Excelix LC Light Valves

Excel Display Corporation
100 Jersey Avenue
Bldg. B, Suite 201B
New Brunswick, NJ 08901

Tel: (732) 246-3728 Fax: (732) 246-3753
Email: excelix@excel-display.com

LCD LIGHT VALVES OR OPTICAL SHUTTERS

A LC light valve or optical shutter can be fabricated by using the same principles employed in the field-effect twisted nematic liquid crystal displays. The device consists of a twisted nematic liquid crystal cell, which has two continuous unpatterned electrodes and two transmissive polarizing plastic sheets serving as the polarizer and analyzer. In the natural state the LC cell twists the vector of the passing light by 90 degrees. However, the twisting power can be nullified by applying an electric field of certain strength. Therefore by placing the LC cell between a polarizer and an analyer we have a light valve which can be turned on and off directly by electronic means. The light valve can be made normally closed (or opened) by simply arranging the axes of polarizer and analyzer parallel (or orthogonal).

Transmission and speed are the two major characteristics of an optical shutter. The most important factors that should be carefully considered when incorporating LC optical shutters in a new design are transmission, its spectral profiles, the response times, and their voltage and temperature dependence. Unlike mechanical light shutters, the opened state of the LC shutter is not 100% transmissive, and its closed state not 100% opaque. However, on the other hand, it does provide a certain extent of gray scale.

TRANSMISSION

The transmission of the LC light valve depends mainly on the birefringence of the LC material, and the transmittance and efficiency of the polarizing sheets used. By judiciously selecting from the different polarizing sheets available, both the attenuation of incident light and the contrast ratio can be manipulated within a certain range.

Theoretically the transmission of a polarizer is 50% of the unpolarized light. In the real world, the less-than-100% polarizer efficiency will allow more light through, while the reflection and absorption of the polarizing material will decrease the light transmitted. The transmission of the current commercially available plastic sheet polarizer ranges from 38% to 48% for the neutral gray types. Correspondingly, the polarizing efficiency decreases from 99% to 80%.

As an integrated unit, the LC light valves can achieve 45% transmission when low-efficiency polarizer is used and an attenuation better than 99% when high efficiency polarizer is used. It is worth noting that the poorer the efficiency of the polarizer the higher the transmission in both the opened and closed states. In the other words, high transmission usually means low contrast ratio. It should also be noted that a normally closed LC valve is more efficient than the normally open one. The transmission in the open state is about the same, however, in the closed state, the normally closed LC valve has lower transmission.

The contrast ratio (or the extinction of incident light in the closed state) can be greatly enhanced with only a moderate decrease of the open-state transmission by stacking up two or more LC shutters in an appropriate way.

GRAY SCALE

The transmission spectrum of a neutral gray polarizer is quite flat in the visible region from 450-750 nm. By turning it partially on, it serves as a neutral density filter with variable optical density. However, as evident from the transfer curve (transmission vs voltage), the effective voltage range for achieving a gray scale is between threshold voltage, V(th), and the saturation voltage, V(sat). Normally the S-shaped curve is steep. This results in a fairly narrow voltage range for manipulating the gray scale. There are various ways to broaden the transfer curve. It should be noted that since the transfer curve is temperature dependent, the voltage for a consistent degree of grayness has to be temperature compensated. It is even so when the usable voltage is restricted to a narrow range. Generally the Transfer curve moves to the left about -5 to -10mv/degree C.

SPECTRAL PROFILE

When color polarizers are used in the LC light valve, different spectrum regions of the incident light are attenuated to different degrees. It is therefore possible to devise an LC light valve to modulate a certain color of the light.

SPEED

The response times of an LC optical shutter is determined by a number of parameters, notably, LC formulation, temperature, thickness of LC layer, applied voltage.

Special LC mixtures have been formulated to have T(on) and T(off) in the order of 10 milliseconds. The response times of a typical LC light shutter is listed in the following table:

All Times Expressed in Milliseconds

V(appl)	T(delay)	T(rise)	T(off)	T(Bounce)
4V	24	12	10	--
6V	22	8	15	--
8V	10	5	18	--
10V	7	4	30	70
20V	2.5	0.35	25	85
30V	1.0	0.30	20	90
40V	0.7	0.20	20	100

It is clear that increasing the applied voltage speeds up the turn-on time (which consists of the delay time and the rise time). However, in doing so it either slows down the turn-off time, or at sufficiently high voltages produces the annoying bounce. Again, the bounce time is determined by the applied voltage and the formulation of the liquid crystal. Both T(on) and T(off) can be shortened, and the bounce minimized or eliminated by making the LC layer thinner. Reducing the thickness of the LC layer, however, is limited by the birefringence of the LC mixture. Below a certain thickness, an LC light valve will have a lower extinction coefficient in the closed state thereby allowing more light to pass through.

The effect of temperature generally speeds up the response times of LC light shutter as shown in the Figure.

EXCELIX LC LIGHT VALVES

Excel Technology International has standard LC light valves available in the Excelix LV series. We also provide light valves of different sizes and with special characteristics tailored to the requirements of individual customer. For more technical information and pricing, please call (732) 246-3724.