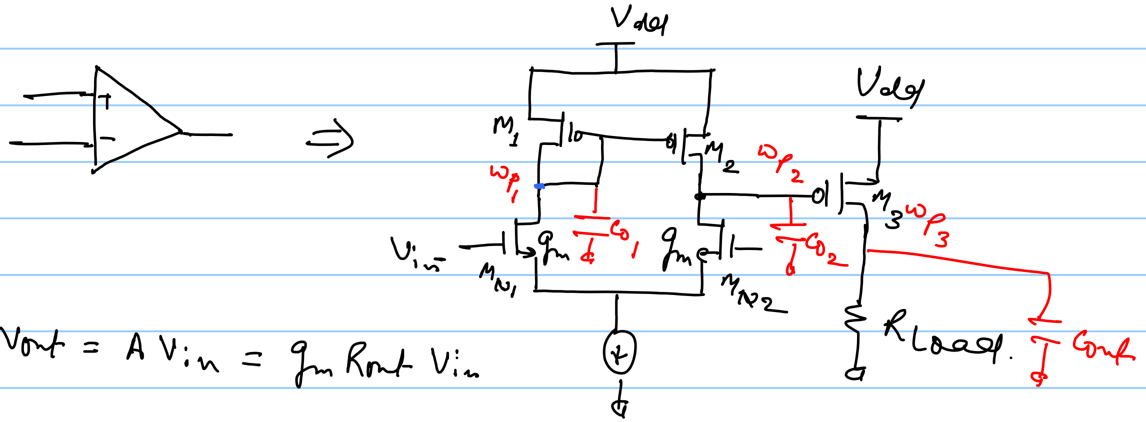
In order to find the poles.

$$\omega_p = \frac{1}{RC}$$

we need find nodes with high R & C



$$V_{out} = A\,V_{in} = g_m R_{out} V_{in}$$

$$\omega_{p_1} = \frac{1}{C_{o_1} \times R_{o_1}} = \frac{1}{C_{o_1} \times \left(\frac{1}{g_{m_1}}\right)} = \frac{g_{m_1}}{C_{o_1}} \qquad \left(R_{ds} >> \frac{1}{g_{m_1}} \right)$$

In saturation, drain current

$$I_d = \frac{1}{2} \mu_p C_{ox} \frac{W}{L} \left(|V_{gs}| - |V_{tn}| \right)^2$$

$$g_m = \frac{\partial I_d}{\partial V_{gs}} = \mu C_{ox} \frac{W}{L} \left(V_{gs} - V_{tn} \right)$$

$V_{th} \simeq 500mV$ for $180nm$ CMOS

$V_{gs} - V_{tn} \approx 100mV$

$I_d = 50\mu A$, $\frac{W}{L} = \frac{10\mu}{1\mu}$

$\mu_p C_{ox} \simeq 50\mu A/V^2$

$g_m = 50\mu \times 10 \times 100m = 50\mu A/V$

$\frac{1}{g_m} = 20K\Omega$

$C_{gb} \approx 5\, fF/\mu m^2$

$C_{o_1} = 10 \times 5\, fF/\mu m^2 = 50\, fF$

$\omega_{p_1} \approx \dfrac{1}{20k \times 50\, fF} = 1\, G\, rad/sec$

we can ignore ω_{p_1}.

$\omega_{p_2} = \dfrac{1}{(R_{o2} \| R_{o2n})\, C_{o2}}$

$r_{ds} = \dfrac{1}{\lambda I_d}$, $\lambda =$ channel length modulation

$\lambda \approx 0.5 - 1/V$ for $L = 180\, nm$

$\lambda \propto \dfrac{1}{L}$

Let's assume $L = 1\mu m$

$\lambda \approx 0.1$ to $0.2\ /V$

assume $\lambda = 0.1$

$I_d = 10\ \mu A$

$$R_{o_2} = \frac{1}{0.1 \times 10\mu} \approx 1 M\Omega$$

$R_{on} = 1 M\Omega$

$R_{o_2} = 500 k\Omega$

$Co_2 \rightarrow$ we need to find the size of M_3

Assume Max. load current $= 10 mA$

M_3 has to be in saturation.

