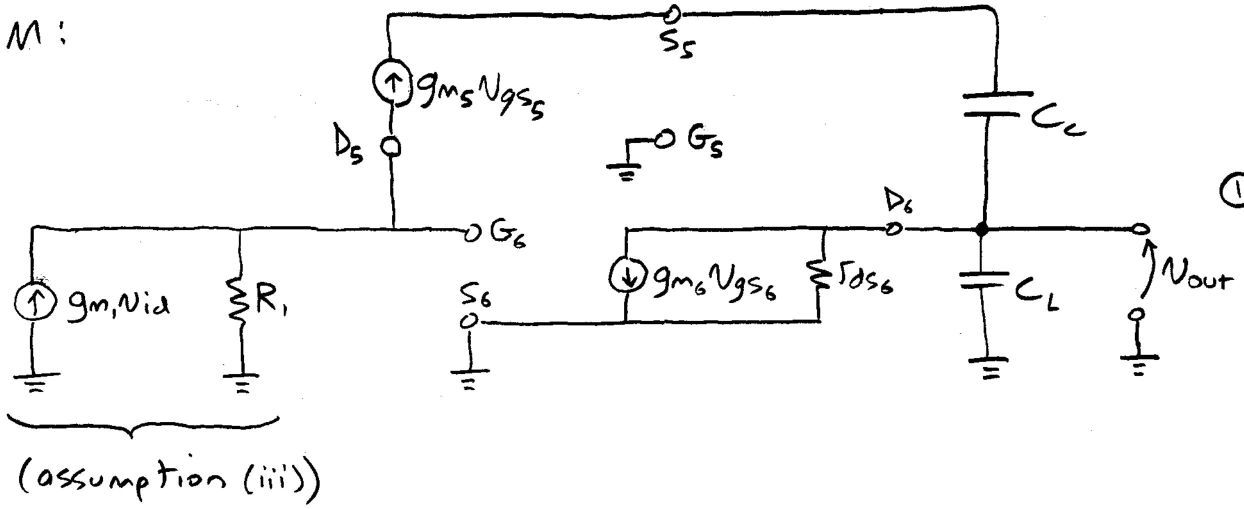
SSM:



1. Use ZVTC Theorem:

Let $C_1 = C_c$, $C_2 = C_L$ (Let R_1' and R_2' be the corresp. driving pt. resistances)

Inspection of ① $\Longrightarrow$ $R_2' = r_{ds6}$

To find R_1, set $v_{id} = 0$, $C_c = 0$, and $C_L = 0$, and insert a test source v_x across S_5 and D_6. Then $R_1' = v_x / i_x$ where i_x = current through the test source:

$$\left.\begin{array}{l} v_{out} = -r_{ds6}(i_x + g_{m6} v_{gs6}) \\ v_{gs6} = i_x R_1 \end{array}\right\} \Rightarrow \underbrace{v_{out} = -i_x r_{ds6}(1 + g_{m6} R_1)}_{②}$$

$$\left.\begin{array}{l} v_{out} + v_x + v_{gs5} = 0 \\ g_{m5} v_{gs5} = -i_x \end{array}\right\} \Rightarrow \underbrace{v_{out} = -v_x + i_x / g_{m5}}_{③}$$

$$②, ③ \Longrightarrow -i_x r_{ds6}(1 + g_{m6} R_1) - i_x / g_{m5} = -v_x$$

$$\therefore \quad R_1' = r_{ds6}(1 + g_{m6} R_1) + 1/g_{m5}$$

$$\therefore \quad \boxed{\omega_{-3dB} \cong \frac{1}{C_c[r_{ds6}(1 + g_{m6} R_1) + 1/g_{m5}] + C_L r_{ds6}}} \qquad ④$$

