Lecture 8: Active Loads II & Current Sources

- **Announcements:**
  - HW#3 due tomorrow at 8 a.m.
  - HW#4 will be online soon
  - Videos of recorded lectures accessible by the lecture table on the website (soon)
- **Lecture Topics:**
  - Analysis of actively loaded circuits (continued)
  - Current Sources
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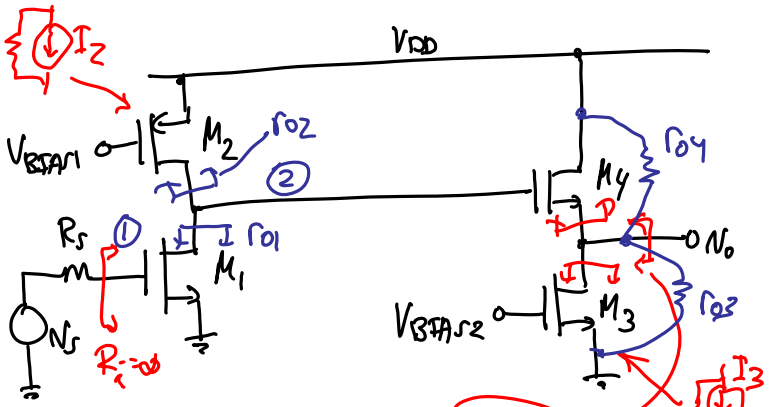
- **Last Time:**

Ex. Multi-Stage Actively-Loaded MOS Ckt.



Want R_i, R_O, A_{V1}, ω_H.

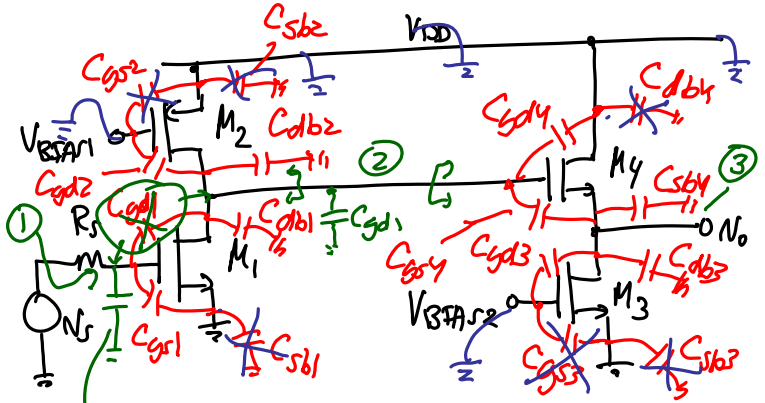
$R_O = r_{O3} \| r_{O4} \| \frac{1}{g_{m4}+g_{mb4}}$

$a_V = \frac{V_O}{V_S} = \frac{V_{①}}{V_S} \cdot \frac{V_②}{V_{①}} \cdot \frac{V_O}{V_②}$

$= (1) \| (-g_{m1}(r_{O1} \| r_{O2})) \cdot \frac{g_{m4}(r_{O3} \| r_{O4})}{1+(g_{m4}+g_{mb4})(r_{O3} \| r_{O4})}$

$a_V = -g_{m1}(r_{O1} \| r_{O2}) \left(\frac{g_{m4}}{g_{m4}+g_{mb4}} \right)$

Now, tackle freq. response:



$C_M = (1+g_{m1}(r_{O1} \| r_{O2}))C_{gd1}$

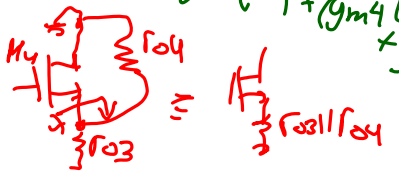
dominant

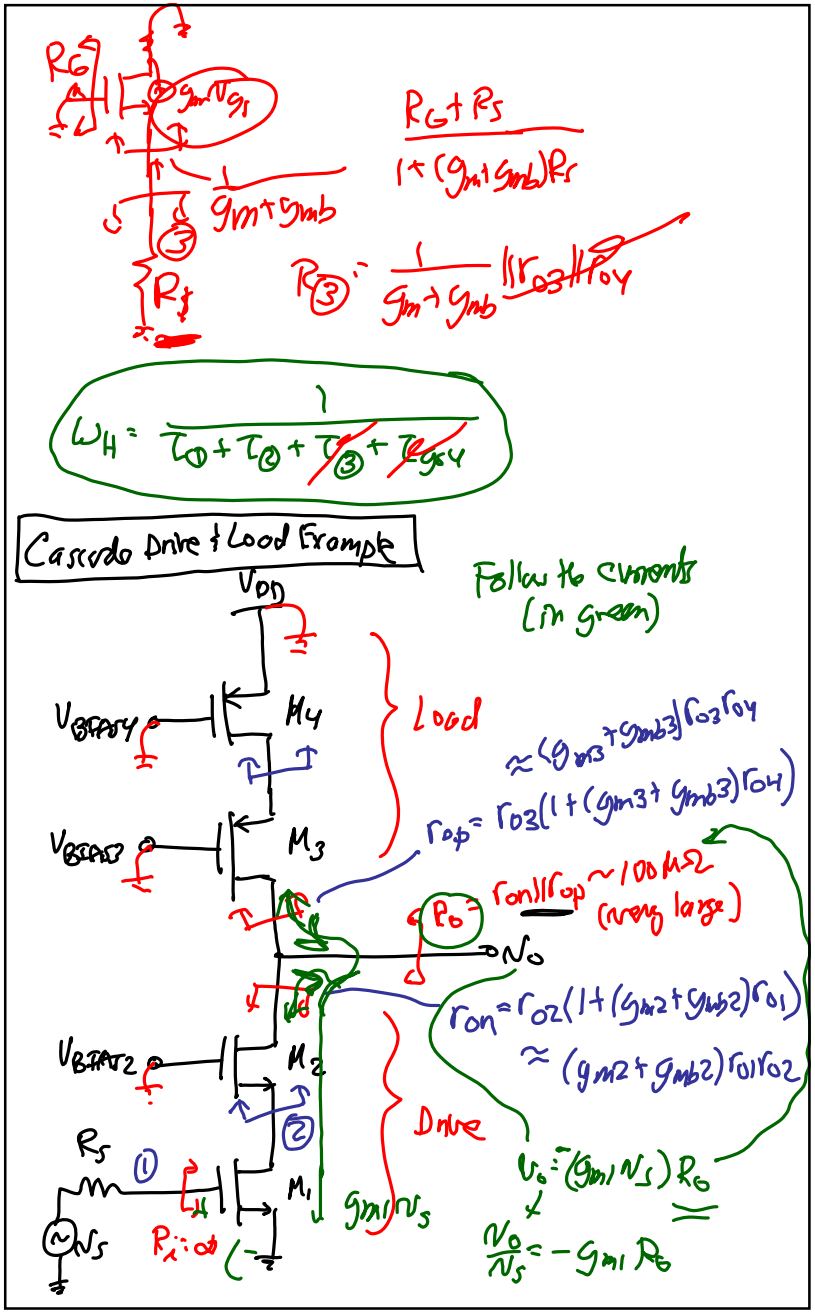
$\tau_① = \{C_{gs1} + C_{gd1}(1+g_{m1}(r_{O1} \| r_{O2}))\} R_S$

$\tau_② = \{C_{db1} + C_{db2} + C_{gd1} + C_{gd2} + C_{gd4}\}(r_{O1} \| r_{O2})$

$\tau_③ = \{C_{gd3} + C_{db3} + C_{sb4}\}\left(\frac{1}{g_{m4}+g_{mb4}}\right)$

$\tau_{gs4} = C_{gs4}\left\{\frac{(r_{O1} \| r_{O2}) + (r_{O3} \| r_{O4})}{1+(g_{m4}+g_{mb4})(r_{O1} \| r_{O2})}\right\} \simeq C_{gs4}\left(\frac{2}{g_{m4}+g_{mb4}}\right)$



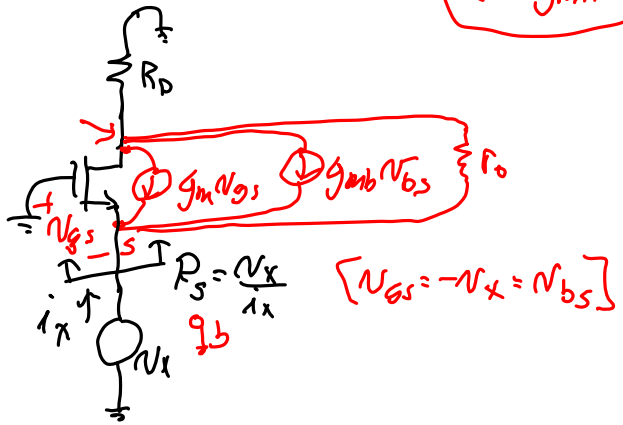


Gain: $a_v = \frac{v_{①}}{v_s} \cdot \frac{v_{②}}{v_{①}} \cdot \frac{v_o}{v_{②}}$ (G_{m2})

$= (1)(-g_{m1} R_{②}) \left(\frac{g_{m2} + g_{mb2}}{1 + r_{op}/r_{o2}}\right) R_o$

$= -g_{m1} \left(\frac{1 + r_{op}/r_{o2}}{g_{m2} + g_{mb2}}\right) \left(\frac{g_{m2} + g_{mb2}}{1 + r_{op}/r_{o2}}\right) R_o$

$\Rightarrow a_v = -g_{m1} R_o$



KCL: $i_x = -g_m v_{gs} - g_{mb} v_{bs} + \frac{v_x - i_x R_D}{r_o}$

$i_x \left(1 + \frac{R_D}{r_o}\right) = (g_m + g_{mb}) v_x + \frac{v_x}{r_o}$

$R_S = \frac{v_x}{i_x} = \frac{(1 + R_D/r_o)}{g_m + g_{mb}}$

$G_m = \frac{i_x}{v_x} = \frac{g_m + g_{mb}}{1 + R_D/r_o}$