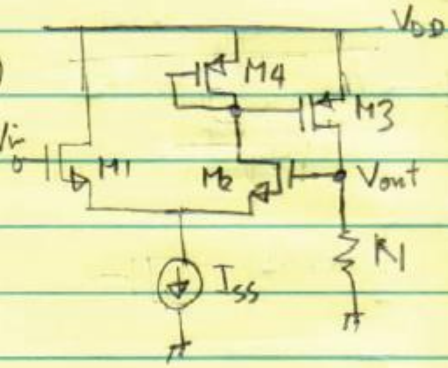
EHB 335E HW #3 Solutions

(1)

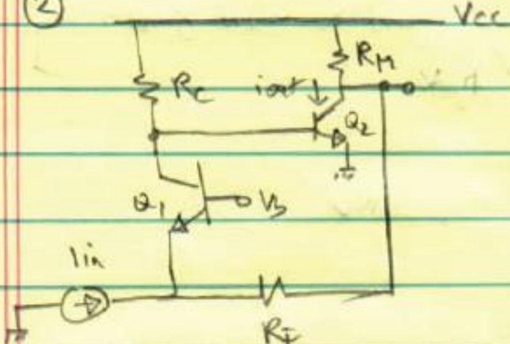


As $V_{in} \uparrow$ $I_{s1} \uparrow$ $I_{s2} \downarrow$

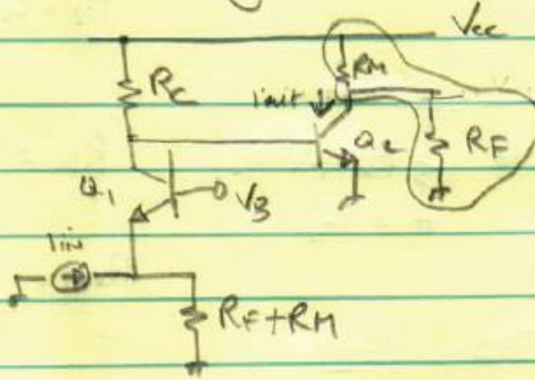
$V_{g,M3} \downarrow$ $I_{d,M3} \downarrow$ $V_{out} \downarrow$ $I_{s2} \downarrow\downarrow$

As can be seen, this is a positive feedback

(2)



With loading effects taken into account:



Since Iout is chosen, all these are considered external

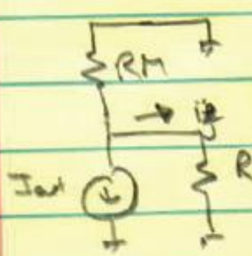
current - current amplifier
shunt - series feedback

$$A_0 = \frac{(R_F+R_M)\,R_C}{\frac{1}{g_{m1}}+(R_F+R_M)}\,g_{m2}$$

$$R_{in} = \frac{1}{g_{m1}} \,//\, (R_M+R_F) \cong \frac{1}{g_{m1}}$$

$$A_0 \cong g_{m2}R_C$$

$$R_{out} = R_M//R_F$$



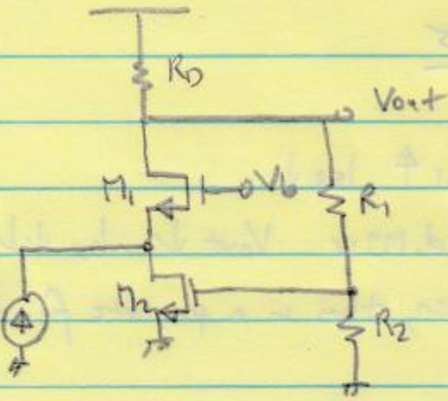
$$i_f = \frac{i_{out}\,R_M}{R_F+R_M} \Rightarrow \frac{i_f}{i_{out}} = \frac{R_M}{R_M+R_F} \simeq \frac{R_M}{R_F} = K$$

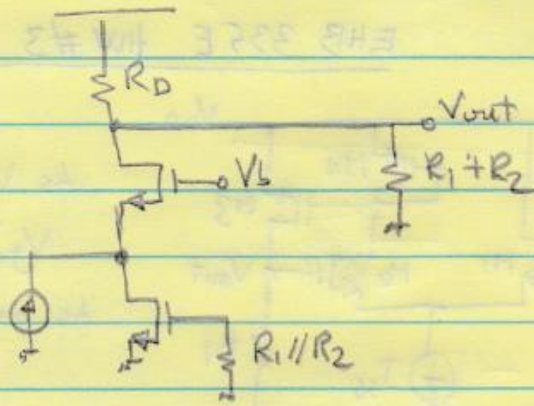
Closed loop gain: $\dfrac{A_0}{1+KA_0}$

Closed loop input resistance $\tilde{R}_{in} = \dfrac{R_{in}}{1+KA_0}$

Closed loop output resistance: $\tilde{R}_{out} = R_{out}(1+KA_0)$

(3)

