Lab 2 CMOS inverter: Cadence schematic, simulation, layout, extraction

HW 3

Midterm 1 in class, Friday 2/19 1 page (2 sides) notes
8% no calculators

Midterm 2 in class Friday 4/1 1:10 - 2:30

Analysis

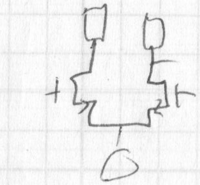
Find an operating point
(solve nonlinear alg.)

Find linear model there
(redraw circuit in local coords)

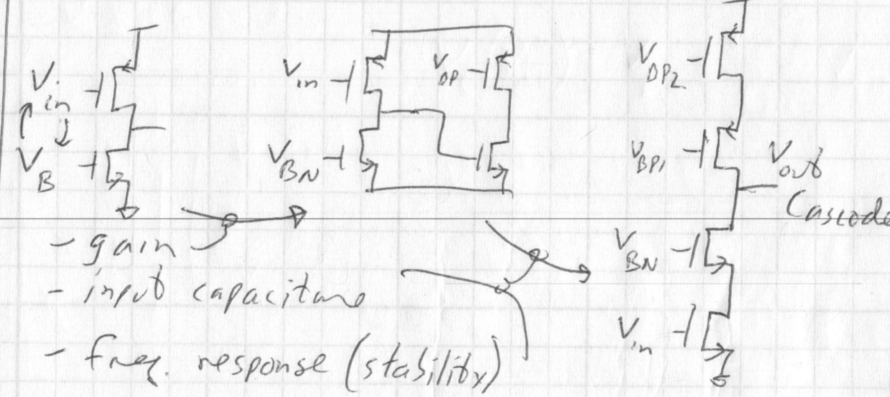
linear analysis
- freq resp (Bode plot)
- time domain response

Design: go the other direction

getting to circuit design
input & output impedance
gain, bandwidth, power, swing

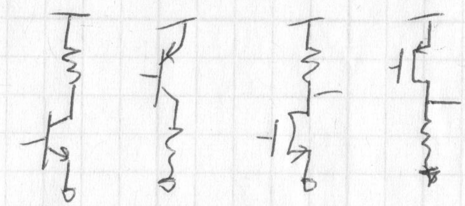


feedback, stability



- gain
- input capacitance
- freq. response (stability)

operating point / bias point



Current depends on V_{out} and R_L

Current determines g_m, r_o for bipolar

some choice for MOS:
- pick the combination of W, L, V_{ov} to set I
- gives you some control over g_m, r_o

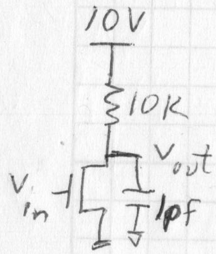
$W/L \rightarrow \frac{2I_d}{V_{ov}}$ $\quad \frac{1}{\lambda I_d} \leftarrow L$

140

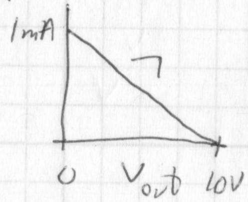
165p

W3L2

$\mu_n C_{ox} = \frac{50\mu A}{V^2}$ $L = 1\mu m$ $V_t = 2V$ $\lambda = 0.01 V^{-1}$



$I_D = \frac{10V - V_{out}}{10K} = 0 - 1mA$

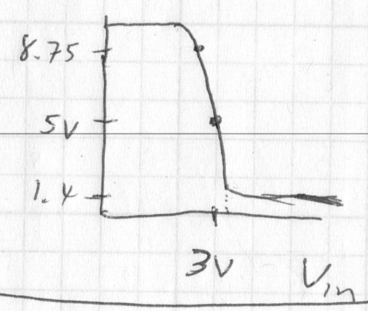


$I_D = \frac{\mu_n C_{ox}}{2} \frac{W}{L} V_{ov}^2 \underbrace{\left(1 + \frac{V_{out}}{100V}\right)}_{\approx 1}$

pick $W = 20\mu m$

$I_D = 500\frac{\mu A}{V^2} V_{ov}^2$

V_{ov}	I_D	V_{out}	A_{vo}
1V	0.5mA	5V	-10
0.5V	0.125mA	10-1.25=8.75	-5
1.4V	1mA	0 (no, $V_{ov} \approx 1.4$)	-14

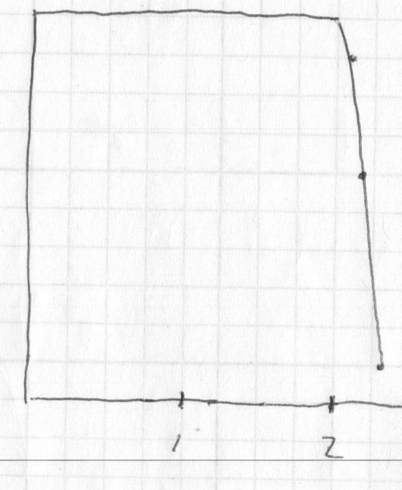


or choose $W = 400$

$I_D \approx \frac{50\mu A/V^2}{2}\left(\frac{400}{1}\right) V_{ov}^2$

$= 10\frac{mA}{V^2} V_{ov}^2$

V_{ov}	I_D	V_{out}	A_{vo}
0.1	0.1mA	9	-20
0.2	0.4mA	6	-40
0.3	0.9mA	1	-60



big variation in current $\Rightarrow$ big variation in $g_m, r_o, A_v, \ldots$

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

$= \begin{cases} 1\frac{mA}{V^2} V_{ov} & W = 20 \\ 20\frac{mA}{V^2} V_{ov} & W = 400 \end{cases}$

$A_v = -g_m R_L = \begin{cases} -10\frac{1}{V} V_{ov} & W = 20 \\ -200\frac{1}{V} V_{ov} & W = 400 \end{cases}$

at constant load, larger $\frac{W}{L} \Rightarrow$ more g_m, more gain

$\Rightarrow$ more input capacitance

pick $W = 400$, $V_{ov} = 0.2V$ $(V_i = 2.2V)$

$g_m = \frac{2I_D}{V_{ov}} = \frac{0.8mA}{0.2V} = 4\frac{mA}{V}$

$-g_m R_L = -\left(4\frac{mA}{V}\right)(10K) = -40$

$r_o = \frac{1}{\lambda I_D} = \frac{100V}{0.8mA} = 125K\Omega \gg 10K$ (R_L)

ignore

$10K \| 125K \approx 10K$