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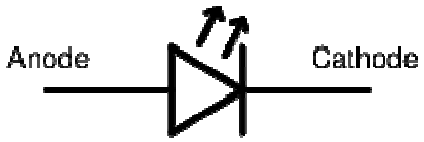
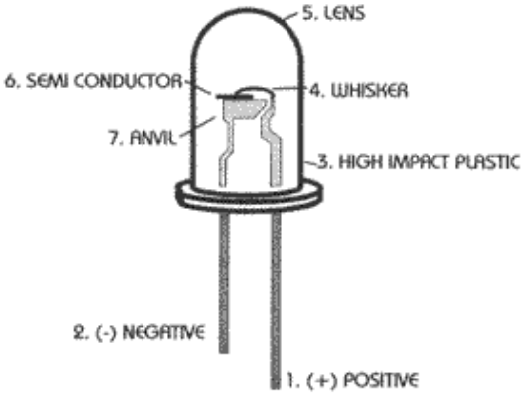
Technical Information

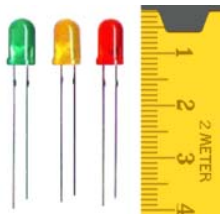
An LED (Light Emitting Diode) is a unique type of semiconductor diode. Like a normal diode, the LED consists of a chip of semiconducting material impregnated, or doped, with impurities to create a p-n junction. As in other diodes, current flows easily from the p-side, or anode, to the n-side, or cathode. This effect is a form of electroluminescence.



LED schematic symbol



LED construction

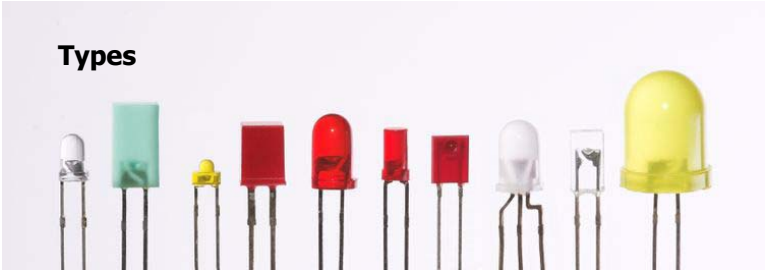


LEDs are usually constantly illuminated when a current passes through them, but flashing LEDs are also available. Flashing LEDs resemble standard LEDs but they contain a small chip inside which causes the LED to flash with a typical period of one second. This type of LED comes most commonly as red, yellow, or green. Most flashing LEDs emit light of a single wavelength, but multicoloured flashing LEDs are available too. The semi-conducting chip is encased in a solid plastic lens. The package may be coloured.

LED characteristics for both indoor and outdoor applications:

- Low power consumption per lumen of output
- Low heat production
- Extremely long life, up to 100,000 hours
- Dimmable
- Shock resistant
- Flexibility
- Ease of installation

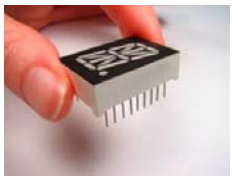
Types



LEDs are produced in a variety of shapes and sizes ranging from 1.8mm up to 20mm wide LEDs. They come in round, square, rectangular or triangular shapes. The 5 mm cylindrical package (red, fifth from the left) is the most common, estimated at 80% of world production.

There are three main types of LEDs:

- Miniature
- Alphanumeric
- Lighting



Miniature LEDs

These are mostly single-die LEDs used as indicators. They come in various-size packages: surface mount, 2 mm, 3 mm or 5 mm. Common package shapes are round - dome or flat top, rectangular - flat top (often seen in LED bar-graph displays), triangular or square - flat top.

There are three main categories of miniature single die LEDs:

- Low current — typically rated for 2 mA at around 2 V (approximately 4 mW consumption).
- Standard — 20 mA LEDs at around 2 V (approximately 40 mW) for red, orange, yellow & green, and 20 mA at 4–5 V (approximately 100 mW) for blue, violet and white.
- Ultra-high output — 20 mA at approximately 2 V or 4–5 V, designed for viewing in direct sunlight.

Five- and twelve-volt LEDs

These are miniature LEDs incorporating a series resistor, and may be connected directly to a 5 V or 12 V supply.

Lighting LEDs

LEDs used as a replacement for incandescent light bulbs and fluorescent lamps are known as solid-stage lighting (SSL) – packaged as a cluster of white LEDs grouped together to form a light source. They come in different shapes, among them the light bulb shape and MR16 shape. The average commercial SSL currently outputs 32 lumens per watt (lm/W) and new technologies promise to deliver up to 80lm/W. The long life of LEDs make SSL very attractive. They are also more mechanically robust. Currently, solid-stage lighting is becoming more available for household use.

Colour

LEDs are made from gallium-based crystals that contain one or more additional materials such as phosphorous to produce a distinct colour. Thus, it is the chemical makeup of the LED semiconductor that determines the colour of the light the LED produces.

Manufacturing variations and varying thicknesses in the phosphor make the LEDs produce light with different colour temperatures, from warm yellowish to cold bluish.

The colour of the LED plastic lens is often the same as the actual colour of light emitted, but not always. For instance, purple plastic is often used for infrared LEDs, and most blue devices have clear housings. The encapsulation may also be clear or semi opaque to improve contrast and viewing angle.

LEDs are classified in single and multi-colour LEDs.

Multi-colour LEDs

A "bi-colour LED" is actually two different LEDs in one case. It consists of two dies connected to the same two leads but in opposite directions. Current flow in one direction produces one colour, and current in the other direction produces the other colour. Alternating the two colours with sufficient frequency causes the appearance of a third colour.

