Important RF Microelectronics Formulas PDF

Formulas
Examples
with Units

List of 18
Important RF Microelectronics Formulas

1) Drain Current of Low Noise Amplifier Formula

Evaluate Formula

Formula

$$I_d = \frac{g_m \cdot \left(V_{gs} - V_{th} \right)}{2}$$

Example with Units

$$11.99\,\text{A} = \frac{2.18\,\text{S} \cdot \left(43\,\text{V} - 32\,\text{V} \right)}{2}$$

2) Drain Resistance of Low Noise Amplifier Formula

Evaluate Formula

Formula

$$R_d = \frac{A_v}{g_m}$$

Example with Units

$$3.6697\,\Omega = \frac{8}{2.18\,\text{S}}$$

3) Energy Stored in all Unit Capacitances Formula

Evaluate Formula

Formula

$$E_{tot} = \left(\frac{1}{2}\right) \cdot C_u \cdot \left(\sum \left(x, 1, K, \left(\left(\frac{n}{K} \right)^2 \right) \cdot \left(\left(V_1 \right)^2 \right) \right) \right)$$

Example with Units

$$37.5\,\text{J} = \left(\frac{1}{2}\right) \cdot 6\,\text{F} \cdot \left(\sum \left(x, 1, 2, \left(\left(\frac{2}{2} \right)^2 \right) \cdot \left(\left(2.5\,\text{V} \right)^2 \right) \right) \right)$$

4) Equivalent Capacitance for n Stacked Spirals Formula

Evaluate Formula

Formula

$$C_{eq} = 4 \cdot \frac{\left(\sum \left(x, 1, N - 1, C_m + C_s \right) \right)}{3 \cdot \left(\left(N \right)^2 \right)}$$

Example with Units

$$2.6667\,\text{F} = 4 \cdot \frac{\left(\sum \left(x, 1, 2 - 1, 4.5\,\text{F} + 3.5\,\text{F} \right) \right)}{3 \cdot \left(\left(2 \right)^2 \right)}$$

5) Feedback Factor of Low Noise Amplifier Formula

Evaluate Formula

Formula

$$\alpha = \frac{g_m \cdot R_s - 1}{2 \cdot g_m \cdot R_s \cdot A_v}$$

Example with Units

$$0.0613 = \frac{2.18\,\text{S} \cdot 23\,\Omega - 1}{2 \cdot 2.18\,\text{S} \cdot 23\,\Omega \cdot 8}$$

6) Gate to Source Voltage of Low Noise Amplifier Formula

Evaluate Formula

Formula

$$V_{gs} = \left(\frac{2 \cdot I_d}{g_m}\right) + V_{th}$$

Example with Units

$$43\,\text{V} = \left(\frac{2 \cdot 11.99\,\text{A}}{2.18\,\text{S}}\right) + 32\,\text{V}$$

7) Input Impedance of Low Noise Amplifier Formula

Evaluate Formula

Formula

$$Z_{in} = \left(\frac{1}{g_m}\right) + \alpha \cdot Z_l$$

Example with Units

$$1.0695\,\Omega = \left(\frac{1}{2.18\,\text{S}}\right) + 0.06 \cdot 10.18\,\Omega$$

8) Load Impedance of Low Noise Amplifier Formula

Evaluate Formula

Formula

$$Z_l = \frac{Z_{in} - \left(\frac{1}{g_m}\right)}{\alpha}$$

Example with Units

$$10.1881\,\Omega = \frac{1.07\,\Omega - \left(\frac{1}{2.18\,\text{S}}\right)}{0.06}$$

9) Noise Figure of Low Noise Amplifier Formula

Evaluate Formula

Formula

$$NF = 1 + \left(\frac{4 \cdot R_s}{R_f}\right) + \gamma$$

Example with Units

$$14.8286\,\text{dB} = 1 + \left(\frac{4 \cdot 23\,\Omega}{35\,\Omega}\right) + 11.2$$

10) Output Impedance of Low Noise Amplifier Formula

Evaluate Formula

Formula

$$R_{out} = \left(\frac{1}{2}\right) \cdot \left(R_f + R_s\right)$$

Example with Units

$$29\,\Omega = \left(\frac{1}{2}\right) \cdot \left(35\,\Omega + 23\,\Omega\right)$$

11) Return Loss of Low-Noise Amplifier Formula

Evaluate Formula

Formula

$$\Gamma = \text{mod}\,\underline{us}\left(\frac{Z_{in} - R_s}{Z_{in} + R_s}\right)^2$$

Example with Units

$$0.8301\,\text{dB} = \text{mod}\,\underline{us}\left(\frac{1.07\,\Omega - 23\,\Omega}{1.07\,\Omega + 23\,\Omega}\right)^2$$

12) Source Impedance of Low Noise Amplifier Formula

Evaluate Formula

Formula	Example with Units
$R_s = 2 \cdot R_{out} - R_f$	$23\,\Omega = 2 \cdot 29\,\Omega - 35\,\Omega$

