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EFFICIENT LIGHTING SYSTEM AND WAYS TO IMPLEMENT IT

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ABSTRACT

Modern societies are becoming increasing dependent on reliable and secure energy supplies to underpin economic growth and community prosperity. Economic growth is an important factor in electricity demand growth. Although world gross domestic product (GDP) growth slows in International Energy Outlook 2016 (IEO2016) in comparison with past two decades, electricity demand continues to increase. World net electricity generation increases to 69% by 2040, from 21.6 trillion kWh in 2012 to 25.8 trillion kWh in 2020 and 36.5 trillion kWh in 2040. Electricity is the world's fastest growing form of end-use energy consumption, as it has been for many decades. However, energy-saving solutions have been becoming increasingly essential in recent years because of environmental issues such as climate change and global warming. Environmental problems are very important issues and these problems are largely caused by the excessive use of energy. A light account for approximately 20% of the world's total energy consumption. The main goal of efficient lighting is to help cut lighting operational costs 30% to 60% while enhancing lighting quality, reducing environmental impacts, and promoting health and work productivity. Fluorescent lamps, Low-Mercury Fluorescent lamps, High-Intensity Discharge Lamps, Incandescent lamps, LED lamps, Fluorescent ballasts, Electronic high-intensity discharge ballasts, and Luminaries are all different sources of energy-efficient lighting.In this paper work the concept is to how we can improve the quality of existing lighting schemes through the use of energy efficient lighting technologies.

1. INTRODUCTION

Lighting accounts for about 11% of energy use in residential buildings and 18% in commercial buildings. Both conserving lighting use and adopting more efficient technologies can yield substantial energy savings. Some of these technologies and practices have no up-front cost at all, and others pay for themselves over time in the form of lower utility bills. In addition to helping reduce energy use, and therefore greenhouse gas emissions, other benefits may include better reading and working conditions and reduced light pollution. New lighting technologies are many times more efficient than traditional technologies such as incandescent bulbs, and switching to newer technologies can result in substantial net energy use reduction, and associated reductions in greenhouse gas emissions. In the recent trends the use of electronic load is increasing very fast and the gap between demand and supply have made the reliability and power quality a critical issue. The most waste of energy is caused by the inefficient use of the consumer electronics.
Particularly, a light accounts for a great part of the total energy consumption. Various light control systems are introduced in current markets, because the installed lighting systems are outdated and energy-inefficient. Hence, various controlling mechanism like infrared sensors, motion sensors, automatic timers, dimmers etc have been proposed for efficient power consumption with existing lighting schemes. Later in this paper a judicious comparison of various lighting scheme has been done and the optimum choice has been taken into consideration.

1.1General lighting information

There is no substitute for good lighting design, which focuses on light quality as well as light quantity. The environment is lit for people so lighting should be both functional and attractive. Understanding some basic lighting concepts can help when designing energy efficient lighting solutions.

1.1.1Electric light

1. **How much light did we start with? –** The light produced by a light source (typically a lamp) is measured in lumens (lm) and is called luminous flux
2. **Where is the light going? –** If light is directed towards a surface, rather than scattered and uncontrolled, the light level will be higher on the surface. This is called luminous flux or light intensity and is measured in candela (cd)
3. **How much light got there? –** The light arriving at a surface is called illuminance and this is measured in lux. Illuminance does not take into account how the surface will respond to the light, only how much gets there. 1 Lux= 1lm/sq. mtr.

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4. **How does the surface look once it has been lit? –** a white wall will reflect a lot of the light directed at it and will effectively become a light source, while a black wall will not reflect much light. The luminance of a surface is measured in candela per square metre (cd/m^2).
5. **Luminous Efficacy:** Luminous efficacy of a source (LES) is the ratio of lumens per unit input power (lm/W). Input power is generally assumed to be electricity.
6. **Color Rendering Index (CRI):** It is the quantitative measure of the ability of a light source to reveal the colors of various objects faithfully in comparison with an ideal light source. It is a scale from 0-100% indicating how accurate a given light source is at rendering color when compared to a reference light source. The higher the CRI, the better the color rendering ability.

