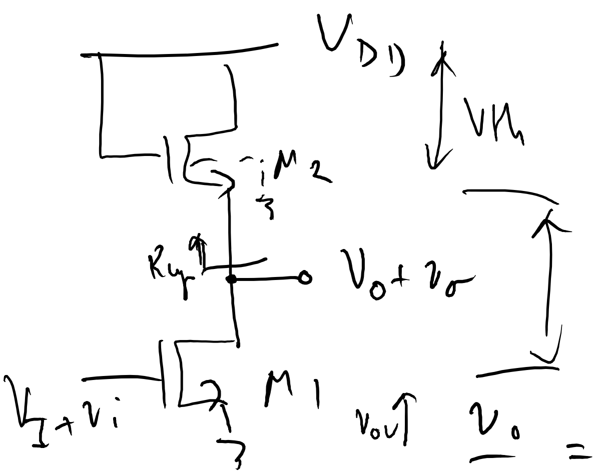
Active loads:

CS with active diode load:



$$R_{up} = \frac{1}{g_{m2} + g_{mb2}} \,||\, r_{o2}$$

$$R_{out} = R_{up} \,||\, r_{o1}$$

$$\frac{v_o}{v_i} = -g_{m1} \cdot R_{out} = -g_{m1} \frac{1}{g_{m2} + g_{mb2}} \,||\, r_{o1} \,||\, r_{o2}$$

$$\simeq -\frac{g_{m1}}{g_{m2} + g_{mb2}}$$

If $g_{mb2} = 0$

$$\frac{v_o}{v_i} \simeq -\frac{g_{m1}}{g_{m2}} = -\sqrt{\frac{\left(\frac{W}{L}\right)_1}{\left(\frac{W}{L}\right)_2}}$$

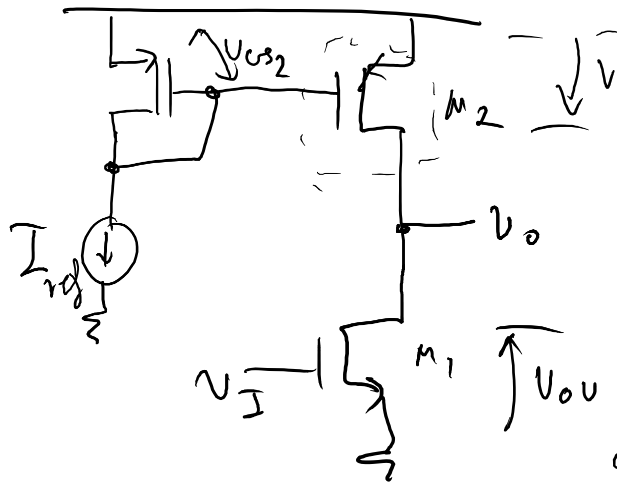
Conditions DC point:

M_2 saturation : $V_O < V_{DD} - V_{th}$

M_1 saturation : $V_I > V_{th}$

$V_O > V_I - V_{th} = V_{OV}$

b)



$R_{out} = r_{o1} \| r_{o2}$

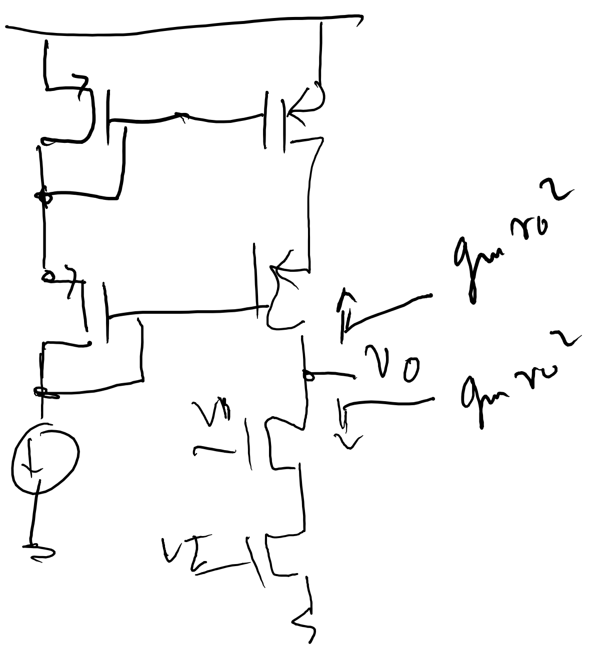
$\frac{v_o}{v_i} = -g_{m1} \cdot R_{out} = -g_{m1} \underbrace{r_{o1} \| r_{o2}}_{r_o}$

