofitnost mechanical shocks on switches. The common contact ofa switch experience similar forcesiwhen the switch is subjected to a mechanical shock, and the effect can be judged by consiijering the position ofthe contacts and the direction ofthe shock. If a shock pulse has a fairly(siı:nplewaveform (such as half-sine), It is usually specified in terms ofacceleration versus time. If the shock wave is complex and can not readily be expressed in this way, it is sometimes specified in terms of acceleration versus frequency, and resulting graph is called a shock speetrum, If the duration of the shock pulse is of the same order of magnitude as half natural period of some part of the switch mechanism, its effects on the switch may be amplified or attemıated. Thus a shock pulse having a 50g peak acceleration may separate the closed contacts of a switch, while a steady acceleration of 50g in the same direction would not [5].

2.7.2 Vibration

Vibration is an oscillating movement which may have a consistent, repetitive pattern or may be irregular, Thus the acceleration may vary regular or irregular, Most laboratory vibration test provide simple harmonic motion, which is a sine wave, The acceleration then follows a negative sine wave and specified in terms of frequency and maximum acceleration. In application where the vibration does not follow a simple waveform, conditions may be more di:fficult to specify. In some instance, the vibration is not periodic and the acceleration varies erratically.

In vibration, as with other forms of acceleration, the common contact is a passenger in the switch and experiences an apparent force in the direction opposite to that of the acceleration. With vibration, the acceleraiion .is along an axis, first in one direction, then in the opposite direction. The magnitude and direction of acceleration are reversed rapidly, and the rate of change affects the response of the switch to the vibration. The closed contacts of a vibration switch may remain closedat lOg, 50Hz, but may separate momentarily at 10g, 50 Hz.
In summary, accelerationis a1:ıy charlge ofthe velocity's magnitude or direction. Shock-artd vibration are forms iofacceletatioıı in which<acceleration varies with time. The common contact, as a .passeııĝefiı:i the•i switch,·behaves as though it were forced in the direction opposite that ofthe·>acceleration. With this in mind, one can judge whether a given acceleration, shock, ôrvibtation will act to caııse closed contacts to open or open contacts to closed [5].

2.8 Effect of Circuit Parameters on Switch Life

2.8.1 CurrentRating ofa Switch

The published current rating of a switch at a given voltage represents 'the maximum electrical Ioad the switch is· designed to control, As a role it is based on connection of the circuit to either the normally open normaily closed throw of the switch, and does not necessarily apply where both throws of'one pöie are connected simultaneously. If the switch has more than one pole, the electrical rating usually applies with one throw of each pole connected. The current rating generally assıımes that, in the case of pushbutton and snap-action-type switches, the plunger of the switch is driven to full over travel and full release during actuation. The switch can close the circuit, carry the steady-state current indeflnitely, and open the circuit during each cycle of operation through life. The ability of the switch to close and open the circuit reliably is affected by the current versus time characteristics of the circuit.

Occasionally, the suggestion is made that switches be provided with mirumum·voltage•and current ratings, i.e., vahıes of voltage and current below which they should not be used. This derives from the erroneous impression that a given switch will develop performance problems below specific Ievels of voltage and current. In practice, this is not the case, A clean switch usually can control microvolt-microampere circuits without di:fficulty. There is no particular voltage or currenr Ievel at which problem begin, and there is no technically valid way by which to set minimum electrical ratings. It is possible to establish minimum ratings on the hasis ofarbitrary,resistance Ievels [6J.

2.8.2 Closing the\(;;ifcuit

In a de resistive\çircuitrsuch as an electrical heater, the steady-state current is present at the instant of switch.\clôsure: As the switch contacts strike and then bounce apart, each rebound draws an electric arc.iThis melts metal on the surfaces of the contacts, and some of the metal is evaporated. Th.er~ füay be some general erosion of material from both contacts, and a net transfer of material:rrônıione to other, The contacts then re-close on molten metal, sometimes forming a weld>vyhenithe.. metal solidifies. The higher the current the stronger the weld is Iikely to be, and?tfı.~.fügher.the force that the switch mechanism will have to provide to open the circuit. The strôngest weld occurs when the load is characterized by a high inrush current. If the inrush d.ırt'eı:ıt/petsists during part or all of the contact bounce time, conditions are conducive to sev~r~liarcing and strong welds. Capacitive circuits often have high current at switch closer, encqµ.ı-«ğing contact welding, The highest current of all occurs when the switch is closed on a short çirc:u.it. Unless the switch is specially designed to with-stand closure on a short circuit, life uı:ıderitlıis oondition can be predicted as zero.

In a de inductive circuitt~ereis a time delay as the magnetic filed builds up in the coil before current reaches its steady;state Ievel. Since most of the contact bouncing occurs during the low-current part of the ttaı:ısient;there is little contact deterioration and almost no tendency to weld during closure.

In ac circuits the current transients combine with the alternation of the current, and the switeh closes at random points önthe current wave, including current peaks and zero current, Ac inductive circuits, such as those containing solenoid coils, almost always involve moving iron and consequent inrush current, Switches are designed to resist. contact deterioration and the effects of contact welding throughout' life, but in alt>circuits, .the lower the current on switch closure the lenger will be the life of'the switch[6].

2.8.3 Carrying the Steady-State Current

Once the contacts have closed and stabilized, the switch carries the steady-state ctırl'ent of the circuit. This is simply a matter of>.côntrolliııg the (1"2 R) heating, and seldom>presents a problem. 1 A ac has the same<h~a.tiıg. effect as 1 A de, since the equivalence of the two is based on heating. ControLbôdiesin:ıa.yimpose limitations on temperature rise at rated current. Except for very unusual overloads or short-circuiı conditions, However, switch life is unaffected by the current the closed switch carries [6].

2.8.4 Openmg the Circuit

Before the contacts can separate, any welds holding them together must be fractured by the switch mechanism. Many switches are designed to do this. In a de resistive circuit the steady-state current is present at the instant of switch opining, When the contacts of the switch separate far enough to extinguish the arc, nothing fiırther happens. Arc time in a de resistive circuit usually is very short and energy is low. There is some erosion and migration of contact material.

In a de inductive circuit arcing is more severe, because the energy stored in the magnetic field of the coil is partially dissipated in the arc as the field collapses, The arc often persists after the contacts are fully separated, and contact erosion and migration contimıe as long as the arc lasts. During the life of the switch, migration gradually narrows the space between the open contacts and eventually may draw and sustain an arc, destroying the switch. Normal arcing melts and evaporates contact material, some of which may condense on surfaces of adjacent insulators. The intense heat of the arc itself may gradually deteriorate insulators that are near it. The general effect is to reduce their insulation resistance and dielectric strength. This is encouraged in a de inductive circuit by the voltage transient that occurs just as the arc goes out. The current drops suddenly to zero, prodıicing a voltage proportional to its rate of change. There is a little effect on the switch life because of the short duration of the high-voltage transient. Switches are designed to withstand these conditions during life, but at the end of switch life, one possible mode of failure is electrlcal breakdown of an insulator. The m~er the soorcevoltaıe the more 'Qrevalent is thls mode of switch faihıre (61,

2.9 Summary

In this chapter we have discussed switches, the types of switches we have seen 12 types of switches, the effect öf the circuit parameter on the life-time of switches, and the effects of the acceleration (shock and vibration). Also the contact material, terminology of switches, and the use of the switches in the hostile environment were been discussed,

CHAPTER THREE
LIGHT

3.1 Overview

In this chapter we will review the light, what is light? What are the properties of light? What is the characteristic of light? What is the structure of Iight? Also in this chapter V1e will discuss how we can use the light in communication, with brief information about color' wavelength,

As will as in this chapter we will discuss about the photon, visible light, infrared, EM radiation spectrum, photo detector the characteristics, principles, cell structure and cell characteristics and the Ieaser principles and properties.

