Important Signal and IC Amplifiers Formulas PDF

Formulas
Examples
with Units

List of 17
Important Signal and IC Amplifiers Formulas

1) IC Amplifiers Formulas

1.1) Emitter Resistance in Widlar Current Source Formula

Evaluate Formula

Formula

$$R_e = \left(\frac{V_{th}}{I_o}\right) \cdot \log10\left(\frac{I_{ref}}{I_o}\right)$$

Example with Units

$$0.9092\,\text{k}\Omega = \left(\frac{25\,\text{V}}{5\,\text{mA}}\right) \cdot \log10\left(\frac{7.60\,\text{mA}}{5\,\text{mA}}\right)$$

1.2) Finite Output Resistance of IC Amplifier Formula

Evaluate Formula

Formula

$$R_{fo} = \frac{\Delta V_o}{\Delta I_o}$$

Example with Units

$$1.4565\,\text{k}\Omega = \frac{1.34\,\text{V}}{0.92\,\text{mA}}$$

1.3) Intrinsic Gain of IC Amplifier Formula

Evaluate Formula

Formula

$$G_i = 2 \cdot \frac{V_e}{V_{ov}}$$

Example with Units

$$96 = 2 \cdot \frac{0.012\,\text{V/µm}}{250\,\text{V}}$$

1.4) Output Current Formula

Evaluate Formula

Formula

$$I_{out} = I_{ref} \cdot \left(\frac{I_{t2}}{I_{t1}}\right)$$

Example with Units

$$29.3636\,\text{mA} = 7.60\,\text{mA} \cdot \left(\frac{4.25\,\text{mA}}{1.1\,\text{mA}}\right)$$

1.5) Output Current of Wilson Current Mirror Formula

Evaluate Formula

Formula

$$I_o = I_{ref} \cdot \left(\frac{1}{1 + \left(\frac{2}{\beta^2}\right)}\right)$$

Example with Units

$$5.0667\,\text{mA} = 7.60\,\text{mA} \cdot \left(\frac{1}{1 + \left(\frac{2}{2^2}\right)}\right)$$

1.6) Output Resistance of Widlar Current Source Formula

Evaluate Formula

Formula

$$R_{wcs} = \left(1 + g_m\right) \cdot \left(\left(\frac{1}{R_e}\right) + \left(\frac{1}{R_{sbe}}\right)\right) \cdot R_{fo}$$

Example with Units

$$0.0021\,\text{k}\Omega = \left(1 + 0.25\,\text{S}\right) \cdot \left(\left(\frac{1}{0.909\,\text{k}\Omega}\right) + \left(\frac{1}{20\,\text{k}\Omega}\right)\right) \cdot 1.45\,\text{k}\Omega$$

1.7) Output Resistance of Wilson Current Mirror Formula

Evaluate Formula

Formula

$$R_{wcm} = \frac{\beta_1 \cdot R_{f3}}{2}$$

Example with Units

$$0.0206\,\text{k}\Omega = \frac{55 \cdot 0.75\,\Omega}{2}$$

1.8) Output Resistance of Wilson MOS Mirror Formula

Evaluate Formula

Formula

$$R_o = \left(g_{m3} \cdot R_{f3}\right) \cdot R_{o2}$$

Example with Units

$$4.6875\,\Omega = \left(0.25\,\text{S} \cdot 0.75\,\Omega\right) \cdot 25\,\Omega$$

1.9) Reference Current of IC Amplifier Formula

Evaluate Formula

Formula

$$I_{ref} = I_o \cdot \left(\frac{WL}{WL_1}\right)$$

Example with Units

$$7.5\,\text{mA} = 5\,\text{mA} \cdot \left(\frac{15}{10}\right)$$

1.10) Reference Current of Wilson Current Mirror Formula

Evaluate Formula

Formula

$$I_{ref} = \left(1 + \frac{2}{\beta^2}\right) \cdot I_o$$

Example with Units

$$7.5\,\text{mA} = \left(1 + \frac{2}{2^2}\right) \cdot 5\,\text{mA}$$

2) Signal Amplifier Formulas

2.1) Current Transfer Ratio of Mirror with Base Current Compensation Formula

Evaluate Formula

Formula

$$I_o = I_{ref} \cdot \left(\frac{1}{1 + \frac{2}{\beta^2}}\right)$$

Example with Units

$$5.0667\,\text{mA} = 7.60\,\text{mA} \cdot \left(\frac{1}{1 + \frac{2}{2^2}}\right)$$

