University of Technology
Department of Laser & Optoelectronics Engineering
Final Examination 2011-2012

Subject: optoelectronics
Division: Laser
Examiner: Prof. Dr. Mohamed S. Mehde

Class: fourth year
Time: 3 hours
Date: 13 / 6 / 2012

Answer only five questions

Q.1: The optical detector may be classified conveniently as either thermal or photon devices, Discuss the thermal detector and its types with drawing. [20 M.]

Q.2: The rotation of the plane of polarization in an optically active medium of thickness (d) is $(\pi d/\lambda)(n_r - n_l)$ .the specific rotation of quartz is 29.73° mm^{-1} at $\lambda = 508.6mm$, calculate the difference in refractive indices . [20 M.]

Q.3: Define the following terms with drawing and equations:

(a) Positive and negative Birefringence crystal, use Huygens construction. [20 M.]

(b) Left circular polarization.

(c) Right circular polarization.

Q.4: The principal refraction indices for quartz n_E and n_o are 1.55336 and 1.54425 Respectively, calculate the thickness of a quarter wave plate for sodium D light, $\lambda =$ 589.3 nm, what is the emergent light when plane polarized light is incident, draw the Quarter wave plate. [20 M.]

Q.5: Compute the approximate length of (KD^*P) SHG crystal to be used with a 2MW (Q-switch) Ndi-YAG laser that has abeam diameter with the crystal of 5mm. Assume that we want 20% Conversion Efficiency when properly phased matched, Where second order coefficient $=5x10^{-24}$, index of refraction =1.44, beam area $=2x10^{-5}$, Permittivity & permeability $= 8.85x10^{-12}$, $4\pi x10^{-7}$. [20 M.]

Q.6: Fig. (1) Shows three polarizer's with different angles Find the intensity I_1, I_2, I_3 . [20 M.]

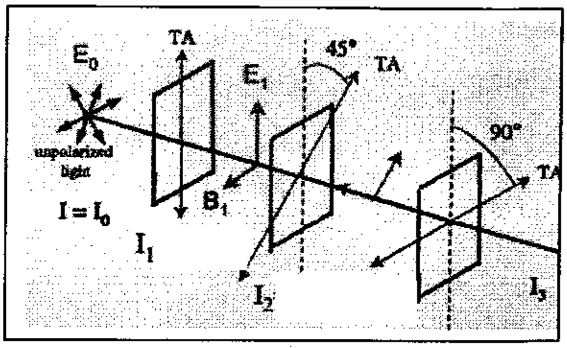

Fig.1

good Luck V.1

١٢/ ٨ = ثمانية من ١٢ (circled 1) Ans. optoelectronics / U-1 / 22-5-2012

$$Q\text{-}1)\ \eta_{SHG} = 2\left(\frac{\mu_o}{\varepsilon_o}\right)^{3/2} \cdot \frac{d^2 \cdot \omega^2 \cdot \ell^2}{n^3} \cdot \frac{\sin^2\left(\frac{\Delta K \ell}{2}\right)}{\left(\frac{\Delta K \ell}{2}\right)^2} \cdot \frac{P \cdot \omega}{A}$$

∴ Assume properly phased matched

$$\therefore \frac{\sin^2 \frac{\Delta K \ell}{2}}{\left(\frac{\Delta K \ell}{2}\right)^2} = 1 \qquad \eta = \frac{P_{SHG}}{P}$$

$$\boxed{\eta_{SHG} = 2\left(\frac{\mu_o}{\varepsilon_o}\right)^{3/2} \cdot \frac{d^2 \cdot \omega^2 \cdot \ell^2}{n^3} \cdot \frac{P \cdot \omega}{A}}$$

$$\omega = 2\pi f = 2\pi \frac{c}{\lambda} = 2\pi \frac{3\times10^8}{1.06\times10^{-6}} = 1.77\times10^{15}$$

$$\omega = 1.8\times10^{15} \text{ rad./sec.}$$

$$A = 2\times10^{-5}\ m^2$$

$$\mu_o = 4\pi\times10^{-7}\ H/m$$

$$\varepsilon_o = 8.85\times10^{-12}\ F/m$$

$$0.2 = 2\times\left(\frac{4\pi * 10^{-7}}{8.85 * 10^{-12}}\right)^{3/2} * \frac{(5\times10^{-24})^2 * (1.8 * 10^{15})^2 \cdot \ell^2_{\times 2\times10^6}}{(1.44)^3 \quad \times 2\times10^{-5}}$$

$$0.2 = 104.7 * 10^6 * 4.8\times10^{-22} * \ell^2 * 10^{11}$$

$$\therefore \ell = 6.3\,m \quad ?? \ \cancel{**}$$ ملاحظة

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(7)

$$Q\text{-}2:- \quad (a)\ \xi(x,t) = \xi_o \cos(\omega t - Kx + \phi) \qquad \nu = f$$

$$= \xi_o \cos(\omega t - Kx)$$

$$= \xi_o \cos\left[2\pi f t - \frac{2\pi}{\lambda} x\right] = \xi_o \cos 2\pi\left[\frac{t}{T} - \frac{x}{\lambda}\right]$$

