Homework 2

1.a) $\overbrace{A_{N-1}\, A_{N-2} \ldots A_1\, A_0}^{N \text{ bits of address}}$, with $A_{N-1} A_{N-2}$ marked as "k-bit groups"

$\frac{N}{K} = \#$ groups

$2^K = \#$ comb / group

Total transistors = Trans for group Combinations + Trans for Output gates

$$= \underbrace{\left(\frac{N}{K}\right)}_{\text{groups}} \cdot 2^K \left(\frac{\text{comb}}{\text{group}}\right) \cdot 2K \left(\frac{\text{trans}}{\text{comb}}\right)$$

$$+ \underbrace{2^N}_{\#\text{ outputs}} \cdot 2\left(\frac{N}{K}\right) \quad \frac{\text{trans}}{\text{output}}$$

$$\text{Total} = \frac{N}{K} \cdot 2^K \cdot 2K + 2^N \cdot 2 \cdot \frac{N}{K}$$

$$\boxed{\text{Total} = N \cdot 2^{K+1} + \frac{2^{N+1} N}{K}}$$

b) $$\frac{d\,\text{Total}}{dk} = N\, 2^{(K+1)} \ln(2) - \frac{2^{(N+1)} N}{K^2}$$

set $\frac{d\,\text{Total}}{dk} = 0$

$$N\, 2^{K+1} \ln(2) = \frac{2^{N+1} N}{K^2}$$

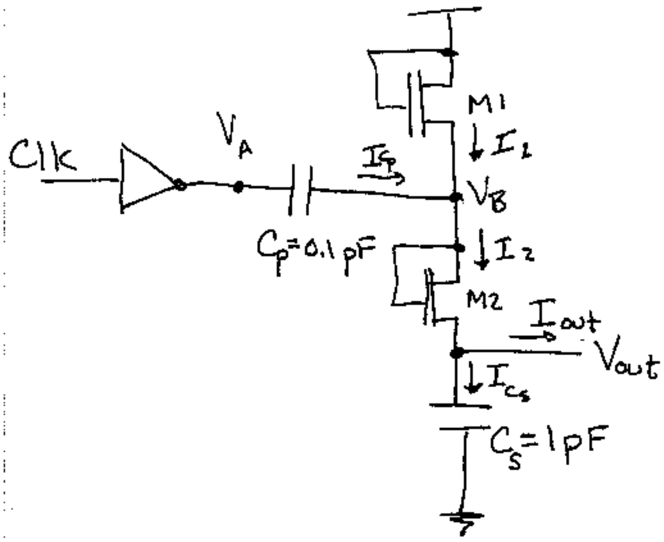
$$\boxed{K^2\, 2^{K+1} = \frac{2^{N+1}}{\ln(2)}}$$

c) Every group gate will be connected to $(\frac{N}{K}-1) \cdot 2^K$ output gates which will provide a fan out for load capacitance of group gates. Also have to account for parasitics of routing from group gates to output gates.

Because of potentially large numbers of series transistors, Need to use Elmore's formula to find rising & falling times for each gate.

Need to find load capacitance of output gates.

Charge Pump Problem



$I_{out} = 1\mu A$

(a) What clock frequency is required to maintain 10 mV ripple

When V_{out} is falling $I_{Cs} = -I_{OUT}$ because $I_2 = 0$ because M2 is off.

To fall 10 mV we have

$$I_{Cs} = C_s \frac{dV_{OUT}}{dt} \Rightarrow dt = C_s \frac{dV_{out}}{I_{Cs}}$$

$$t = 1pF \frac{10mV}{1\mu A} = 10nS$$

Clock Period = 20nS

f_{clock} = 50 MHz

(b) FIND the Average V_{out} for 10 mV ripple

$$I_2 = \frac{\beta_n}{2}\left(V_B - V_{out} - V_{Tn}\right)^2$$

$$\frac{dV_{out}}{dt} = \frac{1}{C_s}\left(I_2 - 1\,\mu A\right) \geq 1\,\frac{V}{\mu s}$$

@ $t = 0$ $V_B = 2V_{DD} - V_{Tn}$ so we have

$$\frac{\beta_n}{2}\left(2V_{DD} - 2V_{Tn} - V_{out}\right)^2 \geq \left(1\frac{V}{\mu s}\right)\left(1\,pF\right) + 1\,\mu A$$

Solving for V_{out} gives

$$V_{out} \approx 5.7\ V$$