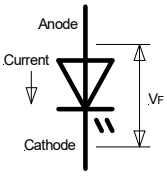
Using LED Indicator Lamps

Introduction

A light emitting diode [LED] does exactly what it says on the packet. It is a P-N semiconductor junction diode, specially formulated to generate visible light from the P-N junction when current is passed through it. The colour of the light depends on the semiconductor material used in its manufacture.



Because a LED is a diode, it has the usual properties of any diode:

- It will pass current in only one direction, from **Anode** to **Cathode**.
- It has a forward volt drop $\mathbf{V_F}$, which is almost constant irrespective of the current passing through it.

In addition, a LED has a number of other properties which must be taken into account when designing lighting circuits.

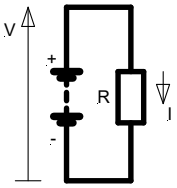
- The light intensity generated by a LED is roughly proportional to the current flowing through it. For most LEDs, the maximum permitted current is usually not much more than 20 mA, and adequate light intensity for most practical purposes will be achieved with a current of between 5 and 10 mA.

- The forward volt drop of a LED varies with manufacturer, construction and, in particular, colour. If you do not have access to a data sheet for your particular LED, the following figures are sufficiently accurate for most design calculations

Colour	**V_F [Volts]**
Red	1.8
Yellow	2.1
Green	2.2
Blue	3.0
White	3.5

- The maximum **reverse** voltage a LED can withstand before it is destroyed is low, usually not much more than 4 V.

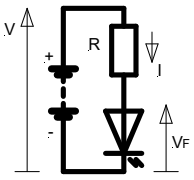
Practical LED Circuits



As described above, a LED is a **current** operated device, but most power supplies are **voltage** sources. A fixed current source can be generated from a voltage source by using a series resistor, calculated using Ohm's Law.

$I = V / R$
$R = V / I$

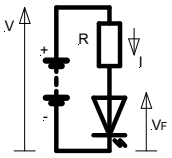
where I = Current in mA, V = Voltage in Volts, R = Resistance in kilohms



For a LED circuit, this equation has to be modified slightly to take into account the forward volt drop of the diode.

$I = (V - V_F) / R$
$R = (V - V_F) / I$

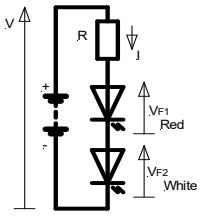
Example Calculation of Resistor Value



Assume	Red LED	[V_F = 1.8 V]
	LED Current = 5 mA	
	Supply Voltage = 9 V	
R = (9 – 1.8) / 5	= 1.44 kilohm	

This resistor value is non-standard, so use nearest preferred value of 1.5 kilohm.

Multiple LEDs



Because LEDs are current operated devices, and can usually all be operated at the same current, when you need more than one LED on the same circuit, you can just connect them all in series.

In this case, however, you must add their respective forward volt drops together when calculating the value of the series resistor and, in order to ensure a reasonably constant current if the supply voltage varies a bit, make sure that the supply voltage is greater than the total forward volt drop by at least 1 V.

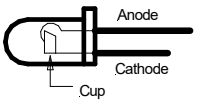
Connection of LEDs in parallel is not recommended. It may work if all of the LEDs are of the same colour and type, but at best there will probably be some brightness variation, and at worst some may not light at all.

Example Calculation of Resistor Value

Assume	Red LED	[V_F = 1.8 V]
	White LED	[V_F = 3.5 V]
	LED Current = 5 mA	
	Supply Voltage = 12 V	
R = (12 – (1.8 + 3.5)) / 5	= 1.34 kilohm	

This resistor value is non-standard, so use nearest preferred value of 1.2 kilohm or 1.5 kilohm.

Determining LED Polarity



As described above, most LEDs have a maximum reverse voltage capability of only about 4 V so, if you connect one the wrong way round on a 9 V battery, you are likely to destroy it.

There are three ways to detect the polarity of a LED visually – The **cathode** [negative] connection –

- **almost always** is the shorter lead.
- **usually** is connected to the cup structure internally.
- **often** has a flat on the body next to it.

But be warned – not all manufacturers adhere to these conventions.

A safer way to determine LED polarity is to test it with a 3 V battery [or 4.5 V for ***blue*** or ***white*** LEDs] and a series resistor of about 1 kilohm. The polarity which causes the LED to light is the correct one. Do not use a voltage higher than 4.5 V to avoid blowing the LED up if you connect it the wrong way round, and make sure you have some series resistance to limit the current to a safe value.

Geoff Garside, B.Sc., C.Eng., MIET
Chief Engineer – ***Timpdon Electronics***