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Application Note [AN-005]

display products group

Liquid Crystal Display (LCD) Modes

Introduction

Unlike cathode ray tubes (CRTs), liquid crystal displays (LCDs) are not emissive i.e. they do not generate their own light source. In order to see an image on an LCD of any type (thin-film transistor (TFT), twisted nematic (TN) or super twisted nematic (STN) LCD etc.) a light source is required. This light source can be either ambient e.g. sunlight or some form of artificial lighting e.g. light emitting diodes (LEDs), cold cathode fluorescent lamp (CCFL) or electroluminescence panels (ELP) etc. on the rear or the front of the display. LCD panels can be designed to operate in a variety of viewing modes to allow operation in any lighting condition, from direct sunlight to total darkness. The polarisers used and the LCD panel construction determine the viewing mode of the LCD. There are three basic modes of an LCD, reflective, transmissive and transflective, each mode of the LCD is described in this application note.

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1 LCD Modes

1.1 Reflective LCD

A reflective mode LCD requires a light source from the front to illuminate the display. Normally the light source is ambient light e.g. sunlight or alternately artificial lighting usually in the form of LED or CCFL with a light-guide mounted on the front of the display to distribute the light uniformly. The ambient light is then reflected from a reflector at the rear of the display, returning through the LCD so an image can be viewed (*Figure 1*). The reflector is normally made of a metallic material that is sputtered or sprayed onto the outside surface of the back polarizer to form a uniform reflective layer.

This is a very energy efficient method for displaying information.

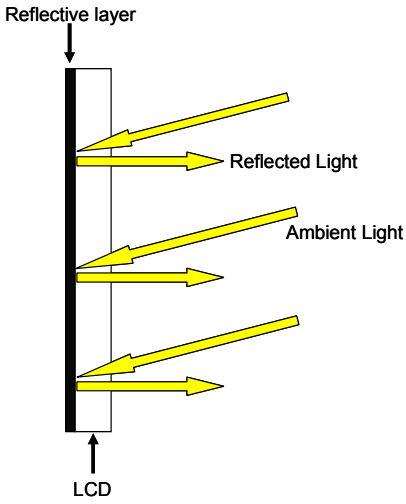

Figure 1: Reflective LCD

Reflective displays are normally used in low-end applications i.e. calculators, digital watches etc. where only simple text (usually segmented or dot matrix) has to be displayed and when the cost of the display is of primary concern. However it is also possible to make graphical reflective LCDs when low power consumption or low costs are important factors.

1.2 Transmissive LCD

In transmissive mode a backlight is necessary for the image to be visible. Transmissive LCDs transmit light from the backlight through the liquid crystal layer and out through the front to the eye of the user (*Figure 2*).

The rear polariser transmits only light that is polarised in a certain direction. In a colour display, each sub pixel transmits only the polarised light of that sub pixel's colour. Much of the backlight's output is blocked by the time the light reaches the liquid crystal because of this polarisation. When a sub pixel is transmitting light, the liquid crystal twists the polarised light through 90 degrees (in case of a TN construction) so that it can pass through the top polarizer. When an electric field is placed between a row electrode and a column electrode, the liquid crystal molecules are disrupted from their default spiral configuration so that they stop twisting

the light. The untwisted light is blocked by the front polarizer, so the sub pixel appears dark to the user.

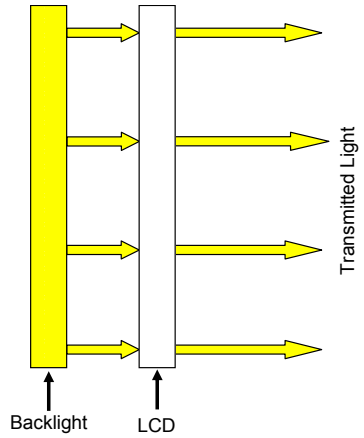

Figure 2: Transmissive LCD

Most LCDs used in portable computers are transmissive. A transmissive LCD looks excellent indoors having high brightness and contrast but the readability becomes poor in direct sunlight. The reason is that sunlight is up to 1,000 times brighter than LCD's backlight, so the reflection of sunlight from the surface of the LCD overwhelms any light coming through the LCD.

1.3 Transflective LCD

Transflective LCDs combine elements of both transmissive and reflective characteristics. Ambient light passes through the LCD and hits the semi-reflective layer. Most of the light is then reflected back through the LCD. However some of the light will not be reflected and will be lost. Alternately a backlight can be used to provide the light needed to illuminate the LCD if ambient light is low. Light from the backlight passes through a semi-reflective layer and illuminates the LCD. However as with ambient lighting some of the light does not penetrate the semi-reflective layer and is lost.

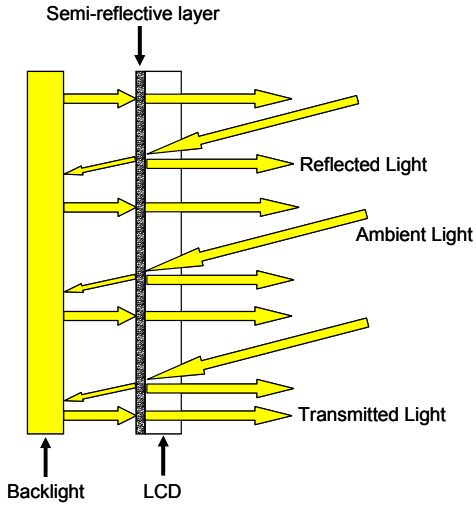

Figure 3: Transflective LCD

Transflective LCDs are used in devices that will operate in a wide variety of lighting conditions (from complete darkness to full sunlight). Under dim lighting conditions transflective LCDs offer visual performance similar to transmissive LCDs, whilst under bright lighting conditions they offer visual performance similar to reflective LCDs. However this performance is a trade-off because the transflective mode is less efficient due to some light loss.

2 Summary

Table 1 is a summary of how good the image will appear using different LCD modes under different lighting conditions.

	Transmissive	Transflective	Reflective
Indoors	Excellent	Good	Poor
Outdoors	Poor	Good	Excellent

Table 1: Comparison of Display Mode in Differing Ambient Conditions

Typical indoor conditions are normal office lighting, whilst typical outdoor lighting conditions are sunny days.

The transflective mode is a good trade-off between the transmissive and reflective modes but does not have the brightness and colour saturation of the transmissive mode indoors or the contrast and brightness of the reflective mode outdoors.

Manufacturing costs of monochrome displays are competitive in either transmissive, transflective or reflective modes and the choice of mode depends on the application. However, in case of colour displays, the transflective and reflective types are expensive to manufacture because the reflective layer is internal in order to remove colour parallax. As a result, most colour displays tend to be transmissive.

Keep safety first in your circuit designs!

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