Power

Monday, February 22, 2010
09:17

Total Energy

$H \to L \to H$ (1 transition cycle)

$E_{dynamic} = C_L V_{DD}^2$

$P_{dynamic} = C_L V_{DD}^2 f_{1\to 0}$

↗ frequency of energy consuming transitions

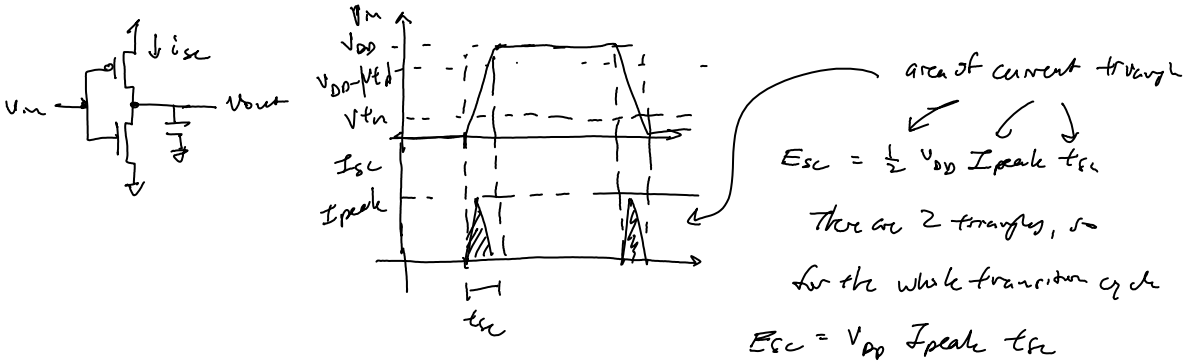
$P_{dynamic} = C_L V_{DD}^2 f \cdot P_{1\to 0 \text{ input}}$

$= V_{DD}^2 f \cdot C_{eff}$ $\quad C_{eff} = C_L \cdot P_{0\to 1}$ (activity)

To reduce $P_{dynamic}$:

freq ↓, V_{DD} ↓, C_L ↓

Short Circuit Current



area of current triangle

$E_{sc} = \frac{1}{2} V_{DD} I_{peak} t_{sc}$

There are 2 triangles, so for the whole transition cycle

$E_{sc} = V_{DD} I_{peak} t_{sc}$

$P_{sc} = V_{DD} I_{peak} t_{sc} f$

Assuming linear rise/fall curve:

$$t_{sc} = \frac{V_{DD} - V_{Tn} - |V_{tp}|}{V_{DD}} \cdot t_{in \to V_{DD}}$$

↗ rise time of input

$$\simeq \frac{t_r}{0.8}$$

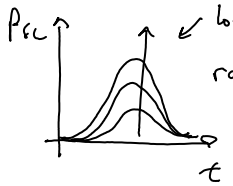
Thus:

$$P_{sc} = V_{DD} I_{peak} f \frac{V_{DD} - 2V_T}{V_{DD}} \cdot \frac{t_r}{0.8}$$

How to reduce P_{sc}?

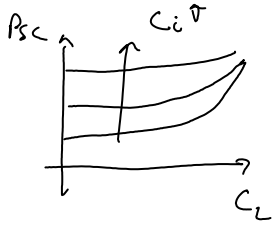
$\Rightarrow$ V_{DD} ↓ $\quad V_{DD} < 2V_T$ $\quad \frac{W}{L}$ ↓ $\quad t_r$ ↓↓ ← make input switch super fast

If C_L is low enough, most of the energy goes to charging it up as opposed to short-circuiting.



raises P_{SC} (but decreases performance and causes power loss to charging it up)

all we're doing is shifting the problem around



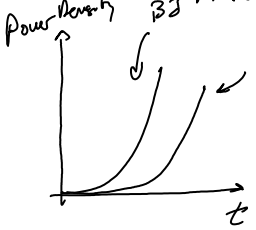
as your rise time increases (C_i), P_{SC} gets worse

3 types of power

$P_{dynamic}$ → circuit is doing work, power loss is ok

P_{SC} → sad, but mostly unavoidable

$P_{leakage}$ → almost equal to $P_{dynamic}$ in deep submicron



We're in big trouble!

→ We're squeezing the last drops out of CMOS by making every power conserving trick