EE 232 Lightwave Devices   HW#4 Solutions
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Commonly used constants

$h\_bar := 1.05459 \cdot 10^{-34}$ (J-sec) $q := 1.6 \cdot 10^{-19}$ (Coul) $mW := 10^{-3}$

$m0 := 9.11 \cdot 10^{-31}$ (kg) $c := 3 \cdot 10^{8}$ (m/sec)

$nm := 10^{-9}$ (m) $\varepsilon 0 := 8.854 \cdot 10^{-12}$ (F/m)

$\mu m := 10^{-6}$ (m) $eV := 1.6 \cdot 10^{-19}$ (Joul)

$nr := 3.5$ $\varepsilon r := nr^2$ $\varepsilon r = 12.25$

1. (a) The expression for S(N) follows directly from the second rate equation by setting dS/dt to zero.
(b) The expression for I(N) follows directly from the first rate equation by setting dN/dt to zero.
(c) Output power is equal to the (photon density) x (effective volume) x (photon energy) x (mirror loss in unit of 1/sec).
Effective volume = active volume / confinement factor
mirror loss in 1/sec = (mirror loss in 1/cm) x (speed of light in semiconductor) = α_m x c/n_r
(d)

$R := 30\%$ $R1 := R$ $R2 := R$ $\Delta\lambda := 200 \cdot nm$ $N\_tr := 10^{18} \cdot 10^{6}$

$A := 10^{-16} \cdot 10^{-4}$ $\lambda p := 1.55 \cdot \mu m$ $\Gamma := 50\%$ $\alpha i := 10 \cdot 100$ $L := 300 \cdot \mu m$

$\beta := 10^{-3}$ $\tau := 10^{-9}$ $Area := 1 \cdot \mu m \cdot 0.1 \cdot \mu m$ $V := L \cdot Area$

$\eta i := 100\%$ $\eta r := 90\%$

$$g(N,\lambda) := A \cdot (N - N\_tr) \cdot \left[1 - \left(\frac{\lambda - \lambda p}{\Delta\lambda}\right)^2\right]$$

$$\alpha m := \frac{1}{2 \cdot L} \cdot \ln\left(\frac{1}{R1 \cdot R2}\right) \qquad \alpha m = 4.013 \times 10^{3}$$

$$\tau p := \frac{1}{\frac{c}{nr}(\alpha i + \alpha m)} \qquad \tau p = 2.327 \times 10^{-12}$$

$$Nth := \frac{\alpha m + \alpha i}{\Gamma \cdot A} + N\_tr \qquad Nth = 2.003 \times 10^{24}$$

$$Rsp(N) := \eta r \cdot \frac{N}{\tau}$$

$$S(N,\beta) := \frac{\beta \cdot Rsp(N)}{\frac{1}{\tau p} - \frac{c}{nr} \cdot \Gamma \cdot g(N,\lambda p)}$$

$$I(N,\beta) := \frac{q \cdot V}{\eta i} \cdot \left(\frac{N}{\tau} + \frac{c}{nr} \cdot g(N,\lambda p) \cdot S(N,\beta)\right)$$

$imax := 80$

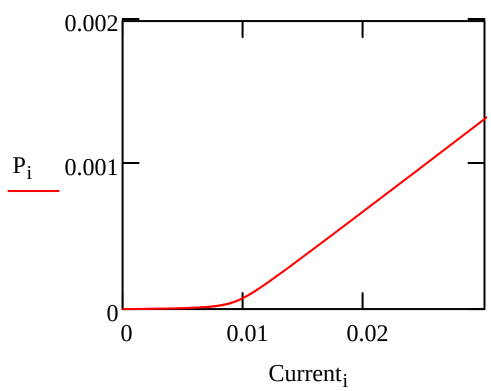
$i := 1 \,..\, imax$

$N_i := \dfrac{\ln(i)}{\ln(imax + 1)} \cdot Nth$

$P_i := \left[\left(\dfrac{1.24}{\dfrac{\lambda p}{\mu m}} \cdot q \right) \left(\dfrac{V}{\Gamma} \cdot \alpha m \cdot \dfrac{c}{nr} \cdot S\left(N_i, \beta\right) \right) \right]$

