LCD Display

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- A **liquid crystal display** (commonly abbreviated **LCD**) is a thin, flat display device made up of any number of color or monochrome pixels arrayed in front of a light source or reflector.
- it uses very small amounts of electric power

LCD Display

- **Liquid crystals** are substances that exhibit properties between those of a conventional liquid, and those of a solid crystal

- # What is Liquid Crystal?
  - There are three common states of matter: solid, liquid or gaseous.
  - **Solids** act the way they do because their molecules always maintain their orientation and stay in the same position with respect to one another.
  - The molecules in **liquids** are just the opposite: They can change their orientation and move anywhere in the liquid. But there are some substances that can exist in an odd state that is sort of like a liquid and sort of like a solid. When they are in this state, their molecules tend to maintain their orientation, like the molecules in a solid, but also move around to different positions, like the molecules in a liquid. This means that liquid crystals are neither a solid nor a liquid.
  - So, do liquid crystals act like solids or liquids or something else? It turns out that liquid crystals are closer to a liquid state than a solid. It takes a fair amount of heat to change a suitable substance from a solid into a liquid crystal, and it only takes a little more heat to turn that same liquid crystal into a real liquid. This explains why liquid crystals are very sensitive to **temperature**

Nematic Phase Liquid Crystals

- **Just as there are many varieties of solids and liquids, there is also a variety of liquid crystal substances. Depending on the temperature and particular nature of a substance, liquid crystals can be in one of several distinct phases . LCDs use Liquid crystals in the nematic phase.**

- **One feature of liquid crystals is that they're affected by electric current. A particular sort of nematic liquid crystal, called twisted nematics (TN), is naturally twisted. Applying an electric current to these liquid crystals will untwist them to varying degrees, depending on the current's voltage. LCDs use these liquid crystals because they react predictably to electric current in such a way as to control light passage**

Twisted Nematic (TN)

- **Twisted Nematic displays contain liquid crystal elements which twist and untwist at varying degrees to allow light to pass through.**
- **When no voltage is applied to a TN liquid crystal cell, the light is polarized to pass through the cell.**

Twisted Nematic (TN)

- **In proportion to the voltage applied, the LC cells twist up to 90 degrees changing the polarization and blocking the light's path.**

- **By properly adjusting the level of the voltage almost any grey level or transmission can be achieved**

- **What is polarization?**

- In ordinary visible light, there are numerous wave components at random polarization angles. When such light is passed through a special filter, the filter blocks all light except that having a certain polarization. When two polarizing filters are placed so a ray of light passes through them both, the amount of light transmitted depends on the angle of the polarizing filters with respect to each other. The most light is transmitted when the two filters are oriented so they polarize light in the same direction. The least light is transmitted when the filters are oriented at right angles to each other.

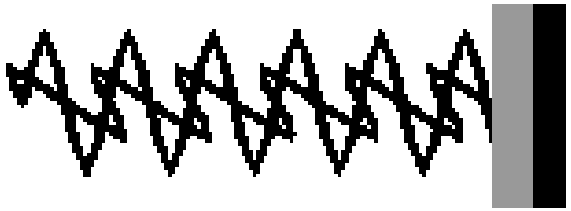
- The effect of polarization on visible light can be striking. In twisted nematic displays (TN displays), polarizing filters are used in conjunction with a special liquid to brighten and darken regions of the display as external voltages are applied. This makes it possible to display alphanumeric characters in wristwatches, cell phones, and various other consumer electronic devices.

