4. Experimental Objectives

1) Understand the basic principle of LC display (TN-LCD).
2) Measure the response curve of LC sample.
3) Calculate parameters such as threshold voltage (Vt) and saturation voltage (Vs).
4) Measure the transmittance of LC switch.
5) Observe transmittance change versus viewing angle.

5. Precautions

1) When mounting/dismounting the LC cell, only hold the edge of the cell, and never squeeze the middle of the cell; keep the surface of the liquid crystal cell clean and free of scratches; prevent the liquid crystal cell from being damp and direct sunlight.
2) Never look directly into the laser.
3) The liquid crystal sample is greatly affected by environmental factors such as temperature. For example, the TN type liquid crystal has a voltage drift of 15% to 35% in the range of 20 °C ± 20 °C. Therefore, it is normal for the results of each experiment to be different. The electro-optic curves of liquid crystal samples at different temperatures can also be compared.

6. Experimental Procedures

1) Measure Liquid crystal electro-optic characteristic

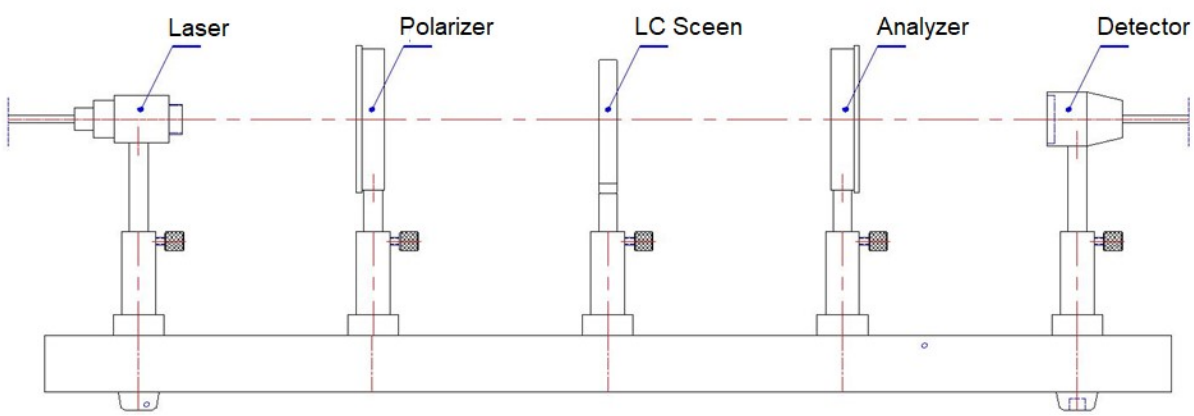


Figure 6 Schematic of experiment setup of liquid crystal electro-optic effect

a) Place the laser, polarizer, LC screen, analyzer, and photo detector at the corresponding positions on the optical bench as shown in Figure 6.
b) Connect the laser, LC screen and photo detector to the corresponding jacks of the electric unit.
c) Adjust the height of the laser so that the laser spot enters the entrance hole of the photo detector.
d) Remove the LC screen and rotate the polarizer to 0°. Rotate the analyzer to make the output laser spot darkest. At this time, the analyzer angle should be at 90°. Place back

the LC screen, the output light spot becomes brighter at this time.

e) Turn on the power of the electric unit. Turn the frequency (Freq.) knob in counterclockwise to the minimum. At this time, the frequency is the maximum value. There is no flash of the light spot, and the readings on the voltage meter and the current meter are stable.

f) Turn the amplitude (Amp.) knob clockwise to gradually increase the amplitude of the square wave signal, observe the reading of the current meter, and record the corresponding amplitude (voltage) and current values in Table 1.

Plot the relationship diagram of amplitude and current. Convert the current to relative transmittance by setting transmittance as 100% when amplitude is 0). Find the cut-off voltage and threshold voltage.

Note that in the process of adjusting the amplitude, between 0 ~ 2 V with step 0.2 V and 2 ~ 5 V with step 0.1 V.

Table 1

Amplitude (V)	Photocurrent (mA)	Transmittance (%)
0		100
0.2		
…		

2) Measure liquid crystal rise time, fall time and response time

a) Repeat Steps a) to d) of the previous experiment.

b) Turn on the power of the electric unit. Connect the “Oscilloscope” port to CH1 of the oscilloscope with BNC cable, and connect the synchronization (Sync) signal to the External trigger port of the oscilloscope. The oscilloscope time scale is set to 10 ms, and the voltage set to 5 mV.

c) Adjust the frequency knob clockwise. At this time, the frequency of the square wave signal decreases and the period increases. It can be observed that the output spot starts to flash, and as the period increases, flash interval becomes longer and longer.

d) Adjust the voltage amplitude to about 3 V. Slowly increase the square wave period, the phenomenon of rising and falling edges can be clearly observed. (The square wave amplitude should not be too strong during the adjustment process, otherwise the output waveform will be distorted)

e) Measure the rise time and fall time with the oscilloscope, and estimate the response speed of the LC screen.

f) Change the amplitude of the signal and record the response time at different amplitudes.

