Experiment No.7

Light Emitting Diodes

Object

The purpose of this experiment is to determine and plot the characteristics of the light emitting diode in the forward-bias region, and to compare between different colored diodes.

Required Parts and Equipment's

1. Variable DC Power Supply.
2. Digital Multimeters.
3. Electronic Test Board(M50).
4. Light Emitting Diodes (LEDs) with different colors (Red, Yellow, and Green).
5. Resistor (470Ω, 1W).
6. Leads and Wires.

Theory

The Light-Emitting Diode (LED) is a semiconductor PN junction diode that emits visible light or near-infrared radiation when forward biased. LEDs switch off and on rapidly, are very rugged and efficient, have a very long lifetime, don't heat up, and are easy to use. They are used as indicators, displays, and as light transmitters.

Various impurities are added during the doping process to vary the color output. The LED is basically, just a specialized type of PN junction diode, made from a very thin layer of fairly heavily doped semiconductor material. Fig.1 depicts the construction of the light emitting diode.

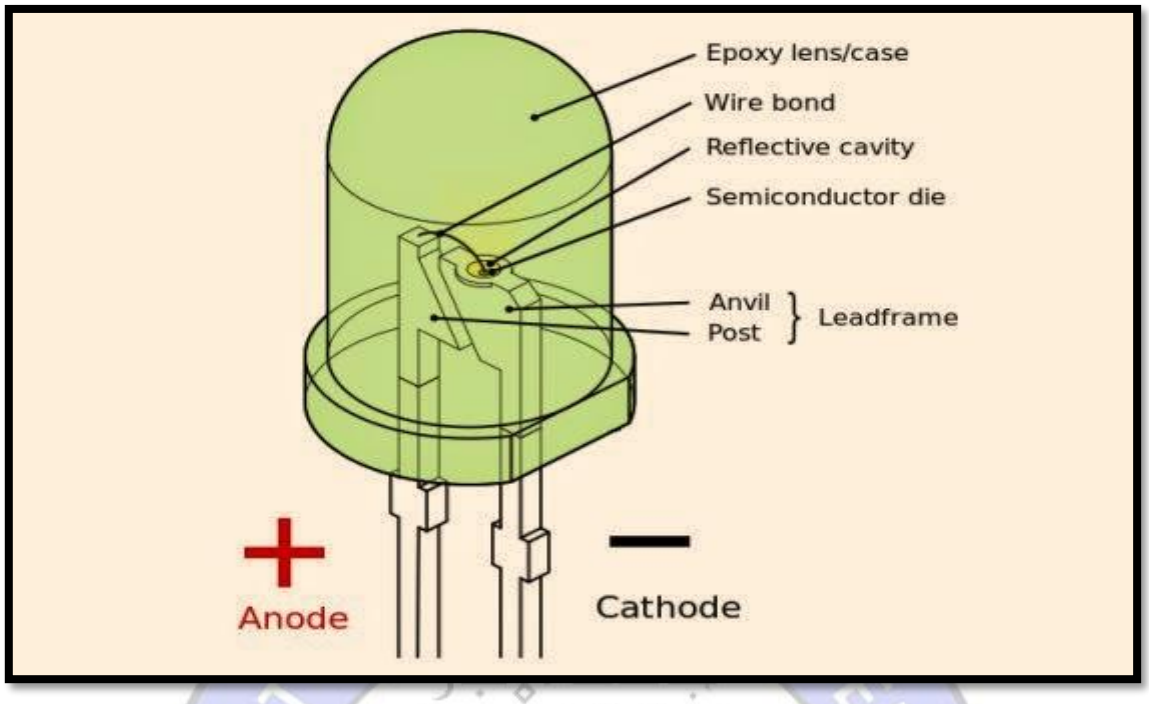


Figure 1: LED Construction

When the diode is forward biased, electrons from the semiconductor's 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. Fig.2 shows the LED external package and its electronic symbol.

