Important Photonics Devices Formulas PDF

Formulas
Examples
with Units

List of 13
Important Photonics Devices Formulas

1) Contact Potential Difference Formula

Evaluate Formula

Formula

$$V_0 = \frac{[BoltZ] \cdot T}{[Charge\text{-}e]} \cdot \ln\left(\frac{N_A \cdot N_D}{\left(n1_i\right)^2}\right)$$

Example with Units

$$0.6238\,\text{V} = \frac{1.4\text{E-}23\,\text{J/K} \cdot 393\,\text{K}}{1.6\text{E-}19\,\text{C}} \cdot \ln\left(\frac{1\text{e+}22\,\text{1/m}^3 \cdot 1\text{e+}24\,\text{1/m}^3}{\left(1\text{e+}19\,\text{1/m}^3\right)^2}\right)$$

2) Energy Density given Einstein Co-Efficients Formula

Evaluate Formula

Formula

$$u = \frac{8 \cdot [hP] \cdot f_r^3}{[c]^3} \cdot \left(\frac{1}{\exp\left(\frac{h_p \cdot f_r}{[BoltZ] \cdot T_o}\right) - 1}\right)$$

Example with Units

$$3.9\text{E-}42\,\text{J/m}^3 = \frac{8 \cdot 6.6\text{E-}34 \cdot 57\,\text{Hz}^3}{3\text{E+}8\,\text{m/s}^3} \cdot \left(\frac{1}{\exp\left(\frac{6.626\text{E-}34 \cdot 57\,\text{Hz}}{1.4\text{E-}23\,\text{J/K} \cdot 293\,\text{K}}\right) - 1}\right)$$

3) Length of Cavity Formula

Evaluate Formula

Formula

$$L_c = \frac{\lambda \cdot m}{2}$$

Example with Units

$$7.878\,\text{m} = \frac{3.9\,\text{m} \cdot 4.04}{2}$$

4) Mode Number Formula

Evaluate Formula

Formula

$$m = \frac{2 \cdot L_c \cdot n_{ri}}{\lambda}$$

Example with Units

$$4.0296 = \frac{2 \cdot 7.78\,\text{m} \cdot 1.01}{3.9\,\text{m}}$$

5) Net Phase Shift Formula

Evaluate Formula

Formula

$$\Delta\Phi = \frac{\pi}{\lambda_o} \cdot \left(n_{ri} \right)^3 \cdot r \cdot V_{cc}$$

Example with Units

$$30.2396\,\text{rad} = \frac{3.1416}{3.939\,\text{m}} \cdot \left(1.01 \right)^3 \cdot 23\,\text{m} \cdot 1.6\,\text{V}$$

6) Optical Power Radiated Formula

Evaluate Formula

Formula

$$P_{opt} = \varepsilon_{opto} \cdot [Stefan\text{-}BoltZ] \cdot A_s \cdot T_o^4$$

Example with Units

$$0.0018\,\text{W} = 0.85 \cdot 5.7\text{E-}8 \cdot 5.11\,\text{mm}^2 \cdot 293\,\text{K}^4$$

7) Proton Concentration under Unbalanced Condition Formula

Evaluate Formula

Formula

$$p_c = n_i \cdot \exp\left(\frac{E_i - F_n}{[BoltZ] \cdot T} \right)$$

Example with Units

$$38.2131\,\text{electrons/m}^3 = 3.6\,\text{electrons/m}^3 \cdot \exp\left(\frac{3.78\,\text{eV} - 3.7\,\text{eV}}{1.4\text{E-}23\,\text{J/K} \cdot 393\,\text{K}} \right)$$

8) Relative Population Formula

Evaluate Formula

Formula

$$n_{rel} = \exp\left(- \frac{[hP] \cdot \nu_{rel}}{[BoltZ] \cdot T} \right)$$

Example with Units

$$1 = \exp\left(- \frac{6.6\text{E-}34 \cdot 8.9\,\text{Hz}}{1.4\text{E-}23\,\text{J/K} \cdot 393\,\text{K}} \right)$$