Vertically polarized output

Vertical filter

Horizontally polarized output

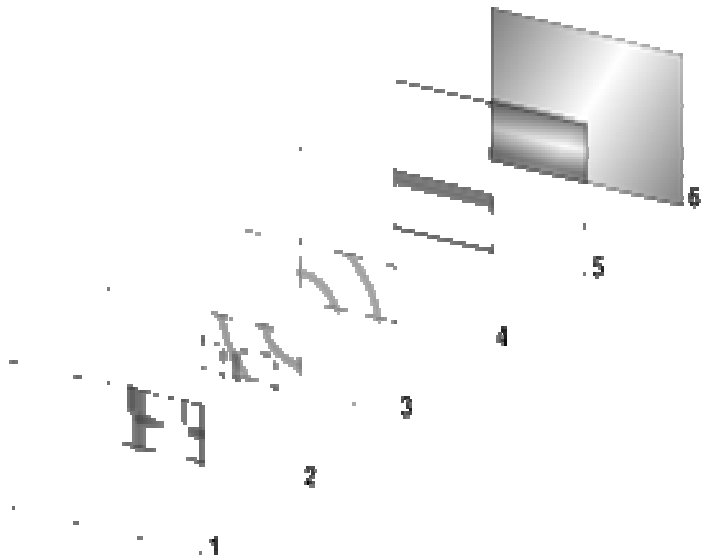
Horizontal filter



Little or no output

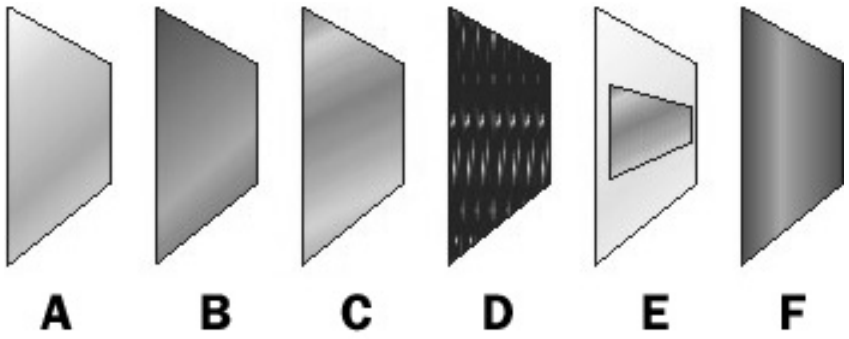
Vertical filter and horizontal filter

LCD Display (1)



1.Vertical filter film to polarize the light as it enters.
2.Glass substrate with ITO electrodes with vertical ridges are etched on the surface is smooth
3.Twisted nematic liquid crystals.
4.Glass substrate with common electrode film (ITO) with horizontal ridges to line up with the horizontal filter.
5.Horizontal filter film to block/allow through light.
6.Reflective surface to send light back to viewer.

LCD Display (2)

