140/240A · 17 SP · W4L2

Midterm 1 in class F 2/17 1 pg 2 sides notes
no silicon!

Section W4-5 here if possible

HW4 due Wed next week

Lab week 5: no lab Th 10-11 OH
2-3+ Review
F 11-12 OH

Brad OH Th 11-12 F 10-11

My OH W 11-12 F 4-5 normally
wk 5: W 11-12, Th 3-4

HW4

CS tradeoffs

Last time: CS amp $A_{vo} = 100$, $\omega_p = 10^7$, $\omega_u = 10^9$ $C_L = 1pf$

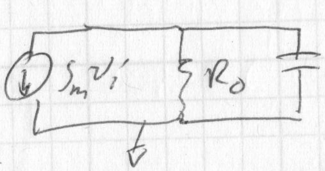
pick $V_{ovn} = V_{ovp} = 100mV$ & $r_{on} = r_{op}$

calculate $L = 0.5\mu m$ $\left(\frac{W}{L}\right)_n = 50$ $W_n = 25\mu$
$W_p = 50\mu$

$I_D = 50\mu A$ $g_m = 1mS$ $R_o = 100K$

step response

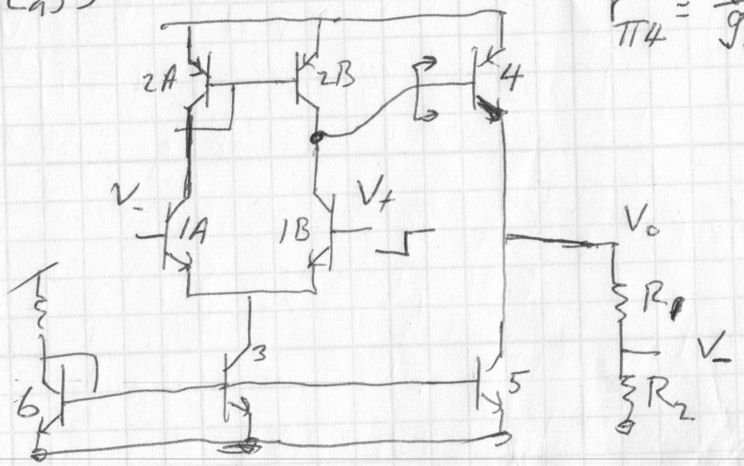
v_i o ... v_o



t/τ	$\frac{v_o/v_i}{A_{vo}}$	% error
1	63%	37%
3	95%	5%
5	99%	1%
7	99.9%	0.1%

$v_o = -g_m R_o \left(1 - e^{-t/\tau}\right) v_i$

Lab 3



$r_{\pi4} = \frac{\beta}{g_m}$

$f = \frac{R_2}{R_1 + R_2}$

$R_{o1} = r_{o1B} \| r_{o2B} \| r_{\pi4}$ $A_{v1} = g_{m1} R_{o1}$ $A_{v2} = g_{m4} R_{o2}$

$R_{o2} = r_{o4} \| r_{o5} \| R_{out}$

is C_L the right capacitance? what about C_{gdn} & C_{gdp}?

$C_{gd} = W C_{ol}'$

$C_{gdn} = (25\mu m)(0.1 fF/\mu m) = 2.5fF$

$C_{gdp} = 50\mu m(0.1 fF/\mu m) = 5fF$

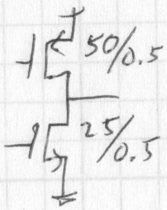
should add C_{dbn}, C_{dbp}

$\approx 10fF$ << 1pF fine

what about input? Say the source resistance is $1M\Omega$ (another amplifier say)

like $\tau_{in} = R_{in} C_{in} < 10^{-7}$ s

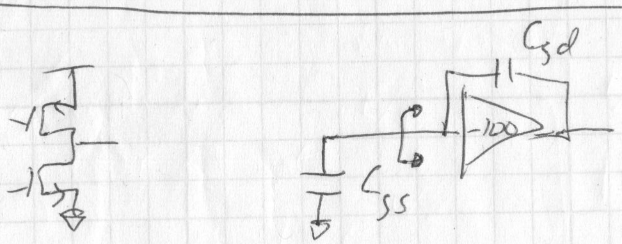
$\Rightarrow C_{in} < 10^{-13}$ F = 100fF input capacitance



