EE119 Homework 9: LCDs and Lasers

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1. The electro-optic characteristics for a TN-LCD and STN-LCD are given in the figure 1. Two vertical lines in each graph indicate the OFF- ON rms-operating voltages for 240:1 multiplexing. (This is a dual scan VGA display, so M = 240 instead of 480.)

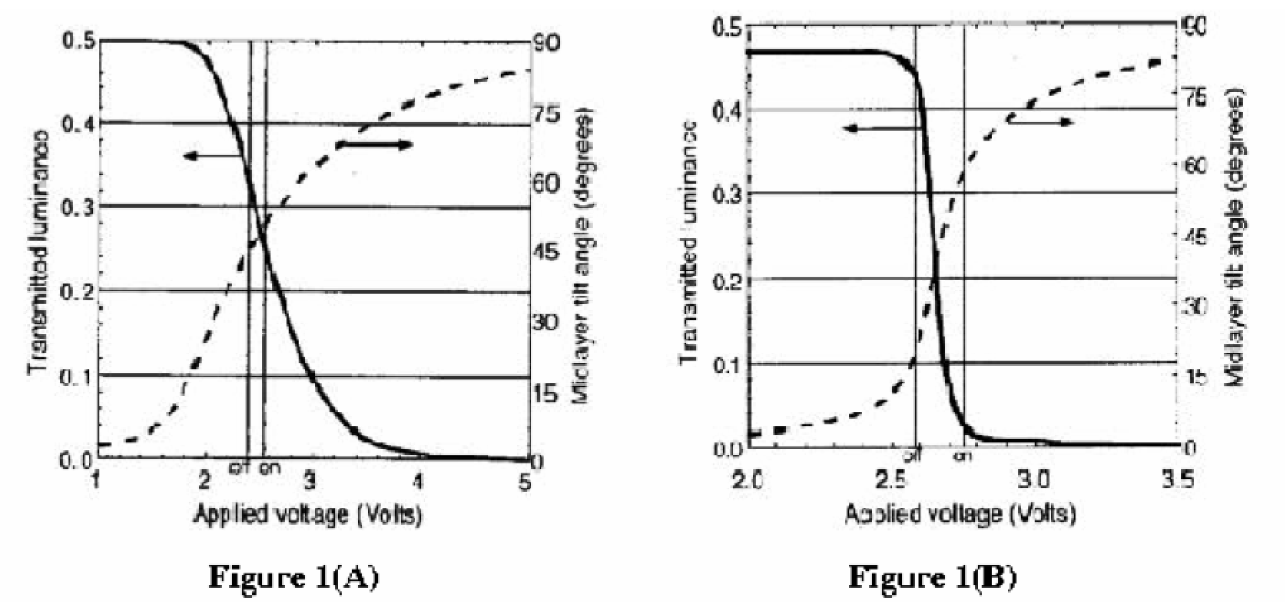

Figure 1: electro-optic characteristics for TN-LCD and STN-LCD

   (a) Which graph corresponds to the characteristics of a TN-LCD? Why?

   (b) The Pixel Contrast Ratio is defined to be

$$PCR = \frac{L_{\text{high}} + (M-1)L_{\text{low}}}{ML_{\text{low}}}$$

   Where M is the number of display rows, L_{low} is the lowest value of transmitted luminance, and L_{high} is the highest value of transmitted luminance. Calculate the PCR for the TN-LCD and STN-LCD displays, using the values shown on the graph in the figure. Explain any difference between the two values.

2. A nematic liquid crystal has n_0=1.52 and n_e=1.75 at λ=577 nm. Find the half-wave-plate thickness at this wavelength.

3. Spontaneous and Stimulated Emission

(a) [Hecht 13.16] Show that for a system of atoms and photons in equilibrium at a temperature T the ratio of the transition rates of stimulated to spontaneous emission is given by

$$\frac{1}{e^{h\nu/k_BT} - 1}$$

(b) [Hecht 13.17] A system of atoms in thermal equilibrium is emitting and absorbing photons with energy of 2 eV. Determine the ratio of the transition rates of stimulated emission to spontaneous emission at a temperature of 300 K. Discuss the implications of your answer. [Hint: See the previous problem.]

4. Resonator cavities

   A cavity, such as the space between two end mirrors on a laser, will allow light to resonate in it if an integer number of half-wavelengths of light fit into the cavity. The end mirrors of a laser are separated by 25 cm, and the cavity is filled with air (n=1).

   (a) What is the spacing between longitudinal modes in the laser cavity?

   (b) The bandwidth of the gain curve is approximately 1500 Mhz. What is the maximum number of possible frequencies that can lase?

   (c) If the length of the cavity were to decrease, how would your answers to (a) and (b) change?

5. To make short pulses of laser light, the different modes in a cavity are fixed relative to one another so that the electric fields add constructively in one place and destructively everywhere else, giving a pulse of light that is as close to a delta function (in time) as possible. The lower limit on the duration of the pulse is the energy-time uncertainty principle, which states that $\Delta E\Delta t \geq \hbar$ or, equivalently $\Delta\nu\Delta t \geq 1/2\pi$. If you want to make a pulse centered at 600 nm that is 10 femtoseconds long, what is the range of wavelengths at which your lasing medium must have gain?

6. [Hecht 13.22] Make a rough estimate of the amount of energy that can be delivered by a ruby laser whose crystal is 5.0mm in diameter and 0.050 m long. Assume the pulse of light lasts 5.0×10^{-6}s. The density of aluminum oxide (Al_2O_3) is 3.7×10^3 kg/m^3. Use the data in the discussion of Fig. 13.6 and the fact that the chromium ions make a 1.79eV lasing transition. How much power is available per pulse?

   You can assume that the concentration of Chromium in Aluminum Oxide is 0.05 % for ruby.