Important BJT Circuit Formulas PDF

Formulas
Examples
with Units

List of 20
Important BJT Circuit Formulas

1) Base Current of PNP Transistor given Emitter Current Formula

Evaluate Formula

Formula

$$I_B = \frac{I_e}{\beta + 1}$$

Example with Units

$$0.0769\,\text{mA} = \frac{5.077\,\text{mA}}{65 + 1}$$

2) Base Current of PNP Transistor using Collector Current Formula

Evaluate Formula

Formula

$$I_B = \frac{I_c}{\beta}$$

Example with Units

$$0.0769\,\text{mA} = \frac{5\,\text{mA}}{65}$$

3) Base Current of PNP Transistor using Common-Base Current Gain Formula

Evaluate Formula

Formula

$$I_B = (1 - \alpha) \cdot I_e$$

Example with Units

$$0.0762\,\text{mA} = (1 - 0.985) \cdot 5.077\,\text{mA}$$

4) Base Current of PNP Transistor using Saturation Current Formula

Evaluate Formula

Formula

$$I_B = \left(\frac{I_{sat}}{\beta}\right) \cdot e^{\frac{V_{BE}}{V_t}}$$

Example with Units

$$0.0771\,\text{mA} = \left(\frac{1.675\,\text{mA}}{65}\right) \cdot e^{\frac{5.15\,\text{V}}{4.7\,\text{V}}}$$

5) Collector Current of BJT Formula

Evaluate Formula

Formula

$$I_c = I_e - I_B$$

Example with Units

$$5\,\text{mA} = 5.077\,\text{mA} - 0.077\,\text{mA}$$

6) Collector Current using Emitter Current Formula

Evaluate Formula

Formula

$$I_c = \alpha \cdot I_e$$

Example with Units

$$5.0008\,\text{mA} = 0.985 \cdot 5.077\,\text{mA}$$

7) Collector to Emitter Voltage at Saturation Formula

Evaluate Formula

Formula

$$V_{CE} = V_{BE} - V_{BC}$$

Example with Units

$$3.15\,\text{V} = 5.15\,\text{V} - 2\,\text{V}$$

8) Common Mode Rejection Ratio Formula

Evaluate Formula

Formula

$$CMRR = 20 \cdot \log10\left(\frac{A_d}{A_{cm}}\right)$$

Example with Units

$$54.4032\,\text{dB} = 20 \cdot \log10\left(\frac{105\,\text{dB}}{0.20\,\text{dB}}\right)$$

9) Common-Base Current Gain Formula

Evaluate Formula

Formula

$$\alpha = \frac{\beta}{\beta + 1}$$

Example

$$0.9848 = \frac{65}{65 + 1}$$

10) Emitter Current of BJT Formula

Evaluate Formula

Formula

$$I_e = I_c + I_B$$

Example with Units

$$5.077\,\text{mA} = 5\,\text{mA} + 0.077\,\text{mA}$$

11) Intrinsic Gain of BJT Formula

Evaluate Formula

Formula

$$A_o = \frac{V_A}{V_t}$$

Example with Units

$$0.266 = \frac{1.25\,\text{V}}{4.7\,\text{V}}$$

12) Output Resistance of BJT Formula

Evaluate Formula

Formula

$$R = \frac{V_{DD} + V_{CE}}{I_c}$$

Example with Units

$$1.13\,\text{k}\Omega = \frac{2.5\,\text{V} + 3.15\,\text{V}}{5\,\text{mA}}$$

13) Output Voltage of BJT Amplifier Formula

Evaluate Formula

Formula

$$V_o = V_{DD} - I_d \cdot R_L$$

Example with Units

$$1.3\,\text{V} = 2.5\,\text{V} - 0.3\,\text{mA} \cdot 4\,\text{k}\Omega$$

14) Reference Current of BJT Mirror Formula

Evaluate Formula

Formula

$$I_{ref} = I_c + \frac{2 \cdot I_c}{\beta}$$

Example with Units

$$5.1538\,\text{mA} = 5\,\text{mA} + \frac{2 \cdot 5\,\text{mA}}{65}$$

15) Short-Circuit Transconductance Formula

Evaluate Formula

Formula

$$G_m = \frac{I_o}{V_{in}}$$

Example with Units

$$1.72\,\text{mS} = \frac{4.3\,\text{mA}}{2.50\,\text{V}}$$

16) Thermal Equilibrium Concentration of Minority Charge Carrier Formula

Evaluate Formula

Formula

$$n_{po} = \frac{\left(n_i\right)^2}{N_B}$$

Example with Units

$$1.1\text{E+}18\,1/\text{m}^3 = \frac{\left(4.5\text{E+}9\,1/\text{m}^3\right)^2}{19\,1/\text{m}^3}$$