$\dfrac{N_{imax}}{Nth} = 0.997$

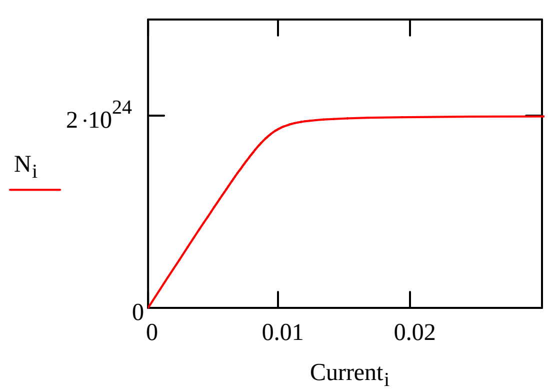
$Current_i := I\left(N_i, 10^{-2}\right)$



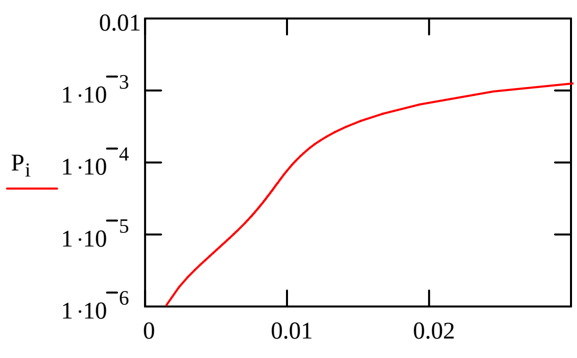
$Ith := \dfrac{q \cdot V}{\eta i} \cdot \dfrac{Nth}{\tau}$

$Ith = 9.613 \times 10^{-3}$

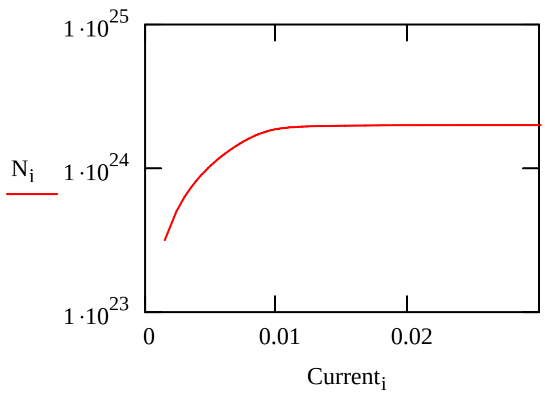
(e)



(f)



