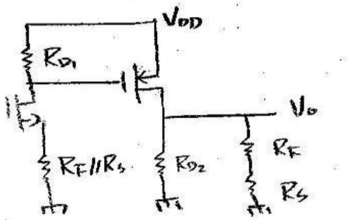
Q1 Q2

(a). V → V



$$\beta = \frac{R_S}{R_F + R_S}$$

$$A_{OL} = \frac{V_i}{V_o} = \frac{g_{m1} R_{D1}}{1 + g_{m1}(R_F // R_S)} \cdot g_{m2}[R_{D2} // (R_F + R_S)]$$

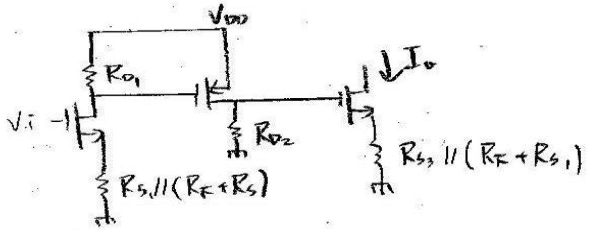
$$\text{Loop Gain} = \beta A_{OL} = \frac{R_S}{R_F + R_S} \cdot \frac{g_{m1} g_{m2} R_{D1} [R_{D2} // (R_F + R_S)]}{1 + g_{m1}(R_F // R_S)} \quad \#$$

$$R_{o,OL} = R_{D2} // (R_F + R_S)$$

$$R_{o,CL} = \frac{R_{o,OL}}{1 + \beta A_{OL}} \quad \#$$

$$A_{CL} = \frac{A_{OL}}{1 + \beta A_{OL}} \quad \#$$

(b). I → V



$$\beta = \frac{I_F}{V_t} = \frac{R_{S3} \cdot R_{S1}}{R_{S3} + (R_F + R_{S1})}$$

$$A_{OL} = \frac{I_o}{V_i} = \frac{g_{m1} R_{D1}}{1 + g_{m1}[R_{S1} // (R_F + R_S)]} \cdot g_{m2} R_{D2} \cdot \frac{g_{m3}}{1 + g_{m3}[R_{S3} // (R_F + R_{S1})]}$$

$$\cong \frac{g_{m2} R_{D1} R_{D2}}{[R_{S1} // (R_F + R_S)] \cdot [R_{S3} // (R_F // R_S)]}$$

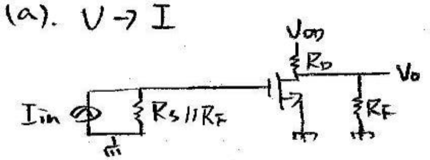
$$\beta A_{OL} = \frac{R_{S3} R_{S1}}{R_{S3} + R_F + R_{S1}} \times \frac{g_{m2} R_{D1} R_{D2}}{[R_{S1} // (R_F + R_S)] \cdot [R_{S3} // (R_F + R_S)]} \quad \#$$

$$R_{o,OL} = g_{m3} r_{o3} [R_{S3} + (R_F + R_{S1})]$$

$$R_{o,CL} = (1 + \beta A_{OL}) R_{o,OL} \quad \#$$

$$A_{CL} = \frac{A_{OL}}{1 + \beta A_{OL}} \quad \#$$

(a). V → I



$$\beta = -\frac{1}{R_F}$$

$$A_{OL} = \frac{V_o}{I_{in}} = -(R_S // R_F) \cdot g_{m1} \cdot (R_D // R_F)$$

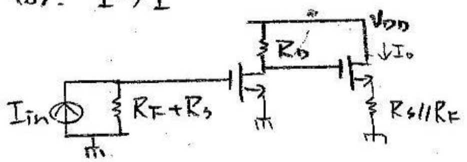
$$\beta A_{OL} = \frac{(R_S // R_F) \cdot g_{m1} \cdot (R_D // R_F)}{R_F} \quad \#$$

$$R_{o,OL} = R_D // R_F$$

$$R_{o,CL} = \frac{R_D // R_F}{1 + \beta A_{OL}} \quad \#$$

$$A_{CL} = \frac{V_o}{V_i} = \frac{1}{R_S} \cdot \frac{A_{OL}}{1 + \beta A_{OL}} \quad \#$$

(b). I → I



$$\beta = \frac{-R_S}{R_S + R_F}$$

$$A_{OL} = \frac{I_o}{I_{in}} = -(R_F + R_S) \cdot g_{m1} R_D \cdot \frac{g_{m2}}{1 + g_{m2}(R_S // R_F)}$$

