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MOSFET Amplifiers Formulas

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List of 20 MOSFET Amplifiers Formulas

MOSFET Amplifiers

1) Zero Bias Junction Capacitance

$$f_x C_{j0} = \sqrt{\frac{\epsilon_{si} \cdot [\text{Charge-e}]}{2}} \cdot \left(\frac{N_A \cdot N_D}{N_A + N_D} \right) \cdot \frac{1}{\Phi_o}$$

[Open Calculator !\[\]\(a870788d6ed9b8fd294b7654a8c8526b_img.jpg\)](#)

$$ex \ 6.6E^{-7}F = \sqrt{\frac{11.7F/m \cdot [\text{Charge-e}]}{2}} \cdot \left(\frac{1.32\text{electrons/cm}^3 \cdot 3.01\text{electrons/cm}^3}{1.32\text{electrons/cm}^3 + 3.01\text{electrons/cm}^3} \right) \cdot \frac{1}{2V}$$

2) Zero Bias Sidewall Junction Capacitance

$$f_x C_{j0sw} = \sqrt{\frac{[\text{Permittivity-silicon}] \cdot [\text{Charge-e}]}{2}} \cdot \left(\frac{N_{A(sw)} \cdot N_D}{N_{A(sw)} + N_D} \right) \cdot \frac{1}{\Phi_{osw}}$$

[Open Calculator !\[\]\(c50c8b7b2cc2cf9ff925edec0ee94c0d_img.jpg\)](#)

$$ex \ 1E^{-7}F = \sqrt{\frac{[\text{Permittivity-silicon}] \cdot [\text{Charge-e}]}{2}} \cdot \left(\frac{0.35\text{electrons/m}^3 \cdot 3.01\text{electrons/cm}^3}{0.35\text{electrons/m}^3 + 3.01\text{electrons/cm}^3} \right) \cdot \frac{1}{0.000032V}$$

Cascode Configuration

3) Downwards Resistance of Cascode Differential Half Circuit

$$f_x R_{on} = (g_m \cdot R_{02}) \cdot R'_{1}$$

[Open Calculator !\[\]\(f1c5da15572e3e09d343161be98f508d_img.jpg\)](#)

$$ex \ 1.3195k\Omega = (0.25mS \cdot 0.91k\Omega) \cdot 5.80k\Omega$$

4) Upwards Resistance of Cascode Differential Half-Circuit

$$f_x R_{op} = (g_m \cdot R_{02}) \cdot R_{01}$$

[Open Calculator !\[\]\(166772600a13ad0a433053f90fe45649_img.jpg\)](#)

$$ex \ 0.557375k\Omega = (0.25mS \cdot 0.91k\Omega) \cdot 2.45k\Omega$$

5) Voltage Gain of Cascode Differential Amplifier given Transconductance

$$f_x A_v = \frac{V_{od}}{V_{id}}$$

[Open Calculator !\[\]\(a8ff699ced33317c53c86f9bf3171905_img.jpg\)](#)

$$ex \ 0.806452 = \frac{25V}{31V}$$




DC Offset 6) Current on Operation with Differential Input Voltage 

$$\text{fx } I_t = \frac{1}{2} \cdot (k'_n \cdot WL) \cdot (V_d - V_t)^2$$

Open Calculator 

$$\text{ex } 0.62977\text{mA} = \frac{1}{2} \cdot (0.02\text{mS} \cdot 5) \cdot (23.049\text{V} - 19.5\text{V})^2$$

7) Maximum Differential Input Voltage of MOSFET given Overdrive Voltage 

$$\text{fx } V_{is} = \sqrt{2} \cdot V_{ov}$$

Open Calculator 


$$\text{ex } 3.535534\text{V} = \sqrt{2} \cdot 2.50\text{V}$$

8) Offset Voltage of MOSFET with Current-Mirror Load 

$$\text{fx } V_{os} = -\frac{2 \cdot V_t}{\beta_{\text{forced}}}$$

Open Calculator 

$$\text{ex } -3.545455\text{V} = -\frac{2 \cdot 19.5\text{V}}{11}$$

9) Output Voltage of Voltage Amplifier 

$$\text{fx } V_{out} = V_s - (I_d \cdot R_L)$$

Open Calculator 

$$\text{ex } 5.9792\text{V} = 6.6\text{V} - (8\text{mA} \cdot 0.0776\text{k}\Omega)$$

