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CMOS Design Characteristics Formulas

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List of 24 CMOS Design Characteristics Formulas

CMOS Design Characteristics

1) Adjacent Capacitance

Open Calculator

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

ex $$7.998947\text{pF} = \frac{12.75\text{V} \cdot 2.98\text{pF}}{17.5\text{V} - 12.75\text{V}}$$

2) Agression Driver

Open Calculator

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

ex $$1.123254 = \frac{1.98 \cdot 0.62 \cdot (8\text{pF} + 2.98\text{pF})}{4\text{pF} + 8\text{pF}}$$

3) Agression Time Constant

Open Calculator

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

ex $$1.2462 = 0.62 \cdot 2.01$$

4) Agressor Voltage

Open Calculator

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

$$17.49938V = \frac{12.75V \cdot (2.98pF + 8pF)}{8pF}$$

5) Branching Effort

Open Calculator

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

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

6) Built-in Potential

Open Calculator

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

$$18.81808V = 0.55V \cdot \ln\left(\frac{1100/m^3 \cdot 1.9e14/m^3}{(17)^2}\right)$$

7) Capacitance Offpath

Open Calculator

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

$$9pF = 12.2pF - 3.2pF$$

8) Capacitance Onpath

Open Calculator

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

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

9) Change in Frequency Clock

Open Calculator

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

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

10) Ground to Agression Capacitance

Open Calculator

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

$$8.829426\text{pF} = \frac{(1.98 \cdot 0.62 \cdot 2.98\text{pF}) - (1.13 \cdot 4\text{pF})}{1.13 - 1.98 \cdot 0.62}$$

11) Lock Voltage

Open Calculator

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

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

12) Off-Path Capacitance of CMOS

Open Calculator

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

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

13) Output Clock Phase

Open Calculator

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

ex $0.439823 = 2 \cdot \pi \cdot 7V \cdot 0.01$

14) Static Current

Open Calculator

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

ex $2.940594mA = \frac{5.94mW}{2.02V}$

15) Static Power Dissipation

Open Calculator

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

ex $5.9994mW = 2.97mA \cdot 2.02V$

16) Thermal Voltage of CMOS

Open Calculator

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

ex $0.549472V = \frac{18.8V}{\ln\left(\frac{1100/m^3 \cdot 1.9e14/m^3}{(17)^2}\right)}$

17) Time Constant Ratio of Agression to Victim

Open Calculator

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

ex $$0.616915 = \frac{1.24}{2.01}$$

18) Total Capacitance Seen by Stage

Open Calculator

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

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

19) VCO Control Voltage

Open Calculator

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

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

20) VCO Offset Voltage

Open Calculator

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

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

21) VCO Single Gain Factor

Open Calculator

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

$$0.011429 = \frac{0.08\text{Hz}}{7\text{V}}$$

22) Victim Driver

Open Calculator

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

$$1.991891 = \frac{1.13 \cdot (4\text{pF} + 8\text{pF})}{0.62 \cdot (8\text{pF} + 2.98\text{pF})}$$

23) Victim Time Constant

Open Calculator

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

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

24) Victim Voltage

Open Calculator

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

$$12.75046\text{V} = \frac{17.5\text{V} \cdot 8\text{pF}}{2.98\text{pF} + 8\text{pF}}$$

Variables Used

- **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

- Constant: **pi**, 3.14159265358979323846264338327950288
  Archimedes' constant
- Function: **ln**, ln(Number)
  Natural logarithm function (base e)
- 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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