J.1 Introduction to Light

Light is one of the most familiar things in our Iives. We see becaııse we have ôrğan.si(ôur eyes) that sense the intensity (brightness) and wavelength (color) of light. We experience Iight in a variety of other ways as well, For example, we sense radiant heat wheriioür skfu•is near a warm object. This is due to our skin's reaction to infrared radiation.

We leam almost all of what we know about the world [illegible] **the interaction of the** objects in the world with electrôrnağrietic tadiation. **Often, the word 'light' is used a little** more broadly, to include electfôrnağrıetic raôiatiôıı tnat **is just outside the range we can see, in** the ultraviolet and infrared.

Light scientists have debated the nature of light, Physicists now recognize that light sometimes behaves like waves and, at other times, Iike particles. When moving from is a form of radiant energy or energy that travels in waves. Since Greek times,

place to place, light acts like a system of waves. In empty space, light has a fixed speed and the wavelength can be measured. In the past 300 years, scientists have improved the way they measure the speed of Iight, and they have determined that it travels at nearly 299,792 kilometers, or 186,281 miles, per second.

When we talk about light, we usually mean any radiation that we can see, These wavelengths range from about 16/1,000,000 of an inch to 32/1,000,000 of an inch. There are otherkinds of radiation such as ultraviolet light and infrared light, but their wavelengths are shorter or lenger than the visible light wavelengths, When Iight hits some form of matter, it behaves in different ways. When it strikes an opaque object, it makes a shadow, but light does bend around obstacles. The' bending of light around edges or around small slits is called diffraction and makes patterns ef'bands or fringes.

All light can be traced to certain energy sources, like the Sun, an electric bulb, or a match, but most of what hits the eye is reflected Iight. When Iight strikes some materials, it is bounced off or reflected. If the material is not opaque, the light goes through it· at a slower speed, and it is bent or refracted. Some light is absorbed into the material and changed.

Into other forms of energy, usually heat energy. The light waves make the electrons in the materials vibrate and this kinetic energy or movement energy makes heat. Friction of the moving electrons makes heat [9].

3.3 Colors

Color is a part of the electro-magnetic spectrum and has .always existed;iSfrlsaac Newton providedthefirst explanation of'color in 1666. Newtonipasseda)narrôwbearn of sunlight through a prismlocated .in .a dark rooın.?()fcourse/allthe visible\spectrum (red, orange, yellow, greeıi,bfüe/ı2~~o,ilıı~···~ôIGtJ~~sfüsplayecfôn·•··the.whitescreen, People already knew that light passed through a prisnı would.show a rainbow or visible spectrum, but Newton's experfments showed tha.fdiffefetıt colors are bent through different angles, Newton also thought all colors can be found in white light, so he passed the Iight through a second prism. Ali the visible colors changed back to white light. Light is the only source of color. The color of an object is seen because the object merely reflects [9].

Table 3.1 Approximate wavelength (in vacuum) and frequency ranges for the various colors.

Color	Wavelength (nm)	Frequency (THz)
Red	780 - 622	384 - 482
Orange	622 - 597	482 - 503
Yellow	[illegible]	[illegible]
Green	577 - 492	520 - 610
Blue	492 - 455	610 - 659
Violet	455 - 390	659 - 769

- 1 terahertz (THz) = 103 GHz = 106 MHz = 1012 Hz,
- 1 nm = 10"3 um= 10-6 mm= 10"9 m.

3.4 Property of Light

3.4.1 Reflection ofLight

The first property of light we consider is reflection :from a surface, such as that ofa rnirror. This is illustrated in Fig. 3.1

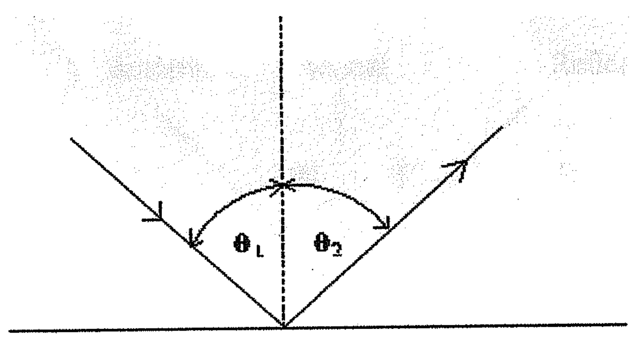


Figure 3.1 Law of'reflection

When light is reflected off any surface, the angle of incidence 9 lis always equal to the angle of reflection 92, the law of reflection is

$$91=92 \quad (3.1)$$

Note:

- The angles are always measured with respect to the normal to the surface.

The Iaw of reflection is· also consistent with the particle picture of light [7J.

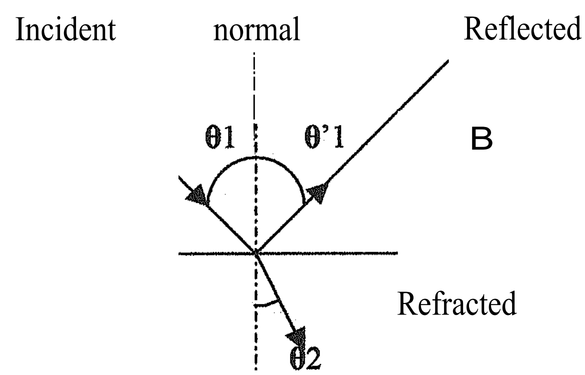
3.4.2 Refraction ofLigbt

When a ray of Iiğhf traveling through a transparent medium encoınters a boundary leading into another trarlsparent medium, as in figure 3.2, part of the ray is reflected and part enters the second ınedfüm. The ray that enters the second mediım is bent at tfie boundary and is said to be refracted. .Th.e incident ray, the reflected ray, the normal, and the refracted ray are an Iie in the safüe{plarle. The angle of refraction, 02 in figure 3.2, depends on the properties of two media arld ônth.eangle of incidence through the relation

$$Sin 92/ \sin 01 = v2/ v1= constant \quad (3.2)$$

Where v1 is the spe~<i öf Iight in medium 1 and v2 is the speed of light in medium 2. The experimental discov~ıy.iof this relation is usually credited to willebrord Snell (1591-1627) and is therefore kııovvii.as SneH's law:

The patlı ofa liğ~t(raythrouglı a refracting surface is reversible. For example, the ray in the figure 3.2 travels.fı'9111/point A to point B. If the ray originated at B, it would follow the same patlı of to reach pôinfA. In the latter case, however, the reflected ray would be in the glass [7].



Figu:re 3.2 The angle of refraction

3.4.3 Speed of Light

The speed of Iight in vacuum is exactly 299,792,458 mis (meters per second) In 1983 the SI (System Interrıational) defined a meter as:

The meter is the length of the patlı traveled by light in vacuum during a time interval of 1/299 792 458 ofa second,

When people refer to the speed of light, they refer to the definition above • the speed of light in a vacuum. The speed ofIight is normally rounded to 300 000 kilometers per second or 186 000 miles per second. The speed of light depends on the material that the light moves through - for example: light moves slower in water, glass and through the atmosphere than in a vacuum. The ratio whereby light is slowed down is called the refractive index of the medium. Irı general, the difference in the speed of Iight in other mediums is· ignored [7].

3.4.4 Qmmtity of Light

Total Iight, or luminance, from a Iight source is measured in lımens. The quantity oflight that falls on a work surface, called illıminance, is measured in hıx or foot-candles, The lux (Ix) equals 1 lumen per sq. meter and the foot-candle (fc) equals one lumen per sq. ft. The divider 10.76 pfövides a good way to convert from hıxto föot-eandles. A light ınetefcanbe used to measure the ilfüıninance, but it does not measure the energy used to pföducetfiai light, nor does it describethe quality of'the light,

Quantity measurements are important. We know from experience that it takes more light to see small objects and tasks of Iow contrast than Iarger, higher contrast tasks. Also, as our eyes age, they require more light. How much light is required to illuminate workspaces or to perform tasks? The lluminating Engineering Society of North America (IESNA) provides light level (illuminance) recommendations, The new IESNA Lighting Handbook, 9th edition, contains the Iatest illuminance recommendations, which are intended to prevent under-lighting and over-lighting. Over-lighting wastes energy and reduces Iighting quality [9].