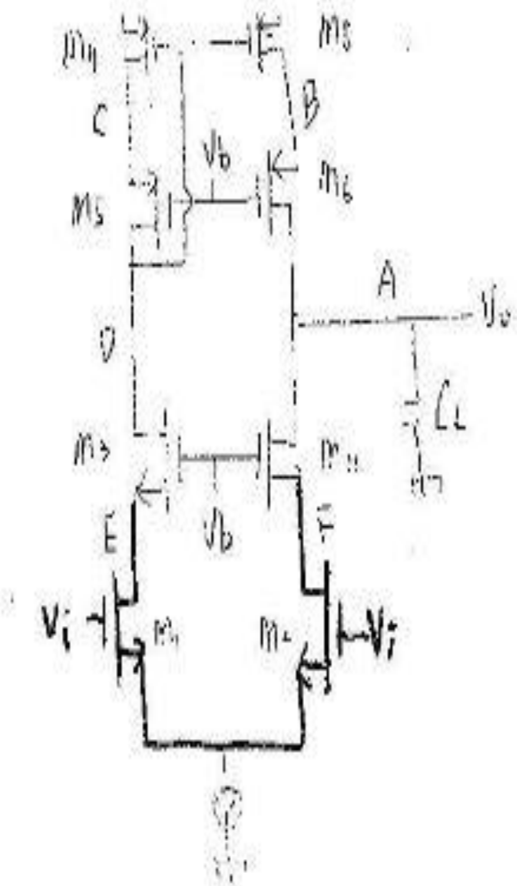
$$\beta A_{OL} = \frac{g_{m1} g_{m2} R_D R_S}{1 + g_{m2}(R_S // R_F)} \quad \#$$

$$R_{o,OL} = \frac{1}{g_{m2}} // R_S // R_F$$

$$R_{o,CL} = (1 + \beta A_{OL}) \cdot R_{o,OL} \quad \#$$

$$A_{CL} = \frac{A_{OL}}{1 + \beta A_{OL}} \quad \#$$

Q3



$$\omega_{pA} = \frac{1}{R_o \cdot C_L}, \quad R_o = g_{m6} r_{o6} r_{o8} \,//\, g_{m4} r_{o4} r_{o2}$$

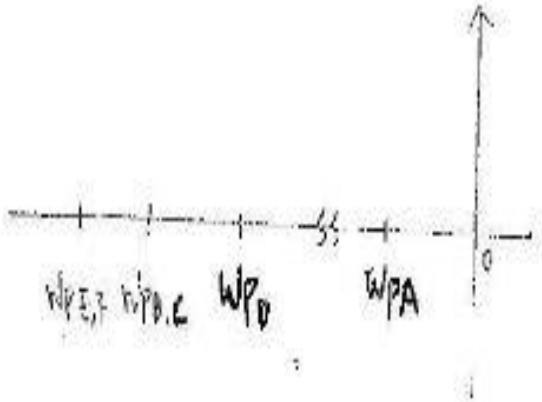
$$\omega_{pB} = \frac{g_{m6}}{C_B}, \quad C_B = C_{db8} + C_{sb6} + [C_{gd8} \,//\, (C_{gs7} + C_{gs8})] + C_{gs6} \cong C_{gs6}$$

$(\text{if } C_{gs} \gg C_{gd} \Rightarrow \text{other})$

$$\omega_{pC} = \frac{gm5}{C_C} \cong \omega_{pB}$$

$$\omega_{pD} = \frac{g_{m7}}{C_D}, \quad C_D = C_{gd5} + C_{gd3} + C_{db5} + C_{db3}$$ +cgs7+cgs8

$$\omega_{pE,F} = \frac{g_{m3}}{C_{E,F}}, \quad C_{E,F} = C_{gs3} + C_{sb3} + C_{db1} \cong C_{gs3}$$



4.
(a). $A_v = g_{m1,2} \cdot (r_{o2} \parallel r_{o4}) \cdot g_{m6} \cdot (r_{o6} \parallel r_{o7})$ #

$W_{P1} = \dfrac{1}{C_L \cdot (r_{o6} \parallel r_{o7})}$, $W_{P2} = \dfrac{1}{(r_{o2} \parallel r_{o4}) \cdot C_{P2}}$, $C_{P2} = C_{gs6} + C_{db4,2}$

