Selected Equations from OPTOELECTRONICS

Optics:

$c = \nu \cdot \lambda \qquad E_{ph} = h \cdot \nu$

$N = n - j \cdot k \qquad \alpha = \frac{4\pi \cdot k}{\lambda_0}$

$n = \frac{c_0}{c} = \frac{\lambda_0}{\lambda} = \frac{Z_0}{Z}$

Black body radiation:

$J_{ph}^* = \sigma \cdot T^4$

$\lambda_{max} \cdot T = 2.898 \cdot 10^{-3}\ \mathrm{mK}$

$J_{ph} = \phi_{ph} \cdot E_{ph}$

$J_{ph} = \frac{1}{2}\Re\{\vec{E} \times \vec{H}^*\} = \frac{1}{2 \cdot Z}|E|^2$

$J_{ph}(x) = J_{ph,0} \cdot e^{-\alpha \cdot x}$

$Z = |\vec{E}|/|\vec{H}| = \sqrt{\mu/\varepsilon}$

Diffraction grating:

$n_1 \cdot \sin\theta_1 + n_2 \cdot \sin\theta_{2,m} = \frac{m \cdot \lambda_0}{P}$

Lomni zakon:

$N_1 \cdot \sin\theta_1 = N_2 \cdot \sin\theta_2$

$\sin\theta_{1crit} = N_2/N_1 \qquad \tan\theta_{1B} = N_2/N_1$

Fresnel coefficients:

$r_{TE} = \frac{N_1 \cdot \cos\theta_1 - N_2 \cdot \cos\theta_2}{N_1 \cdot \cos\theta_1 + N_2 \cdot \cos\theta_2} \qquad t = 1 + r$

$R = |r|^2$

$r_{TM} = \frac{N_1 \cdot \cos\theta_2 - N_2 \cdot \cos\theta_1}{N_1 \cdot \cos\theta_2 + N_2 \cdot \cos\theta_1} \qquad T = 1 - R$

Laser:

$P_{ph} = \eta_D \cdot (I - I_{th})$

$\eta_D = \frac{\partial P_{ph}}{\partial I} \qquad L = m \cdot \frac{\lambda_0}{2 \cdot n}$

$\delta\nu = \frac{c_0}{2 \cdot L \cdot n} \qquad \delta\lambda_0 \approx \frac{\lambda_0^2}{2 \cdot L \cdot n}$

$\phi_{ph}(x) = \phi_{ph,0} \cdot e^{g \cdot x} \qquad g(\phi_{ph}) = \frac{g_0}{1 + \phi_{ph}/\phi_{ph,s}} \qquad g_0 = (N_2 - N_1) \cdot \sigma$

$\phi_{ph}(x) = \phi_{ph,0} \cdot e^{-\alpha_r \cdot x} \qquad \alpha_r = \alpha_s + \alpha_{m1} + \alpha_{m2} \qquad \alpha_m = \frac{1}{2 \cdot L}\ln\frac{1}{R}$

Semiconductor laser:

$g = \frac{g_0}{J_0}(J_{nom} - J_0) \qquad J_{nom} = J \cdot \frac{QE_{int}}{d} \qquad \alpha_r^* = \frac{1}{\Gamma}\alpha_r$

$I_{th} = A \cdot J_0 \cdot \frac{d}{QE_{int}}\left[1 + \frac{\alpha_r^*}{g_0}\right] \qquad d_{Bragg} = \frac{\lambda_0}{4 \cdot n}$

LED:

$E_{ph,peak} = E_G + k_B \cdot T$

$\Delta E_{ph} \approx 3 \cdot k_B \cdot T$

$\Delta\lambda_{FWHM} \approx \lambda_{0,peak}^2 \cdot \frac{3 \cdot k_B \cdot T}{h \cdot c_0}$

Photodetector:

$\lambda_{max} = \frac{h \cdot c}{E_G} \qquad G_L = \frac{d\phi_{ph}}{dx} \qquad SR = \frac{J_{sc}}{J_{ph}} = \frac{I_{sc}}{P_{ph}} \qquad QE = \frac{\phi_e}{\phi_{ph}} = SR \cdot \frac{1}{\lambda} \cdot \frac{h \cdot c}{q}$

Photoresistor:

$J_L = \Delta\sigma \cdot E = \Delta\sigma \cdot U/L$

$\Delta\sigma = q(\mu_n \Delta n + \mu_p \Delta p)$

Photodiode:

$I = I_s\left(e^{\frac{U}{n \cdot U_T}} - 1\right) - I_L$

Avalanche photodiode:

$I_L = M \cdot I_{L,0}$

$M = \frac{1}{1 - \left(\frac{U_R}{U_{BR}}\right)^n}$

Solar cell:

$I = I_{sc} - I_s\left(e^{\frac{U}{n \cdot U_T}} - 1\right) \qquad FF = \frac{I_{MPP} \cdot U_{MPP}}{I_{sc} \cdot U_{oc}} \qquad \eta = \frac{P_{max}}{P_{ph}} = \frac{FF \cdot I_{sc} \cdot U_{oc}}{P_{ph}}$

$I_{sc} = I_s\left(e^{\frac{U_{oc}}{n \cdot U_T}} - 1\right) \qquad I_{MPP} = I_{sc} - I_s\left(e^{\frac{U_{MPP}}{n \cdot U_T}} - 1\right)$

$U_{oc} = n \cdot U_T \cdot \ln\left(\frac{I_{sc}}{I} + 1\right) \qquad U_{MPP} = U_{oc} - n \cdot U_T \cdot \ln\left(\frac{U_{MPP}}{n \cdot U_T} + 1\right)$

Optical fiber:

$\sin\theta_{max} = \frac{NA}{n_0} = \frac{1}{n_0} \cdot \sqrt{n_j^2 - n_p^2}$

$M = \frac{1}{2}\left(\frac{\pi \cdot d}{\lambda}\sqrt{n_j^2 - n_p^2}\right)$

$\alpha[\mathrm{dB/km}] = \frac{1}{L}10\log\frac{P_{ph,0}}{P_{ph}(L)}$

Natural constants:

$c_0 = 299792458\ \mathrm{m/s} \approx 3 \cdot 10^8\ \mathrm{m/s} \qquad h = 6.6261 \cdot 10^{-34}\ \mathrm{J \cdot s} \qquad \mu_0 = 4\pi \cdot 10^{-7}\ \mathrm{N/A^2}$

$q = 1.6022 \cdot 10^{-19}\ \mathrm{As} \qquad k_B = 1.3807 \cdot 10^{-23}\ \mathrm{J/K} \qquad \varepsilon_0 = 8.8542 \cdot 10^{-12}\ \mathrm{As/Vm}$

$U_T = kT/q = 25.66\ \mathrm{mV}\ (T = 297.8\ \mathrm{K}) \qquad \sigma = 5.6704 \cdot 10^{-8}\ \mathrm{W/m^2K^4} \qquad Z_0 = \sqrt{\mu_0/\varepsilon_0} = 376.73\ \Omega$