3.4.5 Quality of Light

Lighting quality includes a number of Iighting parameters that are highly subjective and not easily quantified, including veiling reflections, glare, color, and flicker. Controlling these parameters effectively is essential to creating lighting that meets the needs and expectations of people working in a space, making them comfortable and more productive.

Veiling reflections detract from lighting quality by reducing contrast, which obscures task details. Veiling reflections are nı.ost notlöeable from luminaires (fixtures) located in front of and above the viewing task,

Glare is the sensation produced by brightness (luminance within the visual field) sufficiently greater than the brightness tô which the eye is adapted to cause a Ioss of visual performance. Discomfort glare in buildifig interiors is annoying and diminishes lighting quality by interfering with employee productivity more than with visual performance.

Glare can be controlled by controlling the light level and by blocking the direct view of hare Iamps, Louvers such as fhose in deep-cell parabolic luminaires or Iow-glare acrylic Ienses that reduce surface brightness at high viewing angles may be used, The use of indirect Iighting is the best way to reduce glare in office interiors and is recommended in electronic offlces.

Lamp color also affects lighting quality. Occupant preferences are the best guide for lamp color, Many recommendations regarding combinations of Iamp color temperature and illuminance are how obsolete, However, we do know that when lamps of higher color rendering are used, illuminance may be lowered to achieve equivalent brightness. Occupants who may complain that th~ new high CRI T8 Iamps are too bright have noticed this effect.

Lamp flicker also reduces lighting quality. Flicker comes from fluorescent lamps operated on magnetic ballasts. The Iamps tum on and off 120 times a second, and may produce distraction, eyestrain, nausea, and headaches. Flicker is especially noticeable at high light levels, such as industrial inspection Iighting. Electronic ballasts that operate fluorescent Iamps at high frequency reduce flicker to an imperceptible level.

Visual Comfort Probability (VCP) is a rating of "lighting systems that is expressed as a

Visual Comfort Probability (VCP) is a rating of lighting systems that is expressed as a percentage of people who, when viewing from a specified location and in a specified direction, will find the lighting system acceptable in terms of discomfort glare. The IESNA minimum recommendatlon for electronic offices is 80. Values of VCP are found in lıminaire manufacturers' catalogs in the photometric information.

It is also important to balance lighting for visual performance and visual comfort. The IESNA Lighting Handbook contains recommendations for uniformity between the visual task and background. Also overly diffıse and overly directional Iighting should be avoided [9].

3.4.6 Wavelength

An important property of Iight is its wavelength (frequency), Despite the name 'Iight', not ali light is visible to humarı beings; when light is visible its color is dictated by its wavelength, Ali types of light move in wave-like patterns, In each wave pattern you can see that there are high points and Iow points. The distance between two high points, or low points, is called the WAVELENGTH. Scientists use the Greek letter LAMBDA (1) to describe that distance. Depending on what type of light you are talking about, each type has a different lambda, ör wavelength, Ali of the wavelengths of Iight together are called the EM (electroınağnetic) SPECTRA. Red light has the longest wavelength that we can see; longer waveleriğths are called 'inffa..fed', and may be important in some communications systems. Some mimals can see Iight ofwaveleiiğthsthat are invisible to people [8].

$$\lambda = \frac{C}{F} \qquad (3.3)$$

Where: **C = speed of light**

F = frequency

3.4.7 Intensity of Light

Another important property is the *intensity* Ofthe Iiğht. We perceive variations in intensity as variations in brightness, Normally the intensity of light decreases as we get further from the source, even when the Iight is focused into a narrow beam. This happens because, as it travels through the medium, some of the Iight is scattered (randomly reflected away) and some is absorbed. Thıs, in the same way that Iong electrical cables attenuate (reduce) the strength of an electrical signal, Iong Iight beams are less intense at the receiver than the transmitter. The mathematical principles that govern the attenuation of light are slightly more complicated than those that apply to electricity (at Ieast for direct current), and I won't describe them here.

The light that comes from the sun, or from a light bulb, contains a range of different wavelengths and is said to be *tncoherem.* This means that the overall intensity of the Iight is reduced as different wavelengths cancel each other out. *Coherent* light, as obtained from a LASER, does not suffer this effect, so it remains intense over Iong distances [8}.

$$I = \frac{P}{A} \tag{3.4}$$

Where I = intensity in W/m^2

P=powerin W

A = beam cross-sectional area in m^2

3.5 Light Strueture

During the•early 1900s··scientists proved that Electromagnetic Radiation not only has packs of energy (quanta), but it also moves like a wave as well. It's Iike a stream of individual packets. If you apply this idea to the structure of an atom, there is a nucleus and there are rings/Ievels of energy around it. Each wave that could exist is the orbit of one electron. No two eleetrons can be in the same orbit, or wave. Similarly, every different type of light have a different wavt::Iern.gth. You'd have you nucleus and then orbit "A". Orbit "A" can hold one electron "a." in orbit "B", there would be another electron "b." Each orbit is unique. Each orbit has auniquewaveiength [10].

3.6 Packets of Light

Not only does Iight move fü/~Y~~~·\it ~so moves with a flow of Iittle particles. Scientists cali these particles of light PHOTONS. '}'~e paclcets contain the energy that makes up .the energy of the light, Scientists measure somethlıı̆g catleô the RELATIVE ENERGY of different types of light, Relative energy is an INVERSE. nıeasure of the wavelength. Inverse means '1' divided by the number, So relative energy for a type oflight is '1' divided by the wavelength, When you do that divisionyou can figure out that ifatype of'light hasa shorter wavelength, it has a higher energy.

If you compare different types oflight, you'll see that as you move up the EM spectrum, and the wavelengths get smaller, those types of'light have more energy. The big idea to remember is that light is both waves, andenergy (transmitted with particles) [10].

3.7 Malateaaace of Light

3.7.1 Principles ofLighting Mafütenance:

1. The light output of'lightirıg systems decreases over time.

2. Many lighting systems are over-designed to compensate for Iight loss over time.

3. Improvinğ rnaıntenance praetices can reduce light loss and allow reductions in energy use or imptôveliğht levels.

4. Group maintenance practicea save mone-y.

5. Propef/tpaintenance is the most neglected, most cost-effective way of reducing overall cost öf lighting,

6. When füainteıfa.nce is not performed, performance suffers gradually. The final result is a degradedliğhting system performing as Iow as 50 percent of'its capability [8].

3.7.2 Effed of Mafütenance on Efficiency and Eft'ediveness

When maintenance ••is. not performed on lighting systems, energy use may be reduced. The energy input to the system declines as Iamps bum out and ballasts stop fiınctioning. These savings rnay be ilhısory, though, as building occupants may compensate for the light loss using portable equipment that may be very inefficient. The more effective solution is to maintain light levels by using a maintenance plan to address four recoverable Iight loss factors: Iamp burnout factor, lamp lumen depreciation, luminaire dirt depreciation, and room surface dirt depreciation. These light-loss factors can be recovered by performing maintenance. The figure shows how neglected lighting systems Iose efficiency over time [10].

3.8 Light in. Cemraunicatioas

Light is increasingly important in communications, particularly in the medium of optical fibers, This importance derives :from two important facts. First, light waves are ofa very high :frequency. Second, the frequency ofa signal that can be carried ona particular medium is limited by the frequency of the waveform that it can support. The frequency of a light waveform is so high that, in principle, data can be carried on an optical fiber thousands of times faster than we can currently achieve. At present, it is largely the capabilities of the associated electronic equipment that limit the speed of optical communications.