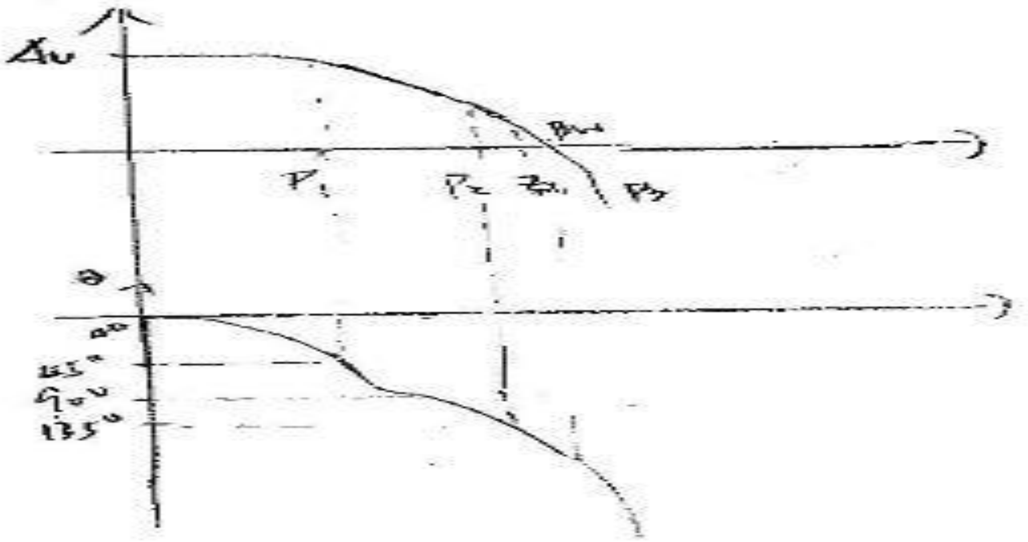
$W_{P3} = \dfrac{1}{\frac{1}{g_{m3}} \cdot C_{P3}}$, $C_{P3} = C_{gs3,4} + C_{db1}$

(b).
$W_{P1} = \dfrac{1}{g_{m6}(r_{o6} \parallel r_{o7}) \cdot C_C \cdot (r_{o2} \parallel r_{o4})}$

$W_{P2} = \dfrac{g_{m6}}{C_L}$, $W_{P3} = \dfrac{1}{\frac{1}{g_{m3}} \cdot C_{P3}}$

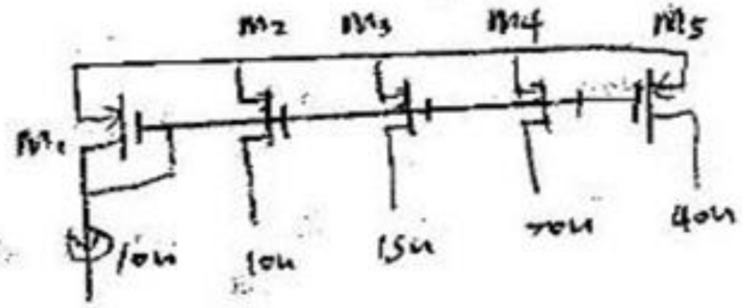
$GB = A_v \cdot W_{P1} = \dfrac{g_{m1,2}}{C_C}$

(c).



$Z_1 = \dfrac{g_{m6}}{C_C}$, $C_L > C_C \Rightarrow P_2 > Z_1$

5、



假設 $V_{ov} = 0.2$

$$5u = \frac{1}{2} \cdot 50u \left(\frac{W}{L}\right)_1 \cdot 0.2^2$$

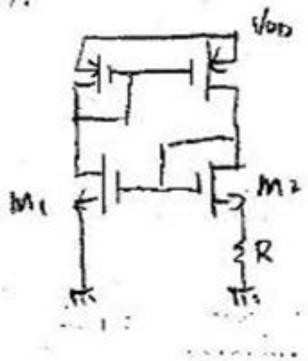
$$\left(\frac{W}{L}\right)_1 = 5.$$

$$\frac{1}{40u \cdot \lambda} > 20k, \quad \lambda < \frac{1}{0.8} \quad \Rightarrow \underline{L = 1u}$$

$$M_1 = \frac{5u}{1u} \cdot 2, \quad M_2 = \frac{5u}{1u} \cdot 2, \quad M_3 = \frac{5u}{1u} \cdot 3$$

$$M_4 = \frac{5u}{1u} \cdot 4, \quad M_5 = \frac{5u}{1u} \cdot 8$$

(b).



$$I_D = \frac{V_{gs1} - V_{gs2}}{R} = \frac{\sqrt{\frac{2I_{D1}}{\beta_1}} - V_{th1} - \sqrt{\frac{2I_{D2}}{\beta_2}} + V_{th2}}{R}$$

$V_{th1} = V_{th2}$

$\beta_2 = 4\beta_1 = 4\beta$

$I_{D1} = I_{D2} = I_D$

$$I_D R = \sqrt{\frac{2I_D}{\beta}} - \sqrt{\frac{2I_D}{4\beta}}$$

$$I_D^2 R^2 = \frac{2I_D}{\beta} - 2 \cdot \sqrt{\frac{4I_D^2}{4\beta^2}} + \frac{2I_D}{4\beta}$$

$$I_D^2 R^2 = \frac{2I_D}{\beta} - \frac{2I_D}{\beta} + \frac{2I_D}{4\beta}$$

$$I_D = \frac{2}{4\beta R^2} = \frac{1}{2\beta R^2}$$ 和 V_{DD} 無關.