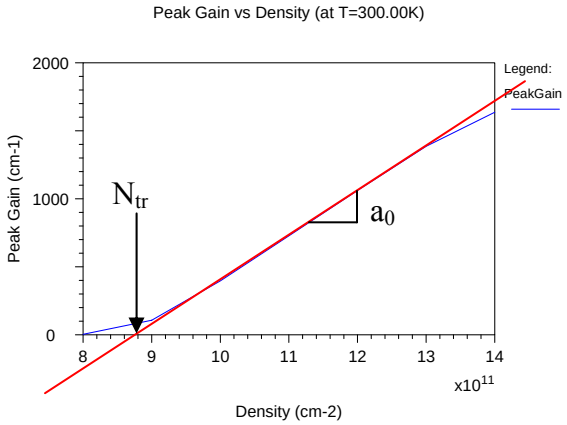
Solutions for LaserMOD Simulation Project

1)

2) $N_{tr} = \left(8.75\times10^{11}\ \text{cm}^{-2}\right)/\,d = 1.09\times10^{18}\ \text{cm}^{-3}$

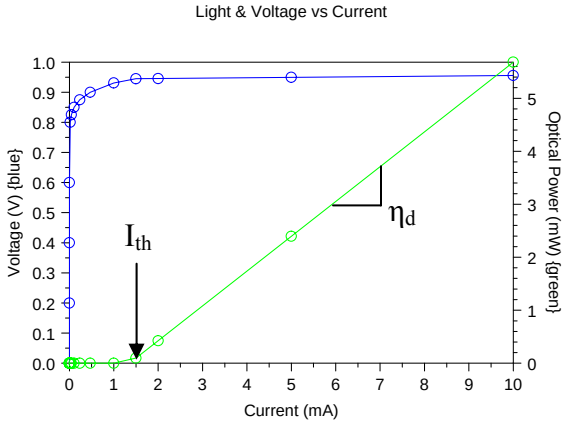
$$a_0 = \frac{1750\ \text{cm}^{-1}}{\left(\frac{(14-8.75)\times10^{11}\ \text{cm}^{-2}}{d}\right)} = 2.67\times10^{-15}\ \text{cm}^2$$



3) I_{th} = 1.5 mA

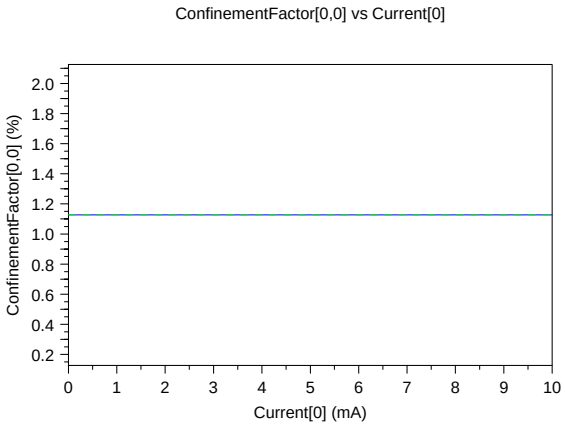
η_d = (5.68 mW)/(10-1.5 mA) = 0.668 W/A

also, η_d = (0.668 W/A)/(0.8 eV) = 0.80 photons/electron



4) $\alpha_m = \frac{1}{(500\,\mu m)}\ln\left(\frac{1}{0.286}\right) = 25\ \text{cm}^{-1}$

5) $\Gamma = 1.13\ \% = 0.0113$



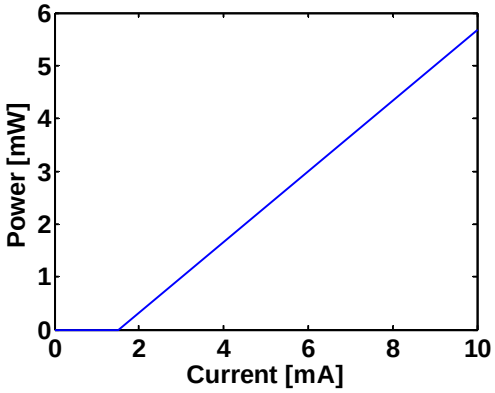
6) $g_{th} = \left(5 + 25cm^{-1}\right)/\,\Gamma = 2655\ \mathrm{cm}^{-1}$

$$N_{th} = \frac{g_{th}}{a_0} + N_{tr} = 2.08\times10^{18}\ \mathrm{cm}^{-3}$$

7) $$\tau_n = \frac{q\left(L\cdot w\cdot d\right)N_{th}}{\eta_i\left(1.75mA\right)} = 1.78\ \mathrm{ns}$$