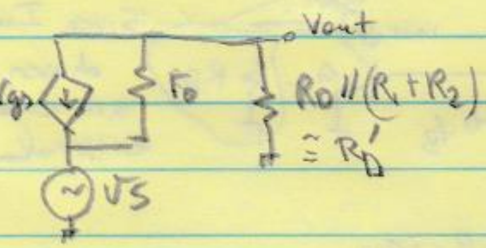




current-voltage amplifier
shunt-shunt feedback

$$R_o = \left(\frac{r_{o2}}{r_{o2} + R_V}\right)\left[R_D // (R_1 + R_2)\right]$$

$R_V = ?$



$$R_{in} = r_{o2} \,//\, R_V$$

$$R_{out} = R_D // (R_1 + R_2) // g_{m1} r_{o1} r_{o2}$$

$$g_m v_s + \frac{v_s - v_{out}}{r_o} = \frac{v_{out}}{R_D'}$$

$$K = \frac{R_2}{R_1 + R_1} \cdot g_{m2}$$

$$v_s\left(g_m + \frac{1}{r_o}\right) = v_{out}\left(\frac{1}{R_D'} + \frac{1}{r_o}\right)$$

$$v_{out} = v_s \frac{\left(g_m + \frac{1}{r_o}\right)}{\frac{1}{R_D'} + \frac{1}{r_o}}$$

$$CL\ R_o = \frac{R_o}{1 + K R_o}$$

$$CL\ R_{in} = \frac{R_{in}}{1 + K R_{in}}$$

$$i_s = g_m v_s + \frac{v_s + v_{out}}{r_o}$$

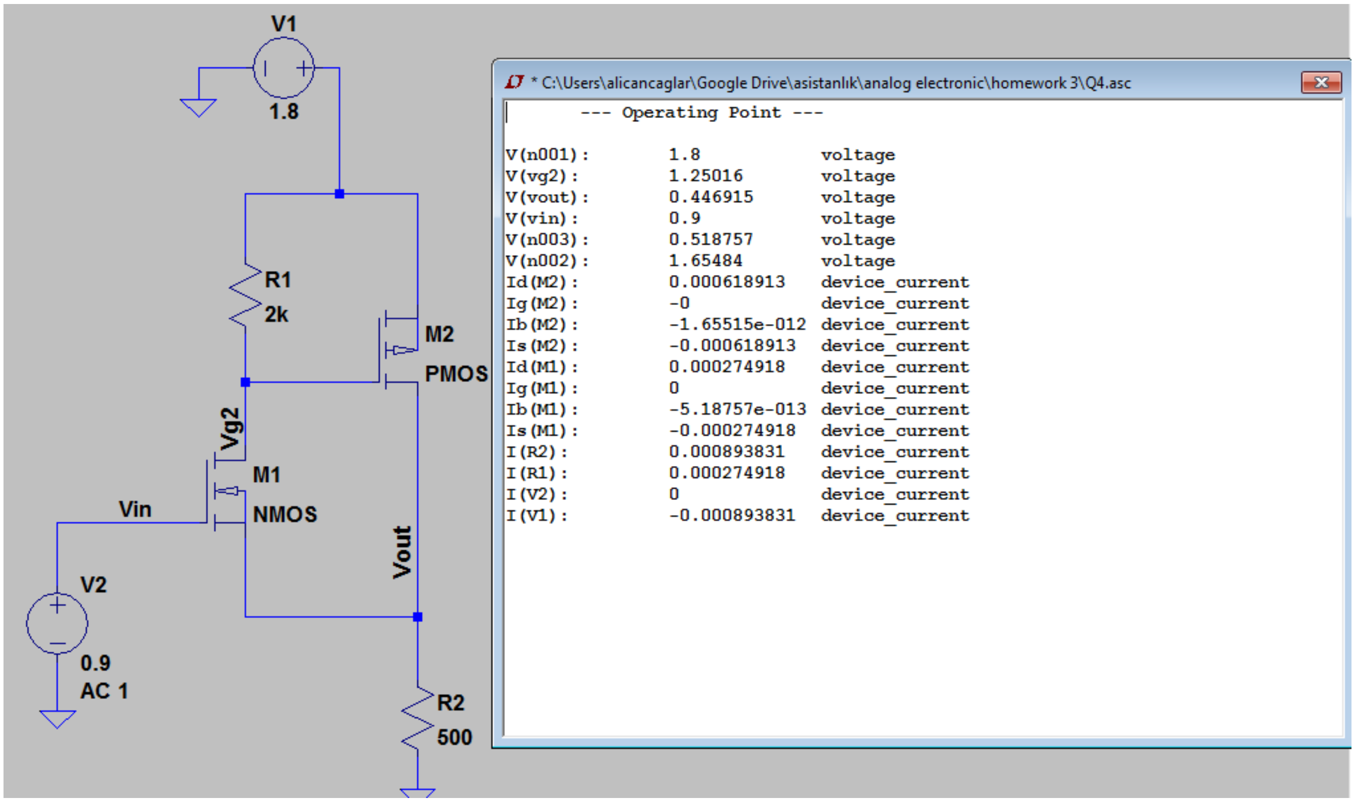
$$CL\ R_{out} = \frac{R_{out}}{1 + K R_{out}}$$

