# Important MOSFET Amplifiers Formulas PDF

Formulas
Examples
with Units

**List of 20**
**Important MOSFET Amplifiers Formulas**

## 1) Zero Bias Junction Capacitance Formula

Evaluate Formula

Formula

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

Example with Units

$$6.6E\text{-}7\,\text{F} = \sqrt{\frac{11.7\,\text{F/m} \cdot 1.6E\text{-}19\,\text{C}}{2} \cdot \left( \frac{1.32\,\text{electrons/cm}^3 \cdot 3.01\,\text{electrons/cm}^3}{1.32\,\text{electrons/cm}^3 + 3.01\,\text{electrons/cm}^3} \right) \cdot \frac{1}{2\,\text{V}}}$$

## 2) Zero Bias Sidewall Junction Capacitance Formula

Evaluate Formula

Formula

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

Example with Units

$$1E\text{-}7\,\text{F} = \sqrt{\frac{11.7 \cdot 1.6E\text{-}19\,\text{C}}{2} \cdot \left( \frac{0.35\,\text{electrons/m}^3 \cdot 3.01\,\text{electrons/cm}^3}{0.35\,\text{electrons/m}^3 + 3.01\,\text{electrons/cm}^3} \right) \cdot \frac{1}{0.000032\,\text{V}}}$$

## 3) Cascode Configuration Formulas

### 3.1) Downwards Resistance of Cascode Differential Half Circuit Formula

Evaluate Formula

Formula

$$R_{on} = \left( g_m \cdot R_{02} \right) \cdot R'_1$$

Example with Units

$$1.3195\,\text{k}\Omega = \left( 0.25\,\text{mS} \cdot 0.91\,\text{k}\Omega \right) \cdot 5.80\,\text{k}\Omega$$

### 3.2) Upwards Resistance of Cascode Differential Half-Circuit Formula

Evaluate Formula

Formula

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

Example with Units

$$0.5574\,\text{k}\Omega = \left( 0.25\,\text{mS} \cdot 0.91\,\text{k}\Omega \right) \cdot 2.45\,\text{k}\Omega$$

### 3.3) Voltage Gain of Cascode Differential Amplifier given Transconductance Formula

Evaluate Formula

Formula

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

Example with Units

$$0.8065 = \frac{25\,\text{V}}{31\,\text{V}}$$

## 4) DC Offset Formulas

### 4.1) Current on Operation with Differential Input Voltage Formula

Evaluate Formula

Formula

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

Example with Units

$$0.6298\,\text{mA} = \frac{1}{2} \cdot \left( 0.02\,\text{mS} \cdot 5 \right) \cdot \left( 23.049\,\text{V} - 19.5\,\text{V} \right)^2$$

### 4.2) Maximum Differential Input Voltage of MOSFET given Overdrive Voltage Formula

Evaluate Formula

Formula

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

Example with Units

$$3.5355\,\text{V} = \sqrt{2} \cdot 2.50\,\text{V}$$

### 4.3) Offset Voltage of MOSFET with Current-Mirror Load Formula

Evaluate Formula

Formula

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

Example with Units

$$-3.5455\,\text{V} = -\frac{2 \cdot 19.5\,\text{V}}{11}$$

### 4.4) Output Voltage of Voltage Amplifier Formula

Evaluate Formula

Formula

$$V_{out} = V_s - \left( I_d \cdot R_L \right)$$

Example with Units

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

## 5) Differential Configuration Formulas

### 5.1) Differential Voltage Gain in MOS Differential Amplifier Formula

Evaluate Formula

Formula

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

Example with Units

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

## 5.2) Input Offset Voltage of MOS Differential Amplifier Formula

Evaluate Formula

Formula

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

Example with Units

$$3.54\text{v} = \frac{24.78\text{v}}{7}$$

## 5.3) Input Offset Voltage of MOS Differential Amplifier given Saturation Current Formula

Evaluate Formula

Formula

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

Example with Units

$$3.5616\text{v} = 19.5\text{v} \cdot \left(\frac{0.8\,\text{mA}}{4.38\,\text{mA}}\right)$$