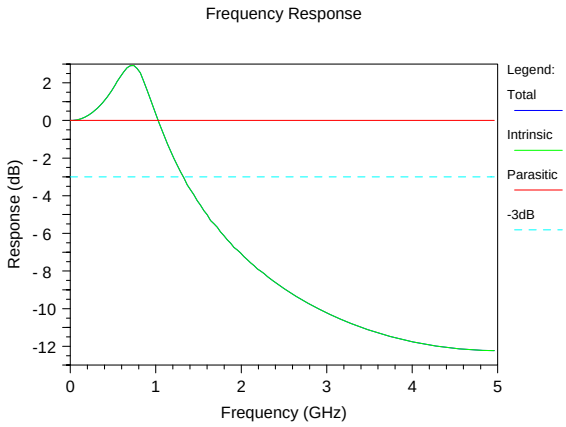
8) $$\eta_d = \eta_i\left(\frac{\alpha_m}{\alpha_m + \alpha_i}\right)\frac{h\nu}{q} = 0.667\ \mathrm{W/A}$$

9)

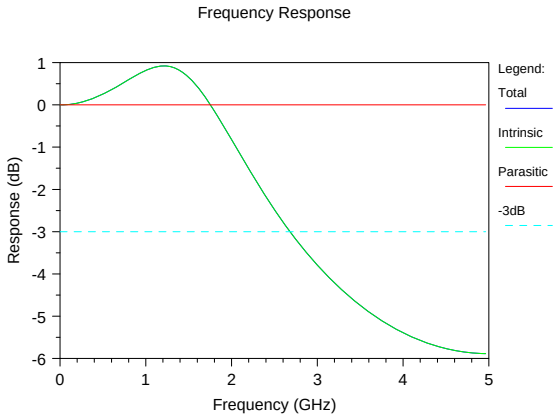


10)

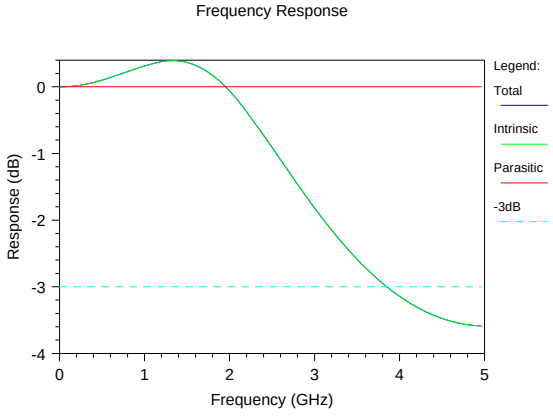
2mA Frequency Response



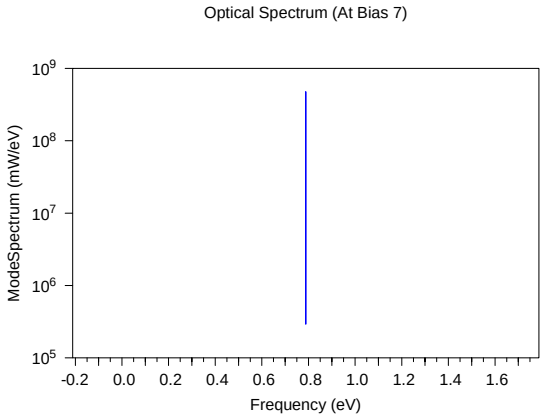
5mA Frequency Response



10mA Frequency Response



11) $hc/q/(0.79\text{ eV}) = 1569$ nm



Design Problem

$$I = I_{th} + \frac{P_0}{\eta_i}\frac{q}{h\nu}\frac{\alpha_m + \alpha_i}{\alpha_m}, \text{ but } I_{th} = \frac{qV}{\eta_i \tau_n} N_{th} = \frac{qV}{\eta_i \tau_n}\left(\frac{g_{th}}{a_0} + N_{tr}\right) = \frac{qV}{\eta_i \tau_n}\left(\frac{\alpha_i + \alpha_m}{a_0 \Gamma} + N_{tr}\right), \text{ so}$$

$$I = \frac{qV}{\eta_i \tau_n}\left(\frac{\alpha_i + \alpha_m}{a_0 \Gamma} + N_{tr}\right) + \frac{P_0}{\eta_i}\frac{q}{h\nu}\frac{\alpha_m + \alpha_i}{\alpha_m}$$

$$\frac{dI}{d\alpha_m} = \frac{qV}{\eta_i \tau_n a_0 \Gamma} - \frac{P_0}{\eta_i}\frac{q}{h\nu}\frac{\alpha_i}{\alpha_m^2}. \text{ Setting this to zero yields}$$

$$\alpha_m = \sqrt{\frac{\tau_n a_0 \Gamma P_0 \alpha_i}{Vh\nu}} \text{ will minimize the current needed.}$$

$\alpha_m = 22.9\ \text{cm}^{-1}$ minimized the current needed to yield 2 mW of output power.

(a) removed
(b) for L = 500 μm, R = 0.318