9) Saturation Current Density Formula

Evaluate Formula

Formula

$$J_0 = [Charge\text{-}e] \cdot \left(\frac{D_h}{L_h} \cdot p_n + \frac{D_E}{L_e} \cdot n_p \right)$$

Example with Units

$$1.6\text{E-}7\,\text{A/m}^2 = 1.6\text{E-}19\,\text{C} \cdot \left(\frac{1.2\text{e-}3\,\text{m}^2/\text{s}}{0.35\,\text{mm}} \cdot 2.56\text{e+}11\,1/\text{m}^3 + \frac{0.003387\,\text{m}^2/\text{s}}{0.71\,\text{mm}} \cdot 2.55\text{e+}10\,1/\text{m}^3 \right)$$

10) Spectral Radiant Emittance Formula

Evaluate Formula

Formula

$$W_{sre} = \frac{2 \cdot \pi \cdot [hP] \cdot [c]^{3}}{\lambda_{vis}^{5}} \cdot \frac{1}{\exp\left(\frac{[hP] \cdot [c]}{\lambda_{vis} \cdot [BoltZ] \cdot T}\right) - 1}$$

Example with Units

$$5.7E\text{-}8\,W/(m^2*Hz) = \frac{2 \cdot 3.1416 \cdot 6.6E\text{-}34 \cdot 3E{+}8\,m/s^{3}}{500\,nm^{5}} \cdot \frac{1}{\exp\left(\frac{6.6E\text{-}34 \cdot 3E{+}8\,m/s}{500\,nm \cdot 1.4E\text{-}23\,J/K \cdot 393\,K}\right) - 1}$$

11) Total Current Density Formula

Evaluate Formula

Formula

$$J = J_0 \cdot \left(\exp\left(\frac{[Charge\text{-}e] \cdot V_0}{[BoltZ] \cdot T}\right) - 1\right)$$

Example with Units

$$7.9148\,C/m^2 = 1.6E\text{-}7\,A/m^2 \cdot \left(\exp\left(\frac{1.6E\text{-}19\,C \cdot 0.6\,V}{1.4E\text{-}23\,J/K \cdot 393\,K}\right) - 1\right)$$

12) Wavelength of Output Light Formula

Evaluate Formula

Formula

$$\lambda_o = n_{ri} \cdot \lambda$$

Example with Units

$$3.939\,m = 1.01 \cdot 3.9\,m$$

13) Wavelength of Radiation in Vaccum Formula

Evaluate Formula

Formula

$$F_w = A \cdot \left(\frac{180}{\pi}\right) \cdot 2 \cdot S$$

Example with Units

$$399.84\,m = 8.16° \cdot \left(\frac{180}{3.1416}\right) \cdot 2 \cdot 24.5$$

Variables used in list of Photonics Devices Formulas above

- **A** Apex Angle *(Degree)*
- A_s Area of Source *(Square Millimeter)*
- D_E Electron Diffusion Coefficient *(Square Meter Per Second)*
- D_h Diffusion Coefficient of Hole *(Square Meter Per Second)*
- E_i Intrinsic Energy Level of Semiconductor *(Electron-Volt)*
- F_n Quasi Fermi Level of Electrons *(Electron-Volt)*
- f_r Frequency of Radiation *(Hertz)*
- F_w Wavelength of Wave *(Meter)*
- h_p Planck's Constant
- **J** Total Current Density *(Coulomb per Square Meter)*
- J_0 Saturation Current Density *(Ampere per Square Meter)*
- L_c Length of Cavity *(Meter)*
- L_e Diffusion Length of Electron *(Millimeter)*
- L_h Diffusion Length of Hole *(Millimeter)*
- **m** Mode Number
- N_A Acceptor Concentration *(1 per Cubic Meter)*
- N_D Donor Concentration *(1 per Cubic Meter)*
- n_i Intrinsic Electron Concentration *(Electrons per Cubic Meter)*
- n_p Electron Concentration in p-Region *(1 per Cubic Meter)*
- n_{rel} Relative Population
- n_{ri} Refractive Index
- $n1_i$ Intrinsic Carrier Concentration *(1 per Cubic Meter)*
- p_c Proton Concentration *(Electrons per Cubic Meter)*
- p_n Hole Concentration in n-Region *(1 per Cubic Meter)*

