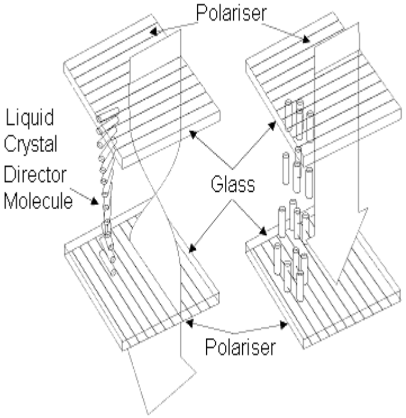
How LCDs Work

LCDs rely on the special properties of a group of chemicals called Liquid Crystals that are transparent and whose molecules are twisted. The twist of the molecules changes the polarisation of transmitted light. The angle of the change can be controlled by subjecting the crystal to an electric field. These properties have been used to develop displays that use the crystals to control the amount of light that is passed through the display.
Light is produced by a backlight



and is passed through a polarising filter. When no field is applied to the LCD, the polarisation of the light is changed as it passes through the LC material (90 degrees in a TN display, up to 270 degrees in an STN system). The light then meets a second polarising filter that is at right angles to the first and the light is transmitted. If a field is applied to the crystal, the angle of twist changes and only a proportion of light is transmitted. In this way the brightness level is controlled, giving the grey scale necessary for high quality images.
The screen is divided up into picture elements (pixels). The image is built up using these pixels. In a colour LCD, each pixel is fitted with either a Red, Green or Blue filter.
The image is made up of a matrix of pixels and the way that the brightness is controlled in each individual pixel, and known as the addressing, is a key difference between two types of LCD.

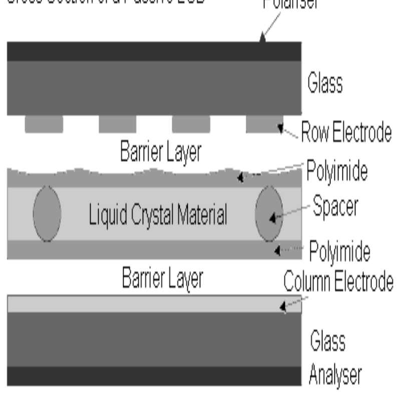
Passive Matrix LCDs

The simplest and therefore lowest cost form of LCD addressing is passive matrix addressing. In this scheme, transparent conductive lines for the rows and columns are applied to the glass above and below the Liquid Crystal (LC) material.
When a voltage is applied between the two points, the crystal re-aligns, changing the light transmission. In order to set different brightness levels for individual pixels, rows are set sequentially. When a row is selected, the appropriate voltages are fed to individual column driver circuits. Current flows through the column lines to the selected row and the LC materials align accordingly. The drive circuits then move to the next row and repeat the operation. When the scanned row reaches the bottom of the display, it starts again at the top of the display.

This kind of scheme could cause a lot of flicker, so LC material is used that has a slow response time - that is, after the crystal is aligned by the field, it takes quite a long time to return to its unaligned state. The slow response means that fast moving objects can be difficult to see and can smear, making single scanned passive matrix displays unsuitable for fast changing graphics or motion video.

A drawback of passive addressing is that there is some influence on other pixels in the same column and row as the pixel that is being set. The effect of this influence is called crosstalk and the visual result is that especially light or dark blocks of pixels on the screen can affect adjacent areas by making them lighter or darker respectively. To reduce the crosstalk effect, makers divide the screen horizontally into an upper and lower half and refresh each separately. This kind of display is called a Dual Scan Twisted Nematic (DSTN) display and is by far the most common form of passive display used in notebook computers, although some low cost computers do still use single scanned displays.

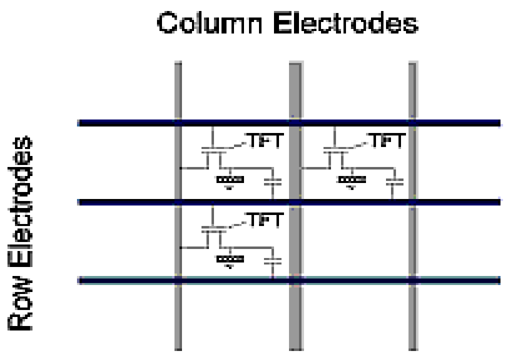
Cross Section of a Passive LCD



Active Matrix LCDs

Active Matrix LCDs

Active Matrix LCDs (AM LCDs) use an electronic switch at every pixel position so that once a pixel is switched on, the field can be maintained by the switch. This allows fast LC material to be used, so that smearing is no longer a problem. The switch, which is usually a Thin Film Transistor (TFT) also isolates the pixel from the influence of adjacent pixels and eliminates crosstalk.

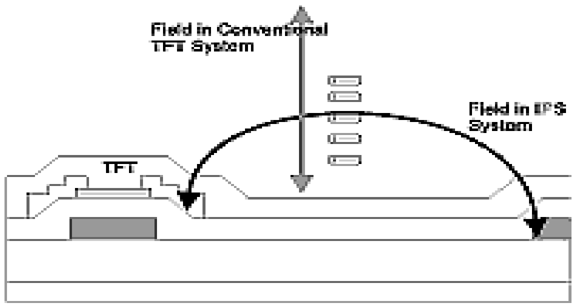


Active Addressing

Viewing Angles
Light emitted from the backlight and transmitted through the rear polariser doesn't only pass through the LC material at right angles to the polarisers. Light also passes obliquely through the LC material and filters which have a different optical effect at these angles. The result is that the optical performance can vary quite dramatically with viewing angle, in extreme cases and angles, leading to contrast inversion, where the dark part of the screen becomes light and vice versa. Typically the viewing angle is wider horizontally, but lower vertically on LCDs that have no special technology for viewing angle improvement.

Restricted viewing angle is a limited problem with small displays on notebook computers where the position of the user is fairly accurately known. (In fact, some makers claim this as an advantage, giving greater confidentiality on aircraft!) In desktop applications the user - or more than one user - may need to see the display from a range of different angles.
A variety of strategies are used to improve the viewing angles on LCDs which are designed for desktop monitors. Some of these technologies lead to reduced optical efficiency which would make the techniques unacceptable on notebook applications because of the increased power consumption for the same level of brightness. This is less of an issue where the panel is for desktop use, as the consumption is still less than an equivalent CRT.

- In-Plane switching
  In this technique, the liquid crystals are arranged to be parallel to the glass substrate, rather than at right angles to it.
- Collimation
  With this technology, a special filter is used to ensure that the light entering the LC material is aligned to be at right angles to the glass. At the surface of the display a further film is used that diffuses the light.
- Compensation Film
  Compensation film is used to compensate for the retardation effects of light travelling through the crystal at an oblique angle to the front face.
- Multi-domain Pixels
  In this method, each pixel is sub-divided and liquid crystals are aligned differently in each subpixel. The different alignments compensate for each other.
- Vertical Alignment
  Vertical alignment uses different LC material which aligns with the substrates when under



All NEC LCDs are TFT Active Matrix. In order to increase viewing angles both In-Plane Switching (Super Fine TFT) and Compensation Films are used.

SFT is available in the following screens:

10.4”	NL6448AC33-24
14.1”	NL10276AC28-02
15”	NL10276AC30-01
18.1”	NL128102AC28-01
20.1”	NL128102AC31-01