

1.6 LIGHT EMITTING DIODE (LED)

A light emitting diode (LED) is known to be one of the best optoelectronic devices out of the lot. The device is capable of emitting a fairly narrow bandwidth of visible or invisible light when its internal diode junction attains a forward electric current or voltage.

The visible lights that an LED emits are usually orange, red, yellow, or green. The invisible light includes the infrared light. The biggest advantage of this device is its high power to light conversion efficiency. That is, the efficiency is almost 50 times greater than a simple tungsten lamp.

The response time of the LED is also known to be very fast in the range of 0.1 microseconds when compared with 100 milliseconds for a tungsten lamp. Due to these advantages, the device wide applications as visual indicators and as dancing light displays.

We know that a P-N junction can convert the absorbed light energy into its proportional electric current. The same process is reversed here. That is, the P-N junction emits light when energy is applied on it. This phenomenon is generally called electro luminescence, which can be defined as the emission of light from a semi-conductor under the influence of an electric field.

The charge carriers recombine in a forward P-N junction as the electrons cross from the N-region and recombine with the holes existing in the P-region. Free electrons are in the conduction band of energy levels, while holes are in the valence energy band.

Thus the energy level of the holes will be lesser than the energy levels of the electrons. Some part of the energy must be dissipated in order to recombine the electrons and the holes. This energy is emitted in the form of heat and light.

The electrons dissipate energy in the form of heat for silicon and germanium diodes. But in Gallium-Arsenide-phosphorous (GaAsP) and Gallium-phosphorous (GaP) semiconductors, the electrons dissipate energy by emitting photons. If the semiconductor is translucent, the junction becomes the source of light as it is emitted,

thus becoming a light emitting diode (LED). But when the junction is reverse biased no light will be produced by the LED, and, on the contrary the device may also get damaged.

All the semiconductors listed above can be used. An N-type epitaxial layer is grown up on a substrate, and the P-region is produced by diffusion. The P-region that includes the recombination of charge carriers is shown is the top. Thus the P-region becomes the device surface. In order to allow more surface area for the light to be emitted the metal anode connections are made at the outer edges of the P-layer.

For the light to be reflected as much as possible towards the surface of the device, a gold film is applied to the surface bottom. This setting also enables to provide a cathode connection. The re-absorption problem is fixed by including domed lenses for the device. All the wires in the electronic circuits of the device is protected by encasing the device.

The light emitted by the device depends on the type of semiconductor material used. Infrared light is produced by using Gallium Arsenide (GaAs) as semiconductor. Red or yellow light is produced by using Gallium -Arsenide-Phosphorus (GaAsP) as semiconductor.

LED Circuit Symbol

The circuit symbol of LED consists of two arrow marks which indicate the radiation emitted by the diode.

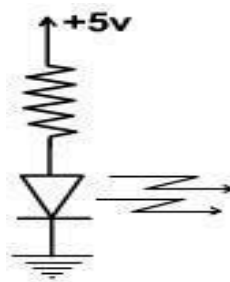


Figure: 1.6.1 Symbol of LED

[Source: "Electronic devices and circuits" by "Balbir Kumar, Shail.B.Jain, and Page: 145]

