3.5 Liquid Crystal Displays (LCDs)

- The liquid crystals are one of the most fascinating material systems in nature, having properties of liquids as well as of a solid crystal. The terms liquid crystal refers to the fact that these compounds have a crystalline arrangement of molecules, yet they flow like a liquid.
- Liquid crystal displays do not emit or generate light, but rather alter externally generated illumination. Their ability to modulate light when electrical signal is applied has made them very useful in flat panel display technology.
- The crystal is made up of organic molecules which are rod-like in shape with a length of ~20 $\mathring{A}$ - 100 $\mathring{A}$. The orientation of the rod like molecule defines the "director" of the liquid crystal.
- The different arrangements of these rod-like molecules leads to three main categories of liquid crystals.

  1. Smectic 2. Nematic 3. Cholesteric

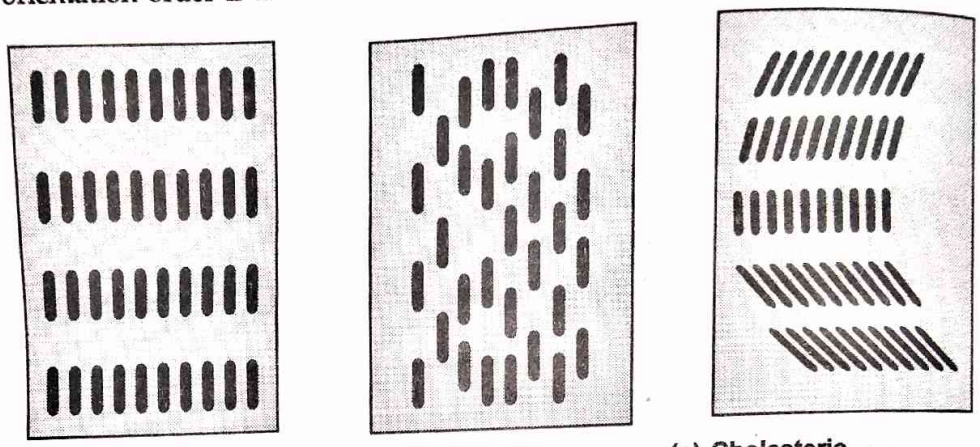
1. Smectic

- The Fig. 3.5.1 (a) shows smectic structure of liquid crystals. In this structure the rod like molecules are arranged in layers, and within each layer there is orientational order over a long range.
- Thus in a given layer, the rods are all oriented in the same direction.

- Also, in the smectic liquid crystals the molecules of different layers are ordered as shown in Fig. 3.5.1 (a).
- Thus both orientation order and positional order is present in the smectic crystals.

2. Nematic

- The Fig. 3.5.1 (b) shows nematic structure of liquid crystals. In the nematic structure the positional order between layer of molecules is lost, but the orientation order is maintained.



(a) Smectic (b) Nematic (c) Cholesteric

Fig. 3.5.1

3. Cholesteric

- The Fig. 3.5.1 (c) shows cholesteric structure of liquid crystals. In these crystals the rod-like molecules in each layer are oriented at a different angle within each layer.
- Orientation order is maintained in each layer.
- The cholesteric liquid crystal is related to the nematic crystal, with the difference being the twist of the molecules as one goes from one layer to another.
- The optical activity of the crystal depends upon the orientation and the twist of the molecules as one goes from one layer to another.

3.5.1 Types of LCDs

- There are two types of liquid crystal displays (LCDs) according to the theory of operation :

  1. Dynamic scattering 2. Field effect.

3.5.1.1 Dynamic Scattering Type LCDs

- The Fig. 3.5.2 shows the construction of a typical liquid crystal display. It consists of two glass plates with a liquid crystal fluid in between.

- The back plate is coated with thin transparent layer of conductive material, where as front plate has a photoetched conductive coating with seven segment pattern as shown in Fig. 3.5.2.
- The Fig. 3.5.3 shows the operation of liquid crystal display.
- In the absence of the electrical signal, orientation order is maintained in the crystal allowing light to transmit. This makes LCD display clear.

