(EL2-3) Light Emitting Diode, LED

Aim of experiment

Determination of the threshold voltage of different LED colors and Plank´s constant, *h.*

Apparatus

LEDs – Resistance-Voltmeter – Ammeter – DC Power Supply.

Theory of experiment

Light Emitting Diodes or LED´s, are among the most widely used of all the different types of semiconductor diodes available today. They are the most visible type of diode that emit a fairly narrow bandwidth of either visible light at different colored wavelengths, invisible infrared light for remote controls or laser type light when a forward current is passed through them.

A "Light Emitting Diode" or LED as it is more commonly called, is basically just a specialized type of PN junction diode, made from a very thin layer of fairly heavily doped semiconductor material.

When the diode is forward biased, electrons from the semiconductors conduction band recombine with holes from the valence band releasing sufficient energy to produce photons which emit a monochromatic (single color) of light. Because of this thin layer a reasonable number of these photons can leave the junction and radiate away producing a colored light output.

Then we can say that when operated in a forward biased direction, Light Emitting Diodes are semiconductor devices that convert electrical energy into light energy.

The construction of a light emitting diode is very different from that of a normal signal diode. The PN junction of an LED is surrounded by a transparent, hard plastic epoxy resin hemispherical shaped shell or body which protects the LED from both vibration and shock, *figure 1.*

Surprisingly, a LED junction does not actually emit that much light so the epoxy resin body is constructed in such a way that the photons of light emitted by the junction are reflected away from the surrounding substrate base to which the diode is attached and are focused upwards through the domed top of the LED, which itself acts like a lens concentrating the amount of light. This is why the emitted light appears to be brightest at the top of the LED.

Unlike normal incandescent lamps and bulbs which generate large amounts of heat when illuminated, the light emitting diode produces a "cold" generation of light which leads to high efficiencies than the normal "light bulb" because most of the generated energy radiates away within the visible spectrum. Because LEDs are solid state devices, they can be extremely small and durable and provide much longer lamp life than normal light sources.

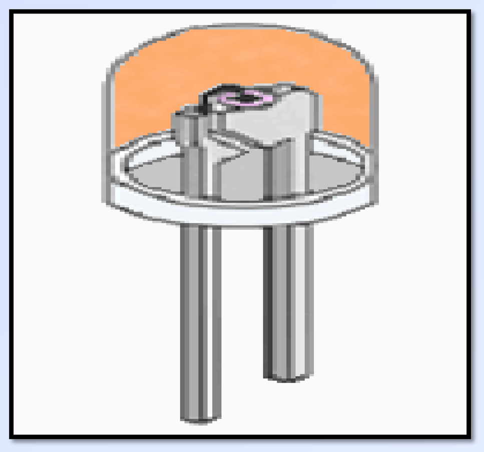

Figure1 LED Construction

Different LED compounds emit light in specific regions of the visible light spectrum and therefore produce different intensity levels. The exact choice of the semiconductor material used will determine the overall wavelength of the photon light emissions and therefore the resulting color of the light emitted.

Thus, the actual color of a light emitting diode is determined by the wavelength of the light emitted, which in turn is determined by the actual semiconductor compound used in forming the PN junction during manufacture.

As a LED is effectively a diode, its forward current to voltage characteristics curves can be plotted for each diode color as shown in *figure 2.*

