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BJT Circuit Formulas

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List of 20 BJT Circuit Formulas

BJT Circuit

1) Base Current of PNP Transistor given Emitter Current

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

Open Calculator 

$$ex \quad 0.076924mA = \frac{5.077mA}{65 + 1}$$

2) Base Current of PNP Transistor using Collector Current

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

Open Calculator 

$$ex \quad 0.076923mA = \frac{5mA}{65}$$

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

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

Open Calculator 

$$ex \quad 0.076155mA = (1 - 0.985) \cdot 5.077mA$$



4) Base Current of PNP Transistor using Saturation Current

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

[Open Calculator !\[\]\(cbe80b694ebd74fcfe136a095b608235_img.jpg\)](#)

$$ex \quad 0.077086mA = \left(\frac{1.675mA}{65} \right) \cdot e^{\frac{5.15V}{4.7V}}$$

5) Collector Current of BJT

$$fx \quad I_C = I_e - I_B$$

[Open Calculator !\[\]\(3e2231b1ad3ca8da8658228c00dd08e0_img.jpg\)](#)

$$ex \quad 5mA = 5.077mA - 0.077mA$$

6) Collector Current using Emitter Current

$$fx \quad I_C = \alpha \cdot I_e$$

[Open Calculator !\[\]\(0d5ec72f61334709c3fc9450209b754f_img.jpg\)](#)

$$ex \quad 5.000845mA = 0.985 \cdot 5.077mA$$

7) Collector to Emitter Voltage at Saturation

$$fx \quad V_{CE} = V_{BE} - V_{BC}$$

[Open Calculator !\[\]\(b64b40baaee5acddc1eab8538ba84754_img.jpg\)](#)

$$ex \quad 3.15V = 5.15V - 2V$$



8) Common Mode Rejection Ratio 

$$fx \quad CMRR = 20 \cdot \log_{10} \left(\frac{A_d}{A_{cm}} \right)$$

Open Calculator 

$$ex \quad 54.40319dB = 20 \cdot \log_{10} \left(\frac{105dB}{0.20dB} \right)$$

9) Common-Base Current Gain 

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

Open Calculator 

$$ex \quad 0.984848 = \frac{65}{65 + 1}$$

10) Emitter Current of BJT 

$$fx \quad I_e = I_c + I_B$$

Open Calculator 

$$ex \quad 5.077mA = 5mA + 0.077mA$$

11) Intrinsic Gain of BJT 

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

Open Calculator 

$$ex \quad 0.265957 = \frac{1.25V}{4.7V}$$



12) Output Resistance of BJT

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

[Open Calculator !\[\]\(e2376d476d06eb31946dc01a69a4403a_img.jpg\)](#)

$$ex \quad 1.13k\Omega = \frac{2.5V + 3.15V}{5mA}$$

13) Output Voltage of BJT Amplifier

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

[Open Calculator !\[\]\(0b5e7e25e8775f7e7e80906ada4f0021_img.jpg\)](#)

$$ex \quad 1.3V = 2.5V - 0.3mA \cdot 4k\Omega$$

14) Reference Current of BJT Mirror

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

[Open Calculator !\[\]\(bd3b31712ad9bab5a241210fa6925cdd_img.jpg\)](#)

$$ex \quad 5.153846mA = 5mA + \frac{2 \cdot 5mA}{65}$$

15) Short-Circuit Transconductance

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

[Open Calculator !\[\]\(7bc43b319a082987e20f7bf78f4bab80_img.jpg\)](#)

$$ex \quad 1.72mS = \frac{4.3mA}{2.50V}$$



16) Thermal Equilibrium Concentration of Minority Charge Carrier

$$\text{fx } n_{po} = \frac{(n_i)^2}{N_B}$$

[Open Calculator !\[\]\(d3fb9f94af8b26d1c844efa9a98805b0_img.jpg\)](#)

$$\text{ex } 1.1E^{181}/m^3 = \frac{(4.5E^{91}/m^3)^2}{191/m^3}$$

17) Total Power Dissipated in BJT

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

[Open Calculator !\[\]\(e1d6102fe77919492c04879c8450f1f5_img.jpg\)](#)

$$\text{ex } 16.14655mW = 3.15V \cdot 5mA + 5.15V \cdot 0.077mA$$

18) Total Power Supplied in BJT

$$\text{fx } P = V_{DD} \cdot (I_c + I_{in})$$

[Open Calculator !\[\]\(ab4e2b3fc7e7887b7a72f548aa6f5e60_img.jpg\)](#)

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

19) Transition Frequency of BJT

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

[Open Calculator !\[\]\(5abce1a84a655b073239ab33e1199487_img.jpg\)](#)

$$\text{ex } 101.3876Hz = \frac{1.72mS}{2 \cdot \pi \cdot (1.5\mu F + 1.2\mu F)}$$



20) Unity-Gain Bandwidth of BJT

[Open Calculator !\[\]\(feabb98897b440bc8695a03336a6e2df_img.jpg\)](#)

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

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



Variables Used










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






Constants, Functions, Measurements used

- **Constant:** **pi**, 3.14159265358979323846264338327950288
Archimedes' constant
- **Constant:** **e**, 2.71828182845904523536028747135266249
Napier's constant
- **Function:** **log10**, log10(Number)
Common logarithm function (base 10)
- **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 ($\text{k}\Omega$)
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 ($1/\text{m}^3$)
Carrier Concentration Unit Conversion 



Check other formula lists

- **Amplification Factor/Gain Formulas** 
- **BJT Circuit Formulas** 
- **Common Mode Rejection Ratio (CMRR) Formulas** 
- **Internal Capacitive Effects and High Frequency Model Formulas** 
- **Resistance Formulas** 
- **Transconductance Formulas** 
- **Voltage Formulas** 

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