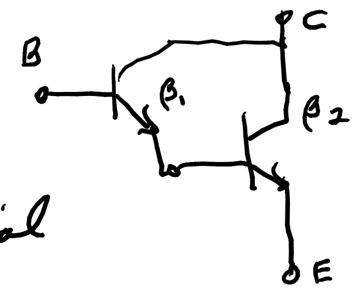
Note Title 2/10/2011

02/23/11
EE 303

Darlington transistor

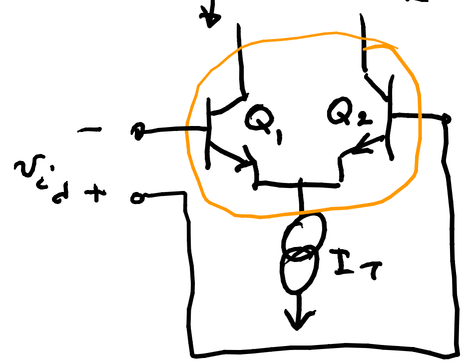


$\beta \approx \beta_1 \beta_2$

page 613 = BJT differential pair
(for OA)

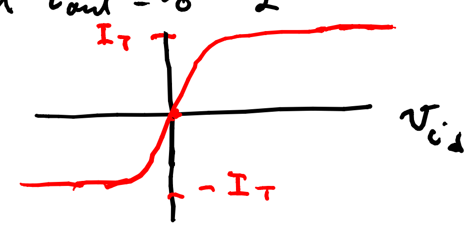
page 595 = MOS " "
(OTA)