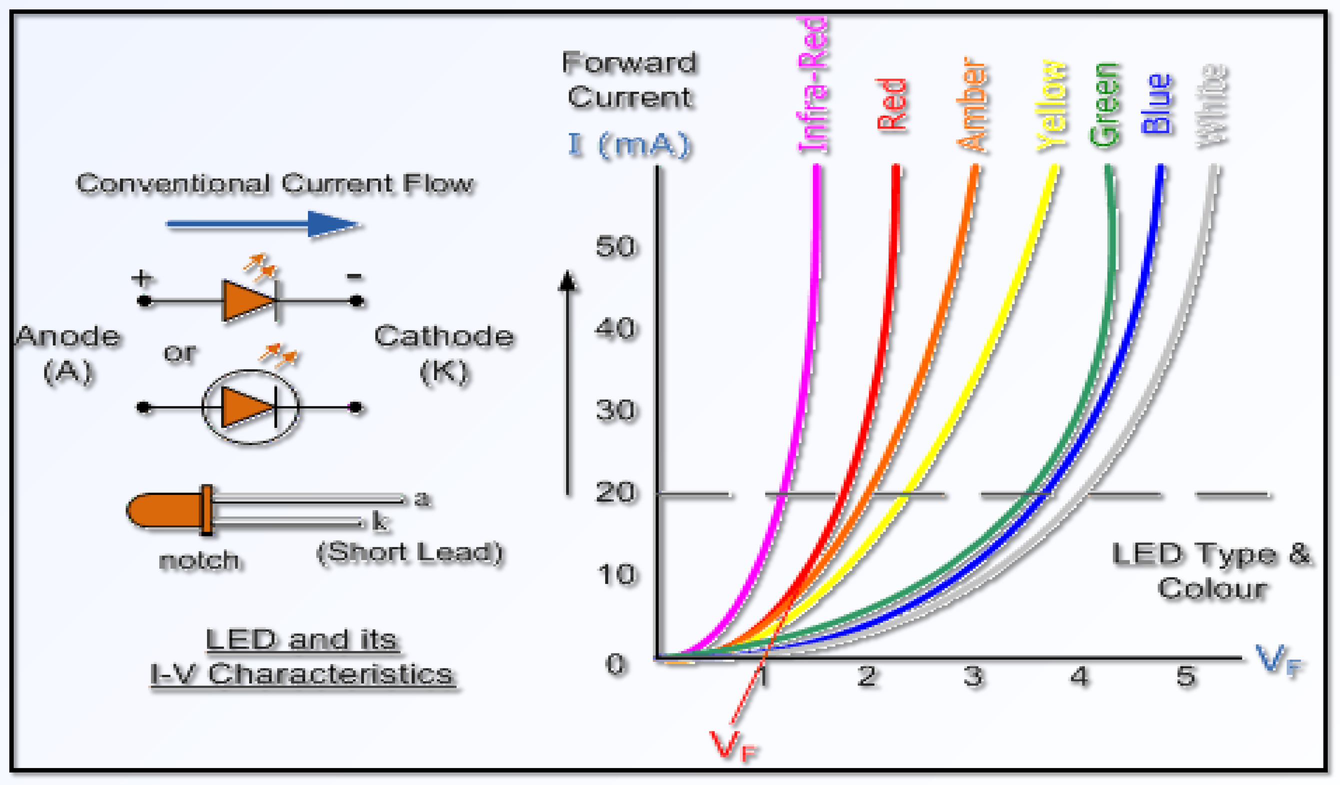

Figure 2 Light Emitting Diode (LED) Schematic symbol and its *I-V* characteristics curves showing the different colors available.

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A LED must have a resistor connected in series to limit the current through the LED, otherwise it will burn out almost instantly. This series resistor value R_S is calculated by simply using Ohm´s Law, by knowing the required forward current I_F of the LED, the supply voltage V_S across the combination and the expected forward voltage drop of the LED, V_F at the required current level, the current limiting resistor, R_S is calculated