3) Measure the characteristic of viewing angle of LC screen

a) Repeat Steps a) to e) of Experiment 1).

b) Set the voltage amplitude to 0 V, rotate the LC screen ± 80°, and measure transmitted light intensity every 20°.

c) Set the voltage amplitude to 2 V and repeat the above measurement process.

7. An example of data recording and processing

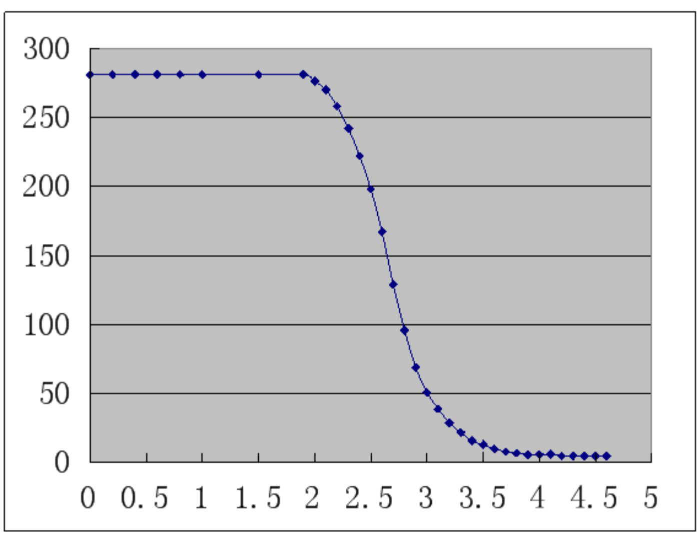
Note: Following data are for reference only, not the criteria for apparatus performance:

1) Measure threshold voltage

Data recorded in the table below:

Amplitude (V)	Current (uA)	Amplitude (V)	Current (uA)	Amplitude (V)	Current (uA)	Amplitude (V)	Current (uA)
0	281	1.8	281	2.8	129	3.7	10
0.2	281	2	276	2.9	96	3.8	8
0.4	281	2.1	270	3	69	3.9	7
0.6	281	2.2	258	3.1	51	4	6
0.8	281	2.3	242	3.2	39	4.1	6
1	281	2.4	242	3.3	29	4.2	6
1.2	281	2.5	222	3.4	22	4.5	5
1.4	281	2.6	198	3.5	16	4.8	4
1.6	281	2.7	167	3.6	13	5	3

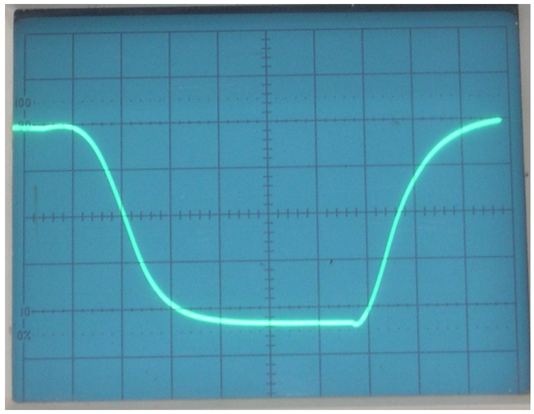
According to the data of the table, the V-I curve is plotted as below:



From the plot, we found the threshold voltage is 2.18 V, where the relatively transmittance is 90%, and the cut-off voltage is 3.21 V, where the transmittance is 10%.

2) Measure response time

On the oscilloscope, we observed the response curve as below:



By reading the abscissa values for ordinate values of 10% and 90%, and calculating the difference, the fall time can be measured as 12 ms and the rise time as 18 ms, then the total response time is 30 ms.

As the amplitude of the drive voltage increases, it can be observed that the falling edge becomes steeper, i.e. the fall time becomes smaller, but the rise time does not change significantly, and the total response time becomes shorter.

3) Transmittance of LC screen at different angles

Data recorded in following table

Angle(°) / Voltage(V)	20	40	60	80	100	120
0	238	243	243	221	201	221
3	199	197	179	168	181	182