Important Charge Carrier Characteristics Formulas PDF

Formulas
Examples
with Units

List of 16
Important Charge Carrier Characteristics Formulas

1) Conductivity in Metals Formula

Evaluate Formula

Formula

$$\sigma = N_e \cdot [Charge\text{-}e] \cdot \mu_n$$

Example with Units

$$0.8652\,S/m = 3e16\,1/m^3 \cdot 1.6E\text{-}19\,C \cdot 180\,m^2/V*s$$

2) Convection Current Density Formula

Evaluate Formula

Formula

$$J_{cv} = \rho \cdot v$$

Example with Units

$$36\,A/m^2 = 3\,C/m^3 \cdot 12\,m/s$$

3) Current Density due to Electrons Formula

Evaluate Formula

Formula

$$J_n = [Charge\text{-}e] \cdot N_e \cdot \mu_n \cdot E_I$$

Example with Units

$$2.9658\,A/m^2 = 1.6E\text{-}19\,C \cdot 3e16\,1/m^3 \cdot 180\,m^2/V*s \cdot 3.428\,V/m$$

4) Current Density due to Holes Formula

Evaluate Formula

Formula

$$J_p = [Charge\text{-}e] \cdot N_p \cdot \mu_p \cdot E_I$$

Example with Units

$$1.6477\,A/m^2 = 1.6E\text{-}19\,C \cdot 2e16\,1/m^3 \cdot 150\,m^2/V*s \cdot 3.428\,V/m$$

5) Electrons Diffusion Constant Formula

Evaluate Formula

Formula

$$D_n = \mu_n \cdot \left(\frac{[BoltZ] \cdot T}{[Charge\text{-}e]}\right)$$

Example with Units

$$44982.4644\,cm^2/s = 180\,m^2/V*s \cdot \left(\frac{1.4E\text{-}23\,J/K \cdot 290\,K}{1.6E\text{-}19\,C}\right)$$

6) Electrostatic Deflection Sensitivity of CRT Formula

Evaluate Formula

Formula

$$S_e = \frac{d \cdot L}{2 \cdot \delta \cdot V_e}$$

Example with Units

$$1.1E\text{-}7\,\text{m/V} = \frac{2.5\,\text{mm} \cdot 50\,\text{mm}}{2 \cdot 1.15\,\text{mm} \cdot 501509\,\text{m/s}}$$

7) Force on Current Element in Magnetic Field Formula

Evaluate Formula

Formula

$$F = i_L \cdot B \cdot \sin(\theta)$$

Example with Units

$$0.6788\,\text{N} = 0.48\,\text{m} \cdot 2\,\text{Wb/m}^2 \cdot \sin(45°)$$

8) Hole Diffusion Length Formula

Evaluate Formula

Formula

$$L_p = \sqrt{D_p \cdot \tau_p}$$

Example with Units

$$0.3622\,\text{m} = \sqrt{37485.39\,\text{cm}^2/\text{s} \cdot 0.035\,\text{s}}$$

9) Holes Diffusion Constant Formula

Evaluate Formula

Formula

$$D_p = \mu_p \cdot \left(\frac{[BoltZ] \cdot T}{[Charge\text{-}e]}\right)$$

Example with Units

$$37485.387\,\text{cm}^2/\text{s} = 150\,\text{m}^2/\text{V*s} \cdot \left(\frac{1.4E\text{-}23\,\text{J/K} \cdot 290\,\text{K}}{1.6E\text{-}19\,\text{C}}\right)$$

10) Intrinsic Carrier Concentration under Non-Equilibrium Conditions Formula

Evaluate Formula

Formula

$$n_i = \sqrt{n_0 \cdot p_0}$$

Example with Units

$$1E+8\,\text{1/m}^3 = \sqrt{1.1e8\,\text{1/m}^3 \cdot 9.1e7\,\text{1/m}^3}$$

11) Intrinsic Concentration Formula

Evaluate Formula

Formula

$$n_i = \sqrt{N_c \cdot N_v} \cdot e^{\frac{-E_g}{2 \cdot [BoltZ] \cdot T}}$$

Example with Units

$$1.3E+8\,\text{1/m}^3 = \sqrt{1.02e18\,\text{1/m}^3 \cdot 0.5e18\,\text{1/m}^3} \cdot e^{\frac{-1.12\,\text{eV}}{2 \cdot 1.4E\text{-}23\,\text{J/K} \cdot 290\,\text{K}}}$$

12) Thermal Voltage Formula

Evaluate Formula

Formula

$$V_t = [BoltZ] \cdot \frac{T}{[Charge\text{-}e]}$$

Example with Units

$$0.025\,\text{V} = 1.4E\text{-}23\,\text{J/K} \cdot \frac{290\,\text{K}}{1.6E\text{-}19\,\text{C}}$$

13) Thermal Voltage using Einstein's Equation Formula

Evaluate Formula

Formula

$$V_t = \frac{D_n}{\mu_n}$$

Example with Units

$$0.025\,\text{V} = \frac{44982.46\,\text{cm}^2/\text{s}}{180\,\text{m}^2/\text{V*s}}$$

