Lighting Technology Overview

Electric lighting began to be developed many years ago and continues to be refined in the present day – Getting SMARTER. Lighting technology is broadly classified mainly into four types of lighting; Incandescent, Fluorescent, Halogen, LED (Light emitting diode). Each produces light using a different technique and each is manufactured a different way. Among these four technologies, LEDs are the most popular form of artificial lighting and is essential to modern society. There are of course other lighting technologies but less commonly used, including neon, argon, plasma, oil, carbon, carbide, metal halide, sodium vapour and xenon.
Traditionally based on the lighting fixture style lighting is classified into two types; Lamps and LEDs. Lamp, a replaceable component that produces light from electricity, could be an Incandescent lamp, fluorescent lamp or halogen lamp. LEDs were treated differently in the past but as LED lighting technology is rapidly progressing LEDs offer a tremendous opportunity. Nowadays LEDs are also packaged into arrays and many other configurations for the innovation in lighting form factors and fit a wider breadth of applications than traditional lighting technologies.

The incandescent lamp is almost the oldest form of lighting. The warm light source is delivered by heating a metal filament to an extremely high temperature, thus producing a usable by-product as light. Typically the life span of an incandescent light is quite short (<1000 hours) and they can be dangerous to use due to explosions at end-of-life, glass breakage and fire risk. Fluorescent lamps are more commonly Compact Fluorescent Lamps (CFL), are a relatively efficient way of creating light. Heating mercury-based gas enclosed in the glass spiral tube produces an ultraviolet (UV) light, which is then passed through a white coating or filter that changes the UV to visible light. CFLs were the efficient lighting before LED technology was into the market. The lifespan of fluorescent lighting is typically higher (up to 10,000 hours) than incandescent lighting (up to 1,000 hours), but unfortunately, CFLs have their own inherent problems. Due to the mercury content in fluorescent lights, disposal at end-of-life now means special recycling facilities are required.

Like CFLs, halogens work by heating a tungsten filament surrounded by an inert gas mixed with the element halogen to an extremely high temperature. Similarly, this produces heat and a by-product as light. Halogen MR16 and GU10 down lights were recently used in homes. The MR16 version is generally a 12-volt lamp which requires a transformer to convert 240 volt AC mains power to 12 volts. This consumes power as well as complicates the installation process somewhat. Halogens pose a huge fire risk, especially when installed too close to roof insulation.

Light emitting diodes are a solid state electronic component. Recent development in the LED industry has significantly improved the quality, functionality and abilities of the new LED chips. Due to this, we have seen an incredible growth in LED products. Offering the widest range of colours, light outputs, fixtures and new features, LED technology is now perhaps the only viable solution to the world's predisposition towards a sustainable future. LED lighting technology is rapidly progressing, and it is very important to know how to control LEDs to ensure success for the end user and to achieve energy savings.

1. Lamps

Artificial lighting is based on systems lamps, ballasts, starters, luminaires and controls. Ballasts are needed for discharge lamps to connect the lamp to the mains. Lamps, ballasts and starters are mounted in the luminaire with the wiring and lamp bases, reflectors distribute and redirect the light emitted from the lamp and louvers shield the user from glare. Ballast providing a controlled current to the lamps is an essential component of any discharge lighting system. Electronic ballasts complying with CELMA energy efficiency scheme classes A1 and A2 are the major power savers.

Following characteristics are to be considered when choosing a lamp for an application, luminous efficacy, Lamp life, Quality of light, Effect of ambient circumstances, Luminaire, Purchase and operation costs. The different types of lamps used are incandescent lamp, Tungsten halogen lamps, Fluorescent lamp, Compact fluorescent lamps, High-Intensity Discharge lamps, Mercury Lamps, Metal halide lamps, High-pressure sodium lamps, Electrode less lamps, each of these lamp types has experienced a steady march of small improvements in material, design, light quality, energy efficiency and manufacturing efficiency throughout the past century.

In an incandescent lamp, which is also called General Lighting Service Lamp (GLS), light is produced by leading current through a tungsten wire. The working temperature of tungsten filaments in incandescent lamps is about 2700 K. Therefore the main emission occurs in the infrared region.

