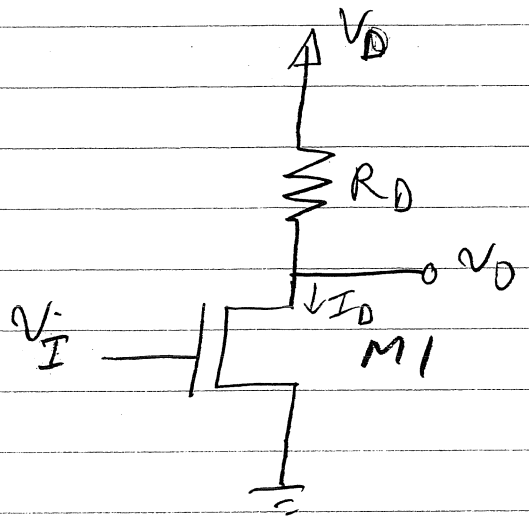
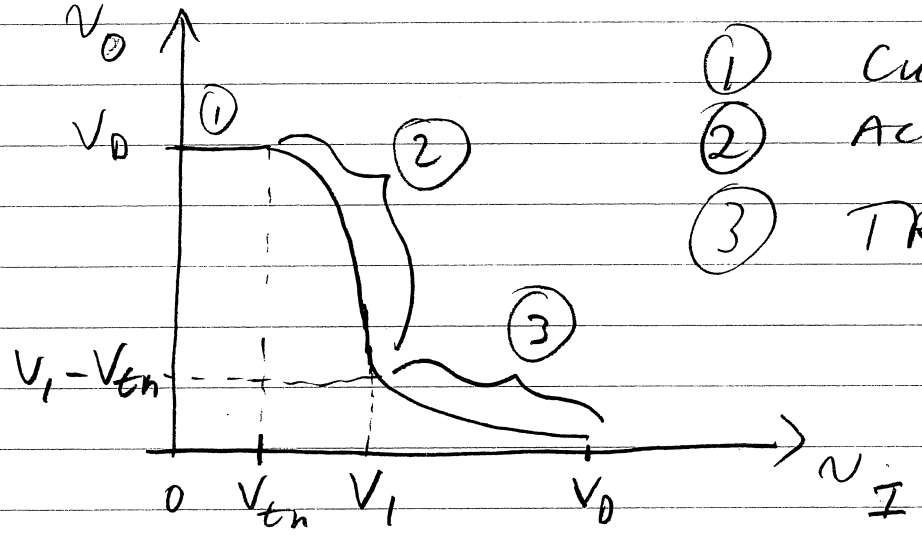
GAIN CELL



ASSUME $\lambda = 0$
$(r_o \to \infty)$

M1

① CUTOFF
② ACTIVE
③ TRIODE



SMALL-SIGNAL GAIN $\frac{v_o}{v_i}$ IS $\frac{dV_O}{dV_I}$

SO $\frac{v_o}{v_i} = 0$ IN ①

$\frac{v_o}{v_i}$ SMALL IN ③

IN (2) (ACTIVE)

GAIN DEPENDS ON g_m WHICH DEPENDS ON I_D

$$\frac{v_o}{v_i} = -g_m R_D \qquad g_m = \frac{2I_D}{V_{OV}}$$

$$V_{OV} = V_{GS} - V_{tn}$$

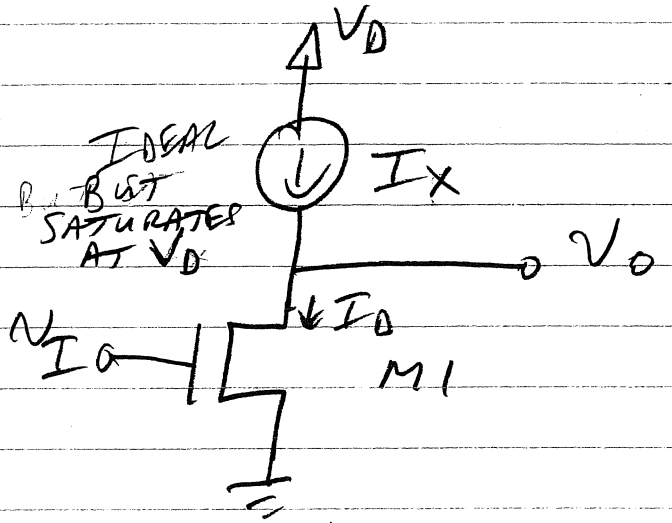
$$V_{OV} = v_I - V_{tn}$$

LARGEST GAIN OCCURS NEAR $v_I = V_1$

FOR A GIVEN TRANSISTOR & I_D (HENCE GIVEN g_m) TO INCREASE $\frac{v_o}{v_i}$ NEED TO INCREASE R_D BUT THEN V_{R_D} TOO LARGE.