$g_m \sim \sqrt{I_D}\ ,\ r_o \sim \frac{1}{I_D}$

$\frac{v_o}{v_i} \sim \frac{1}{\sqrt{I_D}}$ (5 - 100)

BJTs:

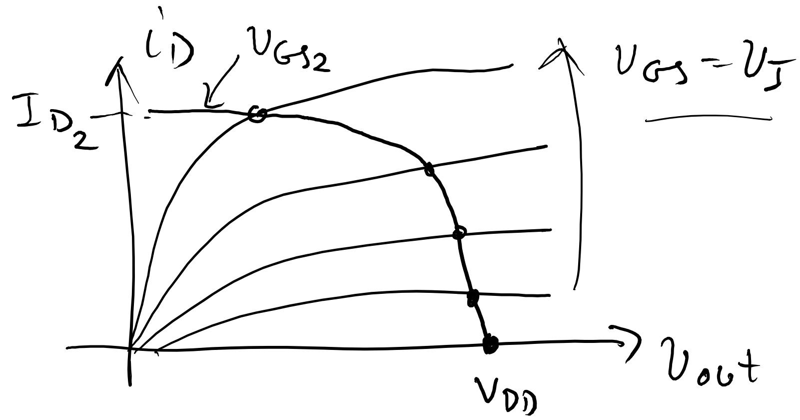
$g_m \sim I_C$
$r_o \sim \frac{1}{I_C}$ } $g_m r_o \sim$ cte. (1000)

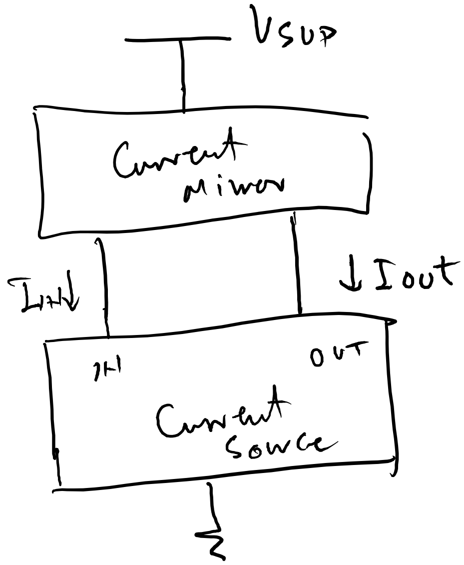


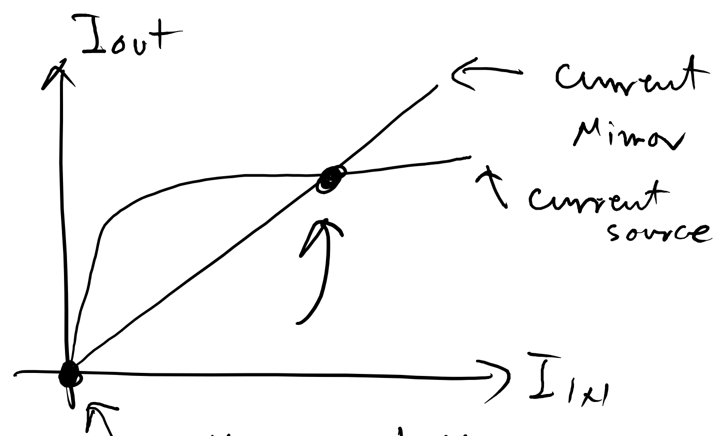
$A_v = -g_m \cdot \left(\frac{g_m r_o^2}{2} \right) = -\frac{(g_m r_o)^2}{2}$

$2V_{ov}$
useful swing.
$2V_{ov}$

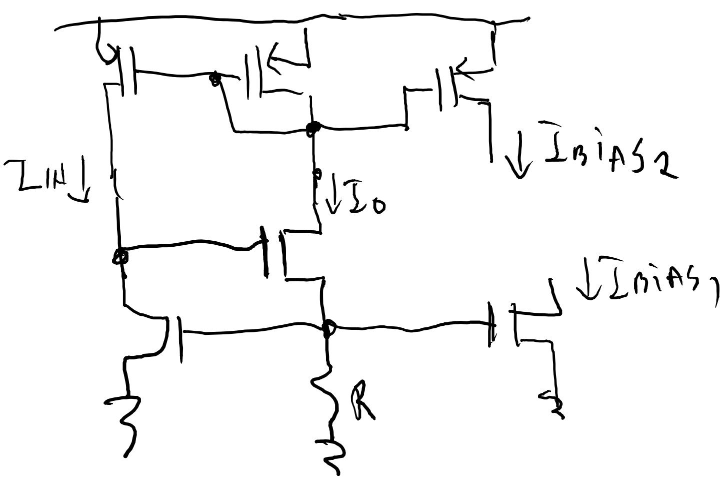
Lecture 14 - Active loads and Diff pairs