In the future we may start to see computer equipment which uses light exclusively for its internal operation. Already some promising results have been achieved in this field, If this technique becomes prominent, then optical communication will be even more important,

Ordinary light bulbs are not much use in communications systems, as they generate light with a wide range of wavelengths. The most common Iight sources in communications are light-emitting diodes (LEDs). These generate Iight with a narrow band of frequencies, and which therefore appears coloured, usually red. LASERs ('Iight amplification by stimulated emission of radiation') are capable of generating very intense light beams, which can be tightly focused. These are normally used only for specialized applications, as they require high voltages and nıay•be bright enough to bum. a LASER diode, on the other.haıd,igeııetates a beam that is more füteııse tliaıı an LED, but requires only a Iow vôltağe fo 9perate. L.A.SER diodes are widely usedi ın ı~ser printers and en playets, as weıf ~s?Jeöfflrriüru.Satiôns apparatus.

Remember that aII computers cü~eııtl! a~~l~ble are ~1~1~~~~,~~~.~~s. Tlıetefore we need some mechanism for detecting the Iight beam :from an optical transmitter and producing a corresponding eleetrical signal. In communications, the tl1ost common device for this application is a *photodiode.* In essence this has an electrical resistance that varies with the intensity or wavelength of'the light that shines on it [11].

3.9 Cba:racteristk ofLigbt

Because Iight has been described as a source of energy, It is natural to inquire about the energy content and its relation to the spectrum[S].

3.9.1 Photon

No photon description of EM radiation is complete without a discussion of the photon. EM radiation ata particular frequency can propagate only in discrete quantitiesof energy. Thus, if some sources is emitting radiation of one frequency, then in fact it is emitting this energy as a Iarge number of discrete units or quanta. These quanta are called photon. The actual energy of one photon is related to the frequency by

$$W_p = hf = \frac{hc}{\lambda} \tag{3.5}$$

Where W_p = photon energy (J)

$h = 6.63 \times 10^{-34}$ (Planck's constant)

f = frequency (Hz)

λ = wavelength (m)

The energy of one photon is very small compared to electric energy [8].

3.9.2 EM Radiation Speetrum

We have seen that EM radiation is a type of energy that propagate through space at a constant speed or velocity if we specify the direction. The oscillating of this radiation gives rise to a different interpretation of this radiation in relation to our environment, however, in categorizing radiation by wavelength or frequency, we are describing its position in the spectrum ofradiation. Figure 3.3 shows the range of EM radiation from very Iow frequency to very high frequency, together with the associated wavelength in meters from Equation (3.3) and how the bands offrequency related to our world.

This one type of energy ranges from radio signals and visible light to X rays and penetrating cosmic rays and ali through the smooth variation of frequency, In process ..control instnımentation we are particularly interested in two of the bands, infrared and visible Iight.

Even though figure (3.3) present distinct boundaries between EM radiation descriptions, in reality the boundaries are quite indistinct. Thus, the transition between microwave and infrared, for example, is gradual, so that over a considerable band the radiation could be described by either term [8}.

3.9.3 Visible Light

The small band of radiation between approximately 400 nm and 760 nm represents visible light (Figure 3.3). This radiation band covers bands those wavelength to which our eyes (or radiation detectors in our heads) are sensitive [8}.

3.9.4 Intrared Light

The longer-wave radiation band that extends from the limit of eye sensitivity at 0.76>µmis called infrared (JR) radiation, In some cases, the band is further subdivided so 'that iadiatiôri of wavelength 3 to 100 µm is called far infrared [8].

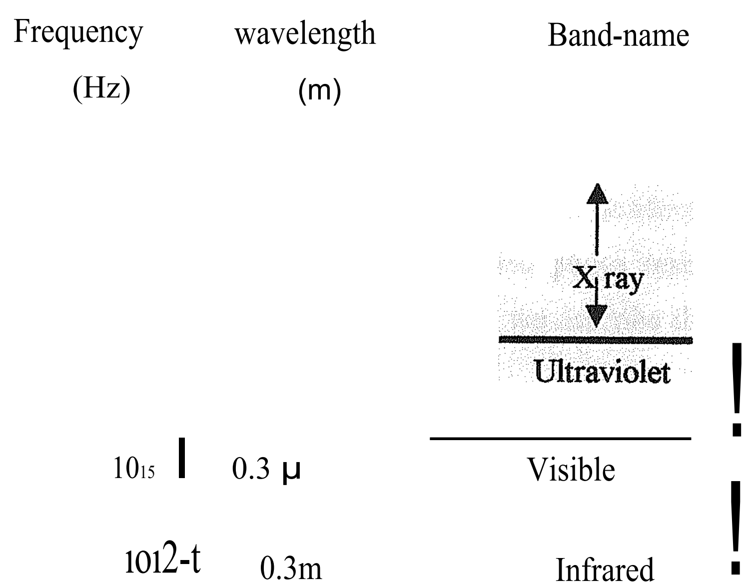


Fig (3.3) The EM radiation spectrum

3.10 Photo Detectors

An important part of any application of Iight to an instrumentation problem is how to measure or detect radiation, In most process-control-related application, the radiation Iies in the range from IR through visible and sometimes UV bands. The measurement sensors generally used are called photo detectors to distinguish them from other spectral ranges of radiation such as RF detectors in radio frequency (RF) application [8].

3.10.1 Photo Detector Characteristics

Several characteristics of photo detectors are particularly important in typical application of these devices in instrurnentation In the following discussion, the various types of detectors are described in terms of'these characteristics.

The particular characteristic related to EM radiation detection is the spectral sensitivity. This is given as a graph of sensor response relative to the maximıım as a fıınction of radiation wavelength. Obviously, it is important to match the spectral response of the sensor to the environment in which it is to be used [8].

3.10.2 Photoconductive Deteeters

One of the most common photo detectors is based on the change in conductivity of a semiconductor material with radiation intensity. The change in conductivity appears as a change in resistance; So that these devices also are called photo resistive cell. Because resistance is the parameter used as the transducer variable, we describe the devices from the point ofview ofresistance changes versus Iight intensity [8].

3.10.2.1 Principle

In a semiconductor photo detector, a photon is absorbed and thereby excites an electron from the valence to the conduction band. As many electrons are exeited into the conduction band, the semiconductor resistance decreases, making the resistance an inverse function of radiation intensity. For the photon to provide such an excitation it must carry at least as much energy as the gap. From Equation (3.6) this indicates a maximum wavelength

$$E_P = \frac{hc}{\lambda_{max}} = \Delta W_g \tag{3.6}$$

$$\lambda_{max} = \frac{hc}{\Delta W_g}$$

Where h = Plank' s constant j-s

ılWg = Semiconductor energy gap (J)

Aıuax = Maximum detectable radiation wavelenğth (m)

Any radiation with a wavelength greater 'than that predicted by Equation (3.6) cannot cause any resistance change inthe semiconductor.

It is important to note that the operation Of a .thermistor involves thermal-energy-exciting electrons in the condition band. To preventthe phötoconductor from showing similar thermal effects, it necessary either to operate the devices at a controlled temperature or to make the gap too large for thermal effects to produce conduction electrons. Both approaches are employed in practice. The upper limit of the cell spectral response is determinedby .many other factors, such as reflectivity and transparency to certain wavelengths [8].

3.10.2.2 CeH Structure

Two common photoconductive semiconductor materials are cadmium sulfide (CdS), with a band gap of 2.42 ev, and cadmium selemde (CdSe), with a 1.74 eV gap. Because of these large gap energies, both materials have a very high resistivity at room temperature. This gives bulk samples a resistance much too large for practical applications. To overcome this, a special structure is used, as shown in figııre (3 .4), that minimizes resistance geometrically and provides maximum surface area for the detector. This result is based on Equation (3.7):

$$R = \frac{pl}{A} \tag{3.7}$$

Where R=resistance (O)
P = resistivity (0-m)

l = length (m)
A = cross-sectional area (m2)

3.10•.2.3 Cell Characteristics

The characteristics of photo detective detectors very considerablywhen different semiconductor materials are used as the active element. These charactedstics are summarized for typical values in Table 3.1 [8].

