Important CMOS Design Characteristics Formulas PDF

Formulas
Examples
with Units

List of 24
Important CMOS Design Characteristics Formulas

1) Adjacent Capacitance Formula

Evaluate Formula

Formula

$$C_{adj} = \frac{V_{tm} \cdot C_{gnd}}{V_{agr} - V_{tm}}$$

Example with Units

$$7.9989\,\text{pF} = \frac{12.75\,\text{V} \cdot 2.98\,\text{pF}}{17.5\,\text{V} - 12.75\,\text{V}}$$

2) Agression Driver Formula

Evaluate Formula

Formula

$$R_{agr} = \frac{R_{vi} \cdot k \cdot \left(C_{adj} + C_{gnd} \right)}{C_{ga} + C_{adj}}$$

Example with Units

$$1.1233 = \frac{1.98 \cdot 0.62 \cdot \left(8\,\text{pF} + 2.98\,\text{pF} \right)}{4\,\text{pF} + 8\,\text{pF}}$$

3) Agression Time Constant Formula

Evaluate Formula

Formula

$$\tau_{agr} = k \cdot \tau_{vi}$$

Example

$$1.2462 = 0.62 \cdot 2.01$$

4) Agressor Voltage Formula

Evaluate Formula

Formula

$$V_{agr} = \frac{V_{tm} \cdot \left(C_{gnd} + C_{adj} \right)}{C_{adj}}$$

Example with Units

$$17.4994\,\text{V} = \frac{12.75\,\text{V} \cdot \left(2.98\,\text{pF} + 8\,\text{pF} \right)}{8\,\text{pF}}$$

5) Branching Effort Formula

Evaluate Formula

Formula

$$b = \frac{C_{onpath} + C_{offpath}}{C_{onpath}}$$

Example with Units

$$3.8125 = \frac{3.2\,\text{pF} + 9\,\text{pF}}{3.2\,\text{pF}}$$

6) Built-in Potential Formula

Evaluate Formula

Formula

$$\psi_o = V_t \cdot \ln\left(\frac{N_a \cdot N_d}{n_i^2}\right)$$

Example with Units

$$18.8181\,\text{V} = 0.55\,\text{V} \cdot \ln\left(\frac{1100\,\text{1/m}^3 \cdot 1.9e14\,\text{1/m}^3}{17^2}\right)$$

7) Capacitance Offpath Formula

Evaluate Formula

Formula

$$C_{offpath} = C_t - C_{onpath}$$

Example with Units

$$9\,\text{pF} = 12.2\,\text{pF} - 3.2\,\text{pF}$$

8) Capacitance Onpath Formula

Evaluate Formula

Formula

$$C_{onpath} = C_t - C_{offpath}$$

Example with Units

$$3.2\,\text{pF} = 12.2\,\text{pF} - 9\,\text{pF}$$

9) Change in Frequency Clock Formula

Evaluate Formula

Formula

$$\Delta f = K_{vco} \cdot V_{ctrl}$$

Example with Units

$$0.07\,\text{Hz} = 0.01 \cdot 7\,\text{V}$$

10) Ground to Agression Capacitance Formula

Evaluate Formula

Formula

$$C_{adj} = \frac{\left(R_{vi} \cdot k \cdot C_{gnd}\right) - \left(R_{agr} \cdot C_{ga}\right)}{R_{agr} - R_{vi} \cdot k}$$

Example with Units

$$8.8294\,\text{pF} = \frac{\left(1.98 \cdot 0.62 \cdot 2.98\,\text{pF}\right) - \left(1.13 \cdot 4\,\text{pF}\right)}{1.13 - 1.98 \cdot 0.62}$$

11) Lock Voltage Formula

Evaluate Formula

Formula

$$V_{lock} = V_{ctrl} - V_{offl}$$

Example with Units

$$2\,\text{V} = 7\,\text{V} - 5\,\text{V}$$

12) Off-Path Capacitance of CMOS Formula

Evaluate Formula

Formula

$$C_{offpath} = C_{onpath} \cdot \left(b - 1\right)$$

Example with Units

$$8.992\,\text{pF} = 3.2\,\text{pF} \cdot \left(3.81 - 1\right)$$

13) Output Clock Phase Formula

Evaluate Formula

Formula

$$\Phi_{out} = 2 \cdot \pi \cdot V_{ctrl} \cdot K_{vco}$$

Example with Units

$$0.4398 = 2 \cdot 3.1416 \cdot 7\,\text{V} \cdot 0.01$$

14) Static Current Formula

Evaluate Formula

Formula

$$i_{static} = \frac{P_{static}}{V_{bc}}$$

Example with Units

$$2.9406\,\text{mA} = \frac{5.94\,\text{mW}}{2.02\,\text{V}}$$

15) Static Power Dissipation Formula

Evaluate Formula

Formula

$$P_{static} = i_{static} \cdot V_{bc}$$

Example with Units

$$5.9994\,\text{mW} = 2.97\,\text{mA} \cdot 2.02\,\text{V}$$

16) Thermal Voltage of CMOS Formula

Evaluate Formula

Formula

$$V_t = \frac{\psi_o}{\ln\left(\frac{N_a \cdot N_d}{{n_i}^2}\right)}$$

Example with Units

$$0.5495\,\text{V} = \frac{18.8\,\text{V}}{\ln\left(\frac{1100\,\text{1/m}^3 \cdot 1.9e14\,\text{1/m}^3}{17^2}\right)}$$