2. LIGHTING CRITERIA

Factors to be considered

1. Efficiency of the Light Source(lm/W)

Choose the most efficient light source that can deliver the desired lighting characteristics required for the application. While the efficiency of the light source is a key component of an energy effective lighting solution, it is only one of a number of selection criteria. Take a low pressure sodium lamp as an example, it is a very efficient light source but its poor colour entering characteristics make it unsuitable for most applications. Lumen efficacy is defined as the ratio of light emitted by a light source to the power consumed by the light source, including power consumed by any auxiliary control gear (Lumens provided per Watt consumed).The higher the lumen efficacy, the more efficient the source is at producing light.

2. Color Rendering

Lamps can be good or bad at rendering or reproducing colors. Define the quality of color reproduction required. Low pressure sodium is particularly poor at reproducing colors but its efficiency makes it very suitable for street lighting where reproduction of color is not of primary importance.

3. Color Appearance (K)

Decide the color of 'white light' that best suits the application. This is referred to as color appearance and can be different for each type of lamp or can vary among models of the same lamp type. Choosing the most appropriate color 'white' can enhance the objects being lit or the ambience of the space. For instance, the lighting in a doctor's waiting area should use a color of 'white' that is 'warm' so that people feel comfortable. Colour appearance defines a lamp's 'whiteness' which is either 'blueish'(cool) or 'redish' (warm) in appearance. The 'whiteness' of different lamp types varies from 1,800 Kelvin (very warm, amber) to 8,000 Kelvin (very cool). There are many colours of 'white' available in the popular ranges oflamps for general use, these are:

- a warm colour 'white' (2,600 to 2,700 K)
- a medium colour 'white' (3,000 to 3,500 K)
- a cool colour 'white' (4,000 K)
- very cool 'white' (6,000 K)

4. Lamp Life (Hours)

Try to choose a lamp with the maximum life expectancy. Expected lamp life may vary on individual lamp types as well as between different lamp types. It is always cost-effective to purchase the longest-life lamp available for a particular lamp type even if it costs a little more.Lamp life is classified in two ways depending on the type of lamp. The first is lamp expiry time also referred to as lamp mortality. This termrefers mainly to light sources with filaments such as tungsten lamps. When the filament breaks, the life of the source has ended. The second classification is based on when the light output of the light source falls to80% of the maintained lumens (lumens given at 2,000 hours). This is used for discharge forms of light source such as fluorescent, metal halide and sodium. Most of these light sources will continue to give light for longer periods of time, but will continue to decrease in light output until they expire.

5. Luminaire Efficiency

This is provided by all reputable manufacturers in their technical descriptions and is referred to as the Light Output Ratio (LOR) of the luminaire (light fitting). LOR is the ratio of the light output of a luminaire to the total light output of the individual lamp it contains. Choose the luminaire with the greatest light output.

6. Light Distribution

Choose a wide or narrow light distribution pattern depending onthe application. An office normally requires wide and even light distribution with good uniformity, whereas a narrow distributionsuits warehouse aisles.

7. Lighting Controls

Lighting controls should provide the right quantity of light as and when required. Lighting can be controlled by time, occupancy and daylight availability. If an area is infrequently used and lights are not routinely switched off when not required a simple presence detector, appropriately positioned, would be a useful automatic control. This would automatically switch lights on and off when personnel entered or left the area. If there is a significant amount of natural light entering into the area, then it would also be prudent to include either a separate daylight sensor or a daylight sensor which is integrated within the presence detector. These sensors are available for recessing into the ceiling or to be surface mounted and can be adjustable on site or factory set. Lighting controls are available with different methods of occupancy detection, infra-red, ultrasonic or microwave. When deciding on which type of detector to use it is important to understand some limitations of the technologies. For example, an infra-red sensor which reacts to changes in heat patterns in a space works best in small open spaces rather than areas with partitions, cabinets etc. which can block the beams. The further away a moving object is from an infra-red sensor the larger the motion needs to be to register with the device. Both ultrasonic and microwave sensors detect in a sonic manner and unlike infra-red sensors do not need a direct line of sight of the motion source. They will detect very slight movement but this can sometimes