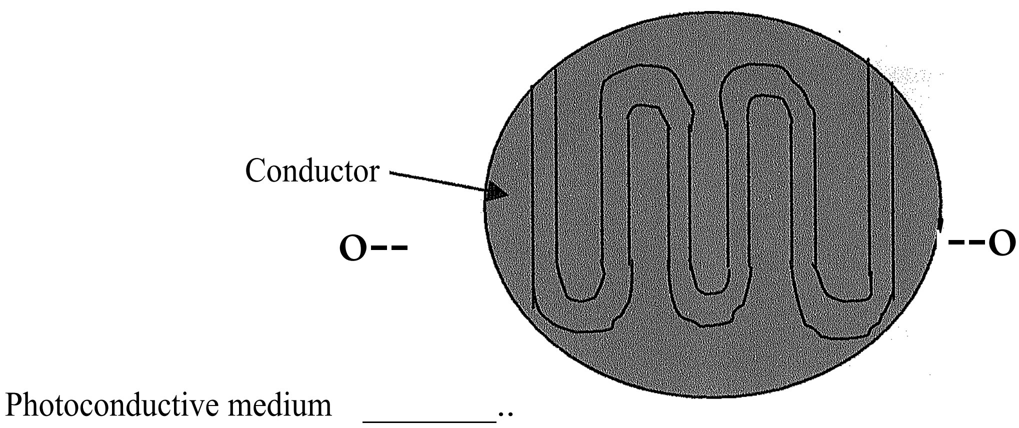


Figure 3.4 The photoconductive cell

Table 3.1 Photoconductor Characteristics

Photoconductor	Time constant	Spectral Band
	~ 100 ms	0.47 to 0.71 µm
CdSe	~ 10 ms	0.6 to 0.77 J:1ffi
PbS	~ 400 µm	1 to 3 JJ,l'tl.
PbSe	~ 10 µm	1.5 to4µm

3.11 Laser Principles

3.11.1 Stimulation Emission

The basic operation of the laser depends on a principle formulated by Albert Einstein regarding the mission of radiation by excited atoms. He found that if several atoms in .a material are excited to the same level and one of the atoms emits its radiation before the others, then the passage of this radiation by such excited atoms can also stimulate them to de-excite. It is significant that when stimulated to de-excite, the emitted radiation willbe inphase and in the same direction as the stimulating radiation. This effect is shown in figure (3. 5), where atoma emits radiation spontaneously. When this radiation passes by atoms b, c, and so on, they also are stimulated to emit in the same direction and inphase (coherently). Such radiation is also monochromatic because only single transition energy is involved. Such stimulated emission is the first requirement in the realization ofa laser [8].

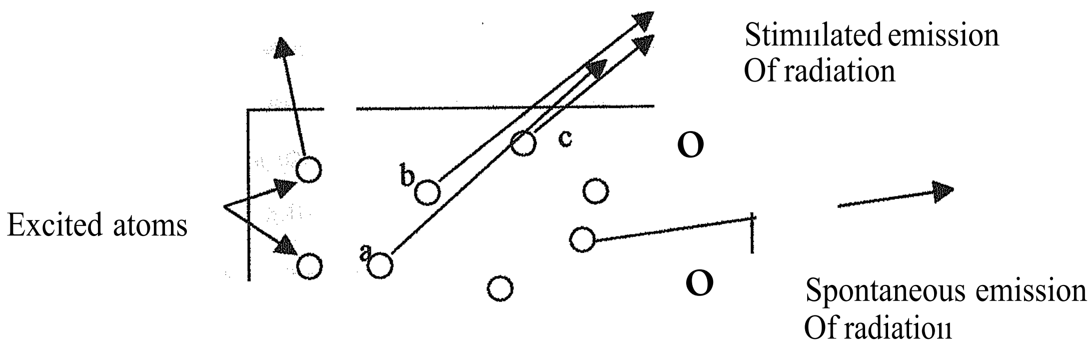


Figure 3.5 Stimulated emission of radiation gives rise to monochromatic, coherent radiation moving in random direction

3.11.2 Laser Structure

To see how the concept of stimulated emission is employed in a laser, consider figure 3.6. We have a host material that also contains atoms having the long-lived states. If some of these atoms spontaneously de-excite; their radiation stimulates other atoms in the radiation path to de-excite, giving rise to pulses of radiation indicated by P_1- P_1- and so on. Now consider one of these pulses directed perpendicularly to mirrors M_1 and M_2. This pulse reflects between the mirrors at the speed of light, stimulating atoms in its path to emit, The majority of excited atoms are quickly de-excited in this fashion. If mirror M_2 is only 60% reflecting, some of this pulse in each reflection will be passed. The overall result is that following excitation, a pulse of light emerges from M_2 thatIs lnönc>cnf-c>matic, coherent, and has very little divergence. This system can also be made to öperate CôHt1t1'uously by providing a continııous excitation of the atoms to replenish those de-excited by stimulat,ed emission [8].

3.11.3 Properties ofLaser Light

The light that comes from the laser is characterized by following properties:

1. Mônochromatic, laser light comes predorninately from a particular energy''' level transition, and is therefore almost monochromatic. (thermal vibration of'the atoıns and the presence of'impurities cause some other wavelength to be present).
2. Coherent, laser light is coherent as it emerges from the laser output mirr<>r ~g, remains so for a certain distance from the laser ; this is called the coherence lenğtlı. (Slight variations in coherency induced by thermal vibration and other effects cause the beam eventually to lose coherency).
3. Divergence, because the laser light emerğes perpendicular to the output mirror, tlıe beam has very little divergence, Typical divergence approximately 0.001 radiatföns [8].

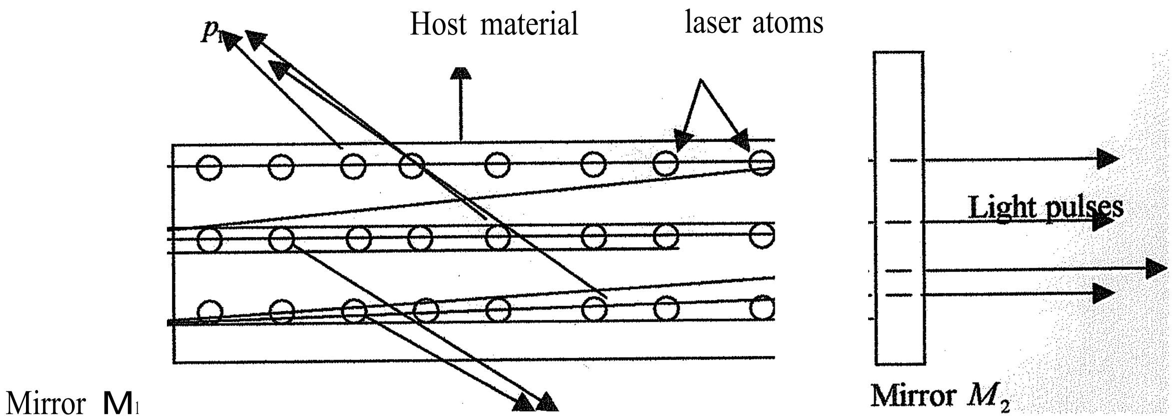


Figure 3.6 A laser gives performance to radiation pulseş emitted perpendiculartp)t~tJ.~çlinğ surfaces

3.12 Summary

So far in this chapter we have discussed the light in general We also discussed the wavelength of colors, and the properties of light (reflection, refraction, speed, quantity, quality, wavelength, intensity).

The maintenance of light was discussed by giving the principles of light maintenance and effect of maintenance on efficiency and effectiveness. The photon, EM radiation spectrum, visible light, infrared, photon detector, photoconductive detector, and leaser have been explained.

In the next chapter will talk about the light activated switch circuit, how does the circuit work? What is the equipment of the circuit? Where we can use it? Also this chapter will containthe diagram of'the circuit and some figures for some equipment,

CHAPTER FOUR

LIGHT ACTIVATED SWITCH

4.1Overview

In this chapter we will explain and design a *light activated switch* circuit, what is the input and the output of the circuit? How does it work? What the problems are after building this circuit? The diagram of the circuit will show how we can connect the circuit, also the components that are used in the circuit will be presented. And in this chapter we will make some improvement on the circuit by using LM 555 timer, with the diagrams of the modified circuit and the LM 555 timer.

