Lamps, LEDs and Circuits

8.8 Induction lamps

Key attributes

Rotationally symmetrical light distribution
Long rated life
Not dimmable

Key application areas

Areas where it is difficult to replace lamps
Commercial and industrial interiors
Retail
Indoor and outdoor public areas

Fig. 8.9 Induction lamp

How they work

A very high-frequency electromagnetic field is coupled into the glass bulb using an antenna protruding into the bulb. This field excites the mercury to produce UV radiation that is then converted into visible light using phosphors, just as in fluorescent lamps. The amalgam technology used in these lamps makes their luminous flux only very slightly temperature dependant. The lamps can only be operated with special electronic ballasts and have a built in microwave screen. Systems have a very long service life due to the absence of any electrodes, however the effects of lumen depreciation should still be considered. As yet there are no dimmable electronic ballasts available.

8.9 Light Emitting Diodes (LEDs)

Key Attributes

Good luminous efficacy
Long service life
Low voltage
Durable
Emit very little heat
Small dimensions

Fig. 8.10 LED

Key application areas

Exterior signage, display and directional lighting
Dynamic colour effects

How they work

An LED is a small solid-state semiconductor device that emits light when an electric current passes through it. The LED consists of a diode chip that is encased in an epoxy, plastic, resin or ceramic housing. This LED housing may be in a variety of shapes and sizes and helps determine the optical characteristics of the LED. Generally a second optical controller is used in the form of a lens mounted on the epoxy housing, and the overall characteristics of the system, from the shape and size of the LED to the configuration of the lens and distance from the diode chip to the lens define the final optical performance of the system.

As well as the optical control of the system, designing using LEDs requires careful control of heat removal from the package. Whilst the ratio of light to heat produced by LEDs is much higher than for an incandescent light source (such as a GLS light bulb) they do still produce a significant amount of heat. This heat must be removed from the LED using heat sinking, as LEDs are very sensitive to the junction temperature of the internal diode, and excess heat will shorten the life of the LED or cause failure.

Finally to operate LEDs requires a regulated direct current supply, usually supplied by a self-contained "driver" which converts the AC mains electricity to the correct DC voltage. This driver must be correctly matched to the LED it is powering as incorrect voltage and current will at best provide poor light, and may severely reduce the life of the LED or cause instantaneous failure of the system. The driver must also protect the LED system from voltage fluctuations that may cause damage. The driver can provide a quite advanced level of control, allowing dimming down to 0%, and with a cluster of different coloured diodes and the use of technology such as DMX protocols linked to a light mixing console extremely complex lighting effects may be produced.

LEDs have reasonable electrical efficiency in terms of lumens per watt (i.e. the power input to the driver compared with the light produced by the LEDs) and they are improving all the time but currently they do not compare with the high values from discharge lamp technology.

So the LED is not a true lamp, generally being supplied as a complete electrical and optical system, which is then embodied into a housing.

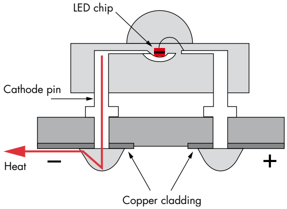

Fig. 8.11 Structure of an LED

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The light produced by an LED is monochromatic and the colour of the emitted light depends on the material used in the fabrication of the LED and varies from red through orange, yellow, green and blue. To produce white light a variety of methods are used. The best method in terms of quality of the spectrum of light is produced using a blue LED with a yellowish phosphor coating, in principal similar to a fluorescent lamp. This is termed a phosphor down conversion. The use of a phosphor does, however, decrease the efficiency of the system. LED packages may also be configured to produce mixed or blended light, either through the use of three or more different coloured LEDs (such as a mixture of red, yellow, green and blue) or through a multicolour LED that incorporates two or more different colour chips within the same epoxy package. These blended systems whilst suitable for lighting within the entertainment industry or in colour changing applications should be used with caution in the wider lighting environment as while they may visually produce white light the actual spectrum of the light is still three or more monochromatic peaks of light and therefore accuracy of colour rendering can be poor.

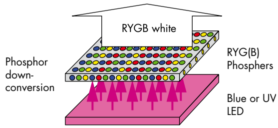

Fig. 8.12 White LED using phosphor coating

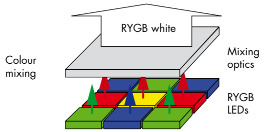

Fig. 8.13 White LED using colour blending

An additional consideration is that the process for producing LEDs cannot accurately reproduce LEDs with identical colour appearances, especially for white LEDs. If a random set of LEDs was taken which were all nominally white they would have differing appearances. To overcome this a process called binning is used, in which the LEDs are sorted into groups of similar colour appearance. The accuracy of the colour match depends upon the bin size, a larger bin size will contain a wider spread of colour appearance than a smaller bin size. However, decreasing the bin size increases manufacturing and LED costs. When using groups of LEDs or LED luminaires it is essential that the LEDs come from the same bin to give a consistent appearance.

When buying LEDs, either as a component to insert into a fixture or as a complete luminaire the LEDs may be supplied in various configurations, varying from individual LEDs to clustered or linear formats. They may also be supplied with or without a secondary lens. This gives flexibility in application, the configuration being chosen to suit the fixture it is to be used within.

Lamps, LEDs and Circuits

A benefit of LED technology is the relatively long life of the systems, manufacturers quote upwards of 50,000 hours life for LEDs, but other factors should be considered. Whilst an LED may produce light for a long period the amount of light produced will deteriorate over time. Therefore, and especially in critical applications such as emergency lighting, care should be taken to ensure that there is still sufficient light output at end of life. This depreciation of light output is mainly due to discoloration of the epoxy housing of the LED over time. Lumen depreciation and LED life varies between manufacturers, and even between colours of LEDs so manufacturers data should be consulted.

So how is an LED luminaire used? A major advantage of LEDs is their small size and long life. This makes them ideal for effects lighting where hidden lights are used to create an atmosphere in a space. Additionally, LEDs are already used extensively in signage and signaling, and in the entertainment industry. The use of LEDs in emergency lighting is becoming more common, and LED luminaires are good for providing guidance and emphasis due to their small size and availability in many colours of light. Impressive applications of LEDs may be seen, including domestic residences, retail and social environments, and in the exterior lighting of buildings. Additionally as the light produced by an LED is "cold" it has major benefits in applications such as museums where heat produced by the lighting of an artifact may cause significant damage to that artifact. However, a limitation of LEDs for this type of lighting is their monochromatic nature, except for phosphor white LEDs.

At the moment the technology is not suitably advanced to allow extensive use in the general lighting environment or more specialized applications such as streetlighting or floodlighting, but with future developments this may come.

Fig. 8.14 Examples of LED package configurations

Fig. 8.15 An example of an LED system integrated with building architecture