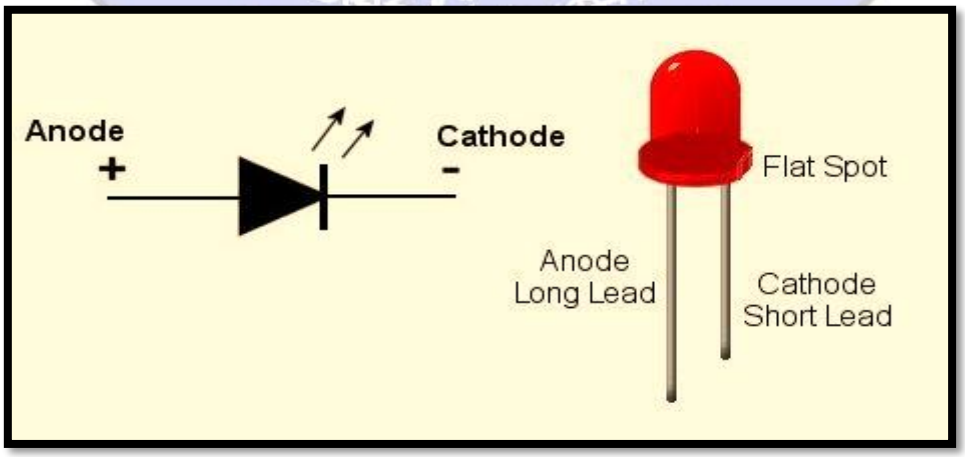


Figure 2: The LED Package and Symbol

As shown from Fig.1, the cathode is the short lead and there may be a slight flat on the body of round LEDs. Light emitting diodes are available in a wide range of colors with the most common being RED, ORANGE, YELLOW and GREEN, and are thus widely used as visual indicators and as moving light displays. Visible LEDs emit relatively narrow bands of green, yellow, orange, or red light. Infrared LEDs emit in one of several bands just beyond red light.

Light Emitting Diodes are made from special semiconductor compounds such as Gallium Arsenide (GaAs), Gallium Phosphide (GaP), Gallium Arsenide Phosphide (GaAsP), Silicon Carbide (SiC) or Gallium Indium Nitride (GaInN) all mixed together at different ratios to produce a distinct wavelength of color. Silicon and germanium are not used because they are heat producing materials and are very poor in producing light. 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 the manufacturing process. Therefore, the color of an LED is determined by the semiconductor material, not by the coloring of the 'package' (the plastic body). Table 1 below shows typical technical data for some LEDs with diffused packages.

Type	Color	I_D Max.	V_D Typ.	V_D Max.	Wavelength
Standard	Red	30mA	1.7V	2.1V	660nm
Standard	Bright red	30mA	2.0V	2.5V	625nm
Standard	Yellow	30mA	2.1V	2.5V	590nm
Standard	Green	25mA	2.2V	2.5V	565nm
High intensity	Blue	30mA	4.5V	5.5V	430nm

Table 1: Some Important Characteristics of Typical LEDs

When an LED is forward biased to the threshold of conduction, its current increases rapidly and must be controlled to prevent destruction of the device. The light output is quite linearly proportional to the forward LED current as shown in Fig.3.

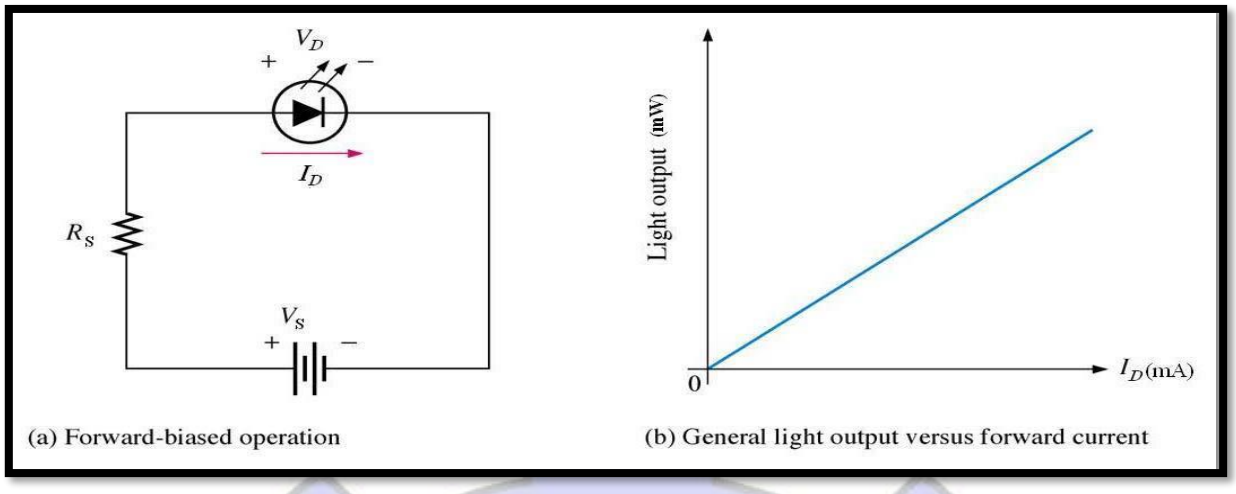


Figure 3: LED Bias Circuit and Power Output Characteristic

A series resistor (Rs) should be used to limit the current through the LED to a safe value. The LED diode voltage drop ranges from about 1.3V to about 3.6V. This resistor is calculated from:

$$R_S = \frac{V_S - V_D}{I_{D(\max)}}$$

Where V_S is the source bias voltage, V_D is the LED voltage drop, and $I_{D(\max)}$ is the maximum current of the LED