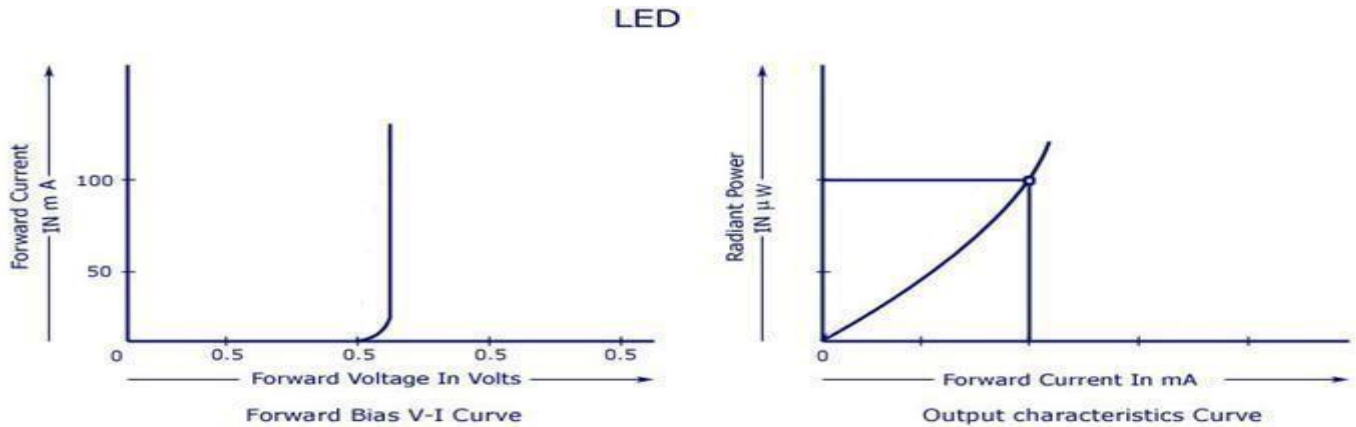


Figure: 1.6.2 LED characteristics curve

[Source: "Electronic devices and circuits" by "Balbir Kumar, Shail.B.Jain, and Page: 145]

The forward bias Voltage-Current (V-I) curve and the output characteristics curve is shown in the figure above. The V-I curve is practically applicable in burglar alarms. Forward bias of approximately 1 volt is needed to give significant forward current. The second figure is used to represent a radiant power-forward current curve. The output power produced is very small and thus the efficiency in electrical-to-radiant energy conversion is very less.

The commercially used LED's have a typical voltage drop between 1.5 Volt to 2.5 Volt or current between 10 to 50 milli amperes. The exact voltage drop depends on the LED current, colour, tolerance, and so on.

LED as an Indicator

The circuit shown below is one of the main applications of LED. The circuit is designed by wiring it in inverse parallel with a normal diode, to prevent the device from being reverse biased. The value of the series resistance should be half, relative to that of a DC circuit.

LED As An Indicator

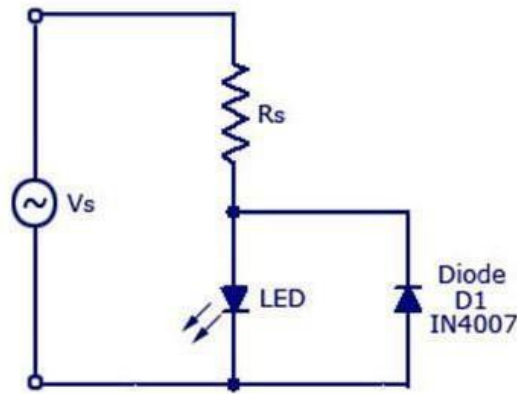


Figure: 1.6.3 LED as an indicator

[Source: "Electronic devices and circuits" by "Balbir Kumar, Shail.B.Jain, and Page: 147]

LEDs displays are made to display numbers from segments. One such design is the seven-segment display as shown below. Any desired numerals from 0-9 can be displayed by passing current through the correct segments. To connect such segment a common anode or common cathode configuration can be used. Both the connections are shown below. The LEDs are switched ON and OFF by using transistors.

➤ **Advantages of LED's**

- Very low voltage and current are enough to drive the LED.
- Voltage range – 1 to 2 volts.
- Current – 5 to 20 mill amperes.
- Total power output will be less than 150 mill watts.
- The response time is very less – only about 10 nanoseconds.
- The device does not need any heating and warm up time.
- Miniature in size and hence light weight.
- Have a rugged construction and hence can withstand shock and vibrations.
- An LED has a life span of more than 20 years.

➤ Disadvantages of LED

- A slight excess in voltage or current can damage the device.
- The device is known to have a much wider bandwidth compared to the laser.
- The temperature depends on the radiant output power and wavelength

Laser diode

A laser diode, or LD, is an electrically pumped semiconductor laser in which the active laser medium is formed by a p-n junction of a semiconductor diode similar to that found in a light-emitting diode.