Tungsten halogen lamps are derived from incandescent lamps. Inside the bulb, halogen gas limits the evaporation of the filament and redeposits the evaporated tungsten back to the filament through the so called halogen cycle.

A fluorescent lamp is a low-pressure gas discharge light source, in which light is produced predominantly by fluorescent powders activated by ultraviolet radiation generated by discharge in mercury. The performance of a fluorescent lamp is sensitive to the ambient temperature.

The CFL is a compact variant of the fluorescent lamp. The overall length is shortened and the tubular discharge tube is often folded into two to six fingers or a spiral. For a direct replacement of tungsten filament lamps, such compact lamps are equipped with internal ballasts and screw or bayonet caps.

In mercury lamp light is produced with electric current passing through mercury vapour. An arc discharge in mercury vapour at a pressure of about 2 bars emits five strong spectral lines in the visible wavelengths at 404.7 nm, 435.8 nm, 546.1 nm, 577 nm and 579 nm.

2. LED

A light-emitting diode (LED) is a semiconductor device that emits visible light when an electric current passes through it. The light is not particularly bright, but in most LEDs it is monochromatic, occurring at a single wavelength.
The material used in the semiconducting element of an LED determines its colour. The two main types of LEDs presently used for lighting systems are aluminium gallium indium phosphide (AlGaInP or AlInGaP) alloys for red, orange and yellow LEDs; and indium gallium nitride (InGaN) alloys for green, blue and white LEDs. Slight changes in the composition of these alloys change the colour of the emitted light. The output from an LED can range from red (at a wavelength of approximately 700 nanometers) to blue-violet (about 400 nanometers). Some LEDs emit infrared (IR) energy (830 nanometers or longer); such a device is known as an *infrared-emitting diode* (IRED).

Compared to most typical light sources used for lighting applications, LEDs still have relatively low light output, and therefore, will continue to be packaged into arrays and other configurations to be useful in such applications. At present, single white LED packages have reached nearly 100 lumens. Of course, the light output varies depending upon wavelength. LEDs are important because due to their efficiency and low energy, they are beginning to replace most conventional light sources. LEDs are incorporated into bulbs and fixtures for general lighting applications. Small in size, LEDs provide unique design opportunities. Some LED bulb solutions may physically resemble familiar light bulbs and better match the appearance of traditional light bulbs.

LEDs offer a tremendous opportunity for innovation in lighting form factors and fit a wider breadth of applications than traditional lighting technologies. LEDs use heat sinks to absorb the heat produced by the LED and dissipate it into the surrounding environment. This keeps LEDs from overheating and burning out. **Thermal management** is generally the single most important factor in the successful performance of an LED over its lifetime. The higher the temperature at which the LEDs are operated, the more quickly the light will degrade, and the shorter the useful life will be.

3. HBLED

High-Brightness LEDs are a new generation of LEDs which are bright enough for illumination applications such as automotive, interior, exterior, and display, room and architectural illumination, task and general lighting, projection display, display backlights and signage. As the name suggests these high brightness LEDs offer much higher levels of luminosity than the standard LEDs. One of the chief reasons for using high brightness LEDs is their improved efficiency over other types of lamp. It is worth comparing HBLEDs with other lamps in terms of lumens per watt.

High brightness LED are LED that produces over 50 lumens (1 candela = 12.75 lumens). It should not be confused with high power LEDs. Although they may be one and the same, high power refers to the power consumption and not the light output. Generally, it is assumed that a high power LED consumes more than 1 watt in power.

HBLED is energy efficient, eco-friendly, low power, and last longer than the average compact fluorescent and incandescent bulbs. High brightness LEDs have a number of advantages like Brighter, Longer life, Low Cost, RoHS manufacturing compatibility over the standard LEDs. Precision designed optics, multiple distributions, lumen outputs and colour temperatures make the HBLED ideal for industrial, commercial, manufacturing, gymnasium and other applications that utilize traditional HID and linear fluorescent high bays.
The High Brightness LED requires a much higher forward current of 350 milliamps, more than a Microcontroller I/O can provide. One solution is to power the LED directly from the main supply and add a MOSFET in series with the LED to control the brightness. The second method is to use Digital Signal Controllers which provides several features which allow for precise control of high brightness LEDs. These features include a High-Speed 10-bit Analog-to-Digital converter with up to 4 million samples per second, a flexible high-speed PWM, a high-speed analog comparator with a fast 20 nanosecond response time, and a flexible clock scheme with 40 MIPS operation speed.

