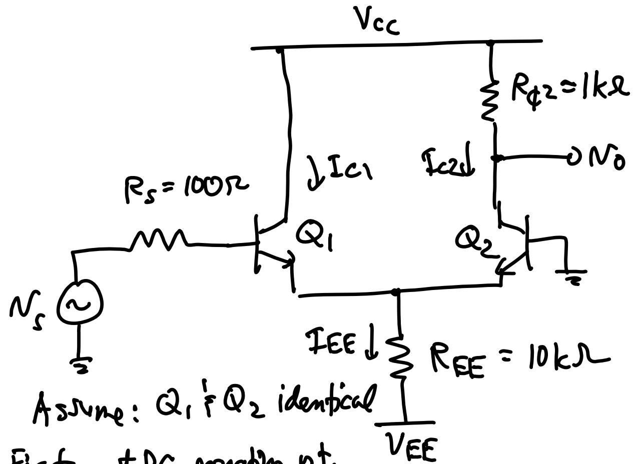
Inspection Analysis on a Multitransistor Ckt.



Assume: Q_1 & Q_2 identical

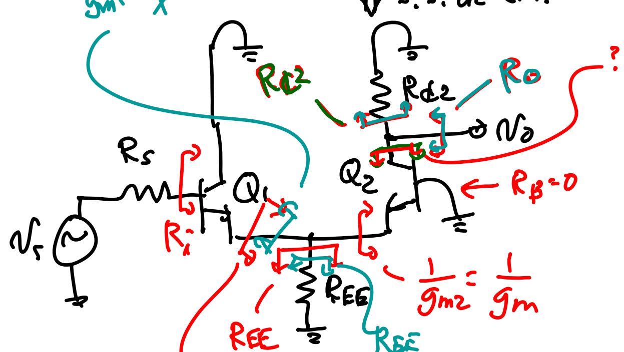
First, get DC operating pt.

$I_{C1} = I_{C2} = \frac{I_{EE}}{2} \rightarrow r_{\pi 1} = r_{\pi 2} = r_\pi$

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

$g_{m1} = g_{m2} = g_m$

$\Downarrow$ s.s. ac ckt.

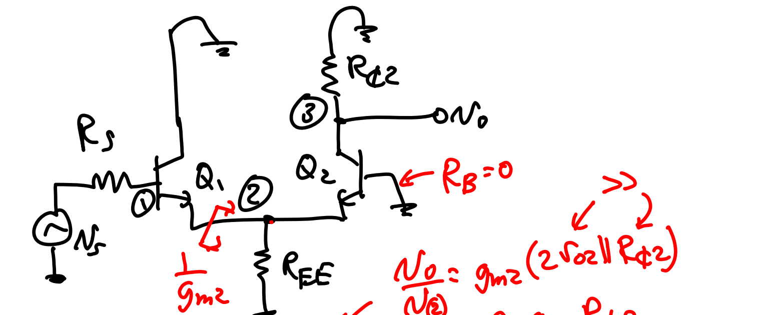


$\frac{1}{g_m} \| R_{EE} \leftarrow 10k\Omega \approx \frac{1}{g_m}$

$\sim 25\Omega$ for $I_C = 1mA$

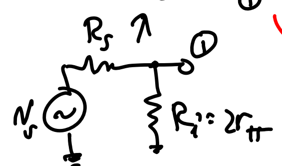
$R_i = r_{\pi 1} + (\beta+1)\frac{1}{g_{m2}} = r_{\pi 1} + r_{\pi 2} = 2r_\pi$

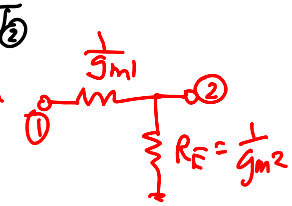
$R_o = r_{o2}\left(1 + \frac{g_{m2}\left(\frac{1}{g_{m1}}\right)}{1+0}\right) \| R_{C2} = (2r_o) \| R_{C2} \approx R_{C2}$



$\frac{v_o}{v_②} = g_{m2}(2r_{o2} \| R_{C2}) \approx g_{m2}R_{C2}$

$\frac{v_o}{v_s} = \frac{v_①}{v_s} \cdot \frac{v_②}{v_①} \cdot \frac{v_o}{v_②}$



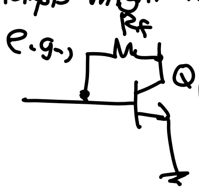


$\frac{v_①}{v_s} = \frac{2r_\pi}{R_s + 2r_\pi}$

$\frac{v_②}{v_①} = \frac{\frac{1}{g_{m2}}}{\frac{1}{g_{m1}} + \frac{1}{g_{m2}}} = \frac{1}{2}$

$$\frac{v_o}{v_s} = \left(\frac{2r_\pi}{R_s + 2r_\pi}\right)\frac{1}{2}g_m R_{C2}$$

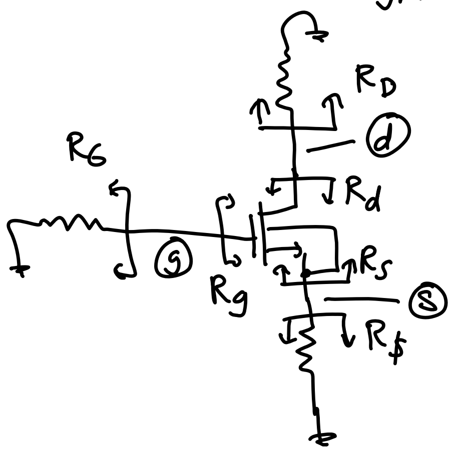
Inspection analysis might not work when there is feedback: e.g.,



MOS Xsistor Ckt.