$$i_s = v_s\left[g_m + \frac{1}{r_o}\,\frac{\frac{1}{R_D'} - g_m}{\frac{1}{R_D'} + \frac{1}{r_o}}\right]$$

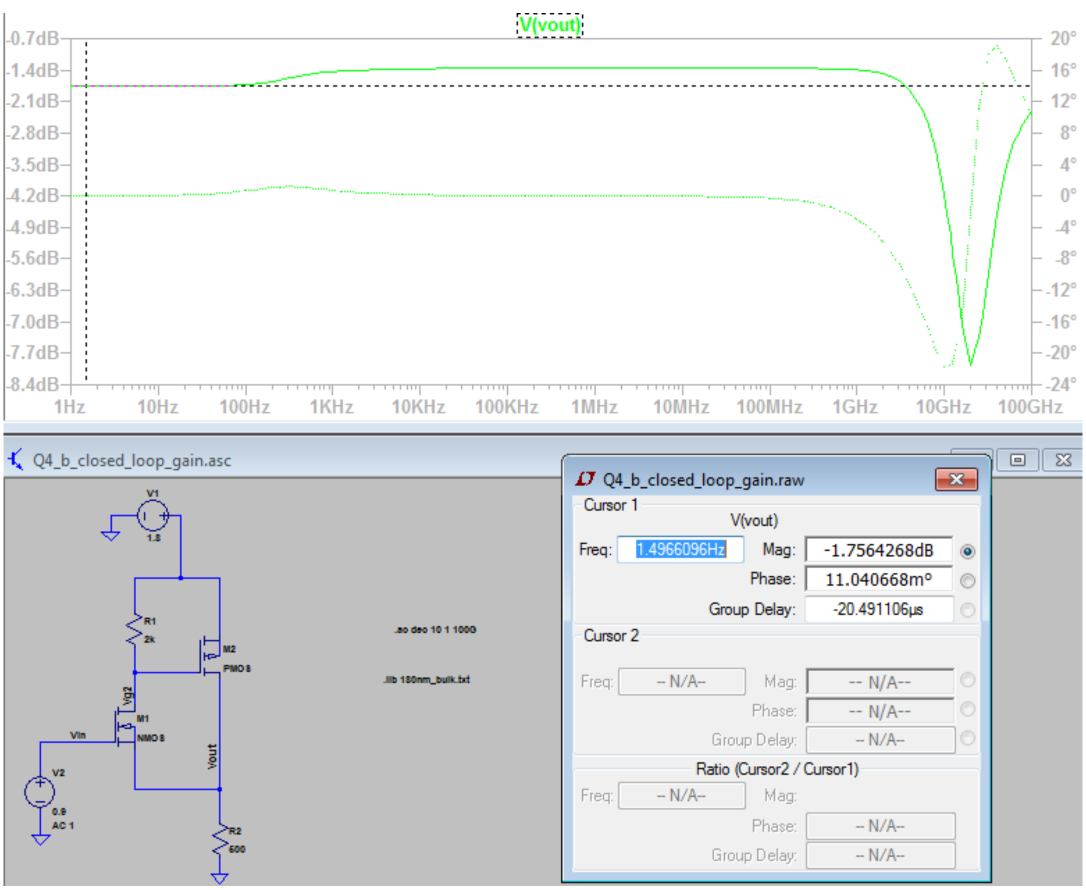
$$i_s = v_s\left[g_m\left(\frac{r_o}{R_D'} + 1\right) + \frac{1}{R_D'} - g_m\right] \Big/ \left(1 + \frac{r_o}{R_D'}\right)$$

$$\frac{v_s}{i_s} = R_V = \frac{R_D'\left(1 + \frac{r_o}{R_D'}\right)}{(g_m r_o + 1)}$$