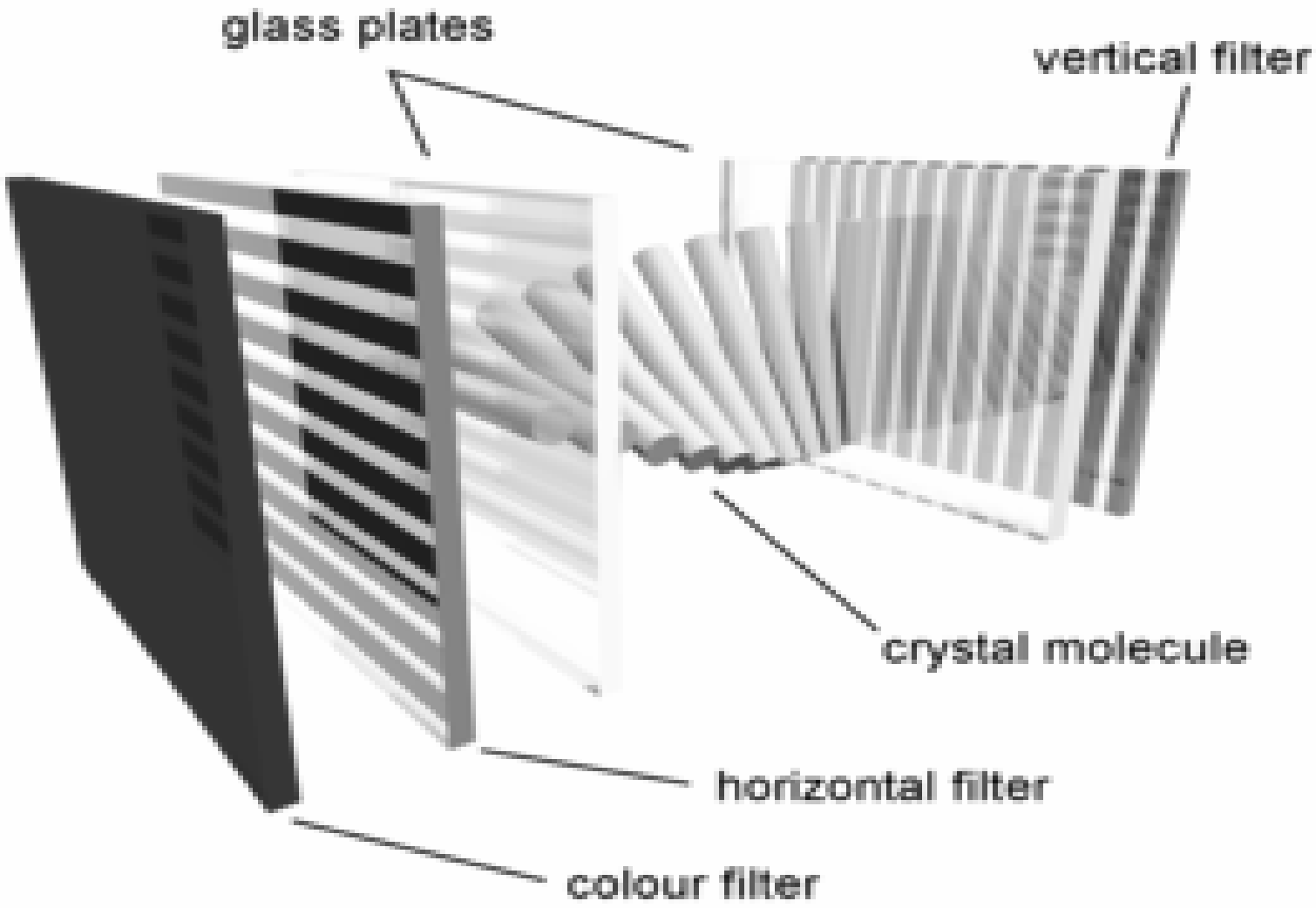


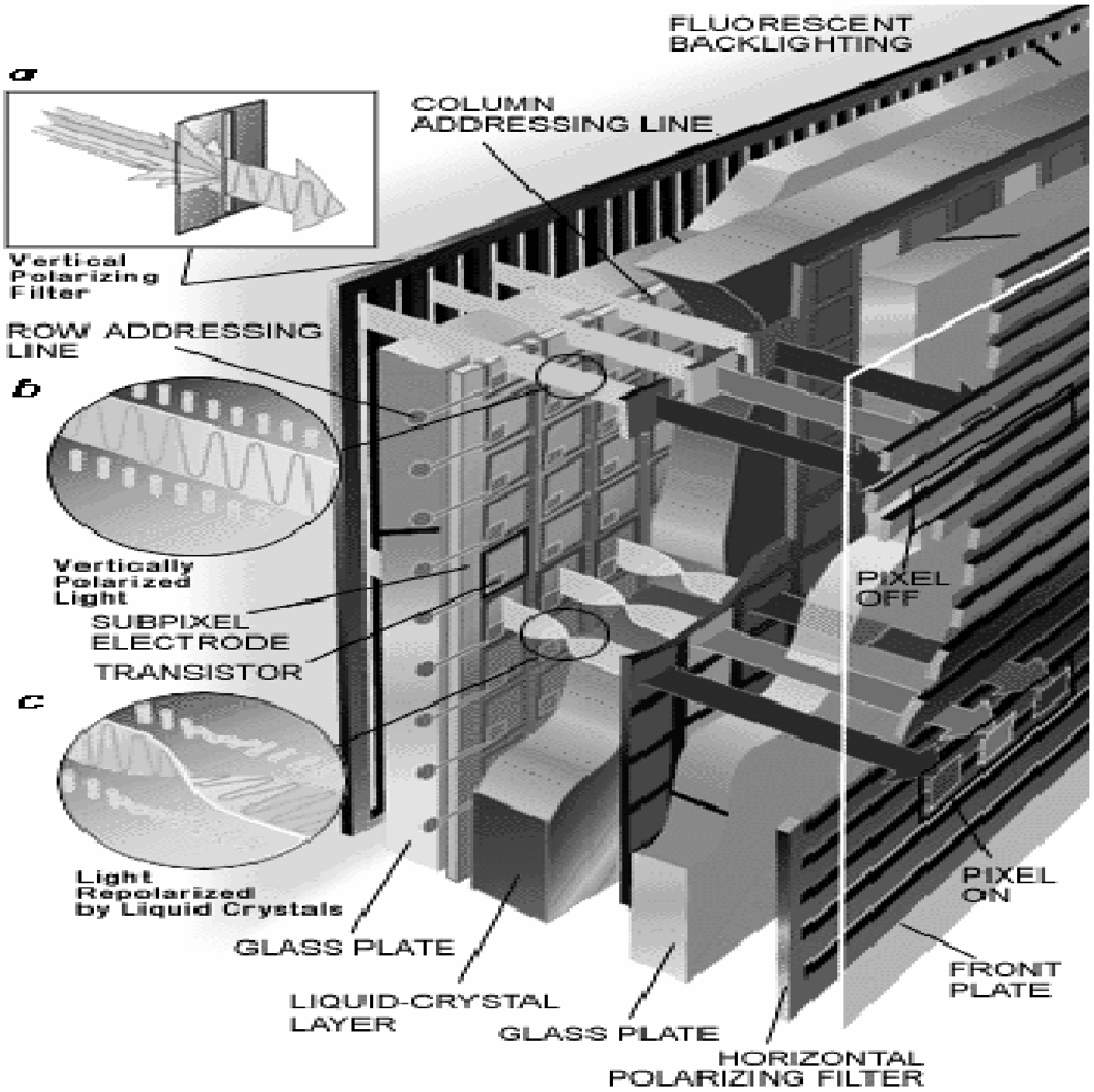
•It has a mirror (A) in back, which makes it reflective.
Then, we add a piece of glass (B) with a polarizing film on the bottom side,
a common electrode plane (C) made of indium-tin oxide on top.
a common electrode plane covers the entire area of the LCD.
Above that is the layer of liquid crystal substance (D).
Next comes another piece of glass (E) with an electrode in the shape of the rectangle on the bottom
and, on top, another polarizing film (F), at a right angle to the first one.