⇒ for now, ignore Body effect (i.e., ignore g_{mb})

⇒ use the same inspection formulas as bipolar; but use $\beta \to \infty$, $r_\pi = \frac{\beta}{g_m} \to \infty$



⇒ referring to the "Inspection Formula Sheet":

Bipolar		MOS
$R_b = \left(\frac{1}{g_m} + R_E\right)(\beta+1)$	$\xrightarrow[\beta\to\infty]{}$	$R_g = \infty$
$R_e = \frac{1}{g_m} + \frac{R_B}{\beta+1}$	$\xrightarrow[\beta\to\infty]{}$	$R_s = \frac{1}{g_m}$
$R_c = r_o\left[1 + \frac{g_m R_E}{1 + R_B/r_\pi}\right]$ ($r_\pi \to \infty$)	$\xrightarrow[\beta\to\infty]{}$	$R_d = r_o[1 + g_m R_f]$

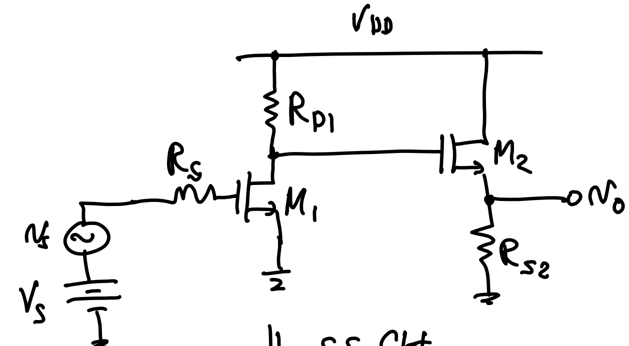
$$\frac{v_d}{v_g} = -G_m R_{ⓓ}, \quad G_m = \frac{g_m}{1+g_m R_f}$$

$$\frac{v_d}{v_s} = -G_m R_{ⓓ}, \quad G_m = -g_m$$

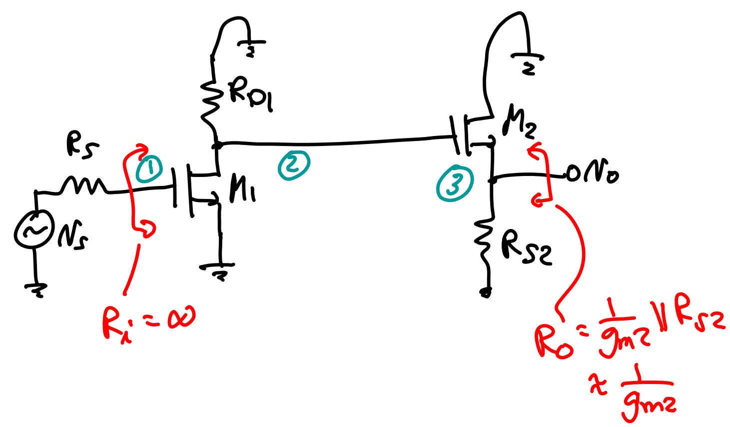
$$\frac{v_s}{v_o} = \frac{g_m R_f}{1+g_m R_f} = \frac{R_f}{\frac{1}{g_m} + R_f}$$

MOS Inspection Analysis

Ex: Common-Source Common-Drain Cascade



⇓ s.s. Ckt.



$$\frac{v_o}{v_s} = \frac{v_1}{v_s}\cdot\frac{v_2}{v_1}\cdot\frac{v_o}{v_2}$$

$r_{o1} \| R_{D1} \approx R_{D1}$

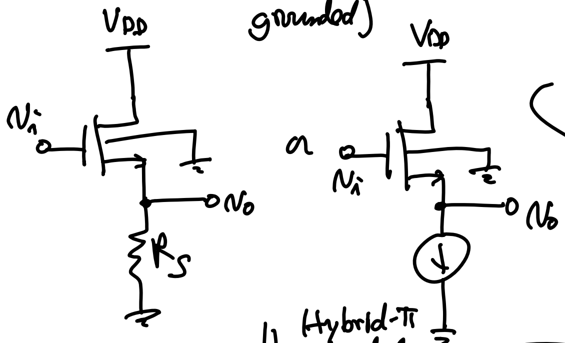
$$\frac{v_o}{v_s} = (1)(-g_{m1}R_{D1})\left(\frac{R_{S2}}{\frac{1}{g_{m2}}+R_{S2}}\right)$$

Problem: Simulate in SPICE → the gain will be from 80-90% of what you calculate!

→ the problem is w/ g_{mb} in the source follower!

← this is one difference between bipolar & MOS hybrid-π models!

Source Follower: (w/ substrate grounded)



due to Body effect: $V_{tn} = V_{to} + \gamma(\ )$

⇓ Hybrid-π Model