$C_{gs} = (25\mu)(0.5\mu)(0.5\frac{fF}{\mu m^2}) + 2.5fF$

$= 6.1 + 2.5 = 8.6fF$

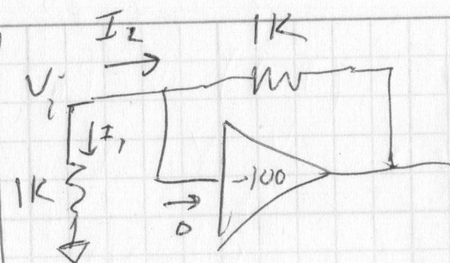
what about C_{gd}? <u>Miller</u>



$Q_{in} = V_i C_{gs} + C_{gd}(V_i - -100V_i) =$

$V_i [\underbrace{C_{gs} + \underbrace{(1-A)C_{gd}}_{C_{miller}}}_{C_{total}}]$

$C_{in} = 8.6fF + 101(2.5fF) = 260fF$



if $V_i = 1V$ $I_1 = 1mA$

$I_2 = 101mA$!

Negative gain works to <u>decrease</u> impedance of something strapped across it.

more voltage ⇒ more current ⇒ lower impedance

too high! How do we drop it?

Reduce A_{vo} - can't. It's a spec.

Reduce C_{gdn} ⇒ reduce W_n

Constrained by $g_m = \frac{2I_D}{V_{OV}}$ 2.18

$= \mu_n C_{ox} \frac{W}{L} V_{OV}$ .19

$= \sqrt{2\mu_n C_{ox} W I_D}$ .20

$W_n \searrow 5x \Rightarrow V_{OV} \nearrow 5X$ $I_D \nearrow 5X$

$W_n = 5\mu m$ $V_{ov} = 500mV$ $I_D = 250\mu A$

pick $W_p = 10\mu m$ $V_{ovp} = 500mV$ } affects output swing & cap.

or $W_p = 250\mu m$ $V_{ovp} = 100mV$

$C_{in} = C_{gsn} + C_{gdn}(1 - A_{vo})$

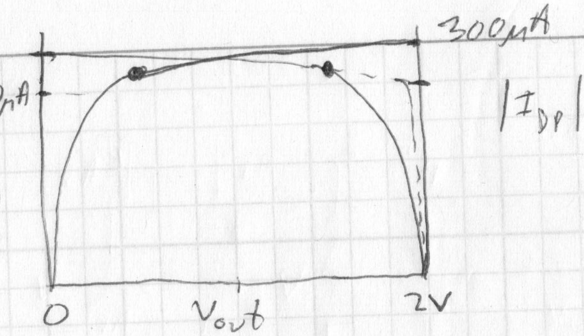
$= \frac{2}{3}(5\mu m^2)(5 \frac{fF}{\mu m^2}) + (5\mu m)(0.1 \frac{fF}{\mu m})(101)$

$= 12.5fF + \frac{101}{2} fF = 63fF$

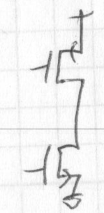
$< 100fF$

$\omega_{p,in} > \omega_{p,out}$

details of $\omega_{p,in}$ are for after mid 1



take a given CS amp



What happens if you:

double W_n, W_p? (2 parallel amps)

double L_n, L_p? W/L const.

double V_{OV}?

what effect on $I_D, g_m, r_o, A_v, \omega_p, \omega_u, C_{in}$?

	double W_n, W_p	double V_{OV}	double L $\frac{W}{L}$ const
I_D	2	4	1
g_m	2	2	1
r_o, R_o	1/2	1/4	2
A_v	1	1/2	2
ω_p	2	4	1/2
ω_u	2	2	1
C_{in}	2	$\approx \frac{1}{2}$	≈ 2
C_{out} parasitic	2 (assumes $C_L >> C_{outp}$)	1 swing!	2

What if I need high gain (small V_{ov}, long L) but low input cap? (or output)

big $\frac{W}{L}$

1) multiple stages

2) cascode - higher output impedance, lower input capacitance } good; lower swing, harder to bias } bad