Current$_i$



2. $j := 0 .. 2$

$\beta_j := 10^{-2-j}$

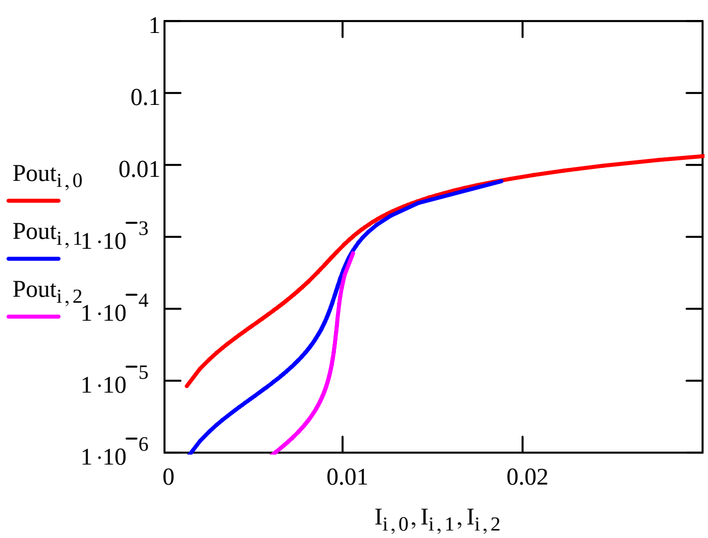
$imax := 200$

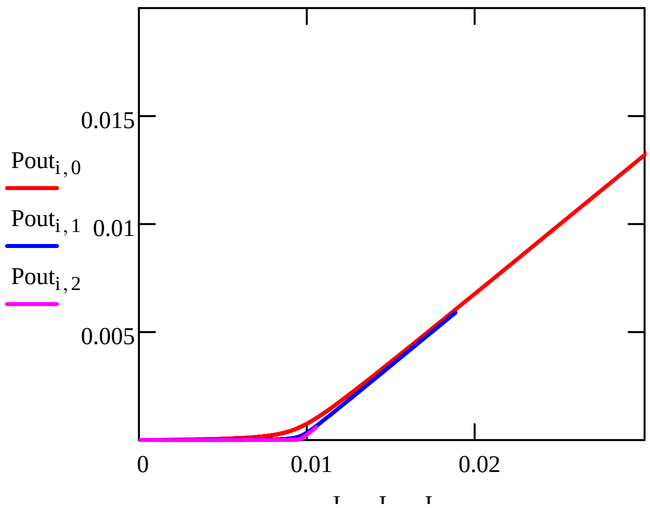
$i := 1 .. imax$

$$N_i := \frac{\ln(i)}{\ln(imax + 1)}\cdot Nth$$

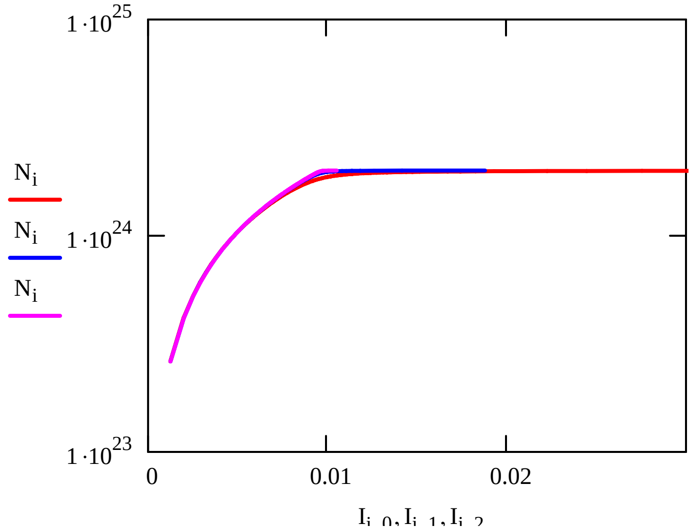
$$Pout_{i,j} := \left[\left(\frac{1.24}{\frac{\lambda p}{\mu m}}\cdot q\right)\left(\frac{V}{\Gamma}\cdot\alpha m\cdot\frac{c}{nr}\cdot S\left(N_i,\beta_j\right)\right)\right]$$

$$I_{i,j} := I\left(N_i,\beta_j\right)$$

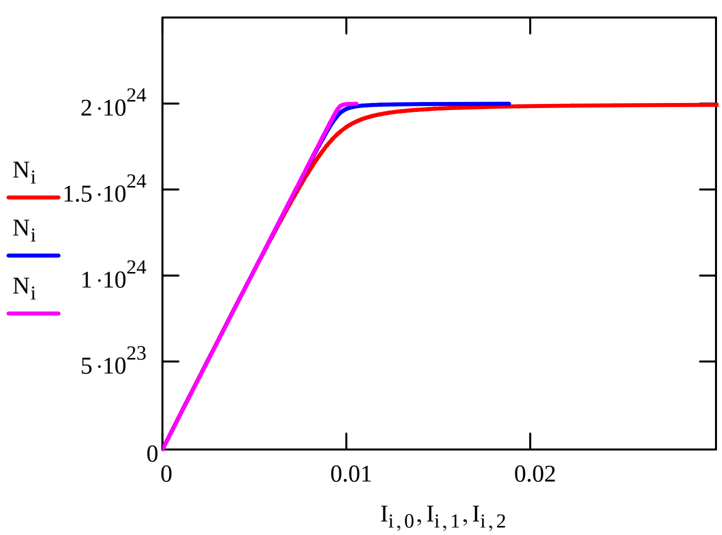




Pout$_{i,0}$
Pout$_{i,1}$
Pout$_{i,2}$
0.015
0.01
0.005
0
0.01
0.02



N$_i$
N$_i$
N$_i$
$1 \cdot 10^{25}$
$1 \cdot 10^{24}$
$1 \cdot 10^{23}$
0
0.01
0.02



N$_i$
N$_i$
N$_i$
$2 \cdot 10^{24}$
$1.5 \cdot 10^{24}$
$1 \cdot 10^{24}$
$5 \cdot 10^{23}$
0
0
0.01
0.02
$I_{i,0}, I_{i,1}, I_{i,2}$