4.2 Introduetten

There is a wide range of applications for light activated switch such as: staircase light timers, outdoor illumination, automatic door openers by a light beam, alarm system, solar tracking system and so on. Many of applicatioris are familiar with the single transistor opto-switch where an LDR (light dependent resistor) is placed between the base and either grounded depending whether a normally on or normally off function is required. This simple circuit is testing how is the LDR is affect on the switch.

4.3 How Does the First Circuit Operates

The circuit diagram shown in figure (4.1) is för a switch of the type that activates a relay when the light level received by the light sensor rises above a certain threshold level, and switched off again when the light level falls back below the threshold level.

The relay coil is driven from the collector of Trl, and the relay will be activated if Tr1 is switched on by a suitable base current and voltage, The voltage and current available at the base of Tr1 is dependent on two main factors, the resistance provided by PCC1, and the setting of VRl. If VRl is set at maximum vahıe PCCl needs to have a resistance of about 100 kO or less in order to bias Tr1 into conduction and activate the relay. In total darkness

PCC 1 has resistance of 200 Jill or more, but only a very loWlightlevehis'.sufficient to reduce its resistance sufficiently to switch on Trl and the relay.

If VRl is set fora lower resistance level, PCCl needs to exhibifal§,Wıer resistance in order to bias Tr1 into conduction, and the sensitivity of the circuit is reduced since PCC1 must be subjected to a higher light level in order to produce this lower resista.rıcei If Vr1 is steady adiusted lower in resistance, the sensitivity of the circuit is progressively red~,ced. With VR1 at virtually minimum resistance even an extremely high level of light will be(ü:ı.~i.i'fficient to operate the circuit. Thus VRl acts as a sensitivity control, and enables the<light threshold Ievel to be varied over extremely wide Iimits.

D1 might at first appear to be superfhıous, butit rnost be borne in mind that a relayicôil is a highly inductive component, and this can result in a high reverse voltage being geri~rated across the relay coil as it is de-energised. The purpose of D1 is to suppress this voltage pµlş~ and prevent it from damaging Trl.

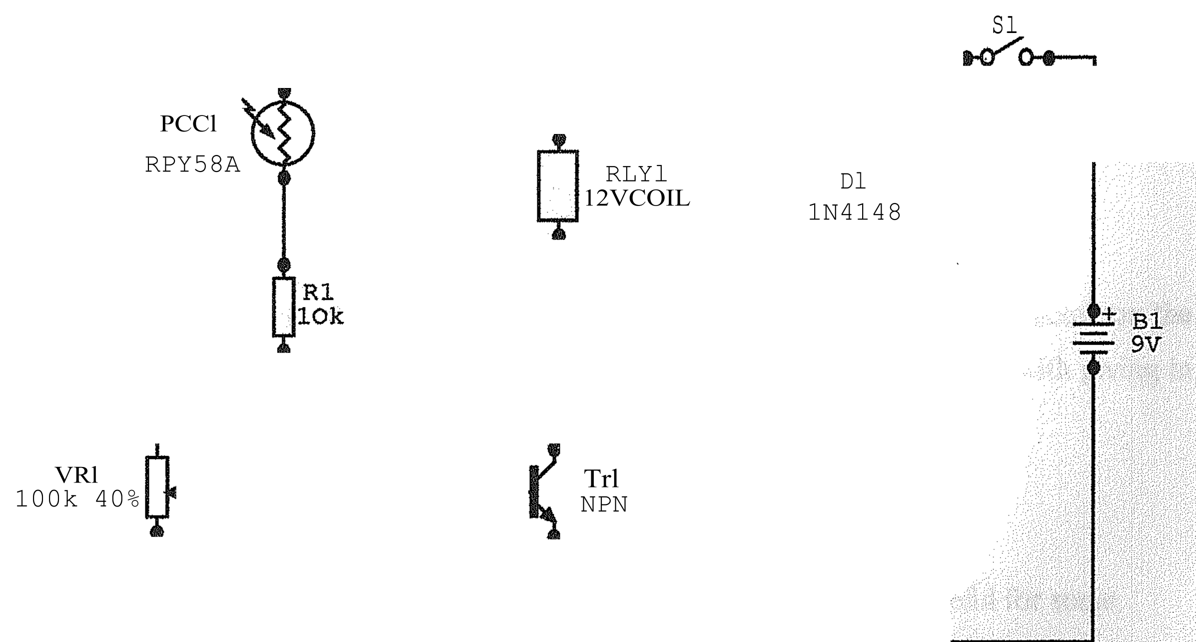


Figure 4.1 The circuit diagram of'the Hght-a.ctivated>svvitçli

4.4 The Cemponeats

The following component have beenused in this circuit:

1) Resistors of 1/3 watt 5%:

• Rl 10 kQ (brown, black, red;iğôld)

•VRl lOOkQ

2) Semiconductors:

• Trl BC109C

• Dl 1N4148

• LED red för the power and green for the outpu

3) Photocell:

PCCl RPY58A

4) Switch:

• S1 SPST miniature toggle type

• RLY 6/12-volt coil having a resistance of 185 ohms or more, and contacts of appropriate type and adequate rating.

5)Battery:

BI size 9-volt

4.5 The Result of The First Circuit

The circuit worked well without facing any faults. A green LED diode was connected on the out put of the circuit to test it, to make sure that it is giving a correct out put with giving in put as shown in figure (4.2).

4.6 The Circuit Problems

• LOR is very sensitive to infrared light; thar causesthis circuit cannot be useful for some applications that are dealing with infrared sources. To avoid this problem specialintrat~tı shield is used for the LOR.

• LOR is sensitive to light level also, so that for each level of light we have to adjust the variable resistance.

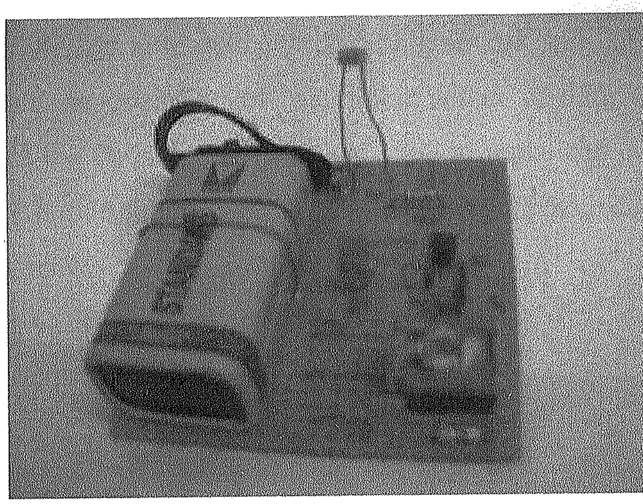


Figure 4.2.a First circuit of Light Activated Switch

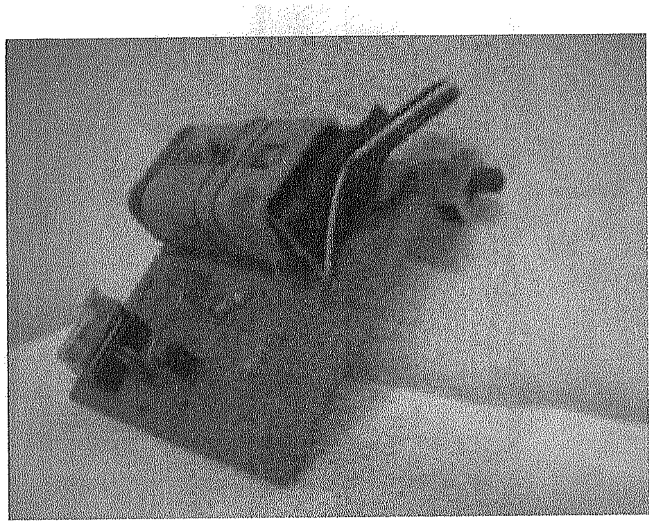


Figure 4.2.b Light Activated Switch

4.7 Imprevement on The FirstCircuit

The first circuit was designed to work just under dark conciitions and when exposed to light. This circuit can be modified to work and switch on under dark and light condition by using a switch that can convert the operation of the circuit wither in dark or in light effective by replacing the LDR and the variable resistor. And also to make the circuit more improvable we are going to use a LM 555 timer as showingin figure 4.3. Which can give a time period to the switch (relay) to turn off.