lead to false signals, e.g. a draught moving a piece of paper, or movement beyond a glass partition or window. Another aspect of control to consider is whether the link between the sensor or sensors is to a single luminaire or to a number of luminaires. If the link is to a single unit an individual connection from the sensor to the luminaire or its supply line is all that is required. This link can provide presence detection and also daylight sensing. Daylight sensing for instance can either switch the lamps on or off, or gradually dim the light sources depending on the availability of daylight, this method of control is referred to as ‘constant lux’ dimming.

2.1 Types of Lighting

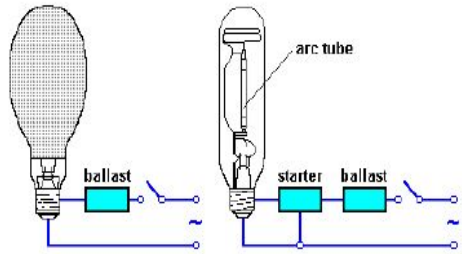
- ***Incandescent Lamp***

These bulbs emit light when an electrical current causes a tungsten filament to glow; however, 90 percent of the energy used for the bulb is emitted as heat rather than light, making these bulbs the least efficient for most household purposes when evaluating them on a lumen (amount of light emitted) output to energy input basis. Halogen bulbs are a type of incandescent that are slightly more efficient than standard incandescent but less efficient than most other alternatives.

- ***Gas Discharge Lamp***

Low pressure discharge

Though these types of lamps are among the most efficient available for outdoor use, they are only useful for certain applications because of their long start-up time, cool-down time, and poor color rendition.14 Low-pressure sodium lamps are typically used for street or highway lighting, parking garages, or other security lighting. Because of their niche application, they are not typically considered as a substitute for other types of less efficient bulbs.



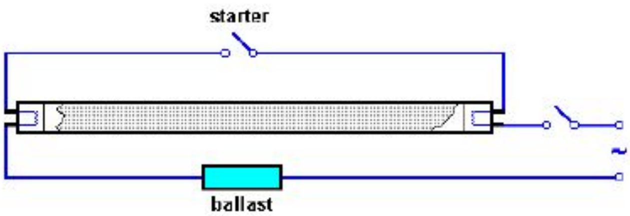
High Pressure Discharge

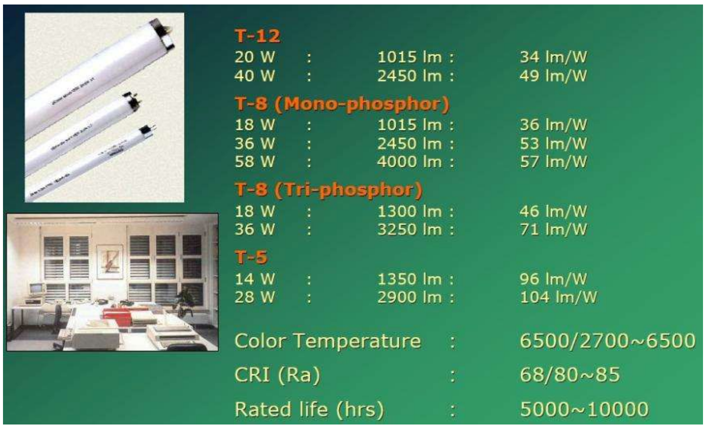
HID lamps come in several varieties with widespread applications. They emit light when a current also regulated through a ballast is passed between two electrodes on either end of a gas-filled tube. An electric arc between two electrodes is used to produce intensely bright light. Mercury, sodium or metal halide act as the conductor.HID have highest efficacy and longest life. They are used generally for outdoor purpose and large indoor arena .Ballast needs time to establish arc and hence they take 10 minutes (max)when first turned on. Mercury, sodium, or metal halide gas can be used, each with different color outputs, lifetimes, and applications. These types of lights are not appropriate for all types of areas and use; for instance, HID lamps have a long start-up period—up to ten minutes—and are best used in areas where lighting must be sustained for several hours (e.g., on sports fields or for street lights). In general, HID bulbs are 75-90 percent more efficient than incandescent bulbs and have a long lifetime, with metal halide and high-pressure sodium bulbs being far more efficient than mercury vapor bulbs.