$V_{dd} = 1.8V \pm 0.2$

$V_{dd\_min} = 1.6V$

V_{out} max $= 1.5V$

$V_{drop\text{-}out} = V_{ds_{min}} = 100 mV$

$\frac{W}{L}$ should be determined for

$(V_{gs} - V_{th}) \leq 100mV$ & $I_d = 10mA$

$$I_d = \frac{1}{2} \mu C_{ox} \frac{W}{L} (V_{gs} - V_{th})^2$$

$$10mA = \frac{1}{2} (50\mu) \frac{W}{L} (100mV)^2$$

$$W/L = \frac{20m}{50\mu \times 10^4 \times 10^{-6}}$$

$$\frac{20 \times 10^{-3}}{50 \times 10^{-8}} = \frac{20}{50} \times 10^5 = 40{,}000$$

$$W = 40{,}000 \times 0.18\mu m = 7200\,\mu m.$$

$$W \times L = 7200 \times 0.18 = 1296\ \mu m^2$$

$$C_{gb} = 5\,\mu F/\mu m^2$$

$$C_{o2} = 6.48\,pF$$

$$\omega_{p_2} = \frac{1}{500k \times 6.48pF} = \frac{1}{5\times10^{5}\times 6.48\times10^{-12}}$$

$$= \frac{10^7}{5\times 6.48} = 0.03\times10^7 = 3\times10^5$$

$$= 300\ \text{krad/sec}$$

ω_{p_2} can't be ignored.

$$\omega_{p_3} = \frac{1}{R_{out} C_{out}}$$

assume $C_{out} = 10pF$

$\lambda \simeq 1$

$$r_{o_3} = \frac{1}{10mA} = 100\,\Omega$$

$$R_{load} = \frac{1.5V}{10mA} = 150\,\Omega$$

$$R_{out} = 100 \parallel 150 = 60\,\Omega$$

$$\omega_{p_3} = \frac{1}{R_{out} \times C_{out}} = 1.67\ G\,rad/sec.$$

ω_{p_3} is outside UGB

Assume

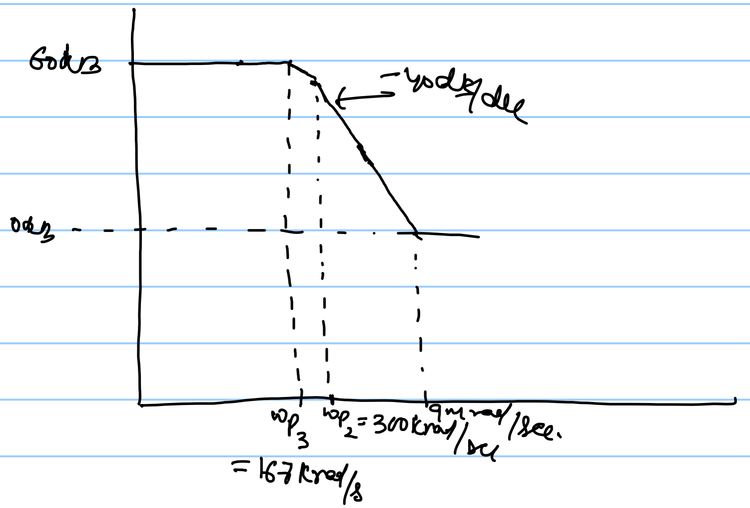
$C_{out} = 10\,uF$

$\omega_{p_3} = 1.67\ krad$

Assume

$C_{out} = 10\,uF$

$\omega_{p_3} = 167\ krad/sec$



PM ≃ 0 ⇒ unstable.

for 60° phase margin

ω_{ugb} should be $\frac{\omega_{p_3}}{1.7}$

ω_{p_2} (compensated) should be $\frac{\omega_{ugb}}{60dB}$

$$\omega_{ugb} = \frac{167K}{1.7} \simeq 100K \text{ rad/s}$$

ω_{p_2} (compensated) = 100 rad/sec.

$$\omega_{p_2} = \frac{1}{500k \times (C_c + C_{o_2})} = 100 \text{ rad/sec},$$

$$C_c + C_{o_2} = \frac{1}{5 \times 10^5 \times 100} = \frac{10^{-7}}{5}$$

$$= \frac{100}{5} \times 10^{-9} = 20 nF$$