14) Time Period of Electron Formula

Evaluate Formula

Formula

$$t_c = \frac{2 \cdot 3.14 \cdot [Mass\text{-}e]}{H \cdot [Charge\text{-}e]}$$

Example with Units

$$0.1552\,\text{ns} = \frac{2 \cdot 3.14 \cdot 9.1E\text{-}31\,\text{kg}}{0.23\,\text{A/m} \cdot 1.6E\text{-}19\,\text{C}}$$

15) Velocity of Electron Formula

Evaluate Formula

Formula

$$V_v = \sqrt{\frac{2 \cdot [Charge\text{-}e] \cdot V}{[Mass\text{-}e]}}$$

Example with Units

$$501508.9862\,\text{m/s} = \sqrt{\frac{2 \cdot 1.6E\text{-}19\,\text{C} \cdot 0.715\,\text{V}}{9.1E\text{-}31\,\text{kg}}}$$

16) Velocity of Electron in Force Fields Formula

Evaluate Formula

Formula

$$V_{ef} = \frac{E_I}{H}$$

Example with Units

$$14.9043\,\text{m/s} = \frac{3.428\,\text{V/m}}{0.23\,\text{A/m}}$$

Variables used in list of Charge Carrier Characteristics Formulas above

- **B** Magnetic Flux Density *(Weber per Square Meter)*
- **d** Distance between Deflecting Plates *(Millimeter)*
- D_n Electron Diffusion Constant *(Square Centimeter Per Second)*
- D_p Holes Diffusion Constant *(Square Centimeter Per Second)*
- E_g Temperature Dependence of Energy Band Gap *(Electron-Volt)*
- E_l Electric Field Intensity *(Volt per Meter)*
- **F** Force *(Newton)*
- **H** Magnetic Field Strength *(Ampere per Meter)*
- i_L Current Element *(Meter)*
- J_{cv} Convection 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** Screen and Deflecting Plates Distance *(Millimeter)*
- L_p Holes Diffusion Length *(Meter)*
- n_0 Majority Carrier Concentration *(1 per Cubic Meter)*
- N_c Effective Density in Valence Band *(1 per Cubic Meter)*
- N_e Electron Concentration *(1 per Cubic Meter)*
- n_i Intrinsic Carrier Concentration *(1 per Cubic Meter)*
- N_p Holes Concentration *(1 per Cubic Meter)*
- N_v Effective Density in Conduction Band *(1 per Cubic Meter)*
- p_0 Minority Carrier Concentration *(1 per Cubic Meter)*

Constants, Functions, Measurements used in list of Charge Carrier Characteristics Formulas above

- constant(s): **[BoltZ]**, 1.38064852E-23
  Boltzmann constant
- constant(s): **[Charge-e]**, 1.60217662E-19
  Charge of electron
- constant(s): **[Mass-e]**, 9.10938356E-31
  Mass of electron
- constant(s): **e**, 2.71828182845904523536028747135266249
  Napier's constant
- Functions: **sin**, sin(Angle)
  Sine is a trigonometric function that describes the ratio of the length of the opposite side of a right triangle to the length of the hypotenuse.
- 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 Millimeter (mm), Meter (m)
  Length Unit Conversion
- Measurement: **Time** in Second (s), Nanosecond (ns)
  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: **Force** in Newton (N)
  Force Unit Conversion
- Measurement: **Angle** in Degree (°)
  Angle Unit Conversion
- Measurement: **Magnetic Flux Density** in Weber per Square Meter (Wb/m²)
  Magnetic Flux Density Unit Conversion
- Measurement: **Magnetic Field Strength** in Ampere per Meter (A/m)
  Magnetic Field Strength Unit Conversion

- S_e Electrostatic Deflection Sensitivity *(Meter per Volt)*
- **T** Temperature *(Kelvin)*
- t_c Period of Particle Circular Path *(Nanosecond)*
- **v** Charge Velocity *(Meter per Second)*
- **V** Voltage *(Volt)*
- V_e Electron Velocity *(Meter per Second)*
- V_{ef} Velocity of Electron in Force Fields *(Meter per Second)*
- V_t Thermal Voltage *(Volt)*
- V_v Velocity due to Voltage *(Meter per Second)*
- **δ** Deflection of Beam *(Millimeter)*
- **θ** Angle between Planes *(Degree)*
- μ_n Mobility of Electron *(Square Meter per Volt per Second)*
- μ_p Mobility of Holes *(Square Meter per Volt per Second)*
- **ρ** Charge Density *(Coulomb per Cubic Meter)*
- **σ** Conductivity *(Siemens per Meter)*
- τ_p Hole Carrier Lifetime *(Second)*

- Measurement: **Volume Charge Density** in Coulomb per Cubic Meter (C/m³)
  Volume Charge Density 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: **Diffusivity** in Square Centimeter Per Second (cm²/s)
  Diffusivity Unit Conversion
- Measurement: **Mobility** in Square Meter per Volt per Second (m²/V*s)
  Mobility Unit Conversion
- Measurement: **Deflection Sensitivity** in Meter per Volt (m/V)
  Deflection Sensitivity Unit Conversion
- Measurement: **Carrier Concentration** in 1 per Cubic Meter (1/m³)
  Carrier Concentration Unit Conversion

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9/18/2024 | 11:34:02 AM UTC