2. KCL at G_6

$$\frac{v_{gs6}}{R_1} - g_{m1} v_{id} + g_{m5}(0 - V_{S5}) = 0$$

$$\therefore v_{gs6} = R_1 (g_{m1} v_{id} + g_{m5} v_{S5}) \qquad (5)$$

KCL at S_5

$$-g_{m5}(0 - V_{S5}) + (V_{S5} - v_{out}) \cdot sC_c = 0$$

$$v_{S5} (g_{m5} + sC_c) = v_{out} \cdot sC_c$$

$$\therefore v_{S5} = v_{out} \cdot \frac{sC_c}{g_{m5} + sC_c} \qquad (6)$$

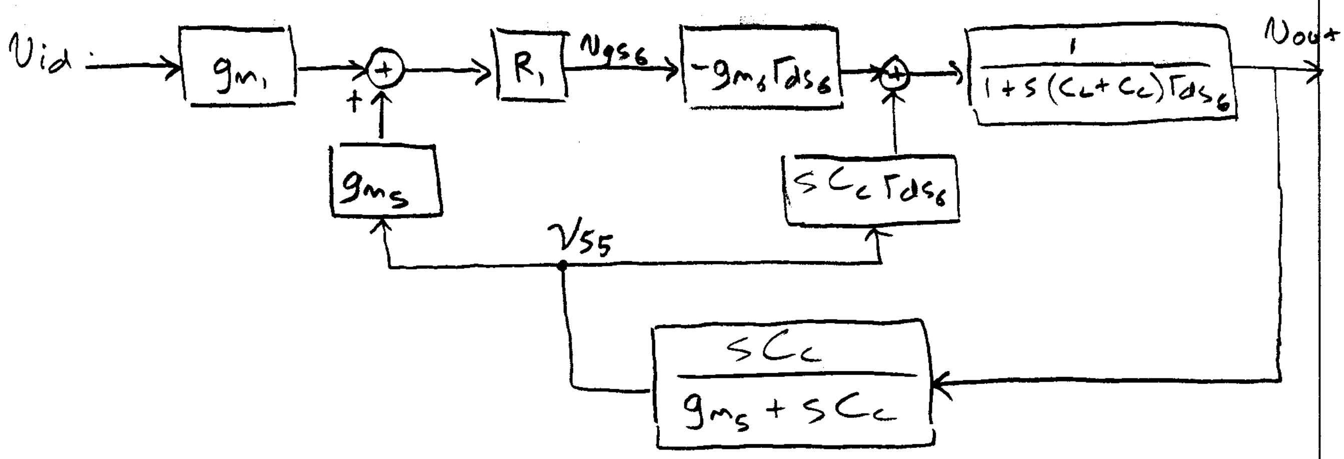
KCL at D_6

$$g_{m6} v_{gs6} + \frac{v_{out}}{r_{ds6}} + v_{out} \cdot sC_L + (v_{out} - (V_{S5}))sC_c = 0$$

$$v_{out}\left[\frac{1}{r_{ds6}} + s(C_L + C_c)\right] = -g_{m6} v_{gs6} + sC_c v_{S5}$$

$$v_{out} = \frac{-g_{m6} r_{ds6} v_{gs6} + sC_c r_{ds6} v_{S5}}{1 + s(C_L + C_c) \cdot r_{ds6}} \qquad (7)$$

(5) - (7) $\Rightarrow$ B.D. :



3.

$$P_1 = \underbrace{-g_{m1} R_1 g_{m6} r_{ds6}}_{\text{call } a_o} \cdot \frac{1}{1 + s(C_L + C_c) r_{ds6}}$$

$$L_1 = -g_{m5} R_1 g_{m6} r_{ds6} \cdot \frac{s C_c}{(1 + s(C_L + C_c) r_{ds6})(g_{m5} + s C_c)}$$

$$L_2 = r_{ds6} \cdot \frac{s^2 C_c^2}{(1 + s(C_L + C_c) r_{ds6})(g_{m5} + s C_c)}$$

$$1 - L_1 - L_2 = \frac{(1 + s(C_L + C_c) r_{ds6})(g_{m5} + s C_c) + a_o\left(\frac{g_{m5}}{g_{m1}}\right) s C_c - r_{ds6} s^2 C_c^2}{(1 + s(C_L + C_c) r_{ds6})(g_{m5} + s C_c)}$$

$$\therefore a(s) = \frac{P_1}{1 - L_1 - L_2}$$

$$a(s) = a_o \frac{g_{m5} + s C_c}{(1 + s(C_L + C_c) r_{ds6})(g_{m5} + s C_c) + a_o\left(\frac{g_{m5}}{g_{m1}}\right) s C_c - r_{ds6} s^2 C_c^2}$$

$$a(s) = a_o \frac{g_{m5} + s C_c}{g_{m5} + s\left[(C_L + C_c) r_{ds6} g_{m5} + a_o\left(\frac{g_{m5}}{g_{m1}}\right) C_c + C_c\right] + s^2 C_L C_c r_{ds6}}$$

$$\boxed{a(s) = a_o \frac{1 + s C_c / g_{m5}}{1 + s\underbrace{\left[(C_L + C_c) r_{ds6} + R_1 g_{m6} r_{ds6} C_c + C_c/g_{m5}\right]}_{\text{call } \beta} + s^2 C_L C_c r_{ds6} / g_{m5}}} \quad (5)$$

Note: (4) $= 1/\beta \Rightarrow$ consistent with prob. 1.

4. denom of (5) $= 1 + \beta s + \alpha s^2$

$$\therefore \boxed{P_1 = -\frac{1}{\beta} \cong -\frac{1}{R_1 g_{m6} r_{ds6} C_c}} \qquad \boxed{z = -\frac{g_{m5}}{C_c}}$$

$$\boxed{P_2 = -\beta/\alpha \cong -\frac{R_1 g_{m6} g_{m5}}{C_L}}$$