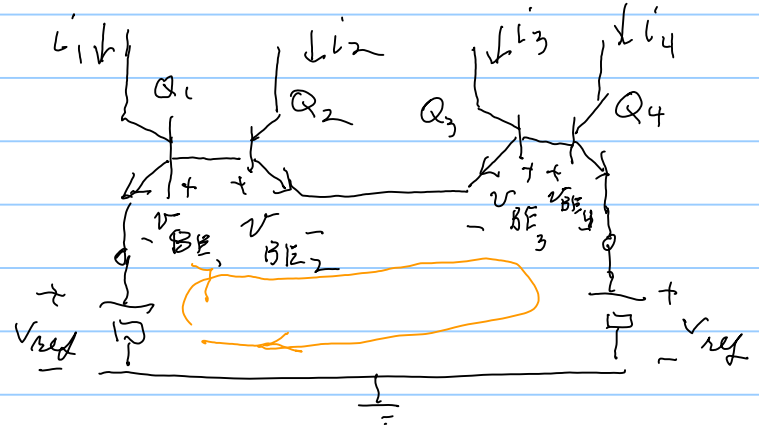
EE 610

12/06/16

Note Title 12/6/2016

translinear circuits



$$i_C = A e^{v_{BE}/V_T}$$

↑ material constant

$$\ln \frac{i_C}{A} = \frac{v_{BE}}{V_T}$$

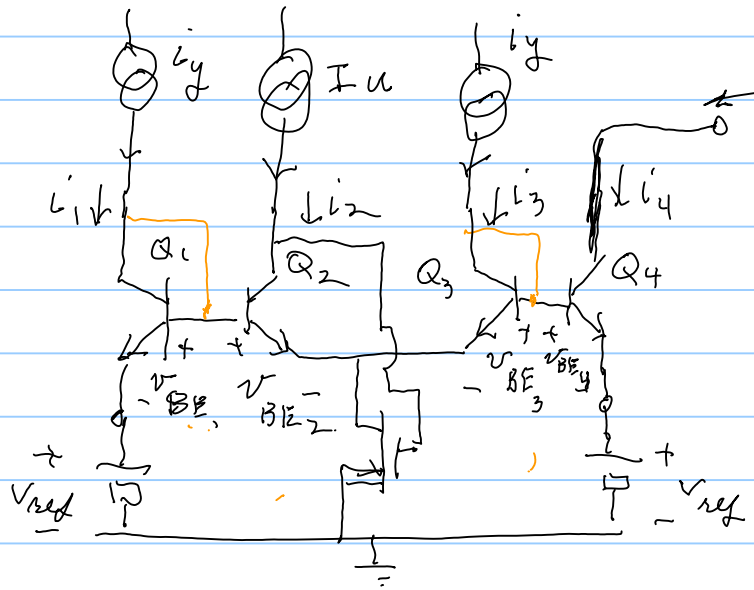
KVL on orange loop

$$v_{BE_1} - V_{ref} - v_{BE_2} + v_{BE_3} + v_{BE_4} + V_{ref} \Rightarrow \frac{v_{BE_1} + v_{BE_3}}{V_T} = \frac{v_{BE_2} + v_{BE_4}}{V_T}$$

Let $Q_1 = Q_2 = Q_3 = Q_4 \Rightarrow A_i = A \quad i = 1, \ldots, 4$

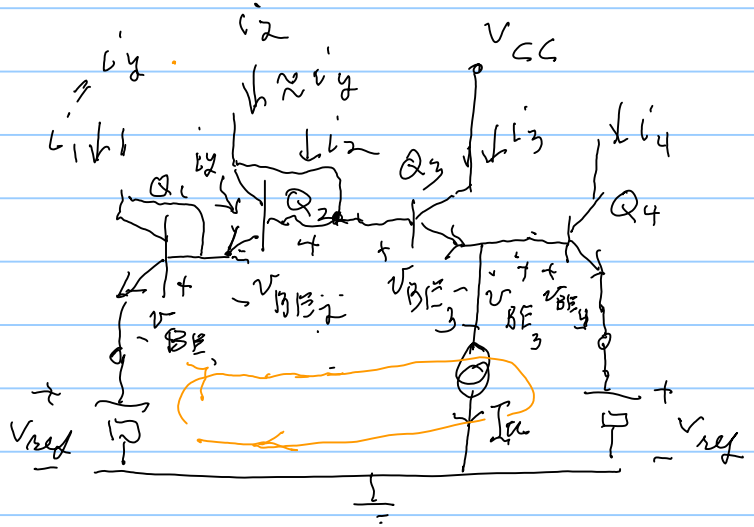
$$-\ln \frac{i_1}{A} + \ln \frac{i_3}{A} = -\ln \frac{i_2}{A} + \ln \frac{i_4}{A} \Rightarrow \ln \frac{i_1 \cdot i_3}{A^2} = \ln \frac{i_2 \cdot i_4}{A^2}$$

raise to exp: $\frac{i_1 \cdot i_3}{A^2} = \frac{i_2 \cdot i_4}{A^2} \Rightarrow i_4 = i_1 i_3 / i_2$