Fig.4 shows the IV characteristics in the forward bias region for some typical diodes with different colored packages.

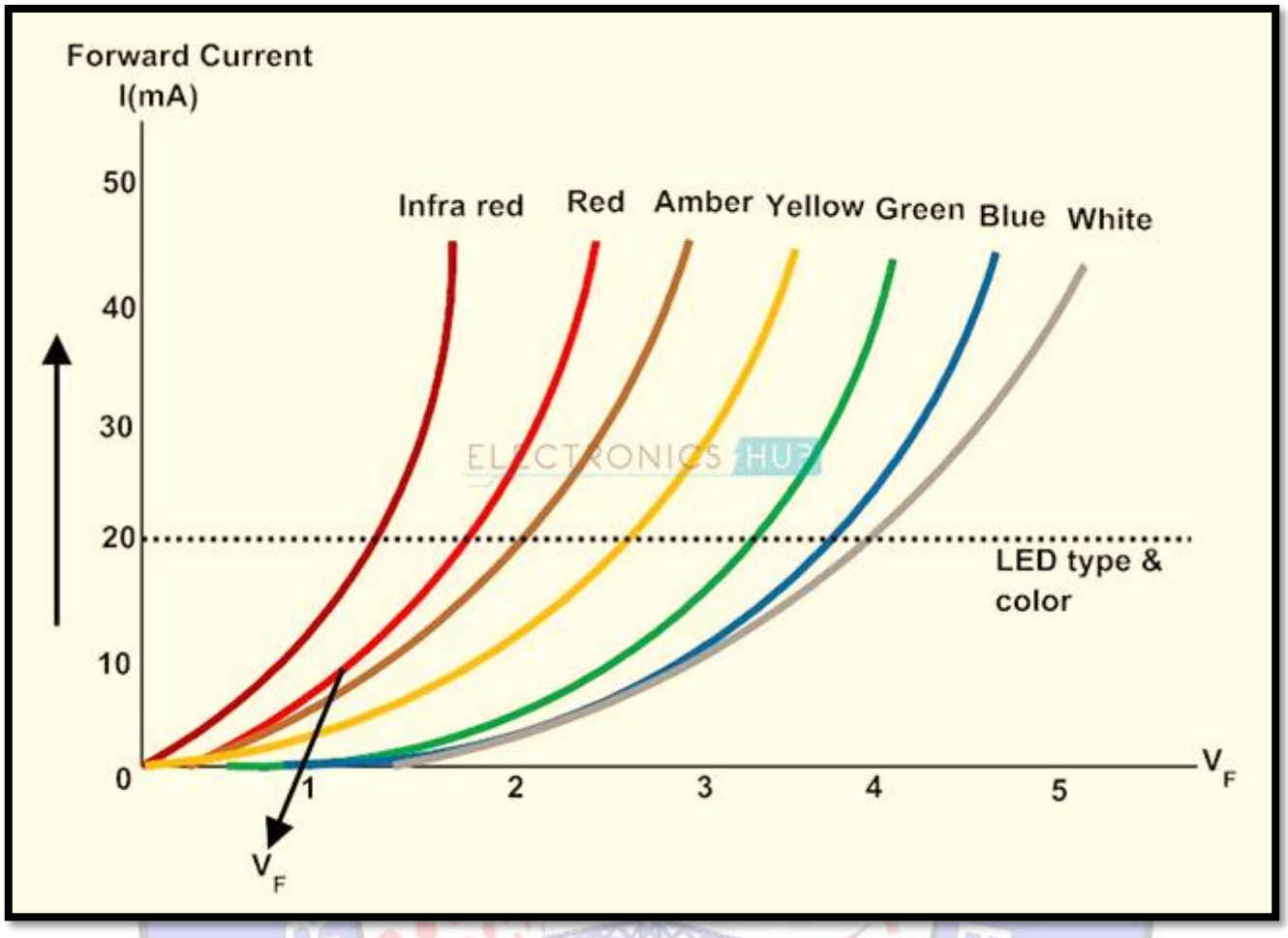


Figure 4: LED I-V Characteristics Curves Showing the Different Colors Available

Procedure

1. Connect the circuit shown in Fig.5, and increase the input DC voltage from 0V to 15V in several steps. Use red LED and record, V_D and, I_D according to Table 2.

