Exp. No. 1
Characteristics of Light Emitting Diode (LED)

Aim of experiment
In this experiment, we study and measure the P-I characteristics of Light Emitting Diode (LED), which used in optical fiber communication as a light source.

Apparatus
1. Optical Fiber Communication Experiment Kit
2. Optical fiber power meter
3. Oscilloscope
4. AVO meter
5. Wires
6. 5m multimode optical fiber

Theory
The role of the optical transmitter is to convert an electrical input signal into the corresponding optical signal and then launch it into the optical fiber serving as a communication channel. The major component of optical transmitters is an optical source. Fiber-optic communication systems often use semiconductor optical sources such as light-emitting diodes (LEDs) and semiconductor lasers because of several inherent advantages offered by them. Some of these advantages are compact size, high efficiency, good reliability, right wavelength range, small emissive area compatible with fiber core dimensions, and possibility of direct modulation at relatively high frequencies [1].

A forward-biased $p-n$ junction emits light through spontaneous emission, a phenomenon referred to as electroluminescence. In its simplest form, an LED is a forward biased $p-n$ homo-junction. Radiative recombination of electron–hole pairs in the depletion region generates light; some of it escapes from the device and can be coupled into an optical fiber. The emitted light is incoherent with a relatively wide spectral width (30–60 nm) and a relatively large angular spread.

The characteristic curve of output power versus input current for a LED is linear over a suitable range of current for a particular LED as shown in Fig.(1). This range generally extends from a few milli-amperes up to
approximately 50 milli-amperes for a LED without a heat sink, or up to 150 milli-amperes for a LED with a heat sink. At lower currents the electron-photon conversion efficiency is low while at higher currents a saturation phenomenon occurs due to the heating of the semiconductor.

Several key characteristics of LEDs determine their usefulness in a given application. These are:

**Peak Wavelength:** This is the LED emits most power at central wavelength; therefore, it should be matched to the wavelengths (850 nm and 1310 nm) that are transmitted with the least attenuation through optical fiber.

\[
\begin{align*}
\text{Output power (mW)} & \quad \text{Current (mA)} \\
0^\circ C & \quad 0 \\
25^\circ C & \quad 5 \\
70^\circ C & \quad 10 \\
\end{align*}
\]

**Fig.(1):** P-I characteristics of LED at several temperatures

**Spectral Width:** Ideally, all the light emitted from an LED would be at the peak wavelength, but in practice, the light is emitted in a range of wavelengths centered at the peak wavelength. This range is called the spectral width of the source.

**Emission Pattern:** The pattern of emitted light affects the amount of light that can be coupled into the optical fiber. The size of the emitting region should be similar to the diameter of the fiber core.

**Speed:** A source should turn on and off fast enough to meet the bandwidth limits of the system. LEDs have slower rise and fall times than lasers.

**Linearity:** is another important characteristic for some applications. Linearity represents the degree to which the optical output is directly proportional to the electrical current input.
LEDs are generally more reliable than lasers, but both sources will degrade over time. This degradation can be caused by heat generated by the source and uneven current densities. LEDs and laser diodes are very similar devices. In fact, when operating below their threshold current, all laser diodes act as LEDs.

**Procedure**
1. Connect the circuit shown in Fig.(2) by using optical fiber trainer.
2. Connect the optical fiber to the LED.
3. Connected second end of optical fiber to the optical power meter.
4. Switch on optical fiber trainer.
5. Change the injection current by varying the variable resistor in steps and record the voltage of photo diode as in table below.

<table>
<thead>
<tr>
<th>$I_{LD}(mA)$</th>
<th>20</th>
<th>25</th>
<th>30</th>
<th>35</th>
<th>40</th>
<th>45</th>
<th>50</th>
</tr>
</thead>
<tbody>
<tr>
<td>$P_o(\mu W)$</td>
<td></td>
<td></td>
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<tr>
<td>$P_o(dBm)$</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>$I_{LD}(mA)$</th>
<th>55</th>
<th>60</th>
<th>65</th>
<th>70</th>
<th>75</th>
<th>80</th>
<th>65</th>
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<tr>
<td>$P_o(\mu W)$</td>
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<td>$P_o(dBm)$</td>
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6. Plot the relation between the optical power and current.

\[ R_b^b = \frac{V_{ce} - V_d - I_d \times 10}{I_d} \]
**Result:**
Plot the relationship between the optical output power and emitter current.

**Discussion**
1. Comment on your results
2. What we mean by spectral width of LED? Is it important? Why?
3. Why we said "LEDs are generally more reliable than lasers"?