$i_4 = i_x = \frac{i_2 \cdot i_3}{i_2} = \frac{i_y^2}{I_u}$

$i_y \geq 0$, $I_u > 0$



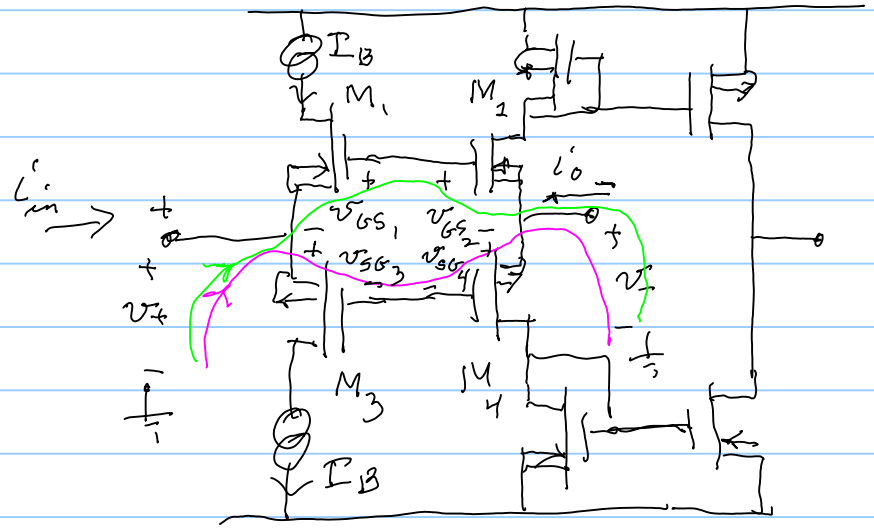
$$0 = -V_{ref} - v_{BE_1} - v_{BE_2} + v_{BE_3} + v_{BE_4} + V_{ref}$$

$$v_{BE_1} + v_{BE_2} = v_{BE_3} + v_{BE_4}$$

$$\ln i_1 \cdot i_2 = \ln i_3 \cdot i_4$$

$$i_4 = i_1 i_2 / i_3 \simeq \left(i_2\left(1 - \frac{1}{\beta}\right)\right)^2 / I_a$$

op-amp via MOS translinear loop



KVL gates/sources

$$0 = -v_{GS_1} + v_{GS_2} + v_{SG_4} - v_{SG_3}$$

$$v_{GS_1} + v_{SG_3} = v_{GS_2} + v_{SG_4}$$

as V_{TO}'s cancel $\Rightarrow$

$$\sqrt{\frac{I_B}{k_n}} + \sqrt{\frac{I_B}{k_p}} = \sqrt{\frac{i_2}{g_{m_n}}} + \sqrt{\frac{i_2 + i_o}{k_p}}$$

$$i_{D_n} = k_n \left(v_{GS} - V_{TO_n}\right)^2 \quad , \quad i_{S_p} = k_p \left(v_{SG} - |V_{TO_p}|\right)^2$$

$$v_{GS} = V_{TO_n} + \sqrt{\frac{i_{D_n}}{k_n}} \qquad v_{SG} = |V_{TO_p}| + \sqrt{\frac{i_{S_p}}{k_p}}$$

$$2\sqrt{I_B} = \sqrt{i_2'} + \sqrt{i_2' + i_o'}$$

green loop: $0 = -v_+ - v_{GS_1} + v_{GS_2} + v_- \Rightarrow v_+ - v_- = v_{GS_2} - v_{GS_1}$

purple loop: $0 = -v_+ + v_{SG_3} - v_{SG_4} + v_- \Rightarrow v_+ - v_- = v_{SG_3} - v_{SG_4}$

add: $2(v_+ - v_-) = v_{GS_2} + v_{SG_3} - v_{GS_1} - v_{SG_4}$ but $v_{GS_1} = v_{SG_3}$ as I_B is in both

$= v_{GS_2} - v_{SG_4}$ & $i_{in}' \equiv 0$

$v_- = v_+ + \dfrac{v_{SG_4} - v_{GS_2}}{2}$ if small signals then probably $v_+ >> (v_{SG_4} - v_{GS_2})/2$ true if $|i_o| \ll i_2$