17) Total Power Dissipated in BJT Formula

Evaluate Formula

Formula

$$P = V_{CE} \cdot I_c + V_{BE} \cdot I_B$$

Example with Units

$$16.1465\,\text{mW} = 3.15\,\text{V} \cdot 5\,\text{mA} + 5.15\,\text{V} \cdot 0.077\,\text{mA}$$

18) Total Power Supplied in BJT Formula

Evaluate Formula

Formula

$$P = V_{DD} \cdot \left(I_c + I_{in}\right)$$

Example with Units

$$16.125\,\text{mW} = 2.5\,\text{V} \cdot \left(5\,\text{mA} + 1.45\,\text{mA}\right)$$

19) Transition Frequency of BJT Formula

Evaluate Formula

Formula

$$f_t = \frac{G_m}{2 \cdot \pi \cdot \left(C_{eb} + C_{cb}\right)}$$

Example with Units

$$101.3876\,\text{Hz} = \frac{1.72\,\text{mS}}{2 \cdot 3.1416 \cdot \left(1.5\,\mu\text{F} + 1.2\,\mu\text{F}\right)}$$

20) Unity-Gain Bandwidth of BJT Formula

Evaluate Formula

Formula

$$\omega_T = \frac{G_m}{C_{eb} + C_{cb}}$$

Example with Units

$$637.037\,\text{Hz} = \frac{1.72\,\text{mS}}{1.5\,\mu\text{F} + 1.2\,\mu\text{F}}$$

Variables used in list of BJT Circuit Formulas above

- A_{cm} Common Mode Gain *(Decibel)*
- A_d Differential Mode Gain *(Decibel)*
- A_o Intrinsic Gain
- C_{cb} Collector-Base Junction Capacitance *(Microfarad)*
- C_{eb} Emitter-Base Capacitance *(Microfarad)*
- **CMRR** Common Mode Rejection Ratio *(Decibel)*
- f_t Transition Frequency *(Hertz)*
- G_m Transconductance *(Millisiemens)*
- I_B Base Current *(Milliampere)*
- I_c Collector Current *(Milliampere)*
- I_d Drain Current *(Milliampere)*
- I_e Emitter Current *(Milliampere)*
- I_{in} Input Current *(Milliampere)*
- I_o Output Current *(Milliampere)*
- I_{ref} Reference Current *(Milliampere)*
- I_{sat} Saturation Current *(Milliampere)*
- N_B Doping Concentration of Base *(1 per Cubic Meter)*
- n_i Intrinsic Carrier Density *(1 per Cubic Meter)*
- n_{po} Thermal Equilibrium Concentration *(1 per Cubic Meter)*
- **P** Power *(Milliwatt)*
- **R** Resistance *(Kilohm)*
- R_L Load Resistance *(Kilohm)*
- V_A Early Voltage *(Volt)*
- V_{BC} Base-Collector Voltage *(Volt)*
- V_{BE} Base-Emitter Voltage *(Volt)*
- V_{CE} Collector-Emitter Voltage *(Volt)*
- V_{DD} Supply Voltage *(Volt)*
- V_{in} Input Voltage *(Volt)*
- V_o Output Voltage *(Volt)*

Constants, Functions, Measurements used in list of BJT Circuit Formulas above

- constant(s): **pi**, 3.14159265358979323846264338327950288 *Archimedes' constant*
- constant(s): **e**, 2.71828182845904523536028747135266249 *Napier's constant*
- Functions: **log10**, log10(Number) *The common logarithm, also known as the base-10 logarithm or the decimal logarithm, is a mathematical function that is the inverse of the exponential function.*
- Measurement: **Electric Current** in Milliampere (mA) *Electric Current Unit Conversion*
- Measurement: **Power** in Milliwatt (mW) *Power Unit Conversion*
- Measurement: **Noise** in Decibel (dB) *Noise Unit Conversion*
- Measurement: **Frequency** in Hertz (Hz) *Frequency Unit Conversion*
- Measurement: **Capacitance** in Microfarad (µF) *Capacitance Unit Conversion*
- Measurement: **Electric Resistance** in Kilohm (kΩ) *Electric Resistance Unit Conversion*
- Measurement: **Electric Conductance** in Millisiemens (mS) *Electric Conductance Unit Conversion*
- Measurement: **Electric Potential** in Volt (V) *Electric Potential Unit Conversion*
- Measurement: **Carrier Concentration** in 1 per Cubic Meter ($1/m^3$) *Carrier Concentration Unit Conversion*

- V_t Thermal Voltage *(Volt)*
- α Common-Base Current Gain
- β Common Emitter Current Gain
- ω_T Unity-Gain Bandwidth *(Hertz)*

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