usually a stable point due to leakage currents

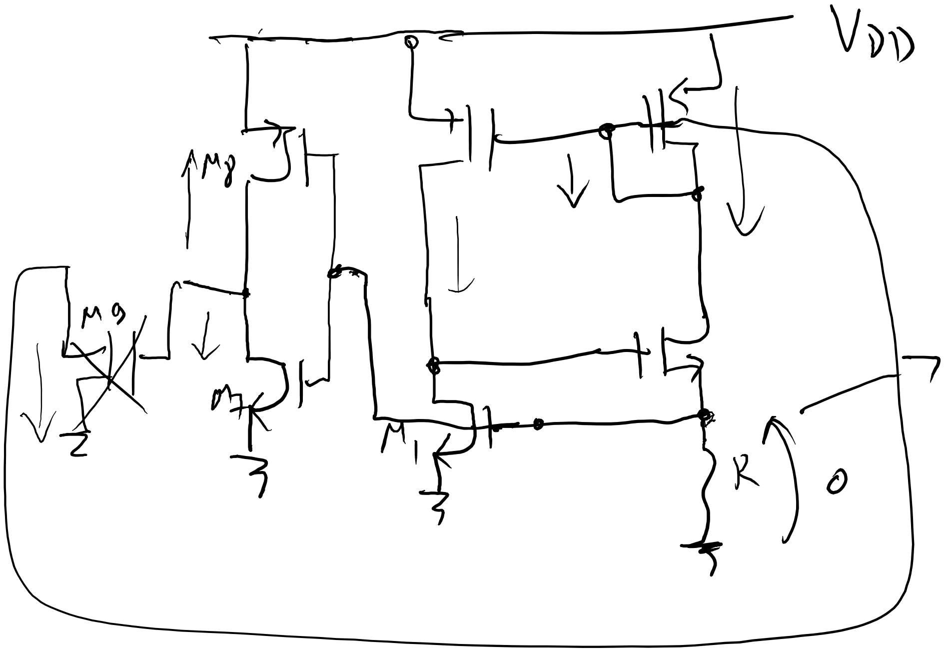


$I_o \uparrow, I_{IN} \uparrow \Rightarrow I_o \uparrow$

PFB loop

but stable as loop gain < 1

Lecture 14 - Active loads and Diff pairs



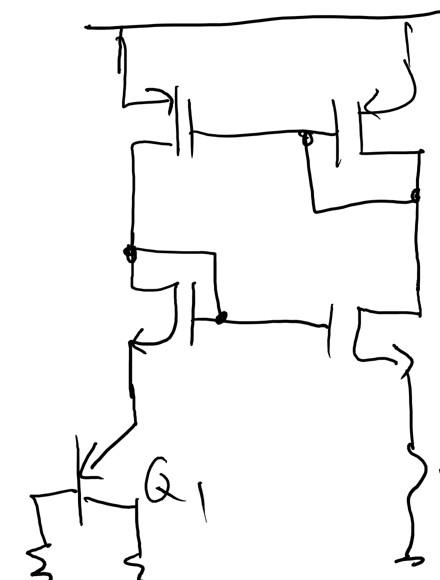
$I_o R$

M_8 still on

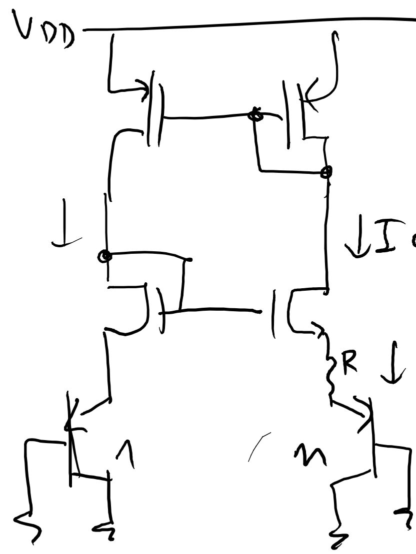
so $\left(\frac{W}{L}\right)_{M7} >> \left(\frac{W}{L}\right)_{M8}$

at stable point $I_o \cdot R$ turns-off M_9.