(7)

$$= \xi_o \cos 2\pi \frac{T}{T}\left(\nu t - \frac{x}{\lambda}\right) = \xi_o \cos K\left[ct - x\right]$$

(b) $180^\circ = \phi$

$$\xi = \xi_o \cos K(ct - x - 180) = -\xi_o \cos K(ct - x)$$

(c) (6)

$$\xi = \xi_o \cos K(ct + x + 270)$$

$$= \xi_o \sin K(ct + x)$$

Q-3:

(a)

$$\xi_1 = \xi_{01}\sin(\omega t - kx + \phi_1)$$

$$\xi_2 = \xi_{02}\sin(\omega t - kx + \phi_2)$$

$$\xi = \xi_{01} + \xi_{02}$$

$$\xi = \xi_{01}\sin(\overbrace{\omega t - kx}^{A} + \overbrace{\phi_1}^{B_1}) + \xi_{02}\sin(\overbrace{\omega t - kx}^{A} + \overbrace{\phi_2}^{B_2})$$

$$= (\xi_{01}\cos\phi_1 + \xi_{02}\cos\phi_2)\sin(\omega t - kx)$$

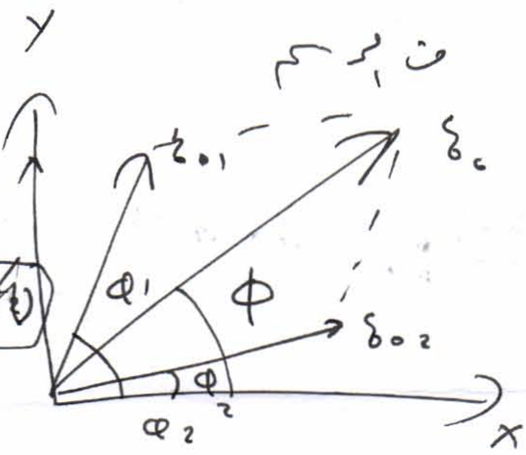
$$+ (\xi_{01}\sin\phi_1 + \xi_{02}\sin\phi_2)\cos(\omega t - kx)$$

This identical to:

$$\xi = \xi_0\sin(\omega t - kx + \phi)$$

$$\boxed{\sin(A \mp B) = \sin A\cos B \mp \cos A\sin B}$$

$$\cancel{\xi_0^2 = \xi_{01}^2 + \xi_{02}^2 + 2\xi_{01}\xi_{02}\cos(\phi_2 - \phi_1)}$$



$$\xi_0^2 = (\xi_{01}\cos\phi_1 + \xi_{02}\cos\phi_2)^2$$

$$+ (\xi_{01}\sin\phi_1 + \xi_{02}\sin\phi_2)^2$$

(b) $$\xi_0^2 = \left(\sum_{i=1}^{n}\xi_{0i}\cos\phi_i\right)^2 + \left(\sum_{i=1}^{n}\xi_{0i}\sin\phi_i\right)^2$$ سعة موجات

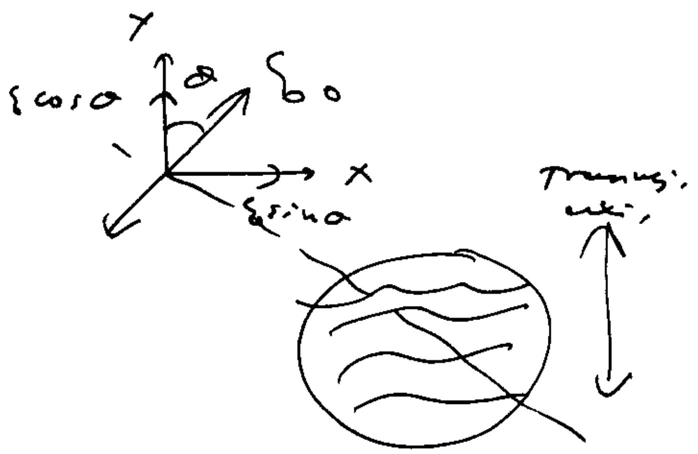
$$\phi = 0, 45, 90, 135, 180$$

$$\xi_0'^2 = [\xi_0 \sin 0 + \xi_0 \sin 45 + \xi_0 \sin 90 + \xi_0 \sin 135 + \xi_0 \sin 180]^2$$

