Midterm Friday

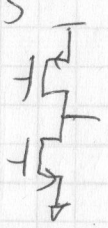
OH

HW - self-grade
- HW4 solutions

CS design

Cascode

CS



$$|A_{v0}| = |-g_m R_o| = \frac{2I_D}{V_{ov}}\left(\frac{1}{\lambda_n I_D} + \frac{1}{\lambda_p I_D}\right)$$

$$= \frac{1}{\lambda V_{ov}} \quad \text{if } \lambda_n = \lambda_p$$

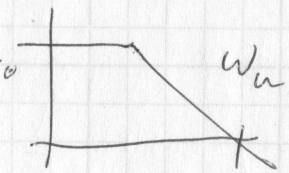
$$\lambda \approx \lambda_0 \frac{L_0}{L} \quad \underline{\text{roughly}}$$

HW4 shows dramatic change in λ for $10\times$ change in L

is $\frac{1}{\lambda I_D}$ a good model?

is V_{DSAT} a good model?

Spec A_{v0}



$$\omega_u = \frac{g_m}{C_{out}} \approx \frac{g_m}{C_L}$$

$$g_m = \frac{2I_D}{V_{ov}} = \mu_n C_{ox} \frac{W}{L} V_{ov}$$

minimum power:

smallest I_D w/ fixed $g_m = \overbrace{\omega_u C_L}^{\text{specs}}$

$\Rightarrow$ smallest $V_{ov} \approx 100mV$ quadratic model

(can do a little better w/ weak inversion)

& sub-V_t

but smaller V_{ov} & fixed g_m means larger $\frac{W}{L}$

$$g_m = \text{const} = \mu_n C_{ox} \underbrace{\frac{W}{L} V_{ov}}$$

$\Rightarrow$ more input capacitance

$\Rightarrow$ { slower input pole or
{ higher power input driver

with no gain constraint (any gain OK) then

double $V_{ov} \Rightarrow \frac{1}{2}\frac{W}{L} \Rightarrow \frac{1}{2}W$ (g_m constraint)

$\Rightarrow \frac{1}{2} A_V \quad (= \frac{1}{\lambda V_{ov}})$

$C_{in} = C_{gs} + (1-A) C_{gd}$

$\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$

$1/4$

typically Miller C_{gd} dominates at low freq.

but with a gain constraint

assume $\frac{1}{\lambda_0 V_{ov,min}} < A_{V,required}$

then must choose $L > L_0$ to set

λ smaller to meet gain spec.

Now doubling V_{ov} means we need

λ to decrease by 2 (gain spec)

L to increase by 2 (λ model)

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with gain constraint, cont.

so double V_{ov} means $\frac{1}{2}\frac{W}{L}$ (unity gain const)

but $2L$, so W remains the same

(gain constraint)

so $C_{in} = C_{gs} + (1-A) C_{gd}$

2x same same

low freq $C_{in} \approx$ same, a little bigger

high freq $C_{in} \approx C_{gs} = 2\times$ bigger

What if I need the lowest input cap?

i.e. $V_{ov} = 5-10\times V_{ov,min}$ (or nV_t)

$5\sim10\times$ C_{gs}, C_{gd} but terrible gain

options

- multiple stages
  OK, but problems w/ coupling, power, stability in feedback
- cascode
  OK, but problems w/ headroom (swing) and biasing