13) Threshold Voltage of Low Noise Amplifier Formula

Evaluate Formula

Formula	Example with Units
$V_{th} = V_{gs} - \frac{2 \cdot I_d}{g_m}$	$32\,V = 43\,V - \frac{2 \cdot 11.99\,A}{2.18\,S}$

14) Total Noise Power Introduced by Interferer Formula

Evaluate Formula

Formula	Example with Units
$P_{n,tot} = \int \left(S_n[x] \cdot x, x, f_L, f_H \right)$	$19.698\,kW = \int \left(7\,Hz \cdot x, x, 46\,Hz, 88\,Hz \right)$

15) Total Power Lost in Spiral Formula

Evaluate Formula

Formula	Example with Units
$P_{tot} = \sum \left(x, 1, K, \left(\left(I_{u,n} \right)^2 \right) \cdot KR_s \right)$	$160\,W = \sum \left(x, 1, 2, \left(\left(4\,A \right)^2 \right) \cdot 5\,\Omega \right)$

16) Transconductance of Low Noise Amplifier Formula

Evaluate Formula

Formula	Example with Units
$g_m = \frac{2 \cdot I_d}{V_{gs} - V_{th}}$	$2.18\,S = \frac{2 \cdot 11.99\,A}{43\,V - 32\,V}$

17) Voltage Gain of Low Noise Amplifier Formula

Evaluate Formula

Formula	Example with Units
$A_v = g_m \cdot R_d$	$7.848 = 2.18\,S \cdot 3.6\,\Omega$

18) Voltage Gain of Low Noise Amplifier given DC Voltage Drop Formula

Evaluate Formula

Formula	Example with Units
$A_v = 2 \cdot \frac{V_{rd}}{V_{gs} - V_{th}}$	$8 = 2 \cdot \frac{44\,V}{43\,V - 32\,V}$

Variables used in list of RF Microelectronics Formulas above

- A_v Voltage Gain
- C_{eq} Equivalent Capacitance of N Stacked Spirals *(Farad)*
- C_m Inter Spiral Capacitance *(Farad)*
- C_s Substrate Capacitance *(Farad)*
- C_u Value of Unit capacitance *(Farad)*
- E_{tot} Energy Stored in All Unit Capacitances *(Joule)*
- f_H Higher End of the Desired Channel *(Hertz)*
- f_L Lower End of the Desired Channel *(Hertz)*
- g_m Transconductance *(Siemens)*
- I_d Drain Current *(Ampere)*
- $I_{u,n}$ Corresponding RC Branch Current *(Ampere)*
- **K** Number of Inductors
- KR_s Substrate Resistance *(Ohm)*
- **n** Value of Node N
- **N** Number of Stacked Spirals
- **NF** Noise Figure *(Decibel)*
- $P_{n,tot}$ Total Noise Power of Interferer *(Kilowatt)*
- P_{tot} Total Power Lost in Spiral *(Watt)*
- R_d Drain Resistance *(Ohm)*
- R_f Feedback Resistance *(Ohm)*
- R_{out} Output Impedance *(Ohm)*
- R_s Source Impedance *(Ohm)*
- $S_n[x]$ Broadened Spectrum of Interferer *(Hertz)*
- V_1 Input Voltage *(Volt)*
- V_{gs} Gate to Source Voltage *(Volt)*
- V_{rd} DC Voltage Drop *(Volt)*
- V_{th} Threshold Voltage *(Volt)*
- Z_{in} Input Impedance *(Ohm)*
- Z_l Load Impedance *(Ohm)*
- α Feedback Factor

Constants, Functions, Measurements used in list of RF Microelectronics Formulas above

- Functions: **int**, int(expr, arg, from, to)
  The definite integral can be used to calculate net signed area, which is the area above the x -axis minus the area below the x -axis.
- Functions: **modulus**, modulus
  Modulus of a number is the remainder when that number is divided by another number.
- Functions: **sum**, sum(i, from, to, expr)
  Summation or sigma (∑) notation is a method used to write out a long sum in a concise way.
- Measurement: **Electric Current** in Ampere (A)
  Electric Current Unit Conversion
- Measurement: **Energy** in Joule (J)
  Energy Unit Conversion
- Measurement: **Power** in Kilowatt (kW), Watt (W)
  Power Unit Conversion
- Measurement: **Noise** in Decibel (dB)
  Noise Unit Conversion
- Measurement: **Frequency** in Hertz (Hz)
  Frequency Unit Conversion
- Measurement: **Capacitance** in Farad (F)
  Capacitance Unit Conversion
- Measurement: **Electric Resistance** in Ohm (Ω)
  Electric Resistance Unit Conversion
- Measurement: **Electric Potential** in Volt (V)
  Electric Potential Unit Conversion
- Measurement: **Transconductance** in Siemens (S)
  Transconductance Unit Conversion

- **γ** Noise Factor of Transistor
- **Γ** Return Loss *(Decibel)*

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