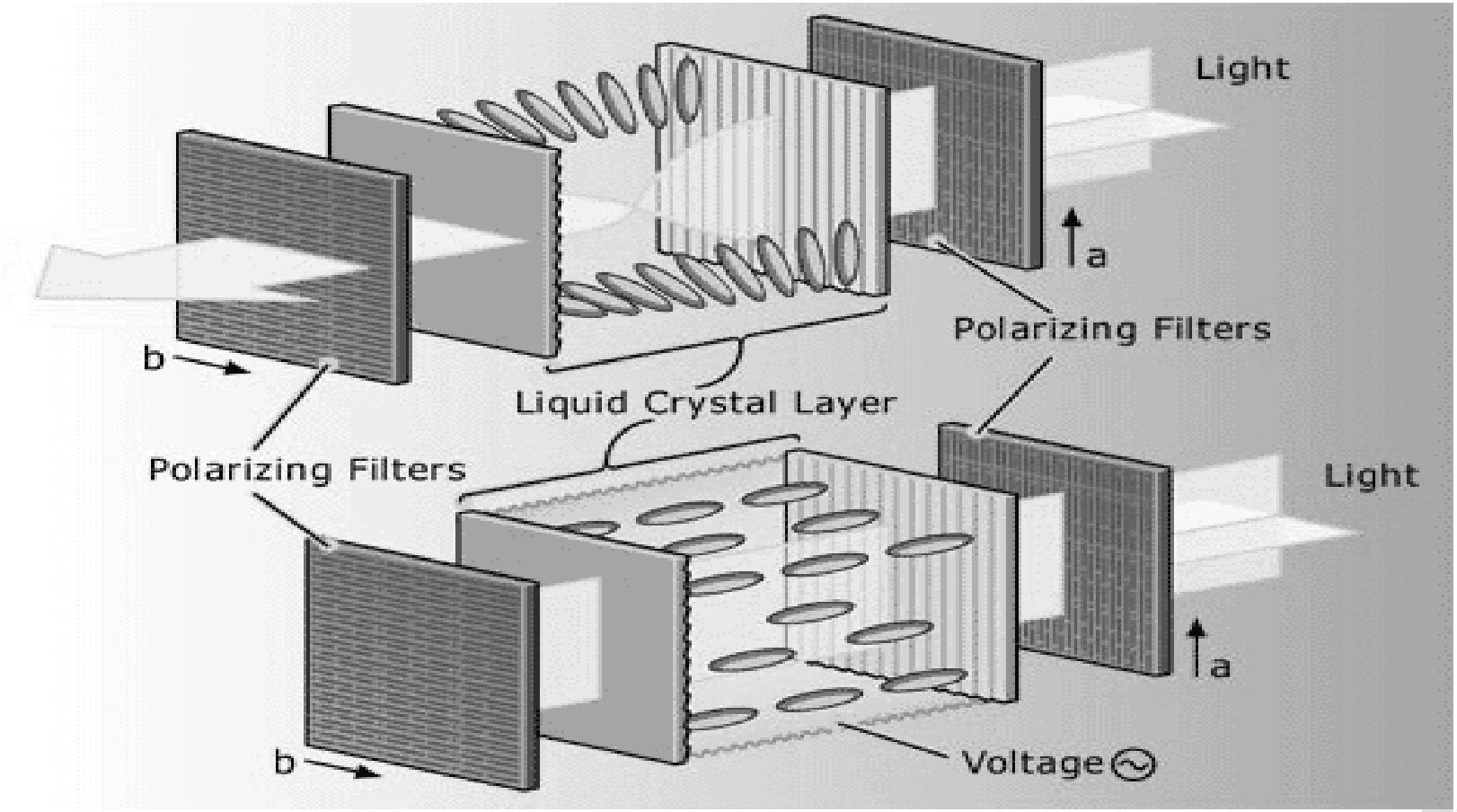
•The electrode is hooked up to a power source like a battery. When there is no current, light entering through the front of the LCD will simply hit the mirror and bounce right back out. But when the battery supplies current to the electrodes, the liquid crystals between the common-plane electrode and the electrode shaped like a rectangle untwist and block the light in that region from passing through. That makes the LCD show the rectangle as a black area.