- ***Fluorescent Lamp***

3 – 5 times as efficient as standard incandescent lamps and last 10 – 20 times longer

Electricity passes through a gas or metallic vapor and causes radiation. Fluorescent tubes are hot cathode lamps.

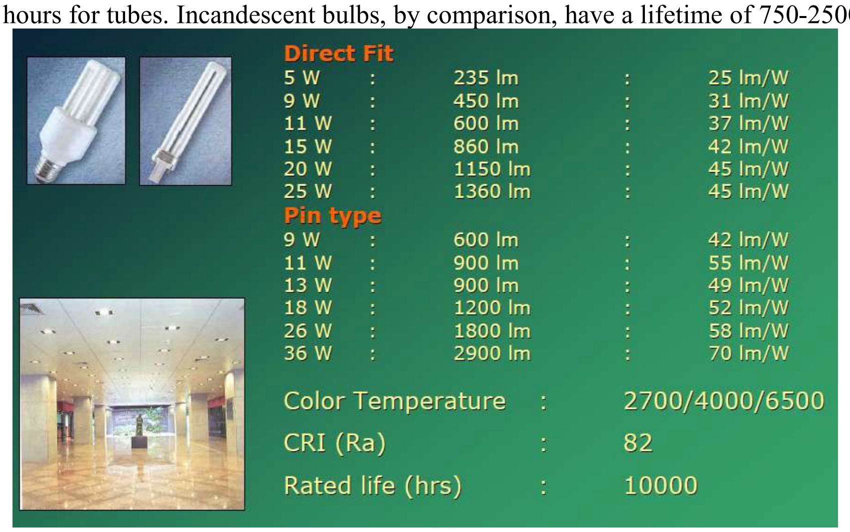




- **Compact Fluorescent Lamp (Cfl)**

These emit light when an electric current causes an internal gas-filled chamber to fill with ultraviolet (UV) light, which is then emitted as visible light through a special kind of coating on the tube. All fluorescent bulbs require a ballast, a component that regulates the current going through the lamp. Ballasts can be integrated into the bulb, as is the case for most CFLs (allowing them to be used interchangeably with most incandescent bulbs) or non-integrated, which require the ballast to be part of the fixture, as is the case for many fluorescent tubes used in schools and offices. Ballasts come in two varieties: magnetic (which are older and less efficient) and electronic (which are newer and much more efficient). Efficiency upgrades for fluorescent tube lights require consideration of the ballasts because they contribute significantly to the overall energy draw of the fixture.

Both CFLs and fluorescent tubes come in a variety of shapes, sizes, and efficiencies . They generally use 75 percent less energy than incandescent light bulbs. A CFL produces between 50-70 lumens per watt, compared to the 10-19 lumens per watt for an incandescent bulb. They are also long-lasting products, with a lifetime of 10,000 hours for CFLs and a lifetime of 7,000-24,000 hours for tubes. Incandescent bulbs, by comparison, have a lifetime of 750-2500 hours.



Do CFLs contain mercury?

- CFLs contain a very small amount of mercury sealed within the glass tubing - an average of 4 milligrams .By comparison the older thermometers contain about 500 milligram of mercury – an amount equal to mercury in 125 CFLs .
- Mercury is an essential part of CFLs; it allows the bulb to be essential part of light source.
- No mercury is released when bulbs are intact or in use .Most makers of light bulb have reduced mercury in their fluorescent lighting products.
- Thanks to technology advances the average mercury content in CFLs has dropped at least 20 % in the past year. Some manufacturers have even made further reductions, dropping mercury content to 1.4-2.5milligrams per light bulb.

