

## EE119 Discussion Section 9

(04/05/10)

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### 1. Photodiode – review on p-n junction, depletion region, bias; charge carrier transport – diffusion and drift; pn photodiode vs. pin photodiode

For a particular PIN photodiode, a pulse of light containing  $5 \times 10^{12}$  incident photons at wavelength of  $1.55 \mu\text{m}$  gives rise to, on average,  $1.5 \times 10^{12}$  electrons collected at the terminals of the device.

- What is the energy incident to the photodiode? What is the quantum efficiency of the photodiode?
- The diffusion length is  $0.5 \text{mm}$  in this detector. If the electron diffusion velocity is  $7 \times 10^6 \text{cm/s}$ , estimate the response time of the detector. (Do not take drift into account.)
- The thickness of the intrinsic layer in the photodiode is typically about  $2.5 \text{mm}$ . If the drift velocity of the electrons in this region is  $10^7 \text{cm/s}$ , estimate the response time of the detector. (Do not take diffusion into account).

### 2. LCD – birefringence in nematic liquid crystal; (super) twisted nematic liquid crystal; electro-optic response of a TN/STN LC cell.

(a) E7 is a nematic liquid crystal with  $n_o=1.52$  and  $n_e=1.75$  at  $\lambda=577 \text{nm}$ . Find the half-wave-plate thickness at this wavelength.

(b) When there is no electric field, a twisted nematic liquid crystal produces a  $90^\circ$  shift in the polarization of light passing through. One can model the layers of twisted nematic liquid crystal as a stack of Polaroid sheets with each of its transmission axis slightly deviate (by an angle of  $\theta$ ) from the one above. With  $\theta = 1^\circ, 0.5^\circ$ , what is the transmitted light intensity compared to that before passing through the liquid crystal?

(c) Given an electro-optic response of a TN/STN LC cell, what is the maximum allowable change in pixel voltage for a 6 bit gray scale display?

### 3. Lasers – laser threshold condition; steady state condition.

- Write down the equation for steady state laser oscillation.
- If two mirrors have 0.95 and 0.99 reflectivity for a cavity laser, what's the gain?
- If the gain coefficient ( $g$ ) of the laser material is known to be  $0.005/\text{cm}$ , how far apart should the mirrors be placed?