The laser diode is the most common type of laser produced with a wide range of uses that include, but are not limited to, fiber optic communications, barcode readers, laser pointers, CD/DVD/Blu-ray Disc reading and recording, laser printing, laser scanning and increasingly directional lighting sources.

A laser diode is electrically a P-i-n diode. The active region of the laser diode is in the intrinsic (I) region, and the carriers, electrons and holes, are pumped into it from the N and P regions respectively.

While initial diode laser research was conducted on simple P-N diodes, all modern lasers use the double-hetero structure implementation, where the carriers and the photons are confined in order to maximize their chances for recombination and light generation. The laser diode epitaxial structure is grown using one of the crystal growth techniques, usually starting from an N doped substrate, and growing the I doped active layer, followed by the P doped cladding, and a contact layer. The active layer most often consists of quantum wells,

The term laser is an acronym that stands for "Light Amplification by Stimulated Emission of Radiation".

SANYO laser diode structure and basic element structure are listed below.

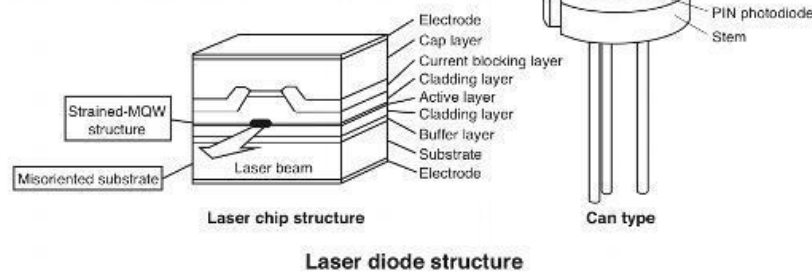


Figure: 1.6.4 Laser Diode

[Source: "Electronic devices and circuits" by "Balbir Kumar, Shail.B.Jain, and Page: 151]

Laser diode L/I characteristic

One of the most commonly used and important laser diode specifications or characteristics is the L/I curve. It plots the drive current supplied against the light output. This laser diode specification is used to determine the current required to obtain a particular level of light output at a given current. It can also be seen that the light output is also very dependent upon the temperature.

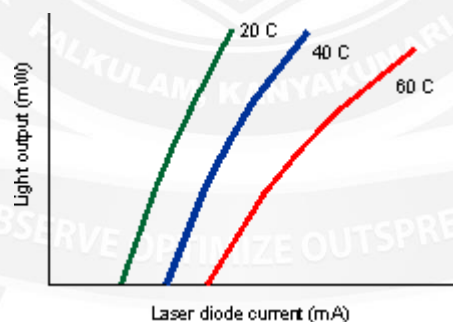


Figure: 1.6.5 Laser diode L/I Characteristic

[Source: "Electronic devices and circuits" by "Balbir Kumar, Shail.B.Jain, and Page: 146]

From this characteristic, it can be seen that there is a threshold current below which the laser action does not take place. The laser diode should be operated clear of this point to ensure reliable operation over the full operating temperature range as the threshold current rises with increasing temperature. It is typically found that the laser threshold current rises exponentially with temperature.

Laser Diode Specifications & Characteristics

A summary or overview of laser diode specifications, parameters and characteristics used in defining laser diode performance for datasheets.

In this section

- Laser diode technology
- Laser diode types
- Structure & materials
- Theory & operation
- Specs & characteristics
- Lifetime, failure & reliability
- Other diodes

When using a laser diode it is essential to know its performance characteristics. Accordingly laser diode specifications are required when designing equipment using laser diodes or for maintenance using near equivalents.

Like any electronics components, many of the specifications are relatively generic, but other parameters will tend to be more focused on the particular component. This is true for laser diode specifications and characteristics.

There are a number of laser diode specifications, or laser diode characteristics that are key to the overall performance and these are outlined.