Differential Configuration 10) Differential Voltage Gain in MOS Differential Amplifier 

$$\text{fx } A_d = g_m \cdot \left(\frac{1}{\beta \cdot R'_1} + \left(\frac{1}{\beta \cdot R'_2} \right) \right)$$

Open Calculator 

$$\text{ex } 7.009 = 0.25\text{mS} \cdot \left(\frac{1}{6.52 \cdot 5.80\text{k}\Omega} + \left(\frac{1}{6.52 \cdot 4.3\text{k}\Omega} \right) \right)$$




11) Input Offset Voltage of MOS Differential Amplifier 

$$\text{fx } V_{os} = \frac{V_o}{A_d}$$

Open Calculator 

$$\text{ex } 3.54\text{V} = \frac{24.78\text{V}}{7}$$

12) Input Offset Voltage of MOS Differential Amplifier given Saturation Current 

$$\text{fx } V_{os} = V_t \cdot \left(\frac{I_{sc}}{I_s} \right)$$

Open Calculator 

$$\text{ex } 3.561644\text{V} = 19.5\text{V} \cdot \left(\frac{0.8\text{mA}}{4.38\text{mA}} \right)$$

13) Input Offset Voltage of MOS Differential Amplifier when Aspect Ratio Mismatches 

$$\text{fx } V_{os} = \left(\frac{V_{ov}}{2} \right) \cdot \left(\frac{WL}{WL_1} \right)$$

Open Calculator 

$$\text{ex } 3.531073\text{V} = \left(\frac{2.50\text{V}}{2} \right) \cdot \left(\frac{5}{1.77} \right)$$

14) Input Voltage of MOS Differential Amplifier on Small-Signal Operation 

$$\text{fx } V_{in} = V_{cm} + \left(\frac{1}{2} \cdot V_{is} \right)$$

Open Calculator 

$$\text{ex } 13.765\text{V} = 12\text{V} + \left(\frac{1}{2} \cdot 3.53\text{V} \right)$$

15) Maximum Input Common-Mode Range of MOS Differential Amplifier 

$$\text{fx } V_{cmr} = V_t + V_L - \left(\frac{1}{2} \cdot R_L \right)$$

Open Calculator 

$$\text{ex } 3.34\text{V} = 19.5\text{V} + 22.64\text{V} - \left(\frac{1}{2} \cdot 0.0776\text{k}\Omega \right)$$


16) Minimum Input Common-Mode Range of MOS Differential Amplifier 

$$\text{fx } V_{cmr} = V_t + V_{ov} + V_{gs} - V_L$$

Open Calculator 


$$\text{ex } 3.36\text{V} = 19.5\text{V} + 2.50\text{V} + 4\text{V} - 22.64\text{V}$$



17) Total Input Offset Voltage of MOS Differential Amplifier given Saturation Current [Open Calculator](#) 

$$\text{fx } V_{os} = \sqrt{\left(\frac{\Delta R_c}{R_c}\right)^2 + \left(\frac{I_{sc}}{I_s}\right)^2}$$

$$\text{ex } 3.543926\text{V} = \sqrt{\left(\frac{1.805\text{k}\Omega}{0.51\text{k}\Omega}\right)^2 + \left(\frac{0.8\text{mA}}{4.38\text{mA}}\right)^2}$$

18) Transconductance of MOS Differential Amplifier on Small-Signal Operation [Open Calculator](#) 

$$\text{fx } g_m = \frac{I_t}{V_{ov}}$$

$$\text{ex } 0.25\text{mS} = \frac{0.625\text{mA}}{2.50\text{V}}$$

Gain 19) Common-Mode Current Gain of Controlled Source Transistor [Open Calculator](#) 

$$\text{fx } A_{cmi} = -\left(\frac{1}{2 \cdot g_m \cdot R_o}\right)$$

$$\text{ex } -1.574803 = -\left(\frac{1}{2 \cdot 0.25\text{mS} \cdot 1.27\text{k}\Omega}\right)$$