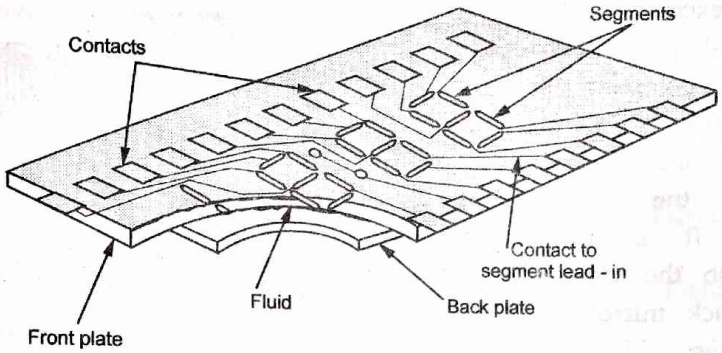


Fig. 3.5.2 Liquid crystal display construction

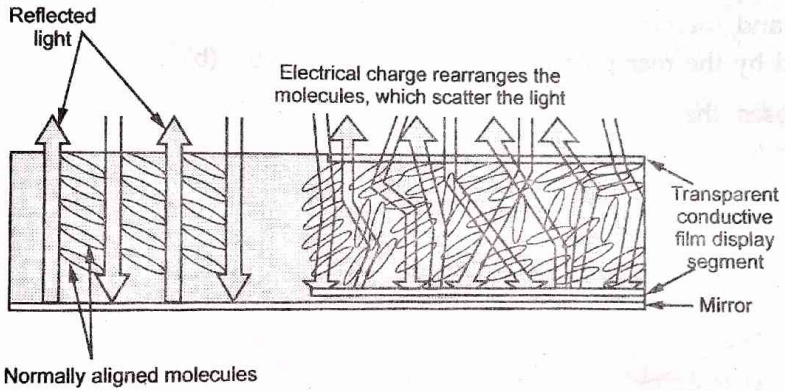


Fig. 3.5.3 Dynamic scattering

- The current through the liquid crystal causes orientation order to collapse. The random orientation results scattering of light which lights display segment on a dark background as shown in Fig. 3.5.4.

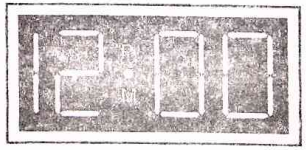


Fig. 3.5.4 Typical liquid crystal

3.5.2 Field Effect Display

- In these displays nematic liquid crystals are used.
- The Fig. 3.5.5 shows operation of field effect liquid crystal display with nematic crystals.

- It consists of two glass plates, a liquid crystal fluid, polarizers and transparent conductors.
- The liquid crystal fluid is sandwiched between two glass plates.
- Each glass plate is associated with light polarizer. The light polarizers are placed at right angle to each other.
- In the absence of electrical excitation, the light coming through the front polarizer is rotated through 90° in the fluid and passed through the rear polarizer. It is then reflected to the viewer by the back mirror as shown in Fig. 3.5.5 (a).

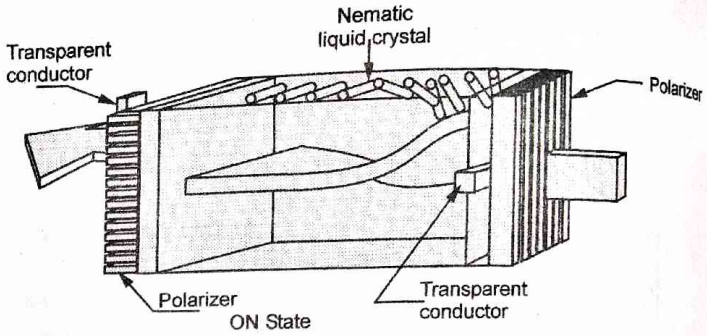
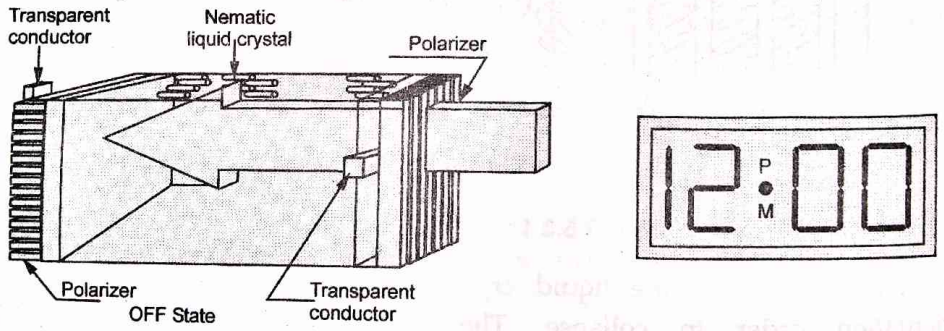


Fig. 3.5.5 (a) Field effect display "ON state"

- On the application of electrostatic field, the liquid crystal fluid molecules get aligned and therefore light through the molecules is not rotated by 90° and it is absorbed by the rear polarizer as shown in Fig. 3.5.5 (b).
- This causes the appearance of dark digit on a light background as shown in Fig. 3.5.5 (c).



(b) (c)

Fig. 3.5.5

3.5.1.3 Advantages of LCDs

1. Less power consumption
2. Low cost
3. Uniform brightness with good contrast
4. Low operating voltage and current

3.5.1.4 Disadvantages of LCDs

1. Poor reliability
2. Limited temperature range.
3. Poor visibility in low ambient temperature.
4. Slow speed
5. Requires an a.c. drive.