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What precaution should take when using CFLs in home?

- CFLs are made of glass and can break if dropped or roughly handled. Be careful when removing the bulb from packaging, installing it, or replacing it. Always screw or unscrew the light bulb by its base (not the glass), and never forcefully twist the CFL into light socket .If a CFL breaks in your home follow the clean up recommendations given by Bureau of Energy Efficiency.

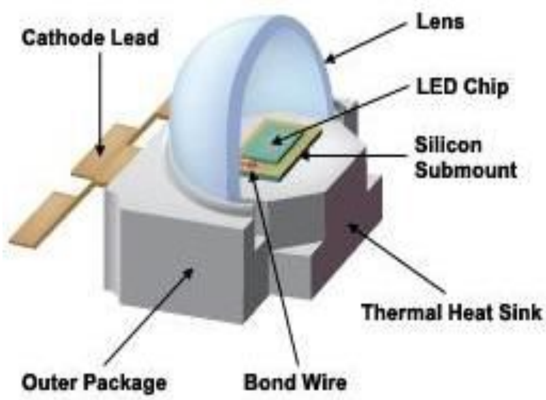
Key Features of CFLs

- Low electrical consumption as compared to conventional lighting products.
- Pollution free due to non-emission of infra red or ultraviolet rays, mercury gases or other harmful rays.
- Do not have ballasts thus, no interference.
- Existing fixtures used since long are used making installation of our lights easy.
- Operates on universal input range.
- Due to long shelf life, no maintenance is required.
- Lasts 5 to 10 times longer than other conventional lighting products virtually eliminating the need for frequent replacement.
- Reduces Carbon Footprints at large scale making it viable to earn carbon credits.
- Suitable for all types of applications

3. SOLID STATE LIGHTING

- **Led**

In light-emitting diodes, electrons and electron holes (atoms that lack an electron) combine, releasing energy in the form of light. It is essentially a semi conductor diode. It consists of a chip of semiconducting material treated to create a structure called a p-n (positive-negative)junction. When an electron meets a hole, it falls into a lower energy level, and releases energy in the form of a photon (light).The specific wavelength or color emitted by the LED depends on the materials used to make the diode. This technology has been around for several decades, but many applications of LEDs for lighting have only recently become available commercially as improved color renditions have been developed and costs reduced. LED fixtures use 75-80 percent less electricity than incandescent bulbs, and can have a lifespan 25 times longer than incandescent light bulbs. LEDs produce in the range of 27-150 lumens per watt, depending on the type of LED. LEDs have small, very bright bulbs and because of their size, LED fixtures are often found in specialty applications such as decorative lamps as well as functional lamps in difficult-to-reach areas, such as for strip lighting, outside lighting, display lighting, stairway lighting, etc. (see the DOE website for more information about current LED applications). LEDs are more durable than most other lighting alternatives and are more controllable because the light can be focused in a particular direction and the LED can be dimmed.



Red LEDs are based on aluminum gallium arsenide(AlGaAs).**Blue LEDs** are made fromindium gallium nitride(InGaN).**Green LEDs** from aluminum galliumphosphide (AlGaP)."White" light is created bycombining the light from red,green, and blue (RGB) LEDs.White - by coating a blueLED with yellow phosphor. Besides, an LED has:

- No Mercury
- CRI of 92, some LED lights are dimmable
- Long Life (> 50000 hrs), high efficacy (102 lm/W)
- They generally consume 80% less power than incandescent lamp and 50% of CFL.
- 12W LED can replace 65W Incandescent

Lifespan of LED Light Bulb

- Most modern LEDs are undergo superior design and manufacturing process that gives them a lifespan of up-to 1,00,000 hours, compared with 10,000 for a compact fluorescent and 1,000 for an incandescent bulb.
- Lifespan of a LED bulb could come down due to the amount of heat a LED produces. This directly depends on die temperature and ambient temperature of the LED.
- Some LED light bulbs show sign of age after a couple of years of use and may produce only 50% of the light output when compared to what it used to produce when it was new. However new technologies are in process to enhance its performance over its life span.
-

Power Consumption of LED Light Bulb

- Most modern LED operate in a range of 2 to 4 volts and consume anywhere between 350mA and 1500mA. The power consumption varies from manufacturer to manufacturer and also because of the purpose for which the LED was designed.
- Another factor that affects power consumption of LEDs is for the fact that LEDs can not be dimmed.
- Nowadays using latest of the LED manufacturing technology, manufacturers are able to produce LEDs that are not only super bright but also consume less power while producing light of higher intensity.

