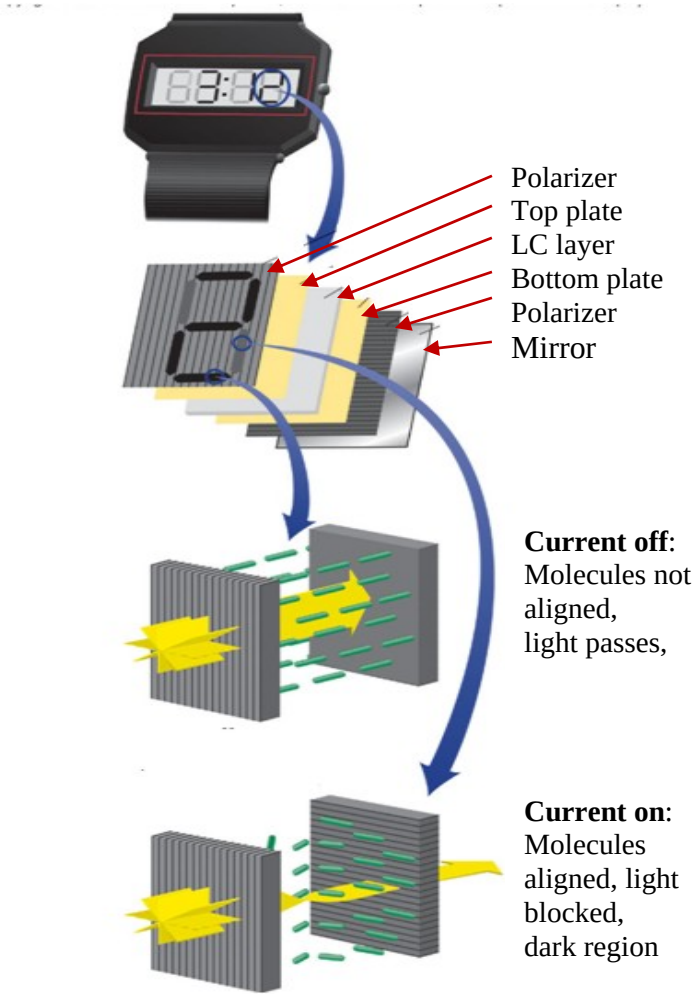
Investigation of a Liquid Crystal Watch

This experiment is modified from a procedure developed by S. M. Condren and G. C. Lisensky in the Lab Manual for Nanoscale Science and Technology at http://mrsec.wisc.edu/Edetc/nanolab/watch/index.html with modifications and additional information by David A. Katz

This experiment deals with the disassembly of an inexpensive liquid crystal display (LCD) watch and testing several of the properties of the LCD panel.

Liquid crystals are commonly used as displays for electronic devices such as watches, calculators, televisions. This is the result of the unusual optical and electrical properties of liquid crystals. The long thin liquid crystal molecules cause light to travel at different speeds along the molecular axis and perpendicular to that axis. This leads to their ability to rotate the plane of polarized light.

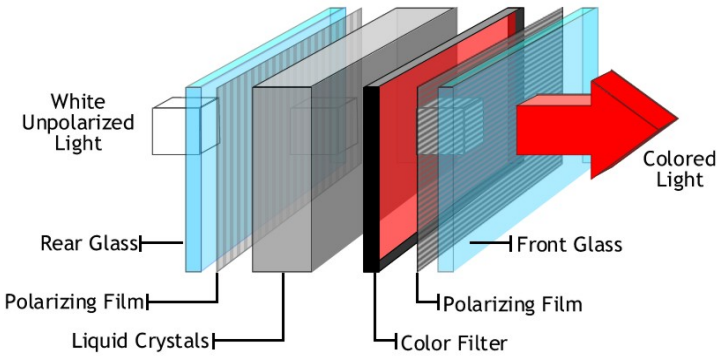
A typical LCD watch is construction is shown on the right.