V_{BE} - self-biased



$I_o = \frac{V_{EB1}}{R}$



$\frac{V_{EB1} - V_{EB2}}{R}$

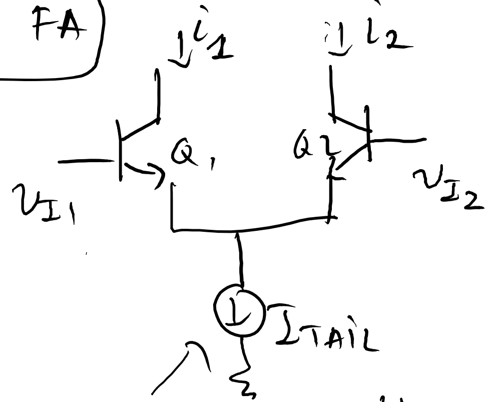
$$V_{EB1} - V_{EB2} = V_T \ln \frac{I_{C1}}{I_{S1}} - V_T \ln \frac{I_{C2}}{I_{S2}}$$

$$= V_T \ln \underbrace{\frac{I_{C1}}{I_{C2}}}_{1} \cdot \underbrace{\frac{I_{S2}}{I_{S1}}}_{n} = V_T \ln(n)$$

EE140 Spring 2014
Vladimir Stojanović

BJTs: **Diff. pairs**

Q_1, Q_2 FA



KVL: $v_{I1} - v_{BE1} + v_{BE2} - v_{I2} = 0$

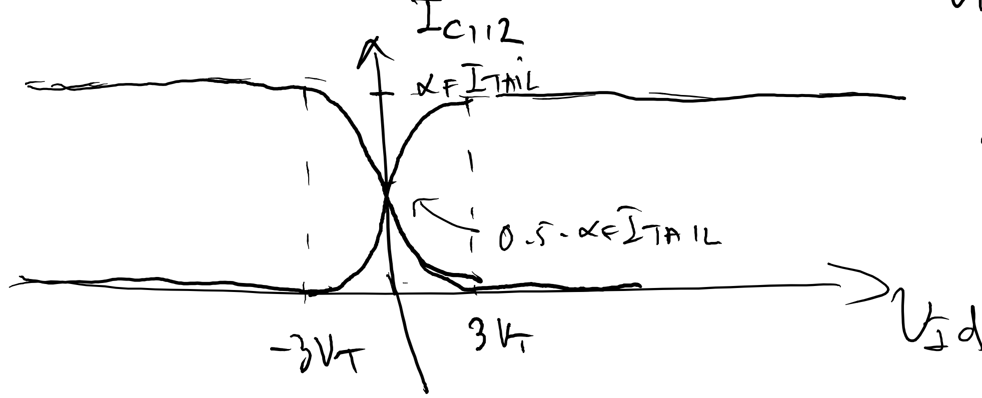
$$v_{I1} - v_{I2} = \underbrace{v_{BE1}}_{V_T \ln \frac{i_{C1}}{I_{S1}}} - \underbrace{v_{BE2}}_{V_T \ln \frac{i_{C2}}{I_{S2}}}$$

$$v_{Id} = v_{I1} - v_{I2} = V_T \ln \frac{i_{C1}}{i_{C2}} \cdot \cancel{\frac{I_{S2}}{I_{S1}}}$$

$$\frac{i_{C1}}{i_{C2}} = e^{\frac{v_{Id}}{V_T}}$$

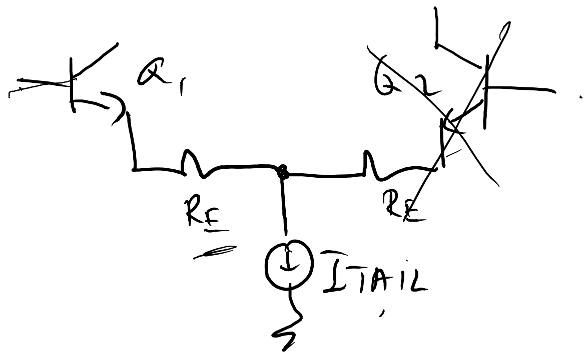
KCL: $i_{E1} + i_{E2} = I_{TAIL} \Rightarrow i_{C1} + i_{C2} = \alpha_F I_{TAIL}$

$$i_{C1} = \frac{\alpha_F I_{TAIL}}{1 + e^{\frac{v_{Id}}{V_T}}}, \quad i_{C2} = \frac{\alpha_F I_{TAIL}}{1 + e^{-\frac{v_{Id}}{V_T}}}$$



v_{Id} input range $\pm 3V_T$

useful input range



$$v_{Id} = V_{BE1} - V_{BE2} + I_{TAIL} \cdot R_E$$