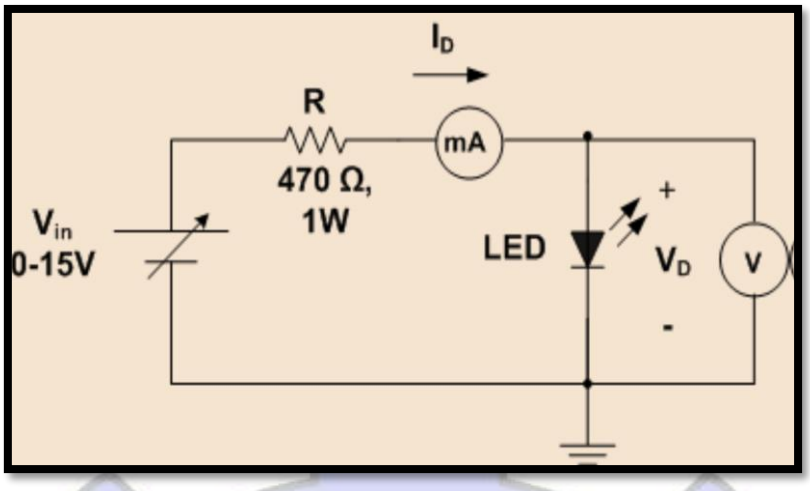


Figure 5: The LED Test Circuit

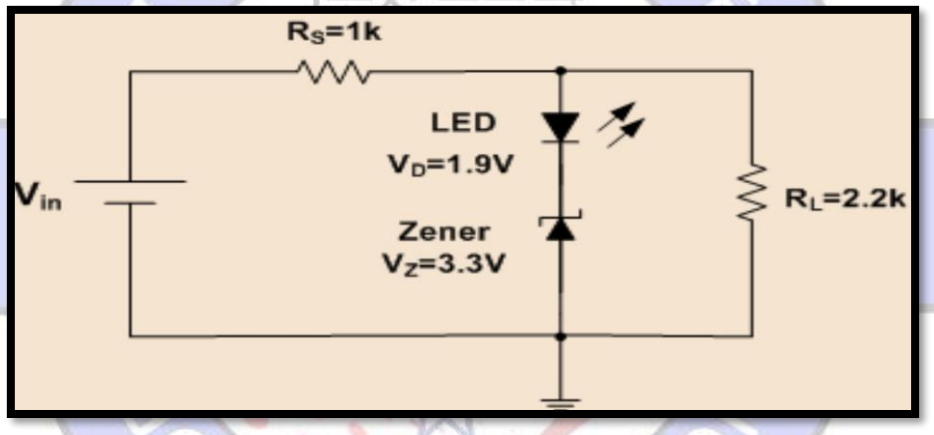
V_{in}(V)	V_D(V)	I_D(mA)
0		
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		

Table 2: Recorded Data of the LED Test Circuit

2. Repeat step 1 after replacing the red LED with a yellow colored one. If possible
3. Repeat step 1 after replacing the LED with a green colored one. If possible

Discussion

1. Plot the forward characteristics of each LED on the same graph.
2. From the sketched curves, determine the threshold voltage for each LED. Determine also the forward static resistance at 10mA for each diode.
3. Which factor determines the color of the emitted light of the LED?
4. A certain LED has a typical forward voltage of 2.2V, and a maximum current of 30mA. If this diode is to be connected to a voltage source of 15V, determine the suitable value of the current limiting resistor. Find the current flowing in the LED when the input voltage is reduced to 8V. Assume the voltage drop across the diode remains constant.
5. Determine the minimum input voltage required to turn on the Zener diode in the following circuit.



6. What are the features of LEDs over conventional bulbs? Name some applications for LEDs.
7. A yellow colored LED with a forward voltage drop of 2.1V is to be connected to a 5.0V stabilized DC power supply. Calculate the value of the series resistor required to limit the forward current to less than 10mA. Also calculate the current flowing through the diode if a 100Ω series resistor is used instead of the calculated first.
8. How can you connect two LED diodes with different colors in parallel to the same DC power supply? Sketch the circuit diagram and justify the method of wiring.