When the current is off, the liquid crystal molecules in all segments of the panel are precisely aligned. In this case, the panel appears silvery because light passes through both polarizers, reflects off the mirrored surface, and then passes back through both polarizers.

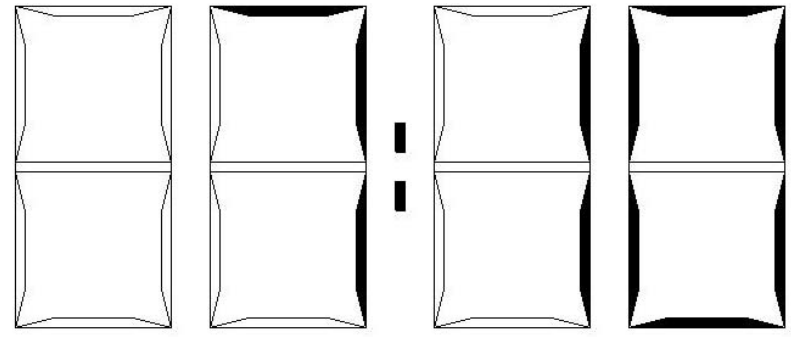
When the current is on, the liquid crystals are twisted, losing the initial alignment of the molecules. The polarized light is no longer aligned with the second polarizer and that segment of the display will appear black against a silver background.

In a television set with an LCD display, the addition of a colored filter between the liquid crystal panel and the top polarizer results in colored light being observed by the viewer.

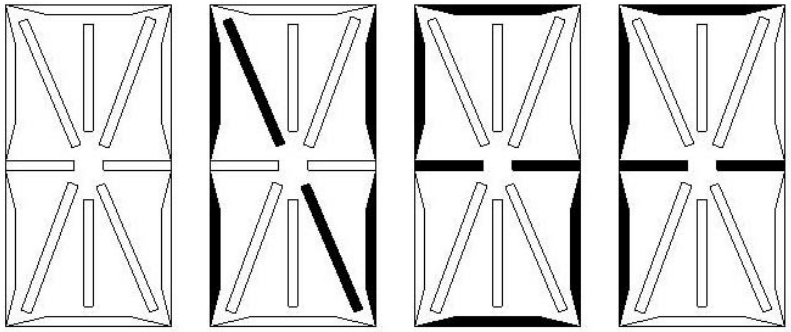


Schematic of an LCD TV

Most of the displays in LCD watches are composed of several 7-segment sections. Each 7-segment section can display one number. The combination of these sections can display the date or time, is shown in the figure below.Figure 4.



7-segment



14-segment

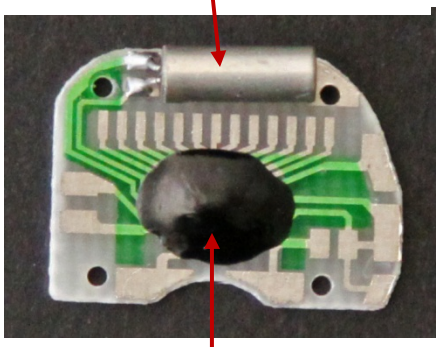
Examining the printed circuit board of the watch, there are two major components, a timing crystal and a controller.

The timing mechanism is a quartz crystal that provides a constant-frequency signal to the electronic circuit in the watch. When the quartz crystal is excited with an electric field, it vibrates at a particular frequency.

The controller is an integrated circuit (IC) that is programmed with the frequency of the quartz crystal. The IC converts a certain number of vibration cycles from the crystal into seconds, minutes, and hours and sends that information to the LCD display "telling" it to turn on specific segments. The IC also allows for the setting of the time and date and storing that information.

Contact between the printed circuit board and the LCD panel is through the conductive rubber laminate that allows for the current to flow in one direction to the panel, but not in the reverse direction.

The quartz crystal



The integrated circuit chip is sealed in here.

