02/28/11
EE303

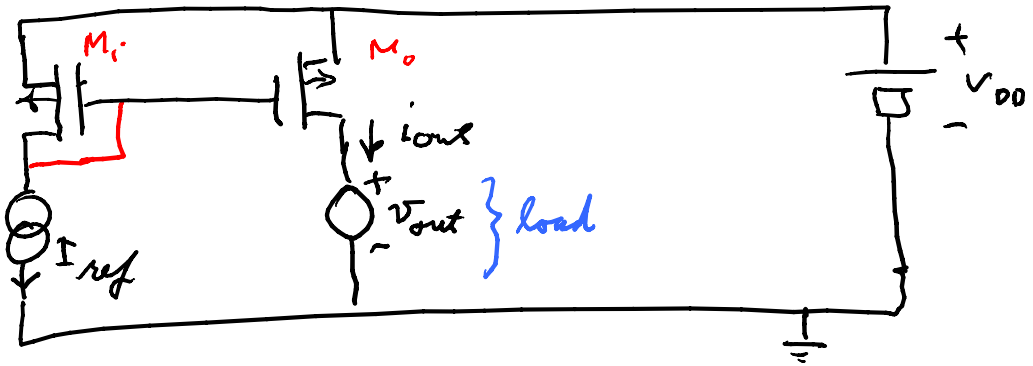
Note Title 2/28/2011

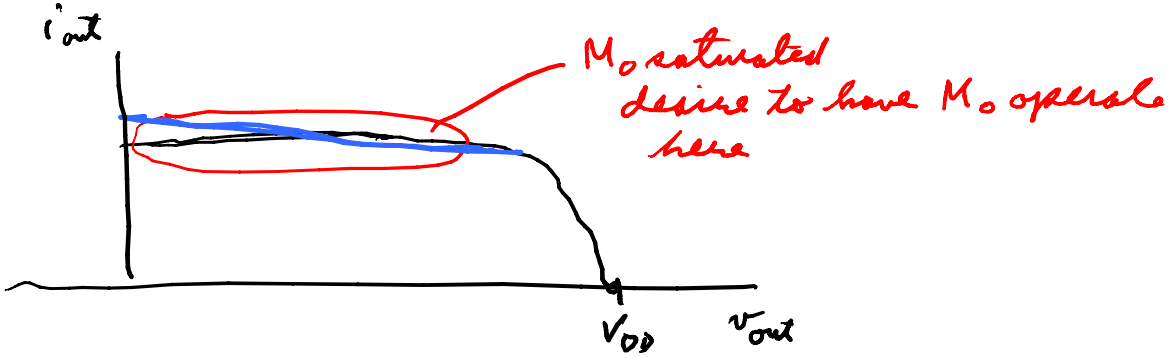
Cascode CM, p. 538

on homework 4
I_T value, can choose but
a good choice is 8 mA

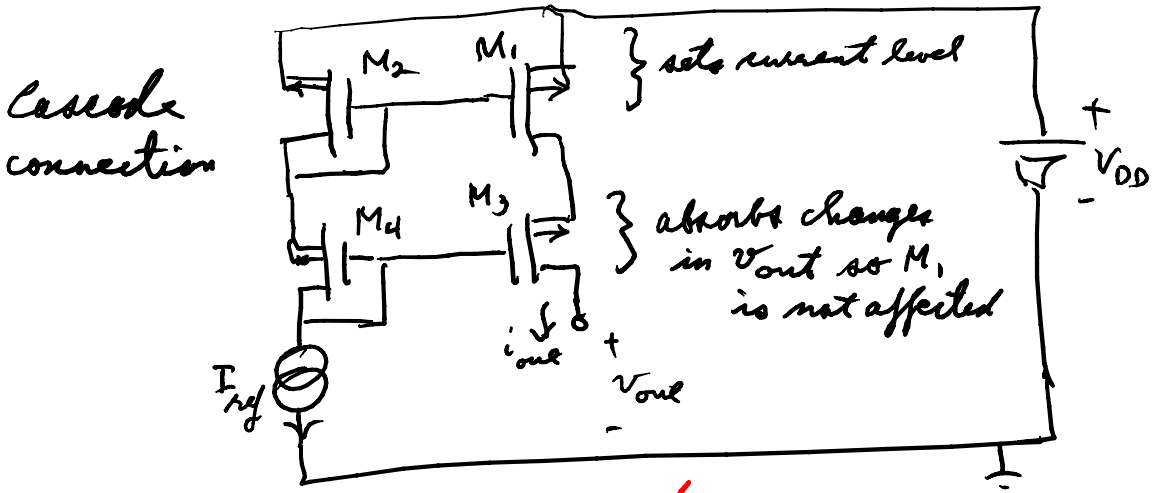
1st present, 4 min M 03/28, W 03/30, M 04/04
(17 yes)
2nd present, 10 min ± 2, M 04/06 – W 05/04