## 5.4) Input Offset Voltage of MOS Differential Amplifier when Aspect Ratio Mismatches Formula

Evaluate Formula

Formula

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

Example with Units

$$3.5311\text{v} = \left(\frac{2.50\text{v}}{2}\right) \cdot \left(\frac{5}{1.77}\right)$$

## 5.5) Input Voltage of MOS Differential Amplifier on Small-Signal Operation Formula

Evaluate Formula

Formula

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

Example with Units

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

## 5.6) Maximum Input Common-Mode Range of MOS Differential Amplifier Formula

Evaluate Formula

Formula

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

Example with Units

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

## 5.7) Minimum Input Common-Mode Range of MOS Differential Amplifier Formula

Evaluate Formula

Formula

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

Example with Units

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

## 5.8) Total Input Offset Voltage of MOS Differential Amplifier given Saturation Current Formula

Evaluate Formula

Formula

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

Example with Units

$$3.5439\text{v} = \sqrt{\left(\frac{1.805\,\text{k}\Omega}{0.51\,\text{k}\Omega}\right)^2 + \left(\frac{0.8\,\text{mA}}{4.38\,\text{mA}}\right)^2}$$

### 5.9) Transconductance of MOS Differential Amplifier on Small-Signal Operation Formula

Evaluate Formula

Formula

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

Example with Units

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

## 6) Gain Formulas

### 6.1) Common-Mode Current Gain of Controlled Source Transistor Formula

Evaluate Formula

Formula

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

Example with Units

$$-1.5748 = -\left(\frac{1}{2 \cdot 0.25\,\text{mS} \cdot 1.27\,\text{k}\Omega}\right)$$

### 6.2) Common-Mode Gain of Controlled Source Transistor Formula

Evaluate Formula

Formula

$$A_{cm} = 20 \cdot \log10\left(\frac{V_{ss}}{V_{is}}\right)$$

Example with Units

$$6.2513\,\text{dB} = 20 \cdot \log10\left(\frac{7.25\,\text{V}}{3.53\,\text{V}}\right)$$

## Variables used in list of MOSFET Amplifiers Formulas above

- $A_{cm}$ 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)*

## Constants, Functions, Measurements used in list of MOSFET Amplifiers Formulas above

- constant(s): **[Charge-e]**, 1.60217662E-19
  *Charge of electron*
- constant(s): **[Permittivity-silicon]**, 11.7
  *Permittivity of silicon*
- 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: **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 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: **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*

- $V_{cm}$ 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
- $\beta$ Common Emitter Current Gain
- $\beta_{forced}$ Forced Common-Emitter Current Gain
- $\Delta R_c$ Change in Collector Resistance *(Kilohm)*
- $\varepsilon_{si}$ Permitivity of Silicon *(Farad per Meter)*
- $\Phi_o$ Built in Junction Potential *(Volt)*
- $\Phi_{osw}$ Built in Potential of Sidewall Junctions *(Volt)*

## Download other Important Amplifiers PDFs

- Important Amplifier Characteristics Formulas
- Important Amplifier Functions and Network Formulas
- Important BJT Differential Amplifiers Formulas
- Important Feedback Amplifiers Formulas
- Important Low Frequency Response Amplifiers Formulas
- Important MOSFET Amplifiers Formulas
- Important Operational Amplifiers Formulas
- Important Output Stages and Power Amplifiers Formulas
- Important Signal and IC Amplifiers Formulas

## Try our Unique Visual Calculators

- Percentage of number
- LCM calculator
- Simple fraction

Please SHARE this PDF with someone who needs it!

## This PDF can be downloaded in these languages

English Spanish French German Russian Italian Portuguese Polish Dutch

*7/8/2024 | 7:32:25 AM UTC*