BJT



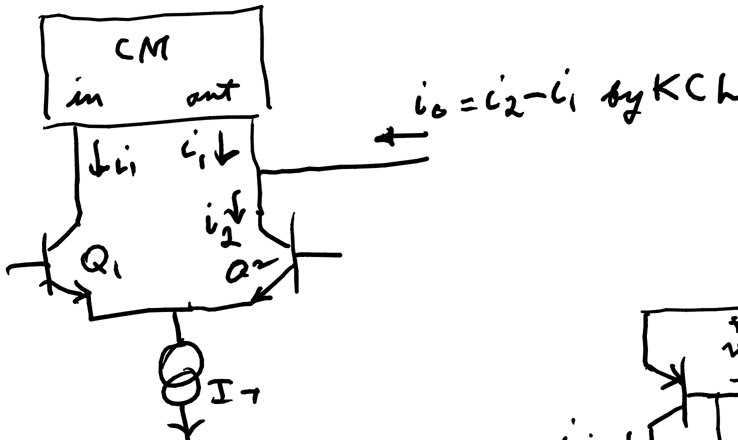
I_T = tail current

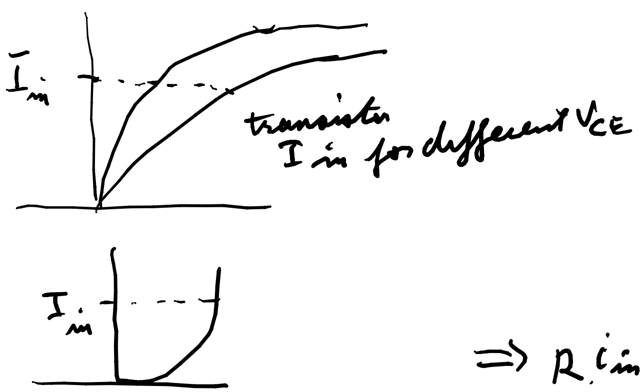
let $i_{out} = i_o = i_2 - i_1$



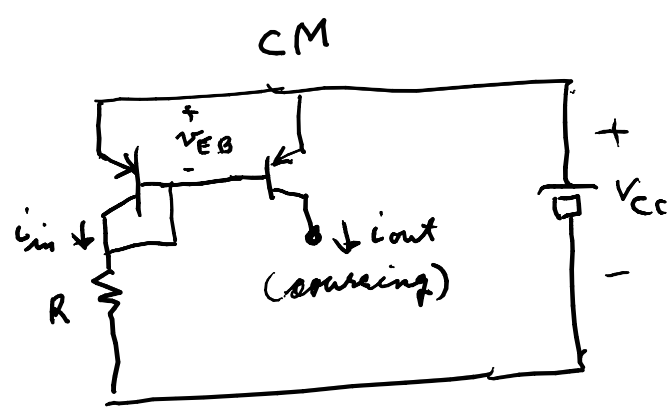
$i_o \approx I_T \tanh(v_{id}/2V_T)$

to get the difference $i_2 - i_1$ use a current mirror





transistor
I_{in} for different V_{CE}



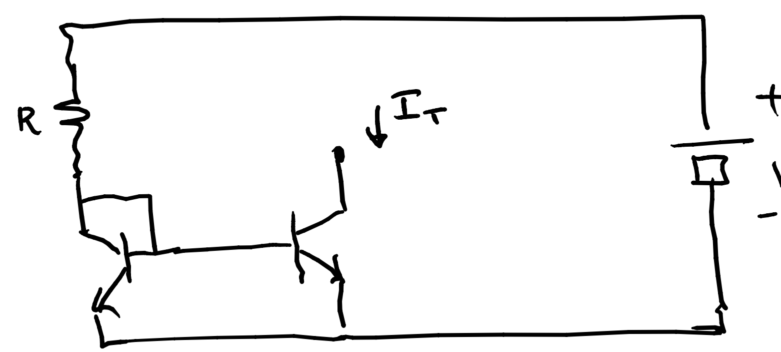
choose R
to give input current

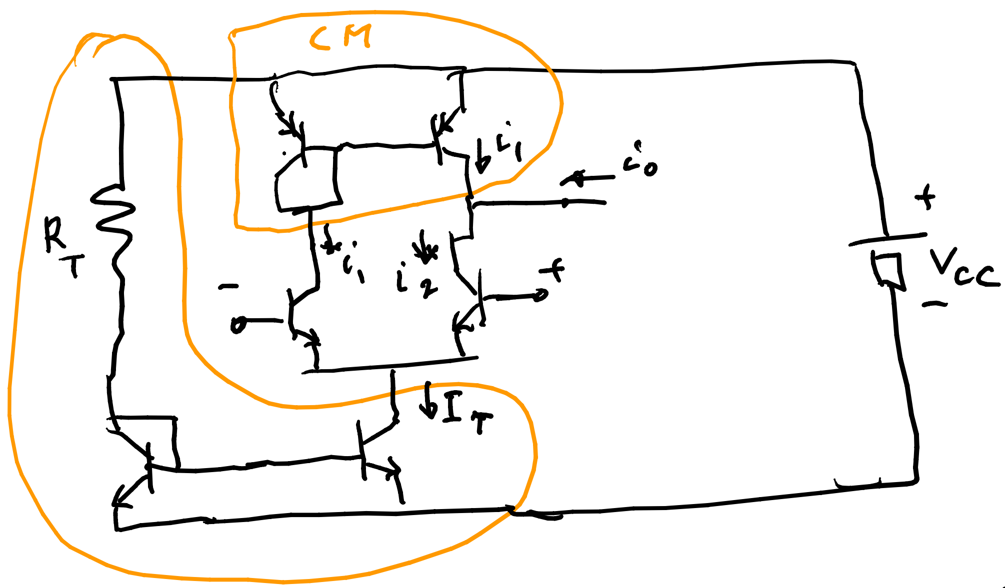
as $v_{EB} \approx 0.7$

$\Rightarrow R\, i_{in} = V_{CC} - V_{EB} \approx V_{CC} - 0.7$

$R = (V_{CC} - 0.7)/(I_T/2)$

To make I_T do the same but "sink" the current





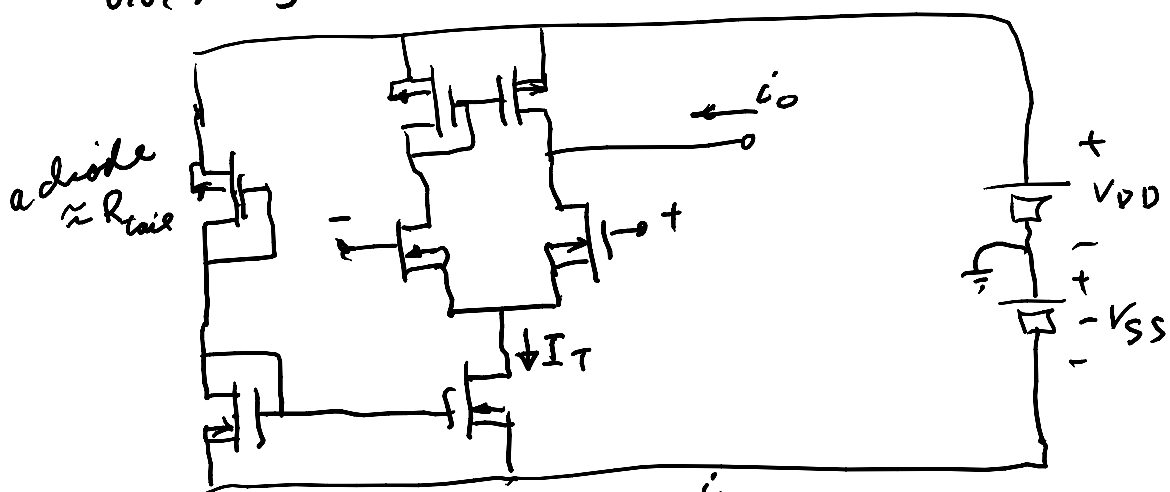
this is a
DVCVS
"differential
voltage
controlled