$$+ [\xi_0 \cos 0 + \xi_0 \cos 45 + \xi_0 \cos 90 + \xi_0 \cos 35 + \xi_0 \cos 180]^2$$

$$\boxed{\xi_0'^2 = 5.8\,\xi_0^2}$$

Q.4: Malus law



$\xi_{inc} = j\xi_0 \cos\theta + i\xi_0 \sin\theta$

The transmission wave is $\xi_{trans} = j\xi_0 \cos\theta$

so the intensity

$$I \propto \xi^2 \cos^2\theta = I_0 \cos^2\theta$$

Q.5: $I = I_0\left(\frac{1}{2} + \frac{1}{2}\sin\left(\pi \frac{V}{V_0}\right)\right)$

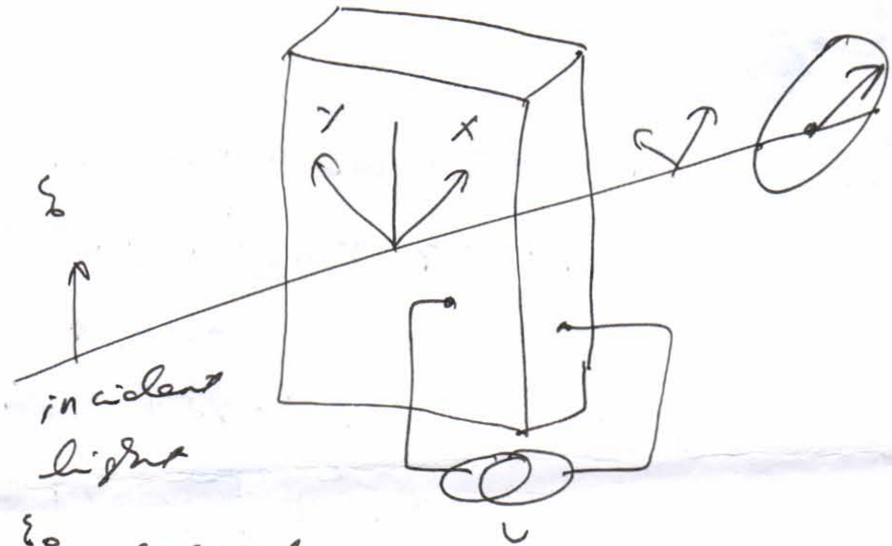
$\frac{V}{V_0} = m \sin\omega t$

for small value of θ $\therefore \sin\frac{\pi V}{V_0} = \frac{\pi V}{V_0}$

$$\therefore I = I_0\left(\frac{1}{2} + \frac{1}{2}\pi\frac{V}{V_0}\right) = \frac{1}{2} + \frac{1}{2}\pi m \sin\omega t$$

$$\frac{I}{I_0} = 0.5 + \frac{\pi m}{2}\sin 2\pi f t$$

Q. 6 :



$$E_x = \frac{E_0}{\sqrt{2}} \cos \omega t$$

$$E_y = \frac{E_0}{\sqrt{2}} \cos \omega t$$

$$\Delta n = |n_e - n_o| = \mp \frac{1}{2} r . n_o^3 E_z$$

$$n_x = n_o - \Delta n$$

$$n_x = n_o + \frac{1}{2} r n_o^3 E_z$$

$$\Phi_x = n_x . L . K$$

$$= \frac{2\pi}{\lambda} n_o + \frac{\pi}{\lambda} r . n_o^3 . V$$

$$\varphi_x = \varphi_o + \Delta \phi$$

$$\phi = \phi_x - \phi_y$$

$$= \phi_o + \Delta\phi - \phi_o + \Delta \phi$$

$$\phi = 2 \Delta \phi$$

$$\boxed{\phi = 2 \frac{\pi}{\lambda} r . n_o^3 V}$$

$$n_y = n_o - \Delta n$$

$$n_y = n_o - \frac{1}{2} r n_o^3 E_z$$

$$\Phi_y = n_y . L . K$$

$$= \frac{2\pi L}{\lambda} x_o - \frac{\pi}{\lambda} \boxed{r n_o^3} V$$

$$\varphi_y = \varphi_o - \Delta\varphi$$

$$\boxed{\therefore \Delta\varphi = \frac{\pi}{\lambda} r . n_o^3 . V}$$