REPLACE R_D WITH CURRENT SOURCE.

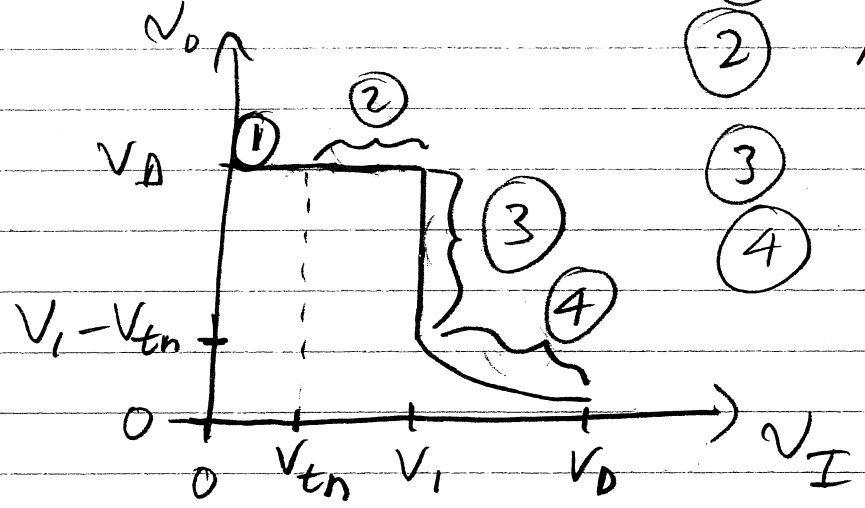
GC3



ASSUME $\lambda = 0$
$(r_o \to \infty)$

M1

1. CUTOFF
2. ACTIVE BUT $I_D < I_X$
3. ACTIVE $I_D = I_X$
4. TRIODE



V_1 OCCURS WHEN

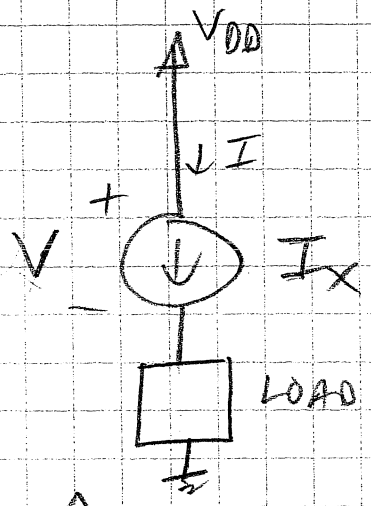
$$I_D = \frac{\mu_n C_{ox}}{2}\left(\frac{W}{L}\right)(V_1 - V_{tn})^2 = I_X$$

GAIN $\frac{V_o}{V_i}$ IN (3) IS ∞ !!