Benefits of using LED light bulbs over standard light bulbs

- Power consumption of LED light bulb is only 10% of the standard light bulb.
- LED light bulbs withstand great amount of vibration, shock and temperature variations.
- LED light bulbs are 10-60 times more energy efficient than incandescent light bulbs.
- Incandescent light bulbs produce light that flickers whereas LED light bulbs produce flicker free light.
- LED bulbs can produce many rich and vibrant colors when compared to incandescent light bulbs.

Key Features of LED light bulbs

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- Pollution free due to non-emission of infra red or ultraviolet rays, mercury gases or other harmful rays.
- Do not have ballasts thus, no interference.
- Existing fixtures used since long are used making installation of our lights easy.
- Operates on universal input range.
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- Suitable for all types of applications.

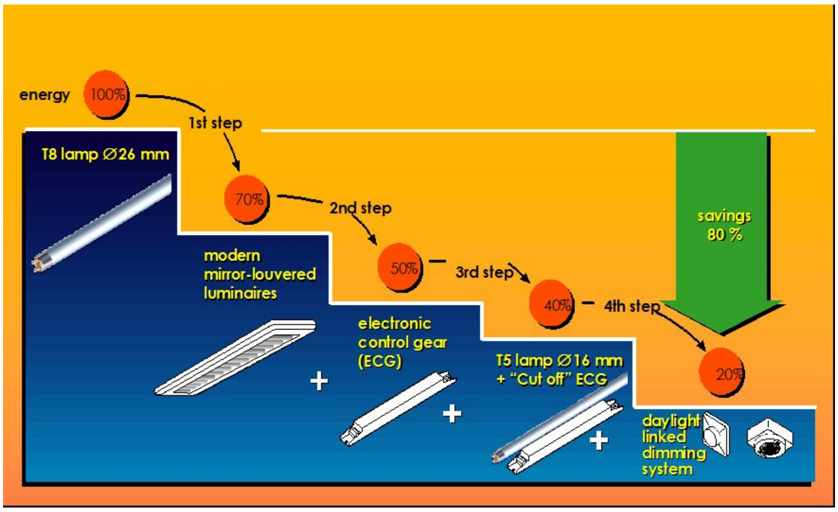


Fig. Energy saving by deploying dimmers

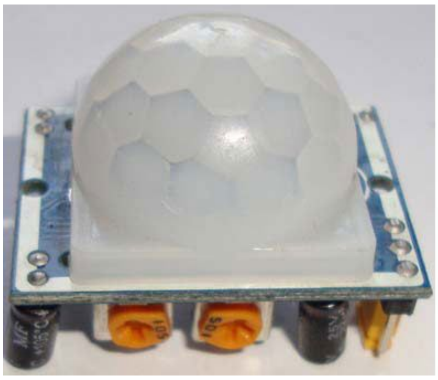
4. LIGHTING CONTROLS MECHANISM

The simplest and the most widely used form of controlling a lighting installation is "On-Off" switch. The initial investment for this set up is extremely low, but the resulting operational costs may be high. This does not provide the flexibility to control the lighting, where it is not required.Hence, a flexible lighting system has to be provided, which will offer switch-off or reductionin lighting level, when not needed. The following light control systems can be adopted atdesign stage:

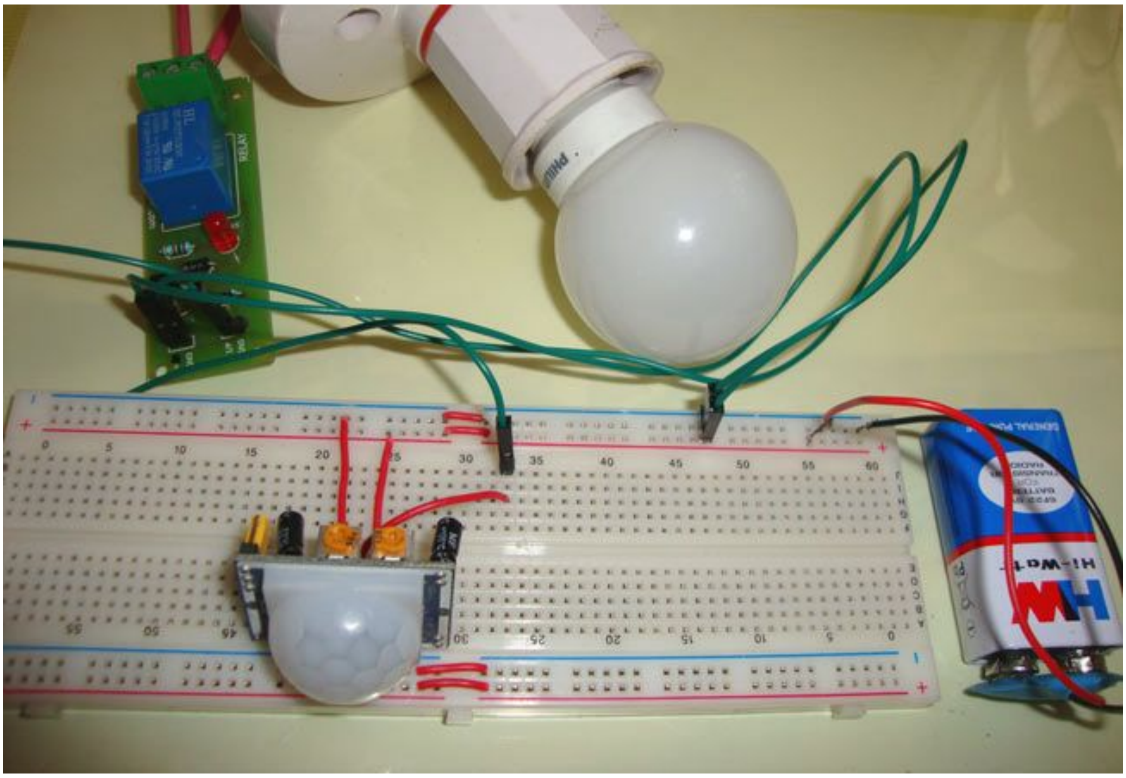
- **Occupancy Sensors**
  These devices – also known as "MOTION DETECTORS" – turn lights OFF and ON in response to human presence i.e. depending upon the person density over an area these sensors will increase or decrease the efficacy of the lights.

- **Timers**
  These represents the most basic type of automation and are very popular for outdoor applications. Timers can be simple (responding to one setting all year round or sophisticated enough to contain several settings that go into effect over time.

- **Passive Infrared Sensors**
  These sensors detects the motion or heat between vertical and horizontal zones. This technology requires a direct line of sight and is more sensitive to lateral motion. PIR sensor is used here to detect the Human body movement, whenever there is any body movement the voltage at output pin changes. Basically it detects the Change in Heat, and produce output whenever such detection occurs. You can learn more about PIR sensor here, there are some useful features in PIR sensor like how to change the distance range, how to set the duration for which the light should be ON etc.



Sensor Implementation



Relay Module
Relay is an electromagnetic switch, which is controlled by small current, and used to switch ON and OFF relatively much larger current. Means by applying small current we can switch ON the relay which allow much larger current to flow. Relay is the good example of controlling the AC (alternate current) devices, using a much smaller DC current. Commonly used Relay is Single Pole Double Throw (SPDT) Relay, it has five terminals as below. When there is no voltage applied to the coil, COM (common) is connected to NC (normally closed contact). When there is some voltage applied to the coil, the electromagnetic field produced. Which attract the Armature (lever connected to spring), and COM and NO (normally open contact) gets connected, which allow larger current to flow. Relays are available in many ratings, here we used 6V operating voltage relay, which allow 7A-250VAC current to flow.