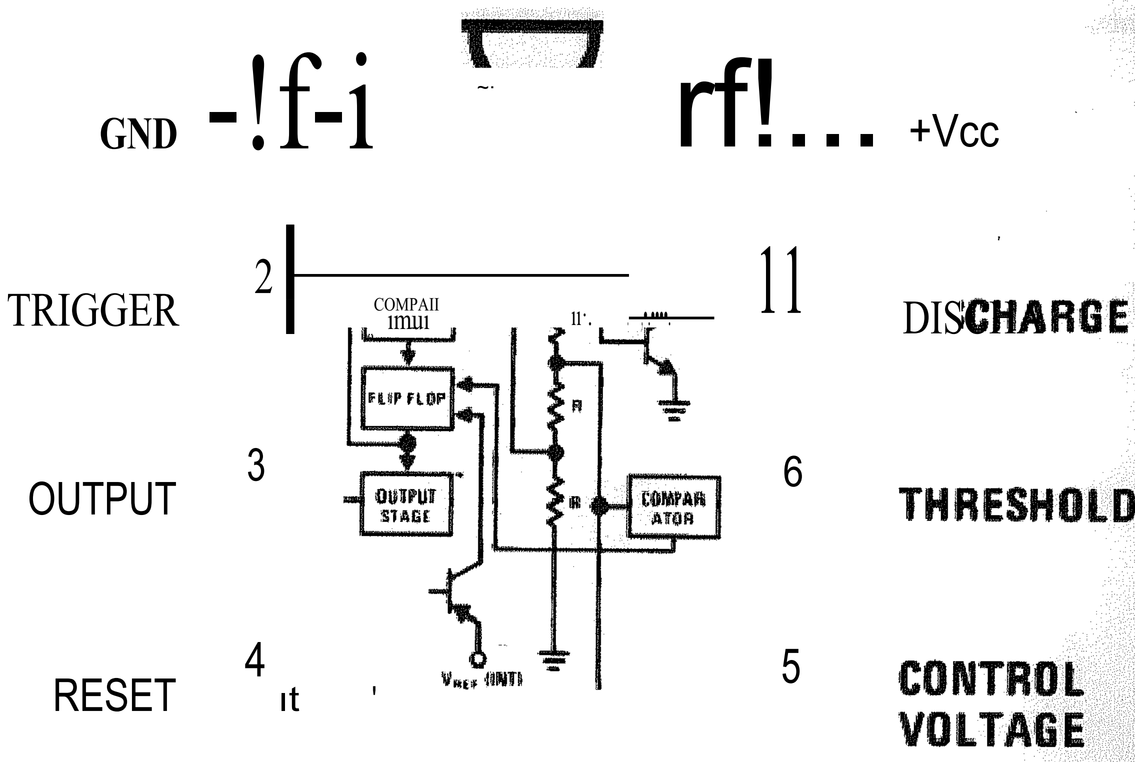
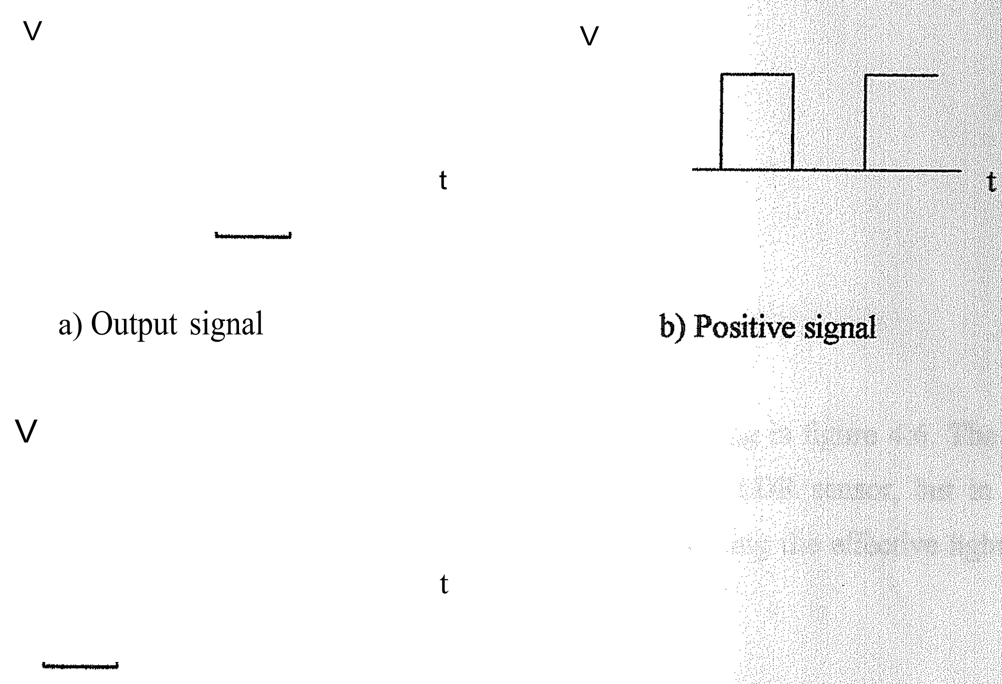


Figure 4.3 LM 555 Timer

4.8 Hew does the seeona circuit work

The operation of this circuit is similar to the first but the difference is in the circuit, here we changed the input module by connecting the LDR with the variable resistance directly as shown in figure4.5, the signal that coming from TR1 passing to the timer (LM 555). In the timer circuit as shown in figure 4.5 we have a capacitor and variable resistor (Vr2) that create the time constant for the timer, the output of TR1is connected to the threshold of the timer (pin 6) and from this pin to trigger (pin 2), after triggering the timer start discharging the capacitor depending upon the variable resistor (Vr2). However, we have here bipolar output, in this circuit, the stand by output is negative, .if an input signal is triggered the timer, the output signal will change immediately to positive edge as shown in figure 4.4. After this operation the timer start discharging the capacitor and the time of discharge is the time period of the output, Therefore, the timer will change to the standby mode (negative output). And in this circuit the light signal is effecting to the transistor (TR2) PNP type, so that it is acting as switch to giving an output from its emitter as showing in figure 4.5.



a) Output signal

b) Positive signal

c) Negative signal

Figure 4.4 The Signals of Time In LM 555

4.9 The Cemponents used in The Improved Second<Circüit

1) Resistors of 1/3 watt 5%:

- R1 100 kO (brown, black, red, gold)
- R2 lkQ
- R3,R4 4700
- RS 12 Q
- VRl, VR2 100 kQ

2) Semiconductors:

- Trl 2SA733 (NPN)
- Tr2 2SC9015 (PNP)
- C1 Capacitor
- LED red for the power and green for the ötitput

3) Photocell:

PCCl RPY58A

4) Switch:

- Sl, S2 SPST miniature toggle type

5) Battery:

B1 size 9-volt

6) TIMER555

4.10 The Result of Tne Second Circüit

The circuit was worked well without any fauff as showing in figure 4.6. The problem.f)iıııwthis circuit is as we mentioned before the sensitivity of an LDR sensor, but in this tırcuıt this problem occur more than the first, while we are converting the effective light eit~et in dark nor in light.