voltage
source

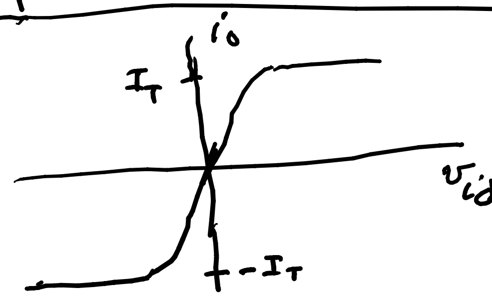
=OTA=
operational
transcon-
ductance

amplifier

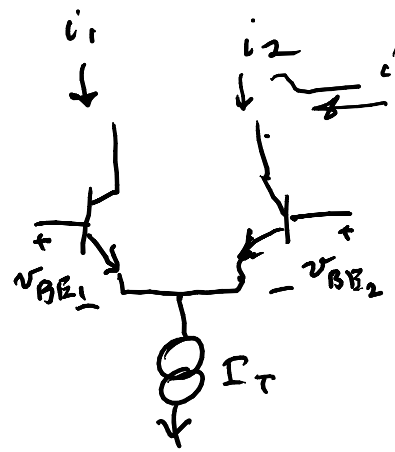
For MOS

P.595





For BJT differential pair



$i_o = i_2 - i_1$

$$-i_{E_1} = I_{SE}\, e^{v_{BE_1}/V_T}$$
$$-i_{E_2} = I_{SE}\, e^{v_{BE_2}/V_T}$$

$$i_1 = \alpha(-i_{E_1})$$
$$i_2 = \alpha(-i_{E_2})$$

if ignore $i_{B's}$: KCL $\Rightarrow$ $0 = i_1 + i_2 - I_T \Rightarrow I_T = \underline{\underline{i_1 + i_2}}$

$$i_o = i_2 - i_1$$

$$v_{id} = v_{BE_2} - v_{BE_2}$$

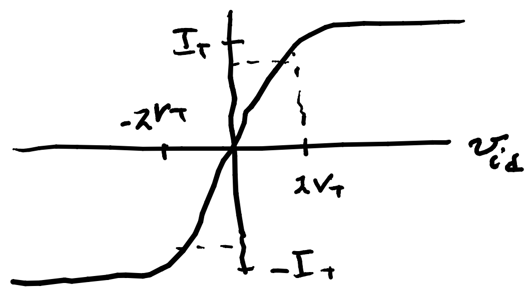
$$I_T = \alpha\left(e^{v_{BE_2}/V_T} + e^{v_{BE_1}/V_T}\right) = \alpha e^{v_{BE_1}/V_T}\left(e^{(v_{BE_2} - v_{BE_1})/V_T} + 1\right)$$