Constants, Functions, Measurements used in list of Photonics Devices Formulas above

- constant(s): **pi**, 3.14159265358979323846264338327950288 *Archimedes' constant*
- constant(s): **[BoltZ]**, 1.38064852E-23 *Boltzmann constant*
- constant(s): **[Charge-e]**, 1.60217662E-19 *Charge of electron*
- constant(s): **[c]**, 299792458.0 *Light speed in vacuum*
- constant(s): **[hP]**, 6.626070040E-34 *Planck constant*
- constant(s): **[Stefan-BoltZ]**, 5.670367E-8 *Stefan-Boltzmann Constant*
- Functions: **exp**, exp(Number) *n an exponential function, the value of the function changes by a constant factor for every unit change in the independent variable.*
- Functions: **ln**, ln(Number) *The natural logarithm, also known as the logarithm to the base e, is the inverse function of the natural exponential function.*
- Measurement: **Length** in Meter (m), Millimeter (mm), Nanometer (nm) *Length Unit Conversion*
- Measurement: **Temperature** in Kelvin (K) *Temperature Unit Conversion*
- Measurement: **Area** in Square Millimeter (mm²) *Area Unit Conversion*
- Measurement: **Energy** in Electron-Volt (eV) *Energy Unit Conversion*
- Measurement: **Power** in Watt (W) *Power Unit Conversion*
- Measurement: **Angle** in Radian (rad), Degree (°) *Angle Unit Conversion*
- Measurement: **Frequency** in Hertz (Hz) *Frequency Unit Conversion*
- Measurement: **Wavelength** in Meter (m) *Wavelength Unit Conversion*
- Measurement: **Surface Charge Density** in Coulomb per Square Meter (C/m²)

- P_{opt} Optical Power Radiated *(Watt)*
- **r** Length of Fiber *(Meter)*
- **S** Single Pinhole
- **T** Absolute Temperature *(Kelvin)*
- T_o Temperature *(Kelvin)*
- **u** Energy Density *(Joule per Cubic Meter)*
- V_0 Voltage Across PN Junction *(Volt)*
- V_{cc} Supply Voltage *(Volt)*
- W_{sre} Spectral Radiant Emittance *(Watt per Square Meter per Hertz)*
- **ΔΦ** Net Phase Shift *(Radian)*
- ε_{opto} Emissivity
- **λ** Photon Wavelength *(Meter)*
- λ_o Wavelength of Light *(Meter)*
- λ_{vis} Wavelength of Visible Light *(Nanometer)*
- v_{rel} Relative Frequency *(Hertz)*

Surface Charge Density Unit Conversion

- Measurement: **Surface Current Density** in Ampere per Square Meter (A/m²)
  Surface Current Density Unit Conversion
- Measurement: **Electric Potential** in Volt (V)
  Electric Potential Unit Conversion
- Measurement: **Diffusivity** in Square Meter Per Second (m²/s)
  Diffusivity Unit Conversion
- Measurement: **Carrier Concentration** in 1 per Cubic Meter (1/m³)
  Carrier Concentration Unit Conversion
- Measurement: **Energy Density** in Joule per Cubic Meter (J/m³)
  Energy Density Unit Conversion
- Measurement: **Spectral Exitance Per Unit Frequency** in Watt per Square Meter per Hertz (W/(m²*Hz))
  Spectral Exitance Per Unit Frequency Unit Conversion
- Measurement: **Electron Density** in Electrons per Cubic Meter (electrons/m³)
  Electron Density Unit Conversion

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