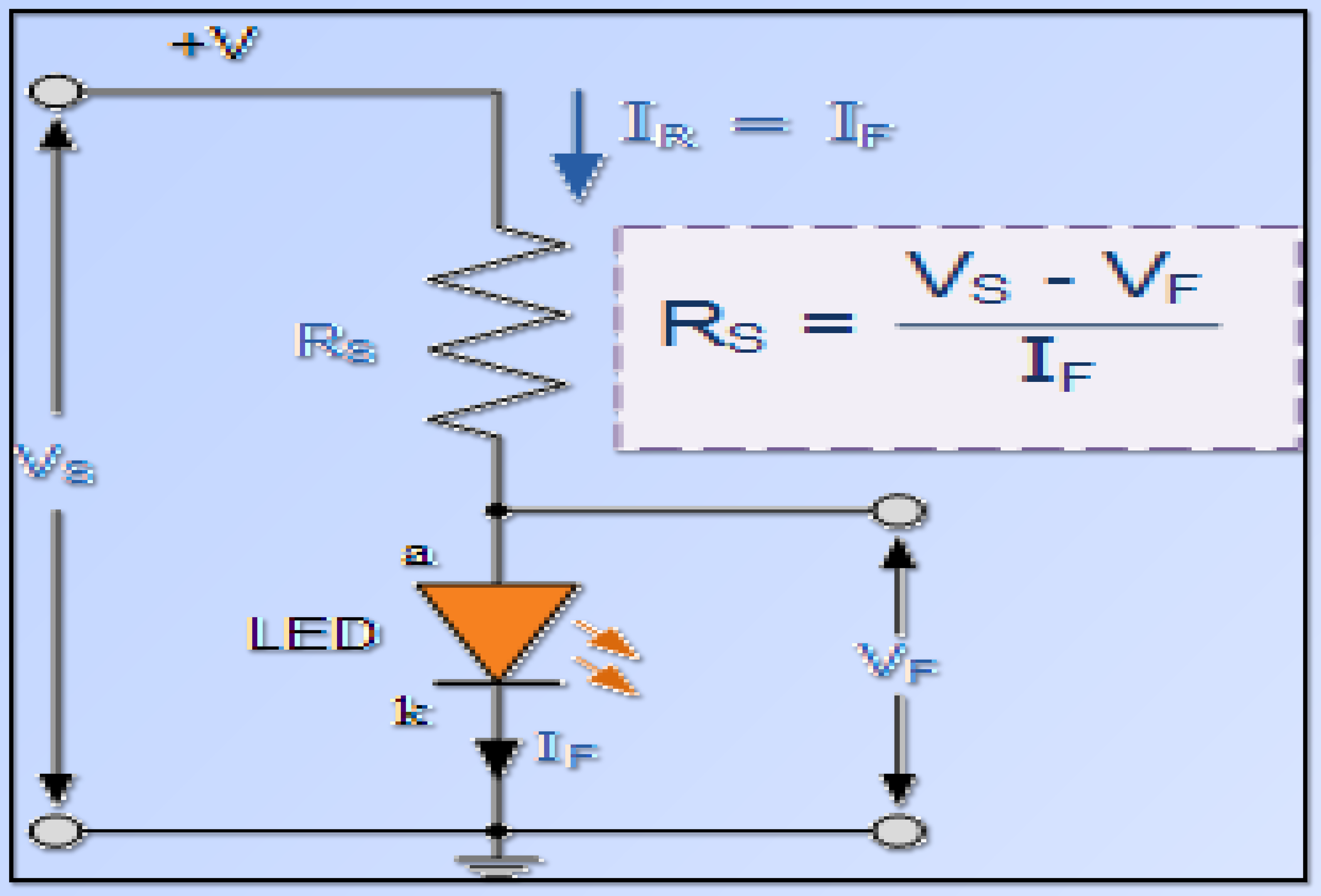

Figure3 LED Series Resistor Circuit

When turned on, the LED will have a forward voltage drop of about *1.1 to 1.5 Volts*. Shorter wavelength diodes (e.g. 850 nm) have the largest voltage drops. As the wavelength increases, the voltage drop decreases. This phenomenon can be related to the band gap energy E_g of the LED.

Equation 1 defines the band gap energy E_g:

$$E_g = hc/\lambda \qquad (1)$$

Where h = Plank's constant, C = speed of light = 3 x 10^8 m/s, λ = emission wavelength in m. At a voltage drop $V_{th}=V_F$, across the LED at which it starts to emit light, equation (1) can be written in the form.

$$eV_{th} = hC/\lambda \qquad (2)$$

where e is the electronic charge.

Using equation (2), one can experimentally predict the threshold voltage of a LED based on its emission wavelength.

Procedure

1. Connect the circuit shown in *figure 3.*
2. Change the potential each *0.1 volt* up to a suitable voltage drop for different LED colors.
3. Record current value at each voltage.
4. Repeat step 2-3 for different LED colors.
5. Draw a graph between the potential V_F on x-axis and the current I_F on *y*-axis.
6. Determine the threshold voltage, V_{th} for each LED colors.
7. Draw the relation between the threshold voltage, V_{th} *for* each LED and 1/λ

   Where λ is the color wavelength, and then calculate Plank's constant.

Results

V_F (V)	I_F(A)		
	Red	Yellow	Green

Color Wavelength λ (m)		V_{th} (V)
Red		
Yellow		
Green		

Slope=

$C = 3x10^8$ *m/s,* $e = 1.6x10^{-19}$ *C*

h =