

## Week #9 – Displays

You can use photos instead of diagrams/or drawings in your lab report where ever it is appropriate and where they can be properly labeled/understood.

Note, sometimes the HeNe lasers tend to polarization sweep over time (rotate in polarization, the laser light has some polarization to it). The best way to avoid this is to allow the laser to warm up for 30-60 minutes before you start lab. How can you tell if a laser is still polarization sweeping? Simple, place one polarizer between the laser and the photodetector and look for a significant change in optical power measured vs. time.

The week's lab tasks are shorter, because you will learn how to use a spectrometer for the 1<sup>st</sup> time! This will be the 1<sup>st</sup> of several weeks where we make use of the spectrometers. **Regarding the spectrometers:**

(1) You will need to bring a laptop with a USB port, and the free Spectrasuite spectrometer software installed on it (scroll down to Discontinued software): <http://www.oceanoptics.com/Technical/softwaredownloads.asp>

You will need a password for the software: fg6zKWBukL

(2) Here is the installation guide and user manual: <http://oceanoptics.com/wp-content/uploads/SpectraSuite.pdf>

The end of this video has a quick way to make sure the install and spectrometer works:  
[https://www.youtube.com/watch?v=B\\_yGJF1BcWY](https://www.youtube.com/watch?v=B_yGJF1BcWY)

This week, you mainly need to see page 132 (Taking Reference and Dark Spectra). Before you make a measurement, you need to store a 'dark spectrum' as a reference that it will compare your measurement too. This is basically like a 'baseline measurement' with no light coming into spectrometer.

### 1. The LCD Display – Goal: create an LCD display from basic components and validate its operating principles.

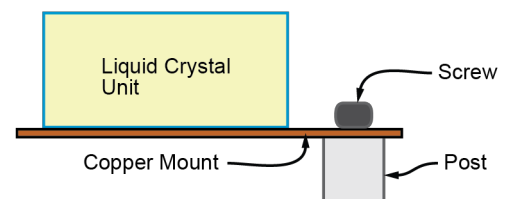
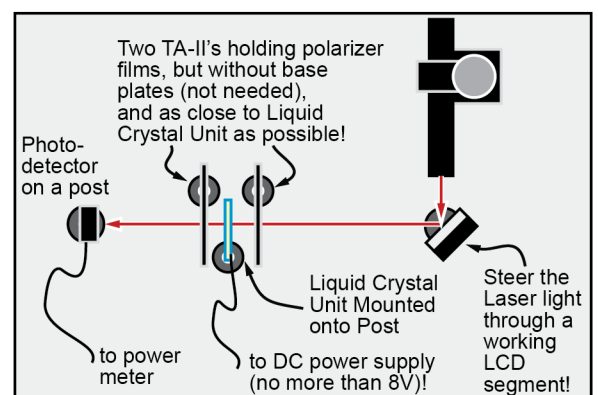
Tips: You should align your polarizers such that you can achieve maximum contrast (max/min transmission) for this experiment. Mount the LCD module to a post (see the hole at the end of the supporting copper mount). Also, keep the polarizers as close as possible to the liquid crystal cell, so you can 'see' the LCD turn on. It is easiest to use the thin polarizer film (not disks) mounted in on the glass and slightly adjust them for maximum contrast. There are 'optical' polarizers and 'display' polarizers, and we will use 'display' polarizers which work better with the LCD. I have not figured out how they are different, if you do, the first person to let me know will get 5% extra credit this week!

Procedure:

(1) Setup your experiment as shown at right, and in the 1<sup>st</sup> diagram at the top of the next page (crossed polarizers). Before you worry about the laser and photodetector, 1<sup>st</sup> setup the LCD display with the polarizers. Put some voltage (5V for example) on the LCD and look for the active segments (pixels). Align the laser path with an active segment. You might even reduce the laser beam diameter to make sure it is all going through the active segment only.

(2) Adjust the polarizers for maximum contrast.

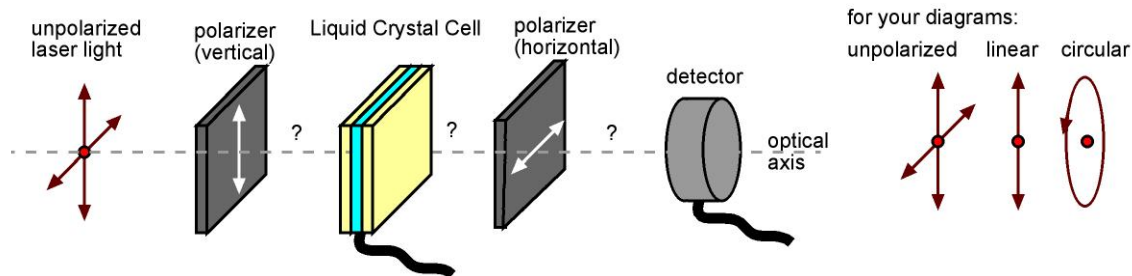
(3) Record transmitted power as a function of applied voltage (0.2 V increments up to 7V, do not apply more than 8V!). Make sure the DC power supply current knobs are set as low as possible to support the needed voltage, no more (is safer this way). Record your maximum contrast (max power/min



power). **Diagram the optical components and light polarization at min and max transmission (fill in blanks for image shown below).**