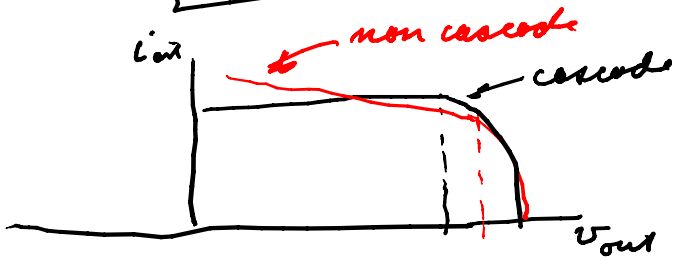
For testing of an i_{out} can make sure the transistors are properly biased



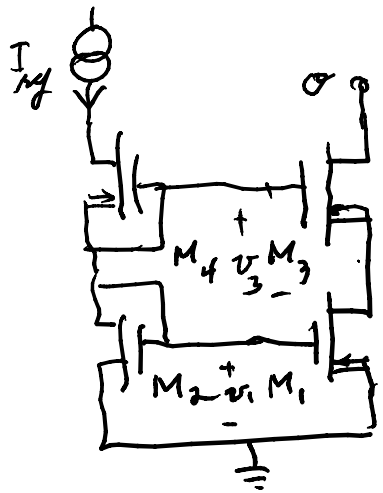


Cascode connection

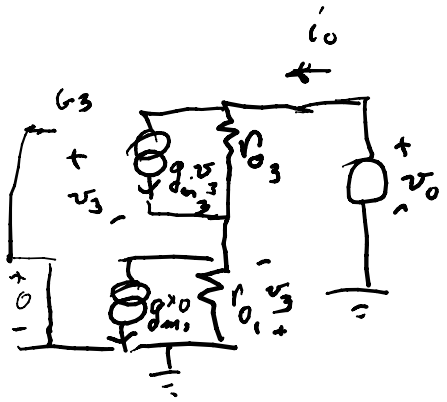




look at



for small signal



$$-v_3 = r_{o_1} \cdot i_o \;, \quad i_o = i_{r_{o_3}} + g_{m_3} v_3 = i_o = i_{r_{o_3}} - g_m r_{o_1} i_o$$

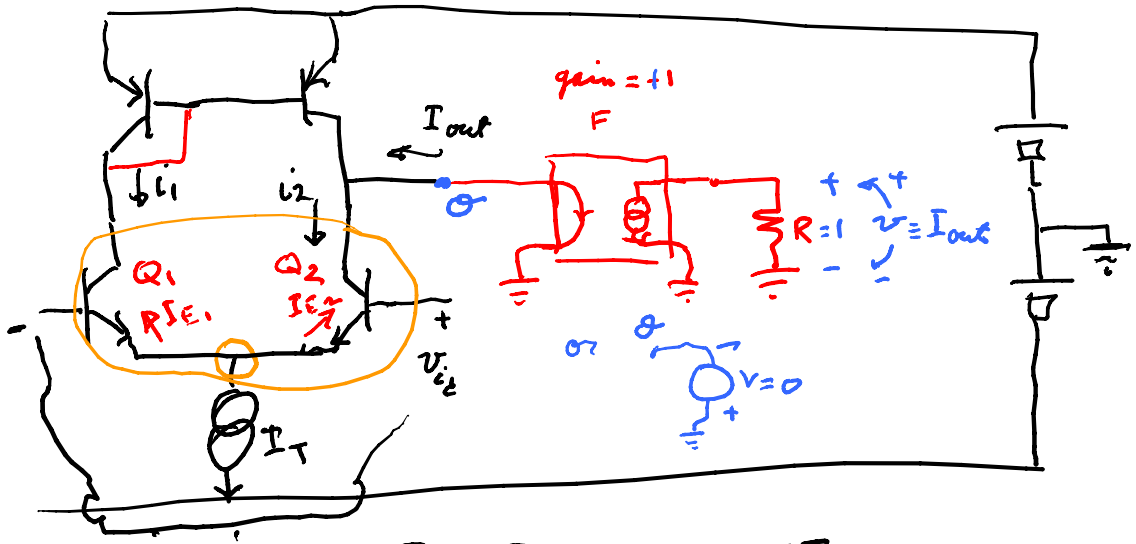
$$i_{r_{o_3}} = (1 + g_m r_{o_1}) i_o \;, \quad v_o = r_{o_3} i_{r_{o_3}} + r_{o_1} \cdot i_o$$

