MT SOLUTIONS

1) MAIN LOOP M2/M3 SHUNT FB PAIR

LOOP GAIN $\simeq g_{m3} r_{o3} \underbrace{1}_{\text{FOLLOWER GAIN}} \simeq 10$

SERIES FB OF M1 A SECOND LOOP...

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2) $A_v = G_m R_o = g_m R_o$

$$R_o \simeq r_{o1} (1 + g_{m2} r_{o2}) g_{m3} r_{o3}$$

$$A_v \simeq (g_m r_o)^3 \simeq 1000$$

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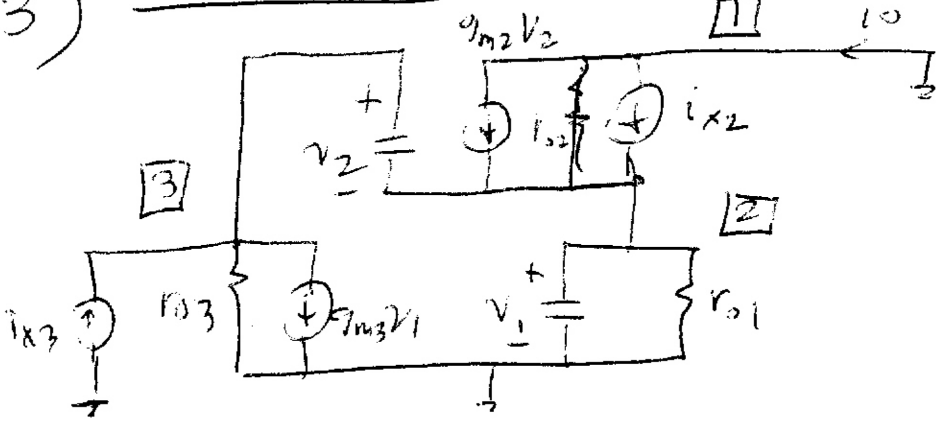
3) $a_1 \simeq 1$ BY INSPECTION

$a_2 \simeq 0$ DUE TO CASCODE / AND GAIN BOOSTING

$a_3 = ?$

→ CALC

3) NOISE CALC



[1] $$i_o = i_{x2} + g_{m2}v_2 - v_1/r_{o2}$$

[2] $$v_1/r_{o1}||r_{o2} = i_{x2} + g_{m2}v_2$$

[3] $$(i_{x3} - g_{m3}v_1)\, r_{o3} = v_1 + v_2$$

$$i_{x3}r_{o3} - A_v v_1 = v_1 + v_2$$

$$v_2 = i_{x3}r_{o3} - (A_v + 1)\, v_1$$

FROM [2] $$\frac{v_1}{r_{o1}||r_{o2}} = i_{x2} + g_{m2}r_{o3}i_{x3} - g_{m2}(A_v+1)v_1$$

$$v_1 \underbrace{\left(\frac{1}{r_{o1}||r_{o2}} + g_{m2}(A_v+1)\right)}_{D} = i_{x2} + A_v\frac{r_{o3}}{r_{o2}}\, i_{x3}$$

FROM [1] $$i_o = i_{x2} - g_{m2}(A_v+1)v_1 - v_1/r_{o2} + g_{m2}r_{o3}\, i_{x3}$$

$$= i_{x2} + A_v\frac{r_{o3}}{r_{o2}}\, i_{x3} - \left(g_{m2}(A_v+1) + \frac{1}{r_{o2}}\right) v_1$$

$$= i_{x2} + A_v\frac{r_{o3}}{r_{o2}}\, i_{x3} - \frac{\left(g_m(A_v+1) + \frac{1}{r_{o2}}\right)\left(i_{x2} + A_v\frac{r_{o3}}{r_{o2}}\, i_{x3}\right)}{D}$$

$$= \left(i_{x2} + A_v\frac{r_{o3}}{r_{o2}}\, i_{x3}\right)\left(1 - \frac{g_m(A_v+1) + \frac{1}{r_{o2}}}{D}\right)$$

$$i_o = \left(i_{x2} + A_v \frac{r_{o3}}{r_{o2}} i_{x3}\right)\left(\frac{D - g_{m2}(A_v+1) + \frac{1}{r_{o2}}}{D}\right)$$

$$= \left(i_{x2} + A_v \frac{r_{o3}}{r_{o2}} i_{x3}\right)\left(\frac{\frac{1}{r_{o1}||r_{o2}} - \frac{1}{r_{o2}}}{D}\right)$$

$$= \left(i_{x2} + A_v \frac{r_{o3}}{r_{o2}} i_{x3}\right)\left(\frac{1 - \frac{r_{o1}||r_{o2}}{r_{o2}}}{1 + g_{m2}\, r_{o1}||r_{o2}(A_v+1)}\right)$$

$$= \left(i_{x2} + A_v \frac{r_{o3}}{r_{o2}} i_{x3}\right)\left(\frac{1 - 1/2}{1 + A_v \frac{1}{2}(A_v+1)}\right)$$

$$= \left(\frac{1}{2 + A_v(A_v+1)}\right)$$

$$a_2 \cong \frac{1}{A_v^2} \qquad a_3 \cong \frac{\frac{r_{o3}}{r_{o2}}}{A_v}$$

DOMINATES NOISE AFTER M1

$$a_1 \simeq 1$$

4) DOM POLE $R_o C_L = r_{o1}(1 + g_{m2} r_{o2}) g_{m3} r_{o3}$

$= 2.5k\Omega \cdot 100 = 250k\Omega$

$C_L = 1pF$

$$\frac{1}{C_o R_L} = \frac{1}{250 \times 10^{-12} \times 10^3} = \frac{10^9}{250} \approx 4 \times 10^6$$

$f_{-3dB} \simeq 636 \text{ kHz}$

$$\omega_{p2} = \frac{1}{C_x \frac{r_{o3}}{A_v}}$$ } RESISTANCE LOWERED BY LOOP GAIN

$$\omega_{p2} = \frac{A_v}{C_x r_{o3}} = \frac{10}{20f \cdot 20k} \simeq 25 \times 10^9$$

$f_{p2} \simeq 4 \text{ GHz}$

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5) $\tau = \frac{C_{Leff}}{F \cdot G_m}$ $C_{Leff} = C_L + (1-F)C_F$

$$= \frac{1p + (1 - 1/5)\,0.5p}{\frac{1}{5}\,4mA} = \frac{5 \times 1.4}{4} 10^{-9}$$

$f = 1/\tau 2\pi = 91 \text{ MHz}$ $PM \simeq 90°$