GC3A

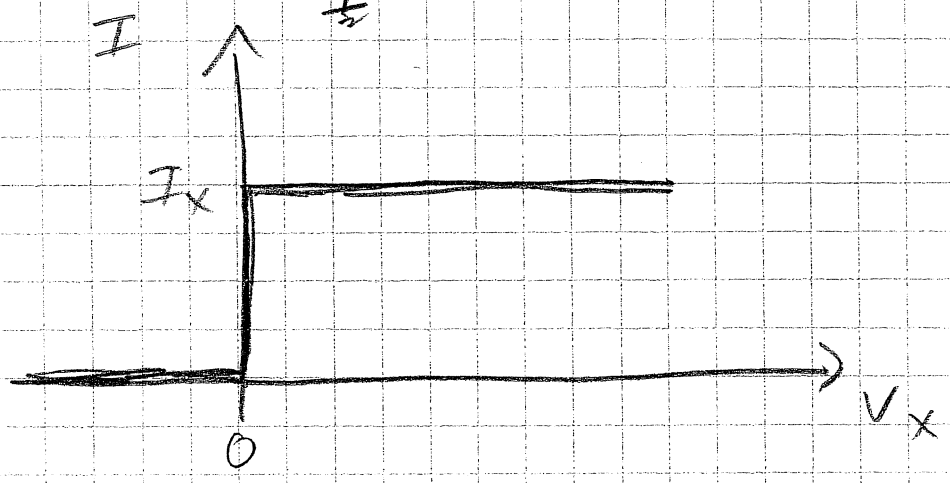
IDEAL CURRENT SOURCE

THAT GOES TO $I=0$ IF $V \to 0$

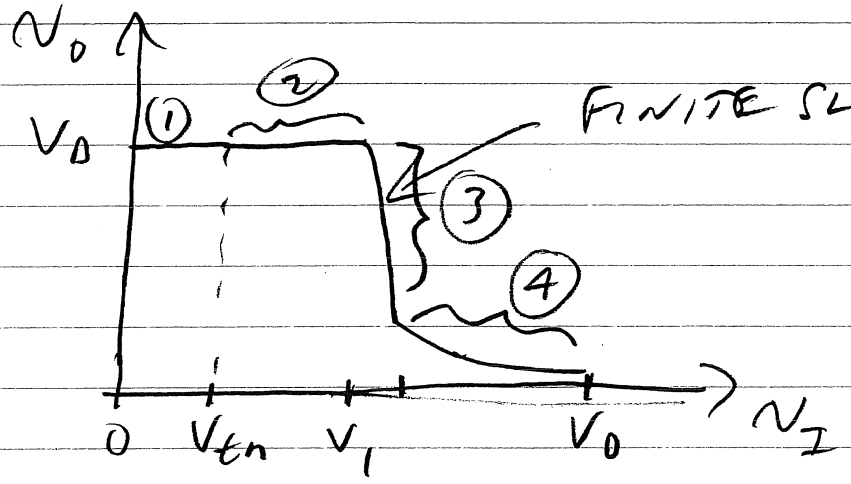


$I = I_X \quad V > 0$

$I = 0 \quad V \leq 0$



NOW ASSUME $\lambda \neq 0$ (r_o FINITE)



IN ③

$$g_m = \frac{2I_D}{V_{OV}} \qquad r_o = \frac{L}{\lambda' I_D} = \frac{V_A' L}{I_D}$$

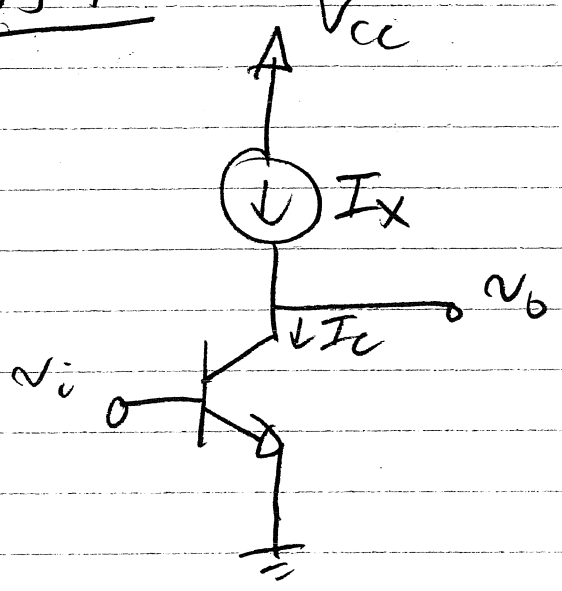
$$\frac{v_o}{v_i} = -g_m r_o = -\frac{2I_D}{V_{OV}} \frac{V_A' L}{I_D}$$

$$= -\frac{2 V_A' L}{V_{OV}}$$

TYPICAL $V_{OV} \approx 0.2\ V$, $V_A' \approx 10\ V/\mu m$ } INTRINSIC GAIN $\approx 20\ V/V$