20) Common-Mode Gain of Controlled Source Transistor [Open Calculator](#) 

$$\text{fx } A_{cm} = 20 \cdot \log_{10}\left(\frac{V_{ss}}{V_{is}}\right)$$

$$\text{ex } 6.251266\text{dB} = 20 \cdot \log_{10}\left(\frac{7.25\text{V}}{3.53\text{V}}\right)$$



Variables Used









- A_{cm} Common Mode Gain (Decibel)
- A_{cmi} Common-Mode Current Gain
- A_d Differential Gain
- A_v Voltage Gain
- C_{j0} Zero Bias Junction Capacitance (Farad)
- C_{j0sw} Zero Bias Sidewall Junction Potential (Farad)
- g_m Transconductance (Millisiemens)
- I_d Drain Current (Milliampere)
- I_s Saturation Current (Milliampere)
- I_{sc} Saturation Current for DC (Milliampere)
- I_t Total Current (Milliampere)
- k'_n Process Transconductance Parameter (Millisiemens)
- N_A Doping Concentration of Acceptor (Electrons per Cubic Centimeter)
- $N_{A(sw)}$ Sidewall Doping Density (Electrons per Cubic Meter)
- N_D Doping Concentration of Donor (Electrons per Cubic Centimeter)
- R_{01} Equivalent Resistance from Primary (Kilohm)
- R_{02} Equivalent Resistance from Secondary (Kilohm)
- R'_1 Resistance of Primary Winding in Secondary (Kilohm)
- R'_2 Resistance of Secondary Winding in Primary (Kilohm)
- R_c Collector Resistance (Kilohm)
- R_L Load Resistance (Kilohm)
- R_o Output Resistance (Kilohm)
- R_{on} Downwards Resistance of Cascode Differential (Kilohm)
- R_{op} Upwards Resistance of Cascode Differential (Kilohm)
- V_{cm} Common-Mode DC Voltage (Volt)
- V_{cmr} Common-Mode Range (Volt)
- V_d Voltage across Diode (Volt)
- V_{gs} Voltage between Gate and Source (Volt)
- V_{id} Differential Input Voltage (Volt)
- V_{in} Input Voltage (Volt)
- V_{is} Differential Input Signal (Volt)



- V_L Load Voltage (Volt)
- V_O Output DC Offset Voltage (Volt)
- V_{od} Differential Output Signal (Volt)
- V_{OS} Input Offset Voltage (Volt)
- V_{out} Output Voltage (Volt)
- V_{OV} Effective Voltage (Volt)
- V_S Source Voltage (Volt)
- V_{SS} Small Signal (Volt)
- V_t Threshold Voltage (Volt)
- WL Aspect Ratio
- WL_1 Aspect Ratio 1
- β Common Emitter Current Gain
- β_{forced} Forced Common-Emitter Current Gain
- ΔR_C Change in Collector Resistance (Kilohm)
- ϵ_{Si} Permittivity of Silicon (Farad per Meter)
- Φ_O Built in Junction Potential (Volt)
- Φ_{OSW} Built in Potential of Sidewall Junctions (Volt)



Constants, Functions, Measurements used

- **Constant:** [**Charge-e**], 1.60217662E-19
Charge of electron
- **Constant:** [**Permittivity-silicon**], 11.7
Permittivity of silicon
- **Function:** **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.
- **Function:** **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:** **Electric Current** in Milliampere (mA)
Electric Current Unit Conversion 
- **Measurement:** **Noise** in Decibel (dB)
Noise Unit Conversion 
- **Measurement:** **Capacitance** in Farad (F)
Capacitance Unit Conversion 
- **Measurement:** **Electric Resistance** in Kiloohm (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:** **Permittivity** in Farad per Meter (F/m)
Permittivity Unit Conversion 
- **Measurement:** **Electron Density** in Electrons per Cubic Centimeter (electrons/cm³), Electrons per Cubic Meter (electrons/m³)
Electron Density Unit Conversion 



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