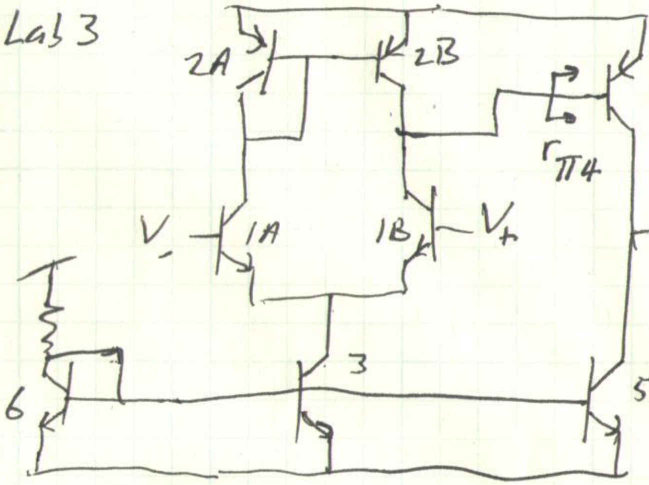
Midterm 1 in class Friday 2/16
Lab 2 due Tues
Lab 3 - part 1 tomorrow

HW 4 Due Wed

Lab 3



$r_{\pi 4} = \frac{\beta}{g_m}$

$= \frac{\beta V_{TH}}{I_C}$

Diode connected

$I_C = \frac{(V_{CC} - 0.7)}{R}$

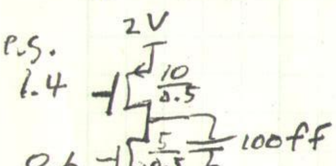
$A_{v1} = g_{m1} R_{O1}$

$R_{O1} = r_{o2B} \| r_{o1B} \| r_{\pi 4}$

$A_{v2} = -g_{m4} R_{O2}$

$R_{O2} = r_{o4} \| r_{o5} \| (R_1 + R_2)$

from last time: 4 different biases



4 wildly different g_m, A_v, ω_u

what if PMOS is input?

$g_m, r_o, A_v, \omega_p, \omega_u$? no change.

C_{in}: C_{gs}, C_{gd}

in saturation, quadratic model

$C_{gs} = \frac{2}{3} WL C_{ox} + W C'_{ol}$

$= \frac{2}{3}(5\mu)(0.5\mu)\left(\frac{5 fF}{\mu m^2}\right) + (5\mu m)\left(0.5 \frac{fF}{\mu m}\right)$

$= 8 fF + 2.5 fF \approx 11 fF$

$C_{gd} = W C'_{ol} = 2.5 fF$

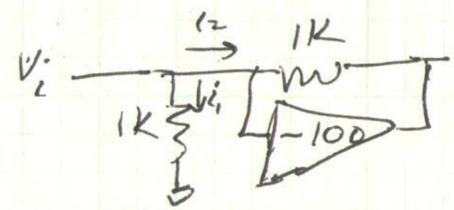
C_{gd}

intrinsic: can't make device work w/o it

extrinsic C'_{ol} parasitic overlap/fringe field.

C_{in} = sum? NO. Miller

Consider



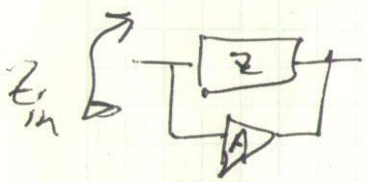
say $V_i = 1 mV \sin\omega t$ $i_1 = 1\mu A \sin(\omega t)$

$i_2 = 101 \mu A \sin(\omega t)$!

negative gain increases voltage across whatever passing is across it, by $(1-A)$

$\Rightarrow$ increases current by $1-A$

$\Rightarrow$ decreases apparent impedance by $1-A$

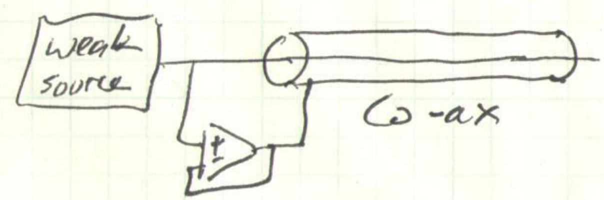


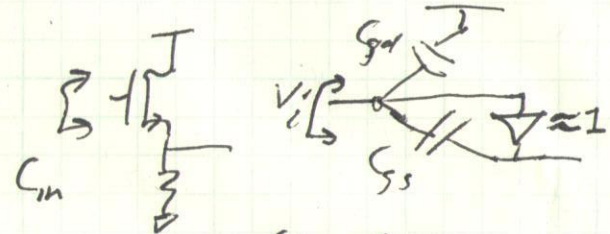
$Z_{in} = \frac{Z}{1-A}$

for capacitors, since $|Z| = \frac{1}{\omega C}$

makes C look bigger by $1-A$

A can be positive





$C_{in} \approx C_{gd}$

for CS, A is negative, and usually large.

e.g. when V_{ov} were 100mV in our design

$A = -100$ so $C_{in} = C_{gs} + (1-A) C_{gd}$

$C_{in} = 10fF + (1 - -100)(2.5fF)$

$= 260fF$ dominated by C_{gd}

if you need to reduce that, what to do?

