Important Semiconductor Characteristics Formulas PDF

Formulas
Examples
with Units

List of 13
Important Semiconductor Characteristics Formulas

1) Conductivity in Semiconductors Formula

Evaluate Formula

Formula

$$\sigma = \left(\rho_e \cdot [Charge\text{-}e] \cdot \mu_n\right) + \left(\rho_h \cdot [Charge\text{-}e] \cdot \mu_p\right)$$

Example with Units

$$0.8681\,\text{S/m} = \left(3.01e10\,\text{kg/cm}^3 \cdot 1.6E\text{-}19\,\text{C} \cdot 180\,\text{m}^2\text{/V*s}\right) + \left(100000.345\,\text{kg/cm}^3 \cdot 1.6E\text{-}19\,\text{C} \cdot 150\,\text{m}^2\text{/V*s}\right)$$

2) Conductivity of Extrinsic Semiconductor for P-Type Formula

Evaluate Formula

Formula

$$\sigma_p = N_a \cdot [Charge\text{-}e] \cdot \mu_p$$

Example with Units

$$0.2403\,\text{S/m} = 1e16\,\text{1/m}^3 \cdot 1.6E\text{-}19\,\text{C} \cdot 150\,\text{m}^2\text{/V*s}$$

3) Conductivity of Extrinsic Semiconductors for N-type Formula

Evaluate Formula

Formula

$$\sigma_n = N_d \cdot [Charge\text{-}e] \cdot \mu_n$$

Example with Units

$$5.7678\,\text{S/m} = 2e17\,\text{1/m}^3 \cdot 1.6E\text{-}19\,\text{C} \cdot 180\,\text{m}^2\text{/V*s}$$

4) Drift Current Density Formula

Evaluate Formula

Formula

$$J_{drift} = J_p + J_n$$

Example with Units

$$49.79\,\text{A/m}^2 = 17.79\,\text{A/m}^2 + 32\,\text{A/m}^2$$

5) Electric Field due to Hall Voltage Formula

Evaluate Formula

Formula

$$E_H = \frac{V_h}{d}$$

Example with Units

$$1.8889\,\text{V/m} = \frac{0.85\,\text{V}}{0.45\,\text{m}}$$

6) Electron Diffusion Length Formula

Evaluate Formula

Formula

$$L_n = \sqrt{D_n \cdot \tau_n}$$

Example with Units

$$44.9912\,\text{cm} = \sqrt{44982.46\,\text{cm}^2\text{/s} \cdot 45000\,\mu\text{s}}$$

7) Energy Band Gap Formula

Evaluate Formula

Formula

$$E_g = E_{G0} - \left(T \cdot \beta_k \right)$$

Example with Units

$$0.7656\,\text{eV} = 0.87\,\text{eV} - \left(290\,\text{K} \cdot 5.7678\text{e-}23\,\text{J/K} \right)$$

8) Fermi Dirac Distribution Function Formula

Evaluate Formula

Formula

$$f_E = \frac{1}{1 + e^{\frac{E_f - E_f}{[BoltZ] \cdot T}}}$$

Example with Units

$$0.5 = \frac{1}{1 + e^{\frac{52\,\text{eV} - 52\,\text{eV}}{1.4\text{E-}23\,\text{J/K} \cdot 290\,\text{K}}}}$$

9) Fermi Level of Intrinsic Semiconductors Formula

Evaluate Formula

Formula

$$E_{Fi} = \frac{E_c + E_v}{2}$$

Example with Units

$$2.63\,\text{eV} = \frac{0.56\,\text{eV} + 4.7\,\text{eV}}{2}$$

10) Majority Carrier Concentration in Semiconductor Formula

Evaluate Formula

Formula

$$n_0 = \frac{n_i^2}{p_0}$$

Example with Units

$$1.6\text{E+}81\,\text{1/m}^3 = \frac{1.2\text{e}81\,\text{1/m}^3{}^2}{9.1\text{e}7\,\text{1/m}^3}$$

11) Majority Carrier Concentration in Semiconductor for p-type Formula

Evaluate Formula

Formula

$$n_0 = \frac{n_i^2}{p_0}$$

Example with Units

$$1.6\text{E+}81\,\text{1/m}^3 = \frac{1.2\text{e}81\,\text{1/m}^3{}^2}{9.1\text{e}7\,\text{1/m}^3}$$

