Laboratory Five

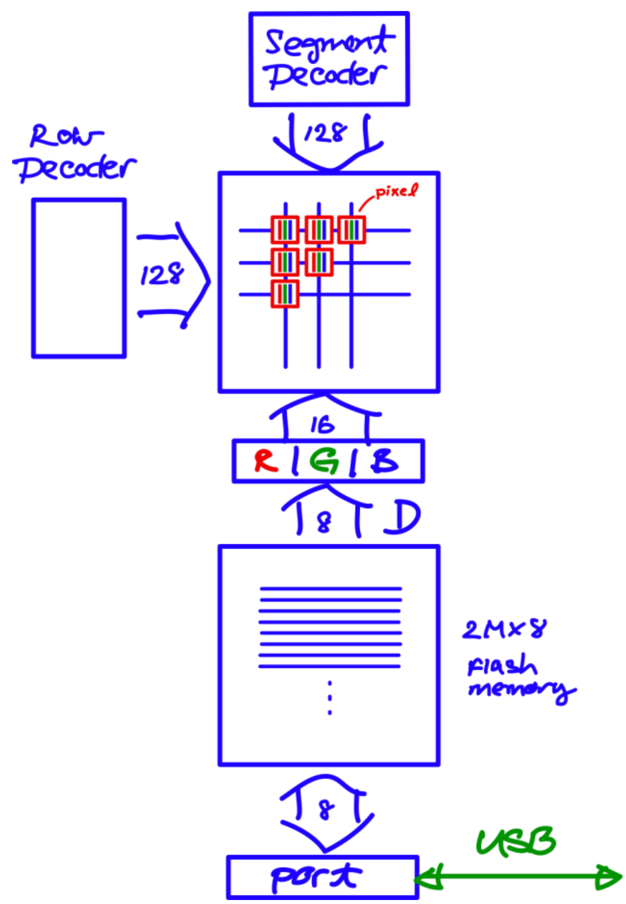
Properties of Mobile Devices

Basic Concepts

Today you will take apart a small mobile device called a photoviewer and examine the circuitry, motherboard and liquid crystal display (LCD) that it uses. The basic concepts are:

1. Mobile devices process and provide visual and audio information. They consist of memory, computing and communication elements, audio projection, image and video display and a battery energy source.
2. Pixels of a LCD generate color via three colored RGB subpixel segments. A lens array can reveal the pixel geometry of the LCD. Pixels are activated by accessing their location with 2-d decoders.
3. Images are generated by providing each segment with a color code through the 16-bit segment register (5 bits for R, 6 bits for G and 5 bits for B), making 2^{16} total colors.
4. The overall light intensity and color is actually controlled by altering the light polarization of each segment.

There is no prelab exercise associated with this lab.



Task One: Parts Identification

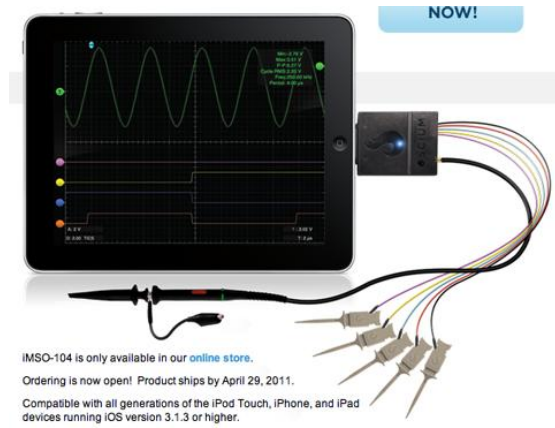
A Block diagram of the photo viewer is shown at right. It consists of a 2M byte USB flash memory, a 128 x 128 LCD (and display RAM) array, row and segment decoders, a 16-bit RGB segment register, other system controller related registers, electronic and power supply parts.

1. Under the direction of your lab instructor, carefully remove the outer shell of the photoviewer and identify the motherboard, bus, LCD and battery components. (Do not connect the USB cable to the connection on the motherboard while the shell is removed.)
2. Examine the photo viewer motherboard front and back-side photos on a desktop folder on your PC. Count (and record in your lab notebook) the number of discrete electronic components designated as:
   a. 'R' or 'RN' (Resistors)
   b. 'C' or 'X' (Capacitors)
   c. 'D' (Diodes)
   d. 'Q' (Transistors)
3. Now find the part numbers for the 2 large ICs on the backside and look up their description and manufacturer on a search engine, such as Google. Record your information in your lab notebook.

Task Two: Viewing Electronic Signals

Electronic information, such as voltage or current, are often available to be measured at test points (TP) in a circuit. Such signals may be observed with oscilloscopes.

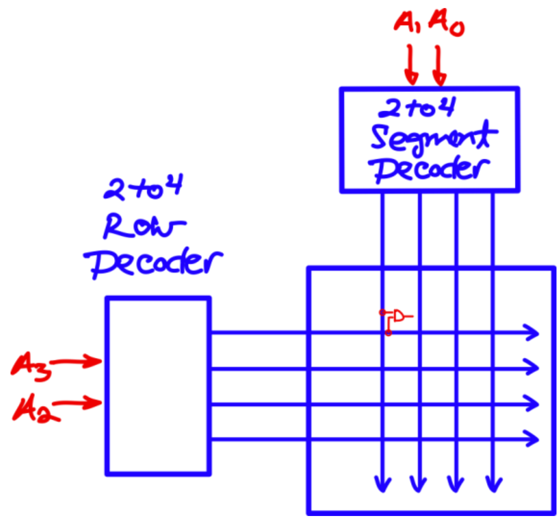
1. Locate test points **TP2** and **TP10** on the motherboard.
2. With the viewfinder shell still removed, press the viewfinder power button, on the other side of the USB port. Examine the signal by touching the iPhone **iMSO** probe to **TP2** (this will show a clock signal). The black wire must also be connected to ground. Show your lab instructor.
3. Now, examine the signal at **TP10** (this will show a raw picture data signal). You will need to press the middle button to start the data transfer before viewing. Show your lab instructor.
4. **Reassemble the Photoviewer**.