reduce W while keeping g_m constant

$$g_m = \begin{cases} \frac{2I_D}{V_{ov}} \\ \mu C_{ox} \frac{W}{L} V_{ov} \\ \sqrt{2\mu C_{ox} \frac{W}{L} I_D} \end{cases}$$

eqn. 2.18-20

decrease W 2x w/ g_m const

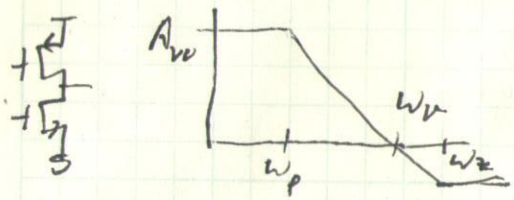
$\Rightarrow$ increase V_{ov} 2X (hurts swing)

$\Rightarrow$ increase I_d 2X (more power)

$\Rightarrow$ decrease r_o 2X

$\Rightarrow$ decrease A_{vo} 2X may not be OK

$\omega_0/2$ ω_u unchanged



if C_L dominates ω_p, ω_u

and $C_{in} \approx A_{vo} C_{gd}$

	double $\frac{W}{L}$	double L and W	double V_{ov}
g_m	2	1	2
r_o	1/2	2	1/4
I_d	2	1	4
A_v	1	2	1/2
ω_p	2	1/2	4
ω_u	2	1	2
C_{in}	2	4	1/2

2 copies of same amp.

Need high gain, but low input cap

$V_{OV} \searrow$ $V_{OV} \nearrow$

$L \nearrow$ $L \searrow$

Need big ω_u and high gain

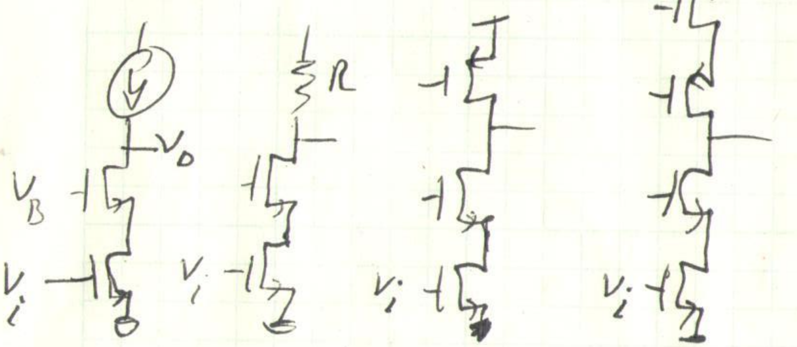
$V_{OV} \nearrow$ $V_{OV} \searrow$

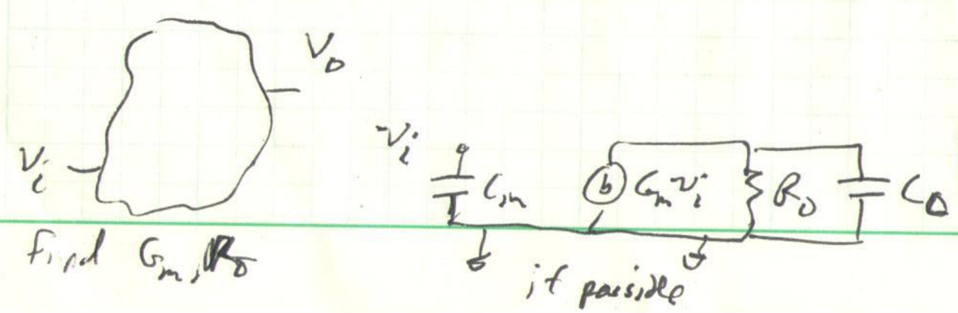
etc.

Need new topologies

more gain: multiple stages or, cascode.

Cascode



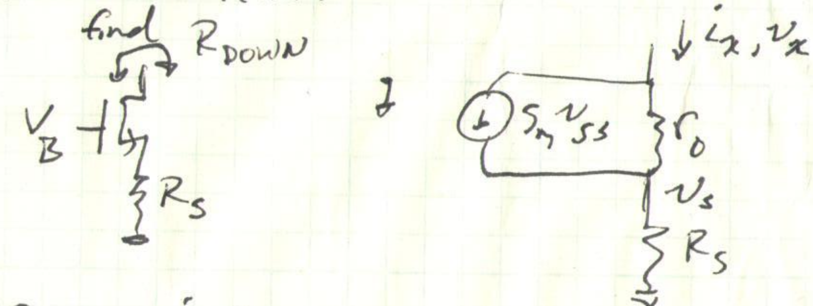


find G_m, R_O

if possible

More 105 review:

find R_{DOWN}



① $v_s = i_x R_s, \; v_{gs} = -v_s$

② KCL @ v_x

$$g_m(-v_s) + \frac{1}{r_o}(v_x - v_s) = i_x$$

$$\frac{1}{r_o} v_x = \left(g_m R_s + \frac{1}{r_o} R_s + 1\right) i_x$$

$$R_{DOWN} = \frac{v_x}{i_x} = r_o\left(1 + \left(g_m + \frac{1}{r_o}\right) R_s\right)$$

$$= r_o\left(1 + g_m R_s\left(1 + \frac{1}{\ldots}\right)\right)$$