12) Mobility of Charge Carriers Formula

Evaluate Formula

Formula

$$\mu = \frac{V_d}{E_I}$$

Example with Units

$$2.9872\,\text{m}^2\text{/V*s} = \frac{10.24\,\text{m/s}}{3.428\,\text{V/m}}$$

13) Saturation Voltage using Threshold Voltage Formula

Evaluate Formula

Formula

$$V_{ds} = V_{gs} - V_{th}$$

Example with Units

$$0.55\,\text{V} = 1.25\,\text{V} - 0.7\,\text{V}$$

Variables used in list of Semiconductor Characteristics Formulas above

- **d** Conductor Width *(Meter)*
- D_n Electron Diffusion Constant *(Square Centimeter Per Second)*
- E_c Conduction Band Energy *(Electron-Volt)*
- E_f Fermi Level Energy *(Electron-Volt)*
- E_{Fi} Fermi Level Intrinsic Semiconductor *(Electron-Volt)*
- E_g Energy Band Gap *(Electron-Volt)*
- E_{G0} Energy Band Gap at 0K *(Electron-Volt)*
- E_H Hall Electric Field *(Volt per Meter)*
- E_l Electric Field Intensity *(Volt per Meter)*
- E_v Valance Band Energy *(Electron-Volt)*
- f_E Fermi Dirac Distribution Function
- J_{drift} Drift Current Density *(Ampere per Square Meter)*
- J_n Electron Current Density *(Ampere per Square Meter)*
- J_p Holes Current Density *(Ampere per Square Meter)*
- L_n Electron Diffusion Length *(Centimeter)*
- n_0 Majority Carrier Concentration *(1 per Cubic Meter)*
- N_a Acceptor Concentration *(1 per Cubic Meter)*
- N_d Donor Concentration *(1 per Cubic Meter)*
- n_i Intrinsic Carrier Concentration *(1 per Cubic Meter)*
- p_0 Minority Carrier Concentration *(1 per Cubic Meter)*
- **T** Temperature *(Kelvin)*
- V_d Drift Speed *(Meter per Second)*
- V_{ds} Saturation Voltage *(Volt)*
- V_{gs} Gate Source Voltage *(Volt)*

Constants, Functions, Measurements used in list of Semiconductor Characteristics Formulas above

- constant(s): **[BoltZ]**, 1.38064852E-23
  Boltzmann constant
- constant(s): **[Charge-e]**, 1.60217662E-19
  Charge of electron
- constant(s): **e**, 2.71828182845904523536028747135266249
  Napier's constant
- Functions: **sqrt**, sqrt(Number)
  A square root function is a function that takes a non-negative number as an input and returns the square root of the given input number.
- Measurement: **Length** in Meter (m), Centimeter (cm)
  Length Unit Conversion
- Measurement: **Time** in Microsecond (µs)
  Time Unit Conversion
- Measurement: **Temperature** in Kelvin (K)
  Temperature Unit Conversion
- Measurement: **Speed** in Meter per Second (m/s)
  Speed Unit Conversion
- Measurement: **Energy** in Electron-Volt (eV)
  Energy Unit Conversion
- Measurement: **Surface Current Density** in Ampere per Square Meter (A/m²)
  Surface Current Density Unit Conversion
- Measurement: **Electric Field Strength** in Volt per Meter (V/m)
  Electric Field Strength Unit Conversion
- Measurement: **Electric Potential** in Volt (V)
  Electric Potential Unit Conversion
- Measurement: **Electric Conductivity** in Siemens per Meter (S/m)
  Electric Conductivity Unit Conversion
- Measurement: **Density** in Kilogram per Cubic Centimeter (kg/cm³)
  Density Unit Conversion
- Measurement: **Diffusivity** in Square Centimeter Per Second (cm²/s)
  Diffusivity Unit Conversion

- V_h Hall Voltage *(Volt)*
- V_{th} Threshold Voltage *(Volt)*
- β_k Material Specific Constant *(Joule per Kelvin)*
- μ Charge Carriers Mobility *(Square Meter per Volt per Second)*
- μ_n Mobility of Electron *(Square Meter per Volt per Second)*
- μ_p Mobility of Holes *(Square Meter per Volt per Second)*
- ρ_e Electron Density *(Kilogram per Cubic Centimeter)*
- ρ_h Holes Density *(Kilogram per Cubic Centimeter)*
- σ Conductivity *(Siemens per Meter)*
- σ_n Conductivity of Extrinsic Semiconductors (n-type) *(Siemens per Meter)*
- σ_p Conductivity of Extrinsic Semiconductors (p-type) *(Siemens per Meter)*
- τ_n Minority Carrier Lifetime *(Microsecond)*

- Measurement: **Mobility** in Square Meter per Volt per Second ($m^2/V*s$)
  Mobility Unit Conversion
- Measurement: **Carrier Concentration** in 1 per Cubic Meter ($1/m^3$)
  Carrier Concentration Unit Conversion
- Measurement: **Heat Capacity** in Joule per Kelvin (J/K)
  Heat Capacity Unit Conversion

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