$$i_o = \alpha\left(e^{v_{BE_2}/V_T} - e^{v_{BE_1}/V_T}\right) = \alpha e^{v_{BE_1}/V_T}\left(e^{(v_{BE_2} - v_{BE_1})/V_T} - 1\right)$$

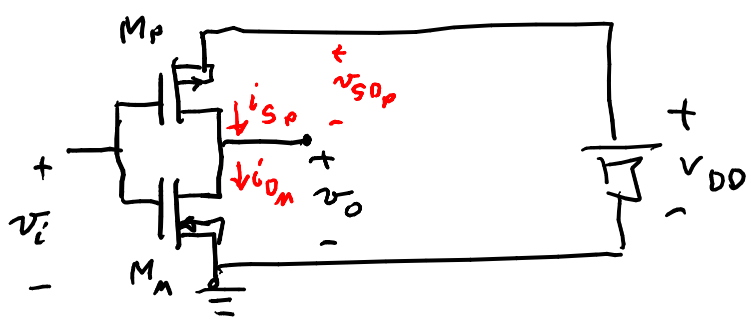
$$\frac{i_o}{I_T} = \frac{e^{v_{id}/V_T} - 1}{e^{v_{id}/V_T} + 1} = \frac{e^{v_{id}/2V_T} - e^{-v_{id}/2V_T}}{e^{v_{id}/2V_T} + e^{-v_{id}/2V_T}} = \tanh(v_{id}/2V_T)$$

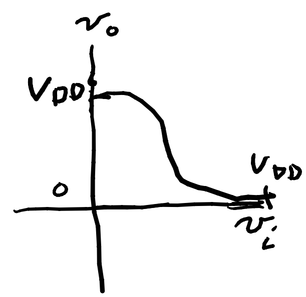
$i_o = \alpha I_T \cdot \tanh(v_{id}/2V_T)$

(see next time)



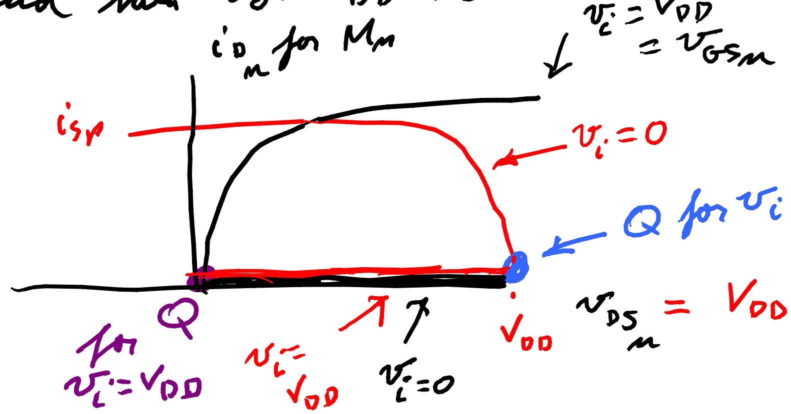
Turn to inverter; CMOS





take M_n as main transistor & M_p as load here if $v_i = 0$ then $v_O = V_{DD}$ & no current flows in either transistor as M_n is turned off as $V_{GS_n} < VTO_n$. When $v_i = V_{DD}$ then M_p is off so no current flows when v_i is 0 or V_{DD}

and then $v_O = V_{DD}$ or 0



$v_{DS_n} = V_{DD} - v_{SD_P} = v_O$

$\Rightarrow$ $v_O = V_{DD}$ when $v_i = 0$

$v_O = 0$ when $v_i = V_{DD}$