Materials needed

An inexpensive LCD watch (not necessarily functioning)
Small screwdriver
Tweezers (forceps)
Scissors
9-Volt battery and battery cap with leads
Tongs
Beaker, with stir bar and hot plate
Thermometer
Polarizing filters
Conductivity tester

Procedure

Your watch may be slightly different from the one shown here.

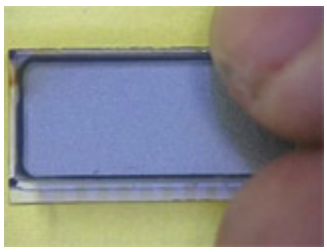
Remove the back plate of the watch to access the interior. If screws are removed, place them in a small container for safe keeping since tiny parts can be easily lost.

Remove the watch assembly from the case.

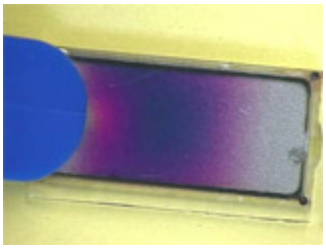
Hold a piece of polarizing film over the watch display. Slowly rotate the polarizer above the LCD panel. Does the orientation make a difference?

Remove the four tiny screws holding the printed circuit board and battery retainer to the white plastic inner case. Remove the electrically conducting pad and the LCD panel. Place the screws, switch contacts, and battery contacts into a small container for safe keeping.

Place the conducting pad flat on the bench top between the contacts of a conductivity device. Gently squeeze the contacts against the rubber pad. What do you observe?



Examine the LCD panel and find the contact area of the panel on the bottom of the wider glass plate. Use a battery cap connected to 9-V battery. Hold one of the leads against the contact area at one end of the panel and rub the other lead along the contact area to address various segments of the LCD panel. Record your observations.



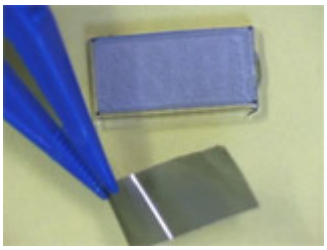
Under pressure liquid crystal materials, such as used in LCD watches, undergo dramatic color changes. Place the LCD panel on a hard surface. Gently press on the surface of the liquid crystal display with your finger. Record your observations.

When a liquid crystal melts, the molecules become less ordered and the display appears black. The change is reversible if the heating is not too severe.

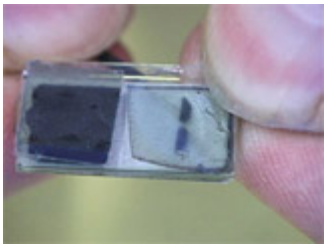
The temperature for the liquid crystals to liquid phase transition can be measured using a hot water bath and a thermometer.

Set a beaker of water on a hot plate. Heat the water slowly, using a thermometer to monitor the temperature.

Holding the LCD panel with a pair of tongs, partially dip it into the beaker of warm water when the temperature is about 30°C. Repeat the procedure every 5° until you see a definite color change. Record the temperature of the water bath and any color changes you observe..



This step is not totally reversible. Remove the top polarizer by carefully prying up one corner and then gently peeling it away.



This step is not totally reversible. Cut the polarizer in half with scissors. Place one half back on the panel in its original orientation. Place the other half back after rotating 90 degrees.

Use a battery cap connected to 9-V battery. Hold one of the leads against the contact area at one end of the panel and rub the other lead along the contact area to address various segments of the LCD panel. Does the orientation make a difference?

With care, the watch can be reassembled in working order.

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Data and Results

Names: _____

Date _____ Course _____ Section _____

Were you able to identify the different parts of the LCD watch?

What happens when you rotate the polarizer over the liquid crystal display?

What happens when the rubber pad is placed between the contacts of the conductivity tester?

Describe your observations when you move the lead from the 9-volt battery over the contacts of the LCD?

What happens when you press your finger on the LCD?

At what temperature does the LCD change color?

If you were able to remove the top polarizer from the LCD and cut it in half. What is the effect of rotating it 90° on top of the display?