HW5.

5. Telescopic ~~diff~~ cascode amplifier

Specs: $V_{DD} - V_{SS} = 5V$

$P_{max} = 1mW$

$A_{V,DM} = 10000$

$A_V = R_{OUT} \cdot G_m = g_m^2 r_o^2 / 2 = 10000$

$\therefore g_m r_o \geq 141$, use 200 to calculate.

$$g_m r_o = \frac{2I}{V_{DSAT}} \cdot \frac{1}{\lambda I} = \frac{2}{\lambda V_{DSAT}} = 200$$

$\therefore \lambda V_{DSAT} = 0.01$

if $V_{DSAT} = V_{DSAT,min} = 0.1V$, $\lambda = 0.1$.

$\therefore L = 1\mu m$, $V_{DSAT} = 0.1V$.

$\because P = 1mW$. $V_{DD} - V_{SS} = 5V$

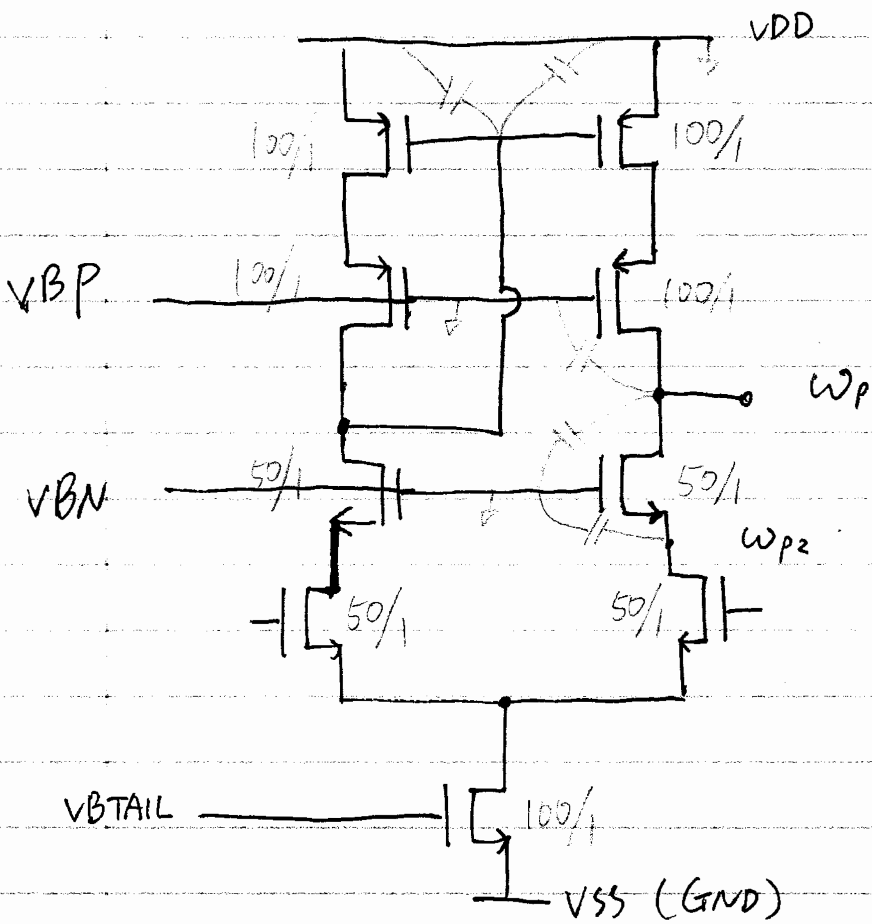
$\therefore I_{tail} = P/(V_{DD} - V_{SS}) = 200\mu A$

$\therefore$ current in each branch is $100\mu A$.

$\therefore \left(\frac{W}{L}\right)_N = 50$, $\left(\frac{W}{L}\right)_P = 100$

Circuit is in next page.

$g_m = 2mS$. $r_o = 100k\Omega$.



$V_{B,tail} = V_T + V_{DSAT} = 0.6V$ above VSS

$V_{BN} = (V_T + V_{DSAT}) + V_{DSAT} + V_{DSAT} = 0.8\ V$ above VSS

$V_{BP} = V_T + 2V_{DSAT} = 0.7\ V$ below VDD

$V_{IN,min} = 2V_{DSAT} + V_T = 0.7V$ above VSS

$V_{IN,max} = VDD - ((V_{DSAT} + V_T) + V_{DSAT}) - V_T = 2V_T + 2V_{DSAT}$ below VDD

$= 1.1\ V$ below VDD

dominant pole is in output node:

$$\omega_{p1} = \frac{1}{R_{OUT} \cdot C_{OUT}} = \frac{1}{\frac{1}{2} g_m r_o^2 C_L} = 10\text{K rad/s}$$

with Load

without load: $C_{OUT} = 2C_{gd} = 50\ fF$

$\therefore\ \omega_{p1} = \frac{1}{\frac{1}{2}g_m r_o \cdot 50fF} = 2M\ rad/s$

mirror pole/zero doublet:

$\omega_{p.m} = g_m / 2C_{gs}$ (ignore C_{gd})

$= 2\ G\ rad/s$

$\omega_z = 2\omega_{p,m} = 4\ G\ rad/s.$

another pole happens in the node of drain of diff FET.

$\omega_p = \frac{1}{R_o \cdot C_o} = \frac{g_m}{C_{gs}} = 4G\ rad/s.$

This pole cancel out the zero from the mirror.

$\omega_u = \begin{cases} \text{w/ Load} & 100M\ rad/s & \text{before } \omega_{p2}. \\ \text{w/o load} & \sim 6G\ rad/s & \text{after } \omega_{p2}. \end{cases}$

For ω_u for $(\omega_{p2} < \omega_u)$. first calculate

$A_v(\omega_{p2}) = A_v(DC) \cdot \frac{\omega_{p1}}{\omega_{p2}}.$

Then $\omega_u = \omega_{p2} \cdot 10^{\frac{\log A_v(P_2)}{2}}$

$= \omega_{p2} \cdot \sqrt{A_v(P_2)}$