Task Three: LCD 2-d Decoder Logic

A small example of the LCD decoder logic circuitry is shown at right. It consists of a 2 to 4 Row decoder, a 2 to 4 column (segment) decoder and a 4 by 4 pixel array. The intersection of the Row and Segment decoder points to a single pixel in the LCD, which consists of 3 color segments. This arrangement is called a passive-matrix. (See link for a demo of operation.)

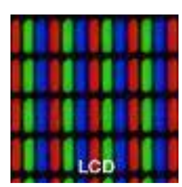
1. Simulate the small LCD array in ***Xilinx*** using library components for the two 2 to 4 decoders. We will model a color segment with a 2-input **AND** gate.
2. Change the address $A_3A_2A_1A_0$ from 0000 to 1111 and observe the output pattern of the 16 **AND** gates. Notice that each pixel position is addressed once each cycle.

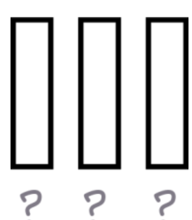


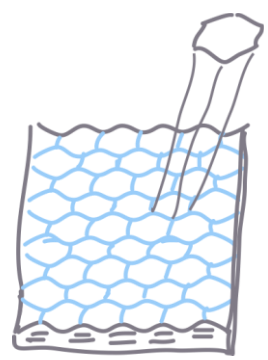
Task Four: Viewing Pixel Geometry

The LCD in the photo viewer is typical of those used in cell phones and keychain displays. The pixel geometry for this LCD is stripe geometry. Each LCD pixel is made up of 3 sub-pixels or segments, one each for the three colors red, green and blue (RGB).

1. Lens arrays are useful for magnifying pixels on the LCD. Place the "fly's eye" array on top of the **reassembled photoviewer**, making sure the flat side of the lens array is up. Then activate the blue ECE 2500 Lab 3 slide on the photoviewer. You should be able to observe the stripe pixel geometry in one of the lens, dominated by a bright blue stripe, as you move your head side to side. Draw what you observe to be the order of the three RGB segments in this case, using the rectangles shown at right. Then fill in one of the rectangles showing the bright stripe.



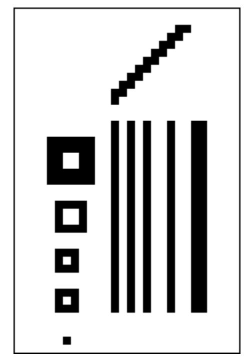




2. The blue slide has 2 lines of text with the words "ECE 2500". Which one of these looks better to you? Open the ECE2500.gif picture in your folder and zoom in to examine the 2 lines of text more carefully. Describe the differences in the appearance of each line of text in the graphic.

3. Next, place the fly's eye array on top of the photoviewer glass window, with the blue ECE 2500 Lab 3 slide still showing on the photoviewer. Observe the pixels in the white text area with one hexagonal lens and fill in the rectangles for all bright segments in that region.

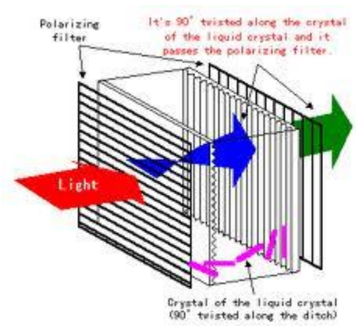
4. Change the slide on the photoviewer to the colored 128 x 128 colored test pattern slide shown at right, and fill in the the rectangles for the bright color segments that you observe in one of the hexagonal lens for the red, blue and green areas.



5. Now bring up the colored 128 x 128 colored test pattern on your PC, containing the test pattern shown in detail. Identify the following test patterns:
   a. 1 pixel spot in a large color base
   b. 1 pixel spot in a 9 pixel box
   c. 4 pixel spot in a 36 pixel box
   d. Staircase
   e. 1 pixel width line, one pixel space
   f. 1 pixel width line, 2 pixel space
   g. 2 pixel width line
6. Display the colored test pattern already loaded on your photo viewer. Describe how the LCD image quality differs from the image on the PC for each color base. How distinct are the single pixel spots and pixel lines for each color? Under what circumstances do the white or black patterns seem to be affected by the surrounding colors?

Task Five: Polarization Characteristics

The LCD in the photo viewer is a passive-matrix, color super twisted nematic (CSTN) LCD color display. Polarization effects are used to control the brightness of each color segment.



1. LCD displays are transmissive in that they vary pixel emission by passing polarized light between back and front polarizing screens. [Newer organic OLED displays are purely emissive and do not use polarization.] View the LCD through a polarizing filter (threads should be oriented toward your eye) to see the effects of polarized light coming from the top screen surface of the LCD. Rotate the filter and explain the effect of the filter on the light coming from the LCD.
2. Now look at the display at various angles off of the vertical 90°. Notice that the intensity of light falls off quickly from the 90°position. Using a protractor, measure the angle at which the display first falls to a flat intensity. Compute 90° minus that angle and take ½ of that and record the result as the LCD viewing angle θ_{view}.