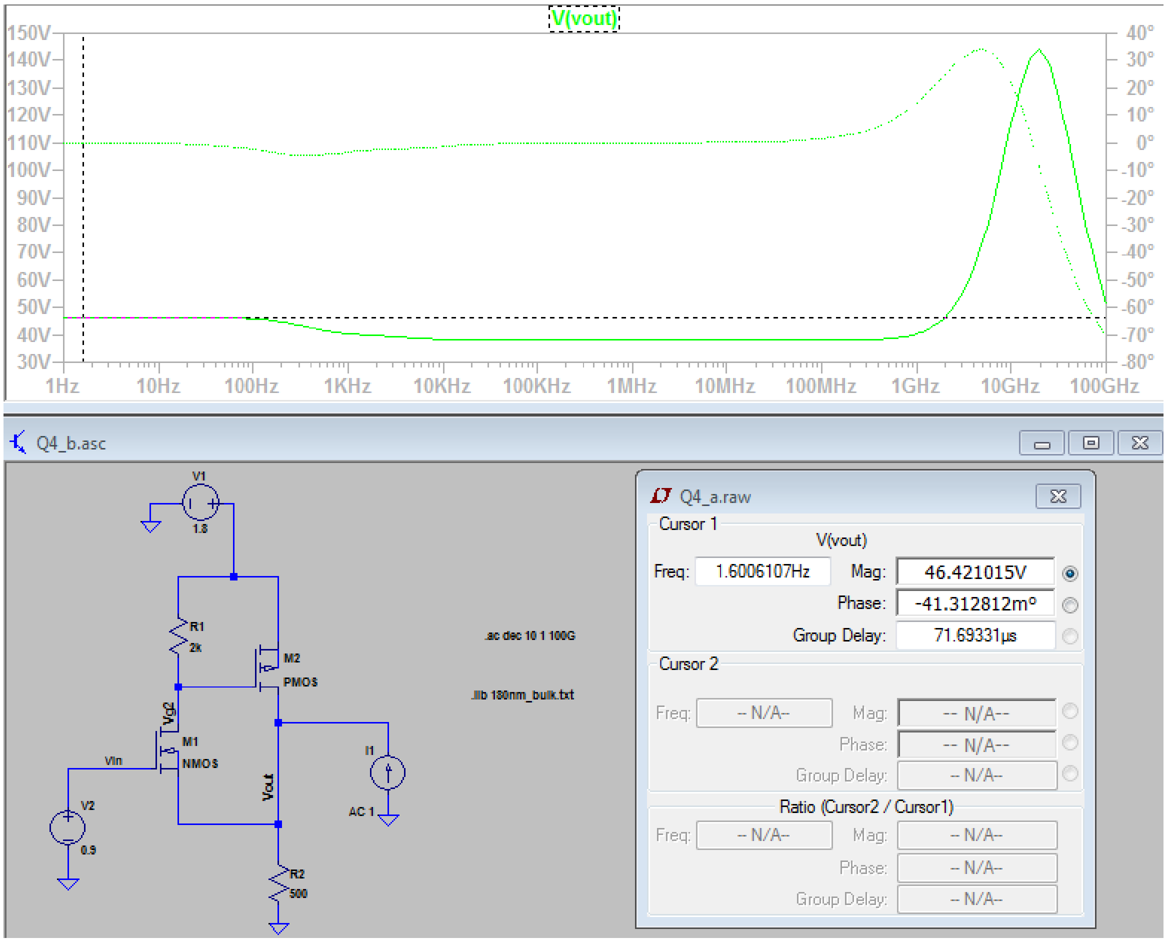
4.a) Operating points of the circuit, when input voltage is 0.9 V.



4.b) Closed loop gain is about -1.75 dB at low frequency.



Output impedance at low frequency is approximately 46.4 ohm.



Input impedance is infinite.