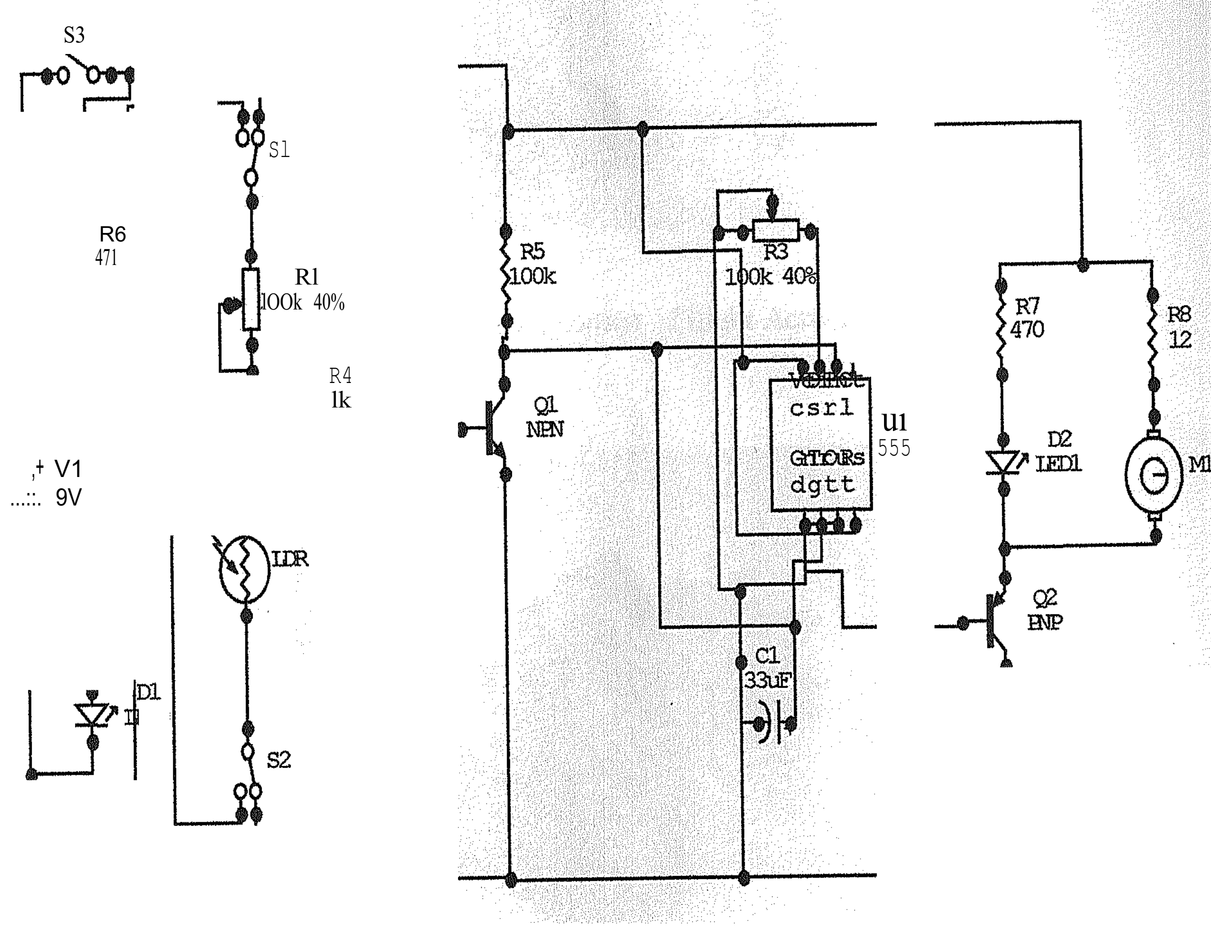


Figure 4.5 Secorid Circuit Diagram

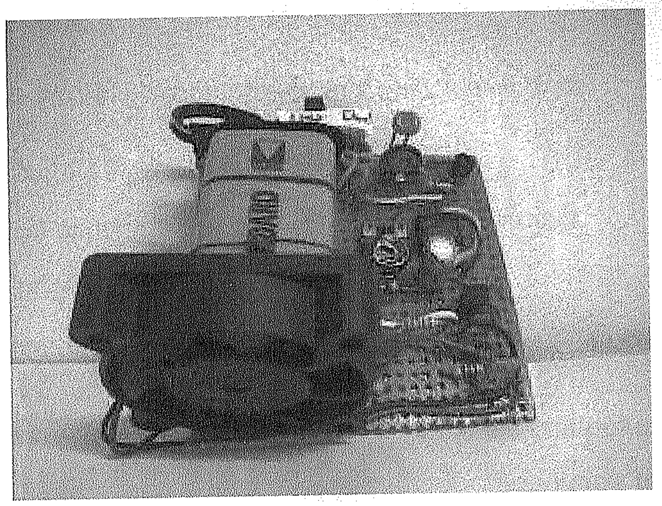


Figure 4.6.a The SecondCircuitöf Light Activated Switch

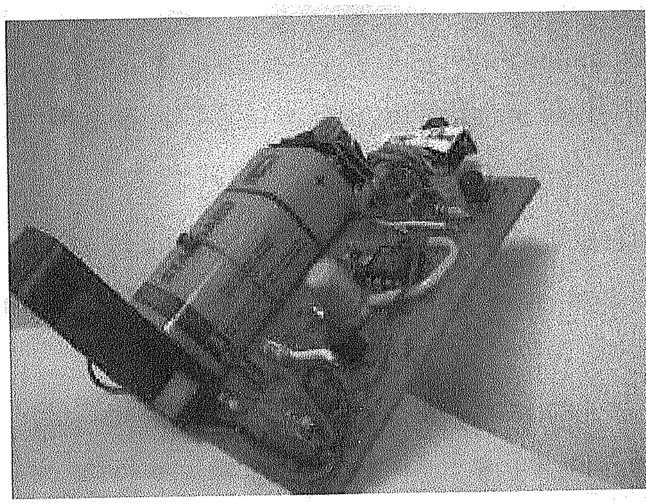


Figure 4.6.b Light Activated Switch

4.11 Summa:ry

in this chapter we have seen an introduction about light activat,ed switch, where we can use it. Also in this chapter we have explained two circuits using an LO:R sensor, the diagram of the first and the second circuits also showed. And the components of both circuits were listed with the intemal diagram ofLM555 Timer,

CONCLUSION

So far from this project we have accomplished our aims which were:

- To design and build a light activated switch.
- To gain hands-on experience in electronic hardware project.
- To modify the original circuit where possible.
- To suggest potential real-life use of switches.

in the first chapter we have seen different types of electronic components and the safety way of using them in any electric circuit, also we learned how to measure them without expecting an error.

in the second chapter we have discussed switches, the types of switches we have seen 12 types of switches, the effect of the circuit parameter on the life-time of switches, and the effects of the acceleration (shock and vibration). Also the contact material, terminology of switches, and the use of the switches in the hestile environment were been discussed.

in the third chapter we have discussed the light in general, the wavelength of colors, and the properties oflight (reflection, refraction, speed, quantity, quality, wavelength, intensity).

The maintenance of light was discussed by giving the principles of light maintenance and effect of maintenance on efficiency and effectiveness. The photon, EM radiation spectrum, visible light, infrared, photon detector, photoconductive detector, and leaser have been explained.

The fourth chapter was an introduction about: light activated switch, where we can use it. Also in this chapter we have explained two circuits using an LDR sensor, the second circuit was a modification ofthe first, the diagram ofthe first and the second circuits also showed.

REFERENCES

[l]. "Assoc. Prof. Dr Adnan Khashrri.anfsJN9te'I,

[2]. Electrical Measurement "Prôf Dr. Khalil Ismailov Abbasoglu" 1999.

[3]. "Pushbutton Switch Termirıôfögy"

[4]. "The Switch in an Electrical Cjrcfüf',~~yhill, Inc, La Grange, 1991.

[5]. Lookwood, J.P," ApplyingPrecisionSwit ches – A Practical Guide." Micro Switch, Freeport, 1973.

[6]. "The ElectricaLCircuit" Grayhill, Inc, La Grafiğe; 1~89.

[7]. " Serway Physics" Fourth Edition,

[8]. Process Contröl ItıstfufuerttatioııTechnôlôgy

[9]. htt://www. Stanfötd. edu/ - gary/controlers

[10]. htt://www. Ohmslaw; com

[11]. htt:/lwww. home: Cogeco.ca