4. LED Bars/Strips

An LED strip light is a flexible circuit board that is populated with LEDs that you can stick almost anywhere you want to add powerful lighting in a variety of colours and brightness. The use of flexible LED strip lights is rapidly rising in modern lighting design around the world. Architects and lighting designers are implementing LED strip lights into residential, commercial, and industrial projects at an increasing rate.

This is due to an increase in efficiency, colour options, brightness, and ease of installation. There are many options available in the market for LED strip lights (also called LED tape lights or LED ribbon lights) few are DC LED Flex Strips, AC LED Flex Strips, LED Rope Light, and High Power LED Strips.

LED flexible strip produces an incredible amount of light and can be used for task lighting, backlighting, desk lighting, garage lighting, and are also good for accent lighting, under cabinet lighting, bar lighting, refrigeration, industrial applications, photography and more. There are colour changing strips called as RGB strips. These LED lights can display any Red-Green-Blue combination colour. These strips require a controller to change colours in flashes or stay on one selected solid colour.

When buying LED strips it is important to not only look at the length of the strip but also a number of LEDs in the length. Ideally, you should look for the strip lights that have the highest amount of LEDs per foot. Make sure you take note of the Lumens/length along with the LEDs/length as this will have a strong effect on light quality and the type of light the strip gives off. First thing when looking for a power supply is knowing what input voltage your LED Strips require. Some require AC/DC, 12V/24V...just make sure you know what your strip needs and get a power supply with that output. Then make sure the wattage of the power supply is at least 10% higher than the wattage your LED strips will consume.

LED strip lights are packaged on a reel (spool) of 5 meters, or 16' 5''. The machines used to "pick and place" the LEDs and resistors on the flexible circuit board are typically 3' 2'' in length, so individual sections are soldered together to complete a whole reel.

5. LED Drivers

LEDs are making their entrance into the lighting field using modern high-efficiency semiconductor material compounds and structures. Solid-state lighting (SSL), offers new possibilities and advantages for the end-user. By using appropriate drivers, control strategy and LEDs, the qualitative and quantitative aspects of the light can be fully controlled. LED drivers are low-voltage devices that convert the line-voltage 120/220/277 V power to the low voltage needed for the LEDs, and may also interpret control signals to dim the LEDs. LED drivers come in either constant current or constant voltage. These two types of drivers are NOT interchangeable, and it is the design of the LED load that determines which driver is appropriate. Both LED lamps and LED fixtures requires LED drivers.

There are two ways to control the brightness of an LED. The first method is using analog dimming, which involves varying the forward current through the

LED to adjust the brightness. The second method uses a digital dimming technique involving switching the forward current on and off for short periods of time. The human eye averages these on and off times together for a perceived brightness.

The cheapest and most basic way to drive LEDs is to use a constant voltage power supply and a resistor in series with the LED to limit the current flowing through it. The selected resistance depends on the magnitude of the voltage source (VIN), on the value of the LED's forward voltage and the forward current of the LED.

Linear power supply (LPS) is an economical, simple and reliable way of driving LEDs. LPSs are based on either integrated circuit (IC) linear regulator or on bipolar junction or field effect transistors operating in the linear region. Switched-mode power supplies (SMPS) lack the main drawbacks of linear power supplies and are therefore the main solution to drive LEDs. Because LEDs are DC components, just DC/DC and AC/DC SMPS types are considered. Efficiency, controllability, small size and low weight are their main advantages over the linear power supplies. An SMPS can provide, if necessary, high currents (e.g., more than 30A) at very low voltages.

The selection of the most appropriate topology to drive LEDs depends on the standards, specifications and application requirements like operation environment conditions, system input voltage, LEDs' forward voltage, number of LEDs and circuit array.

Intelligent drivers are usually based on ASICs switching microcontrollers which include programmable flash memory (EEPROMs), several on-chip Pulse-Width Modulation (PWM) controllers, ADCs (analogue-to-digital converter) and DACs (digital-to-analogue converter) channels. Microcontroller-based LED drivers bring additional benefits such as operational flexibility, efficiency, reliability, controllability and intelligence to the system.