A "tri-colour LED" is also two LEDs in one case, but the two LEDs are connected to separate leads so that the two LEDs can be controlled independently and lit simultaneously.

RGB LEDs contain red, green and blue emitters, generally using a four-wire connection with one common (anode or cathode). These can be combined to produce any colour, including white. RGB LEDs are very popular in the entertainment industry, particularly when used for stage lighting. They can be controlled by DMX units in order to achieve a colour-changing effect on stage.

White Light

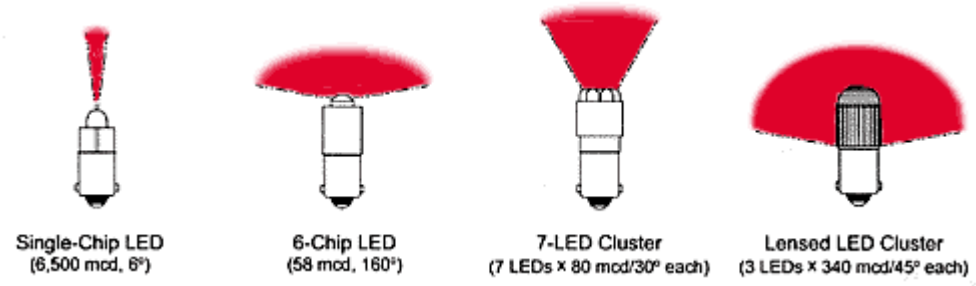
When light from all parts of the visible spectrum overlap one another, the additive mixture of colours appears white.

Ultraviolet and blue LEDs

Blue LEDs can be added to existing red and green LEDs to produce the impression of white light, though white LEDs today rarely use this principle. Most "white" LEDs in production are modified blue LEDs.

Visibility

The light output from an LED chip is very directional. Therefore it is recommended to allow a certain distance between the LED and the surface to be illuminated in order to avoid spotting or uneven light distribution. LEDs have a viewing angle ranging from 6 to 160 degrees.



In each case, the amount of visible light depends on how the LED is being viewed. The single chip may be appropriate for direct viewing in competition with high ambient light. The 6-chip may be better suited to backlight a switch or small legend, while the cluster or lensed LED may be best to illuminate a pilot light or larger lens.

Overall visibility can be enhanced by increasing the number of LED chips in the encapsulation, increasing the number of individual LEDs, and utilizing secondary optics to distribute light.

Brightness

Most typical LEDs are designed to operate with no more than 30-60 milliwatts (mW) of electrical power. One of the key advantages of LED-based lighting is its high efficiency, as measured by its light output per unit power input. White LEDs quickly matched and overtook the efficiency of standard incandescent lighting systems. In 2002, Lumileds made five-watt LEDs available with a luminous efficiency of 18–22 lumens per watt (lm/W). For comparison, a conventional 60–100 W incandescent lightbulb produces around 15 lm/W, and standard fluorescent lights produce up to 100 lm/W.

High-power (≥ 1 W) LEDs are necessary for practical general lighting applications. Typical operating currents for these devices begin at 350 mA. The highest efficiency high-power white LED has a luminous efficiency of 115 lm/W (350 mA).

Operating Life

Operating life is characterized by the degradation of LED intensity over time. When the LED degrades to half of its original intensity after 50,000 hours it is at the end of its useful life although the LED will continue to operate as output diminishes. Unlike standard incandescent bulbs, LEDs resist shock and vibration and can be cycled on and off without excessive degradation.

LED Panels

Most outdoor screens and some indoor screens are built around discrete LEDs, also known as individually mounted LEDs. A cluster of red, green, and blue diodes is driven together to form a full-colour pixel, usually square in shape.

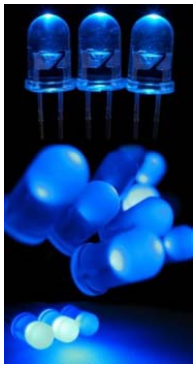
These pixels are spaced evenly apart and are measured from centre to centre for absolute pixel resolution.

Most indoor screens on the market are built using SMD technology (surface mounted device) - a trend that is now extending to the outdoor market. An SMD pixel consists of red, green, and blue diodes mounted on a chipset, which is then mounted on the driver PC board.

Indoor use generally requires a screen that is based on SMD technology and has a minimum brightness of 600 candelas per square meter (cd/m²). This will usually be more than sufficient for corporate and retail applications, but under high ambient-brightness conditions, higher brightness may be required for visibility. Fashion and auto shows are two examples of high-brightness stage lighting that may require higher LED brightness. Conversely, when a screen may appear in a shot on a television show, the requirement will often be for lower brightness levels with lower colour temperatures.

For outdoor use, at least 2,000 cd/m² is required for most situations, whereas higher-brightness types of up to 5,000 cd/m² cope even better with direct sunlight on the screen.

ADVANTAGES OF USING LEDs



- Produce more light per watt than incandescent bulbs - useful in battery powered or energy-saving devices
- Can emit light of an intended colour without the use of colour filters - more efficient and can lower initial costs
- When used in applications where dimming is required, LEDs don't change their colour tint
- Ideal for use in applications that are subject to frequent on-off cycling
- LEDs, being solid state components, are difficult to damage with external shock
- Mostly fail by dimming over time, rather than the abrupt burn-out of incandescent bulbs
- Light up very quickly - a typical red indicator LED will achieve full brightness in microseconds
- Can be very small and are easily populated onto printed circuit boards
- Do not contain mercury
- Have an extremely long life span: upwards of 100,000 hours, twice as long as the best fluorescent bulbs and twenty times longer than the best incandescent bulbs