2.2) Input Resistance in Small-Signal Operation of Current Mirrors Formula

Evaluate Formula

Formula

$$R_i = \frac{1}{g_m}$$

Example with Units

$$4\,\Omega = \frac{1}{0.25\,S}$$

2.3) Output Voltage Gain of Active Loaded CE Amplifier Formula

Evaluate Formula

Formula

$$G_{ov} = -g_m \cdot R_o$$

Example with Units

$$-1.1719 = -0.25\,S \cdot 4.6875\,\Omega$$

2.4) Overall Voltage Gain given Signal Source Formula

Evaluate Formula

Formula

$$G_{vt} = \frac{V_o}{S_i}$$

Example with Units

$$0.7535 = \frac{13.3\,V}{17.65\,V}$$

2.5) Signal Current Formula

Evaluate Formula

Formula

$$I_s = I_p \cdot \sin(\omega \cdot T)$$

Example with Units

$$2.6163\,mA = 3.7\,mA \cdot \sin(90\,deg/s \cdot 0.5\,s)$$

2.6) Voltage Gain of Amplifier with Current-Source Load Formula

Evaluate Formula

Formula

$$A_v = -g_m \cdot \left(\frac{1}{R_{f2}} + \frac{1}{R_{o2}}\right)$$

Example with Units

$$-0.0209 = -0.25\,S \cdot \left(\frac{1}{23\,\Omega} + \frac{1}{25\,\Omega}\right)$$

2.7) Voltage Gain of Small-Signal Operation of Current Mirrors Formula

Evaluate Formula

Formula

$$G_{is} = \frac{g_{m2} \cdot V_{gs}}{I_{ss}}$$

Example with Units

$$0.0476 = \frac{0.25\,S \cdot 4\,V}{21\,A}$$

Variables used in list of Signal and IC Amplifiers Formulas above

- A_v Voltage Gain of Amplifier
- G_i Intrinsic Gain
- G_{is} Short-Circuit Current Gain
- g_m Transconductance *(Siemens)*
- g_{m2} Transconductance 2 *(Siemens)*
- g_{m3} Transconductance 3 *(Siemens)*
- G_{ov} Output Voltage Gain
- G_{vt} Overall Voltage Gain
- I_o Output Current *(Milliampere)*
- I_{out} Output Current given Reference Current *(Milliampere)*
- I_p Current Peak Amplitude *(Milliampere)*
- I_{ref} Reference Current *(Milliampere)*
- I_s Signal Current *(Milliampere)*
- I_{ss} Small Signal Input Current *(Ampere)*
- I_{t1} Current in Transistor 1 *(Milliampere)*
- I_{t2} Current in Transistor 2 *(Milliampere)*
- R_e Emitter Resistance *(Kilohm)*
- R_{f2} Finite Output Resistance 1 *(Ohm)*
- R_{f3} Finite Output Resistance 3 *(Ohm)*
- R_{fo} Finite Output Resistance *(Kilohm)*
- R_i Input Resistance *(Ohm)*
- R_o Output Resistance *(Ohm)*
- R_{o2} Finite Output Resistance 2 *(Ohm)*
- R_{sbe} Small-Signal Input Resistance b/w Base-Emitter *(Kilohm)*
- R_{wcm} Output Resistance of Wilson Current Mirror *(Kilohm)*
- R_{wcs} Output Resistance of Widlar Current Source *(Kilohm)*
- S_i Input Signal *(Volt)*
- T Time in Seconds *(Second)*

Constants, Functions, Measurements used in list of Signal and IC Amplifiers Formulas above

- 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.
- 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.
- Measurement: **Time** in Second (s)
  Time Unit Conversion
- Measurement: **Electric Current** in Milliampere (mA), Ampere (A)
  Electric Current Unit Conversion
- Measurement: **Electric Resistance** in Kilohm (kΩ), Ohm (Ω)
  Electric Resistance Unit Conversion
- Measurement: **Electric Conductance** in Siemens (S)
  Electric Conductance Unit Conversion
- Measurement: **Electric Field Strength** in Volt Per Micrometer (V/µm)
  Electric Field Strength Unit Conversion
- Measurement: **Electric Potential** in Volt (V)
  Electric Potential Unit Conversion
- Measurement: **Angular Frequency** in Degree per Second (deg/s)
  Angular Frequency Unit Conversion

- V_e Early Voltage *(Volt Per Micrometer)*
- V_{gs} Voltage across Gate and Source *(Volt)*
- V_o Output Voltage *(Volt)*
- V_{ov} Overdrive Voltage *(Volt)*
- V_{th} Threshold Voltage *(Volt)*
- WL Aspect Ratio
- WL_1 Aspect Ratio 1
- β Transistor Current Gain
- β_1 Transistor Current Gain 1
- ΔI_o Change in Current *(Milliampere)*
- ΔV_o Change in Output Voltage *(Volt)*
- ω Angular Frequency of Wave *(Degree per Second)*

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