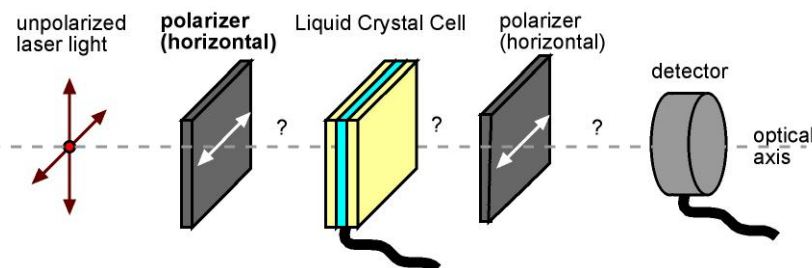
(4) Draw or take a picture of your pixels at min/max transmission.

(5) Plot transmission vs. voltage, label on the diagram where liquid crystal **cell acts like half wave plate, a quarter wave plate, and as a material that has no birefringence at all.**



(6) Setup the LCD polarizers as shown below for aligned polarizers (just flip one over backwards, to invert its polarization).

(7) Draw or take a picture of your pixels at min/max transmission. Explain why this appears as the inverse of the image you saw in step (4).



*Note, you might see your liquid crystal peak out in response at 4-6 V then decrease in response as you go to 8V. What does this mean? This simply means that the liquid crystal thickness and polarizers are setup such that you don't need to switch to the full extreme alignment of liquid crystal with E-field to get the effect that was needed in this commercial LCD panel.*

**2. How a Liquid Crystal Display Creates Millions of Colors** – Goal, measure and validate how an LCD screen creates multiple colors.

Procedure:

(1) rotate a polarizer in front of your screen, what happens, why?

(2) Your laptop uses a white lamp/backlight behind the LCD screen. Using Microsoft power point (or other program) create rectangles on your screen that are colored black (K), red (R), green (G), blue (B), yellow (Y), white (W), and one additional mixed/grayscale color of your choosing. Record the spectrum of the LCD for each of these colors from 400 to 700 nm using the spectrometer (make sure you 'store dark spectrum 1<sup>st</sup> by measuring a black square on the LCD, then make sure you are in 'intensity' mode while measuring). Provide the plots in your lab report and on each plot, paste in the image of each rectangle you drew with its color. For each, draw a diagram of pixels on your laptop for each color generated (three side by side rectangular 'sub-pixels' making a single square 'pixel' (each sub-pixel can produce black or one color R,G, or B).

*Note: You can read the exported spectrometer plot files in excel!*

*Careful, a color on a laptop might not be a pure color. For instance, a bright blue might have some 'green' in it to make it brighter (more like cyan).*

**5. Setup Dismantle and Storage** – Proper care of optical components is just as important to achieving reliable results as is careful experimental setup. Improper handling, setup, dismantling, and storage will detract from your final grade in

this course. Unsure about any component? Just ask. The next group should find all parts neatly stored in the optics kit. There is a card with each kit that shows where each component goes.

**6. Theory/Calculation Problem (LCD Brightness Enhancement Film)** – Goal – theoretically understand how a 3M Brightness Enhancing Film (BEF) makes your LCD display look brighter.

#### What Does it Do?

- Manages the angle of light exiting your display. Reduces the energy needed to power a display. Optimizes light and makes the display much brighter.

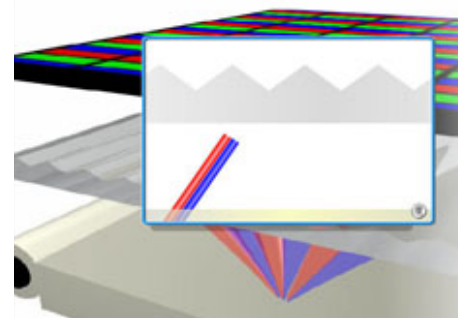
**Where is it used?** Brightness enhancing films are used to increase the brightness and efficiency of any LCD display – from TVs and desktop displays to laptops, tablets and mobile devices.

Procedure:

(1) Assuming the refractive index of the BEF is 1.5 and it is surrounded by air, calculate and diagram the maximum incidence angle from the light source (see diagram below) that can refract out of the pyramidal top surface of the BEF (assume the pyramids are 90/45/45 degree triangles). *Answer should be >80 degrees, FYI.*

(2) What is the half-cone angle (maximum angle) at which light can then move forward on through the LCD display? This should be EASY, no calculation! *Hint, the max angle is at the critical angle, right? So again, this should be easy.*

(3) Explain briefly, how this makes your LCD look brighter for Laptop or CII-phone applications, but why it might not be as good for multi-user (wide view angle) applications like LCD TV.



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**Vikuiti™ BEF II 90/50** [Printer-friendly format](#)

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Vikuiti BEF II 90/50 film utilizes refraction and reflection to increase the efficiency of LCD backlights. Light within the viewing cone (up to 35° off the perpendicular) is refracted toward the viewer while light outside this angle is reflected back and recycled until it exits at the proper angle.

## Vikuiti™ BEF II Operation