$$= \left[r_{o_3}(1 + g_m r_{o_1}) + r_{o_1} \right] i_o$$

$$\Rightarrow \; r_{o_1} \Rightarrow r_{o_1} + (1 + g_m r_{o_1}) r_{o_3} > r_{o_1}$$

with cascode — w/ without

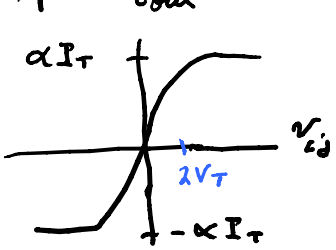
$\frac{1}{\text{slope}} \Rightarrow$ (acts as a better current source)



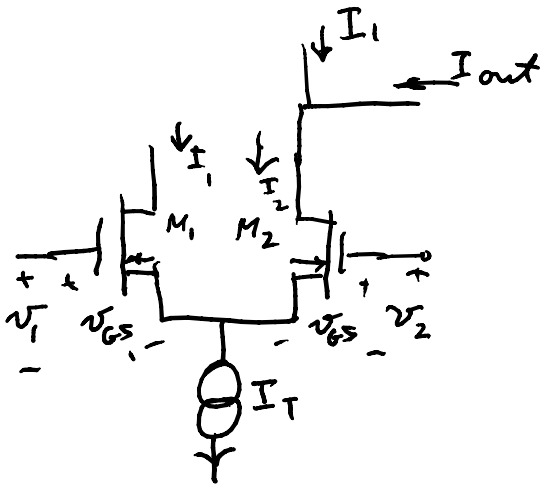
$$I_{out} = i_2 - i_1 = I_{C_2} - I_{C_1} = -\alpha I_{E_2} + \alpha I_{E_1}$$

KCL @ E's: $0 = I_{E_1} + I_{E_2} + I_T$

$$\Rightarrow \quad i'_{out} = \alpha I_T \tanh(v_{id}/2V_T)$$



MOS diff pairs



$v_d = v_2 - v_1$; $I_T = I_1 + I_2$ $\qquad v_2 - v_1 = v_{GS_2} - v_{GS_1}$

$I_o = I_{out} = I_2 - I_1 = i_2 - i_1 \Rightarrow i_2 = I_o + i_1$

$i_2 = I_T - i_1$

operate M_1 & M_2 in saturation

$i_D = \frac{KP}{2}\cdot\frac{W}{L}(v_{GS} - V_{th})^2 \Rightarrow v_{GS_2} = V_{th} + \sqrt{i_2/\beta} \Rightarrow v_d = \sqrt{i_2/\beta} - \sqrt{i_1/\beta}$

$= \beta_n (v_{GS} - V_{th})^2 \qquad v_{GS_1} = V_{th} + \sqrt{i_1/\beta}$

square: $v_d^2 = \frac{i_2}{\beta} + \frac{i_1}{\beta} - 2\frac{1}{\beta}\sqrt{i_1 i_2} \Rightarrow \beta v_d^2 = I_T - 2\sqrt{i_1 i_2}$

$$I_T - \beta v_d^2 = 2\sqrt{i_1(I_T - i_1)} \xrightarrow{\text{square}} i_1 I_T - i_1^2 = \frac{1}{4}(I_T - v_d^2\beta)^2$$

$$i_1 = \frac{I_T}{2} \pm \frac{1}{2}\sqrt{I_T^2 - 4\times\frac{1}{4}(I_T - v_d^2\beta)^2}$$

$$= \frac{I_T}{2} \pm \frac{1}{2}\sqrt{2I_T v_d^2\beta - v_d^4\beta^2} = \frac{I_T}{2} \pm \frac{\sqrt{2}}{2} v_d \sqrt{I_T\beta}\sqrt{1 - \left(\frac{v_d^2\beta}{2I_T}\right)^2}$$

$$i_1 = \frac{I_T}{2} - \frac{\sqrt{2}}{2} I_T\beta \cdot v_d \sqrt{1 - \left(\frac{v_d^2\beta}{2I_T}\right)^2}$$

$$i_2 = \frac{I_T}{2} + \frac{\sqrt{2}}{2} I_T\beta\, v_d \sqrt{1 - \left(\frac{v_d^2\beta}{2I_T}\right)^2}$$

max gives $i_2 = \frac{I_T}{2}$