Relay is configured by using a small Driver circuit which consist a Transistor, Diode and a resistor. Transistor is used to amplify the current so that full current (from the DC source – 9v battery) can flow through coil to fully energies it. Resistor is used to provide biasing to transistor. And Diode is used to prevent reverse current flow, when the transistor is switched OFF. Every Inductor coil produces equal and opposite EMF when switched OFF suddenly, this may cause

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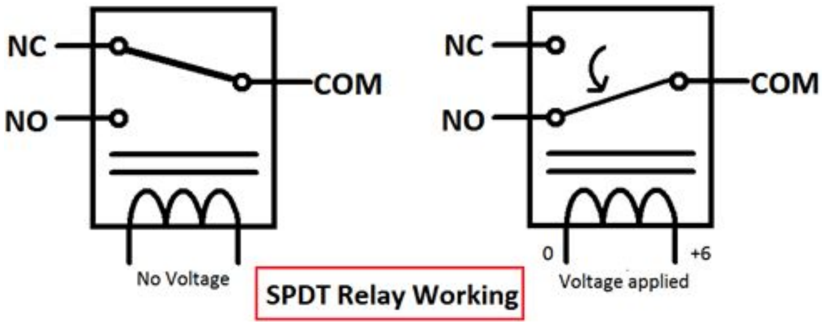
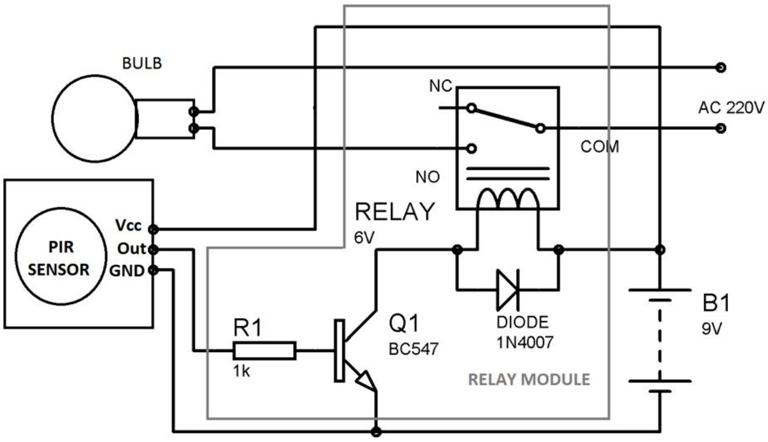
permanent damage to components, so Diode must be used to prevent reverse current. A Relay module is easily available in the market with all its Driver circuit on the board or you can create it by using above components. Here we have used 6V Relay module.



SPDT Relay Working

Relay Module



Equivalent Circuit Diagram For Above Module

5. WORKING OF PIR MODULE

This automatic light circuit can be easily explained. Whenever PIR sensor detects any body movement, its OUTPUT pin becomes HIGH, which applies the triggering voltage to the base of the transistor, transistor get ON, and current started flowing through the coil. Coil in Relay gets energies and create electromagnetic field, which attracts the lever and COM and NO get connected. This allows a much larger current (220v AC) to flow, which turns ON the BULB. You can increase or decrease the Bulb ON duration by setting up PIR sensor.

- **Ultrasonic Sensors**

These detects movement by sensing disturbance in high frequency ultrasonic pattern. Because this technology emits ultrasonic waves that are reflected around the room surfaces, it doesn't require a line of sight.It is more sensitive towards and away from the sensor and its sensitivity decreases relative to its distance from the sensor.

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- **Photocells**

These sensors measure the amount of light available and suitable for both indoor and outdoor applications. When the available light falls below a specified level, the control units switch ON the lights(or adjust the driver to adjust the more light). These sensors can be programmed so that lights do not flip ON and OFF on partially cloudy days.

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