- Each pixel consists of a layer of liquid crystal molecules suspended between two electrodes, and two polarizing filters, the axes of polarity of which are perpendicular to each other. Without the liquid crystals between them, light passing through one would be blocked by the other.
- Before applying an electrical charge, the liquid crystal molecules are in a relaxed state. The grooves on the electrodes cause these molecules to align themselves with the filter’s orientation. The grooves on the two electrodes are perpendicular, so the molecules arrange themselves in a helical structure, or twist (the "crystal"). Light passing through one filter is rotated as it passes through the liquid crystal, allowing it to pass through the second polarized filter. Half of the light is absorbed by the first polarizing filter, but otherwise the entire assembly is transparent.
- When an electrical charge is applied to the electrodes, the molecules of the liquid crystal untwist--- thus reducing the rotation of the entering light. If the liquid crystals are completely untwisted, light passing through them will be polarized perpendicular to the second filter, and thus be completely blocked. The pixel will appear unlit. By controlling the twist of the liquid crystals in each pixel, light can be allowed to pass through in varying amounts, correspondingly illuminating the pixel

Twisted Nematic (TN)




FLUORESCENT BACKLIGHTING
a
COLUMN ADDRESSING LINE
Vertical Polarizing Filter
ROW ADDRESSING LINE
b
Vertically Polarized Light
SUBPIXEL ELECTRODE
TRANSISTOR
c
PIXEL OFF
Light Repolarized by Liquid Crystals
PIXEL ON
GLASS PLATE
FRONT PLATE
LIQUID-CRYSTAL LAYER
GLASS PLATE
HORIZONTAL POLARIZING FILTER



A pair of polarizing filter layers work with the liquid crystals to control emitted light. As light passes through the first filter (a), only vertically aligned light waves remain. If the liquid crystals are in their natural state, they are twisted--which causes the light wave to turn horizontally. If an electric field is applied, the liquid crystals straighten and the cell doesn't bend the light. Since the second filter (b) only lets horizontal light waves through, light that passes through the straight liquid crystals is blocked by the second filter.

Illustration by Steve McGuire

Transmissive and Reflective displays

- LCDs can be either Transmissive or reflective, depending on the location of the light source.
- A transmissive LCD is illuminated from the back by a backlight and viewed from the opposite side (front). This type of LCD is used in applications requiring high luminance levels such as computer displays, televisions, personal digital assistants, and mobile phones. The illumination device used to illuminate the LCD in such a product usually consumes much more power than the LCD itself.
- Reflective LCDs, often found in digital watches and calculators, are illuminated by external light reflected by a reflector behind the display. The absence of a lamp significantly reduces power consumption, allowing for longer battery life in battery-powered devices;

Thank You