17) Time Constant Ratio of Agression to Victim Formula

Evaluate Formula

Formula

$$k = \frac{\tau_{agr}}{\tau_{vi}}$$

Example

$$0.6169 = \frac{1.24}{2.01}$$

18) Total Capacitance Seen by Stage Formula

Evaluate Formula

Formula

$$C_t = C_{onpath} + C_{offpath}$$

Example with Units

$$12.2\,\text{pF} = 3.2\,\text{pF} + 9\,\text{pF}$$

19) VCO Control Voltage Formula

Evaluate Formula

Formula

$$V_{ctrl} = V_{lock} + V_{offl}$$

Example with Units

$$7\,\text{V} = 2\,\text{V} + 5\,\text{V}$$

20) VCO Offset Voltage Formula

Evaluate Formula

Formula

$$V_{offl} = V_{ctrl} - V_{lock}$$

Example with Units

$$5\,\text{V} = 7\,\text{V} - 2\,\text{V}$$

21) VCO Single Gain Factor Formula

Evaluate Formula

Formula

$$K_{vco} = \frac{\Delta f}{V_{ctrl}}$$

Example with Units

$$0.0114 = \frac{0.08\,\text{Hz}}{7\,\text{V}}$$

22) Victim Driver Formula

Evaluate Formula

Formula

$$R_{vi} = \frac{R_{agr} \cdot \left(C_{ga} + C_{adj} \right)}{k \cdot \left(C_{adj} + C_{gnd} \right)}$$

Example with Units

$$1.9919 = \frac{1.13 \cdot \left(4\,\text{pF} + 8\,\text{pF} \right)}{0.62 \cdot \left(8\,\text{pF} + 2.98\,\text{pF} \right)}$$

23) Victim Time Constant Formula

Evaluate Formula

Formula

$$\tau_{vi} = \frac{\tau_{agr}}{k}$$

Example

$$2 = \frac{1.24}{0.62}$$

24) Victim Voltage Formula

Evaluate Formula

Formula

$$V_{tm} = \frac{V_{agr} \cdot C_{adj}}{C_{gnd} + C_{adj}}$$

Example with Units

$$12.7505\,\text{V} = \frac{17.5\,\text{V} \cdot 8\,\text{pF}}{2.98\,\text{pF} + 8\,\text{pF}}$$

Variables used in list of CMOS Design Characteristics Formulas above

- **b** Branching Effort
- C_{adj} Adjacent Capacitance *(Picofarad)*
- C_{ga} Ground A Capacitance *(Picofarad)*
- C_{gnd} Ground Capacitance *(Picofarad)*
- $C_{offpath}$ Capacitance Offpath *(Picofarad)*
- C_{onpath} Capacitance Onpath *(Picofarad)*
- C_t Total Capacitance in Stage *(Picofarad)*
- i_{static} Static Current *(Milliampere)*
- **k** Time Constant Ratio
- K_{vco} VCO Gain
- N_a Acceptor Concentration *(1 per Cubic Meter)*
- N_d Donor Concentration *(1 per Cubic Meter)*
- n_i Intrinsic Electron Concentration
- P_{static} Static Power *(Milliwatt)*
- R_{agr} Agression Driver
- R_{vi} Victim Driver
- V_{agr} Agressor Voltage *(Volt)*
- V_{bc} Base Collector Voltage *(Volt)*
- V_{ctrl} VCO Control Voltage *(Volt)*
- V_{lock} Lock Voltage *(Volt)*
- V_{offl} VCO Offset Voltage *(Volt)*
- V_t Thermal Voltage *(Volt)*
- V_{tm} Victim Voltage *(Volt)*
- Δf Change in Frequency of Clock *(Hertz)*
- τ_{agr} Agression Time Constant
- τ_{vi} Victim Time Constant
- Φ_{out} Output Clock Phase
- ψ_o Built-in Potential *(Volt)*

Constants, Functions, Measurements used in list of CMOS Design Characteristics Formulas above

- constant(s): **pi**, 3.14159265358979323846264338327950288 *Archimedes' constant*
- Functions: **ln**, ln(Number) *The natural logarithm, also known as the logarithm to the base e, is the inverse function of the natural exponential function.*
- Measurement: **Electric Current** in Milliampere (mA) *Electric Current Unit Conversion*
- Measurement: **Power** in Milliwatt (mW) *Power Unit Conversion*
- Measurement: **Frequency** in Hertz (Hz) *Frequency Unit Conversion*
- Measurement: **Capacitance** in Picofarad (pF) *Capacitance Unit Conversion*
- Measurement: **Electric Potential** in Volt (V) *Electric Potential Unit Conversion*
- Measurement: **Carrier Concentration** in 1 per Cubic Meter ($1/m^3$) *Carrier Concentration Unit Conversion*

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