$L = 0.2\ \mu m$

BJT



V_A FINITE

ACTIVE WHEN $I_C = I_X$

WHEN ACTIVE $g_m = \frac{I_C}{V_T}$

$$r_o = \frac{V_A}{I_C}$$

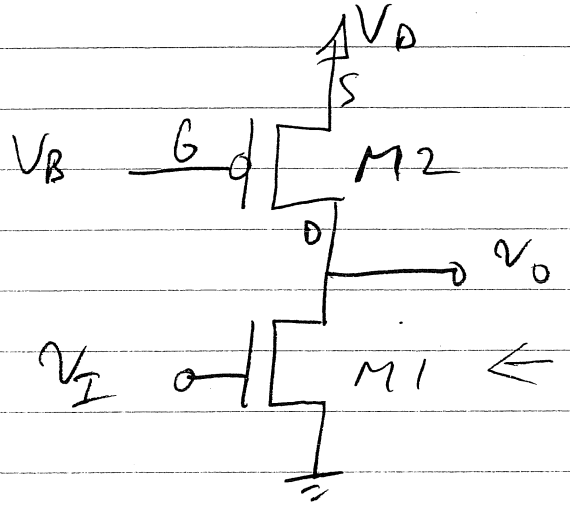
GAIN $\frac{v_o}{v_I} = -g_m r_o$

$$= -\frac{I_C}{V_T}\frac{V_A}{I_C} = -\frac{V_A}{V_T}$$

TYPICAL $V_A \approx 15\,V$, $V_T \approx 25\,mV$ } INTRINSIC GAIN $\approx 600\ V/V$

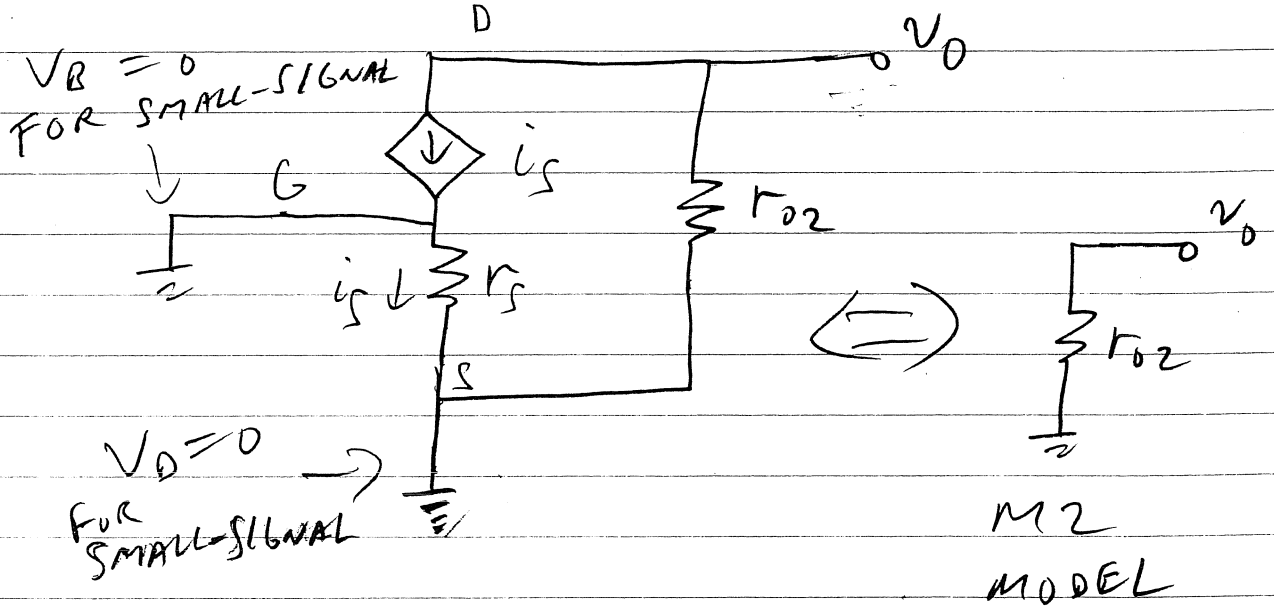
MUCH HIGHER THAN MOSFETS

PRACTICAL CURRENT SOURCE LOAD



V_B IS CONSTANT DC VOLTAGE TO GENERATE I_X

SMALL-SIGNAL MODEL FOR M2



SO INTRINSIC GAIN IS

$$\frac{v_o}{v_I} = -g_{m1}\left(r_{o1} \,||\, r_{o2}\right) = -\frac{1}{2} g_{m1} r_o$$

IF $r_o = r_{o1} = r_{o2}$