LED BASICS

Traditional incandescent bulbs are being phased out and are being superseded by LEDS because they are more efficient. At present small indicator lamps (such as LC1 in the Spares Catalogue) are still available. However some members are beginning to replace traditional bulbs with LEDS.

A tungsten filament lamp will operate on A.C. or D.C. voltage without damage, as long as the rated voltage is not exceeded. A small overvoltage will increase the brightness and shorten the life. Undervoltage will reduce brightness but increase the life.

A silicon rectifier diode is capable of handling large currents when forward voltage is applied and blocking current when high reverse voltage is applied. For example they can be used to switch cab lights over when a Western Diesel is reversed. They are used extensively in TV and radio sets to convert the A.C household mains supply to the required D.C. voltage.

An LED (Light Emitting Diode) differs from a normal silicon diode. The particular semiconductors used for LED manufacture are **gallium arsenide (GaAs), gallium phosphide (GaP), or gallium arsenide phosphide (GaAsP)**. The different semiconductor materials (called substrates) and different impurities result in different colours of light from the LED. Red, Yellow and Green LEDS were the first to be developed. Several years later, Blue LEDS were developed. White LEDS proved more difficult. Small panel indicator lamps came first and now the technology is replacing traditional incandescent lamps of all kinds.

SPECIFICATION FOR TYPICAL 5mm ROUND LED

Specifications:

Dice Material	: GaP
Emitted Colour	: Red
Lens Colour	: Red Diffused
Peak Wavelength	: 697nm
Viewing Angle	: 45°
Luminous Intensity (IV)	: 2.8mcd

Absolute Maximum Ratings (T_a = 25°C)

Reverse Voltage	5V
Reverse Current	10µA (V_R = 5V)
Operating Temperature Range	-40°C to +85°C
Storage Temperature Range	-40°C to +100°C
Lead Soldering Temperature Range 1.6mm (1/16 inch) from body	260°C for 5 Seconds

Electrical/Optical Characteristics at T_a = 25°C

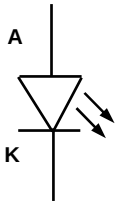
Parameter	Symbol	Minimum	Typical	Maximum	Unit	Test
Luminous Intensity	IV	1.3	2.8	4.2	mcd	IF = 20mA
Viewing Angle	2θ 1/2	-	45	-	degrees	
Peak Emission Wavelength	λP	-	697	-	nm	-
Dominant Wavelength	λD	-	650	-		-
Spectral Line Half-Width	Δλ	-	90	-		-
Forward Voltage	VF	1.7	2.1	2.6	V	IF = 20mA
Power Dissipation	Pd	-	-	45	-	-
Peak Forward Current (Duty 1/10 at 1kHz)	IF (Peak)	-	-	50	-	-
Recommended Operating Current	IF (Rec)	-	10	-	mA	-

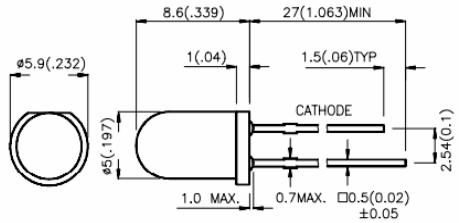
The table above shows some important details which need to be understood to correctly design LEDS into model railways. The 5mm size is similar to the original bulbs in 00 / HO equipment. The specification for other colours is similar. *These are the differences from normal silicon rectifier diodes:-*

* An LED lights when correctly connected to a D.C. voltage supply. A.C. supplies can destroy them because the voltage reverses from positive to negative at a rate of 50Hz (60Hz in the USA).
Note that the Forward Voltage threshold (Vf) of an LED is typically 2 Volts. Below this little or no current will pass and the LED will not light. Above 2 Volts the current will increase rapidly to the point where the LED will overheat and explode. A resistor must always be connected in series with the LED to control the current to a safe level.
* LEDS which are specified for 12V D.C. operation will have a resistor incorporated. If (Rec) of 10mA is the recommended operating current for the basic LED in the above table.
* LEDS which are specified for A.C. operation will actually contain a pair of LED chips, wired in inverse parallel to protect each other from reverse voltage.
* Unlike Rectifier diodes, LEDS can only withstand a Reverse Voltage of around 5 Volts. This means that to use LEDS on a TRIX 14 V A.C. supply, additional components are needed to protect them.

LED Symbol:

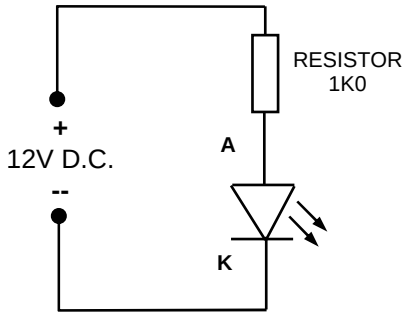
A = Anode (Positive terminal) K = Cathode (Negative terminal)



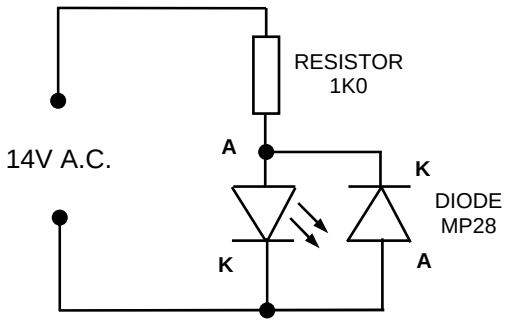


Note that the cathode can be identified by the shorter lead and also by the flat on the flange of the bulb.

Wiring for 12V D.C. supply



Wiring for 14V A.C. supply



Note

The wiring diagrams show basic LEDS with an external resistor.

If a 12 Volt LED with inbuilt resistor is used on a 12V D.C. supply, the external resistor is not required.

N.B: *IF an LED with an inbuilt resistor is used on the 14V A.C. circuit, the MP8 diode must be moved to the position occupied by the external resistor and connected so that its cathode is connected to the anode of the LED to block reverse current.*

If it is wired directly across an LED with an inbuilt resistor, it will cause a short circuit across the power supply!

The MP28 diode in the 14V A.C. diagram protects the LED by bypassing or blocking the reverse voltage cycles.

Calculating the value of LED series resistor

To operate an LED from a given voltage, a resistor needs to be connected in series with it. The correct value in ohms (Ω) can be calculated from the following formula:

R = (Vs – Vf) / If

Vs is the supply voltage, **Vf** is the forward voltage drop across the LED and **If** is the forward current of the LED.

(The values of **Vs**, **Vf and If** are shown on the specification sheet of the chosen LED).

Example

For the red LED shown in the specification above, If = 10mA (0.01A) and Vf= 2.1V

Therefore R = (12 – 2.1) / 0.01 = 990 Ω

The nearest preferred value would be a 1K0 (1,000 Ω) resistor, rated at 0.25 W

Martin Drayson