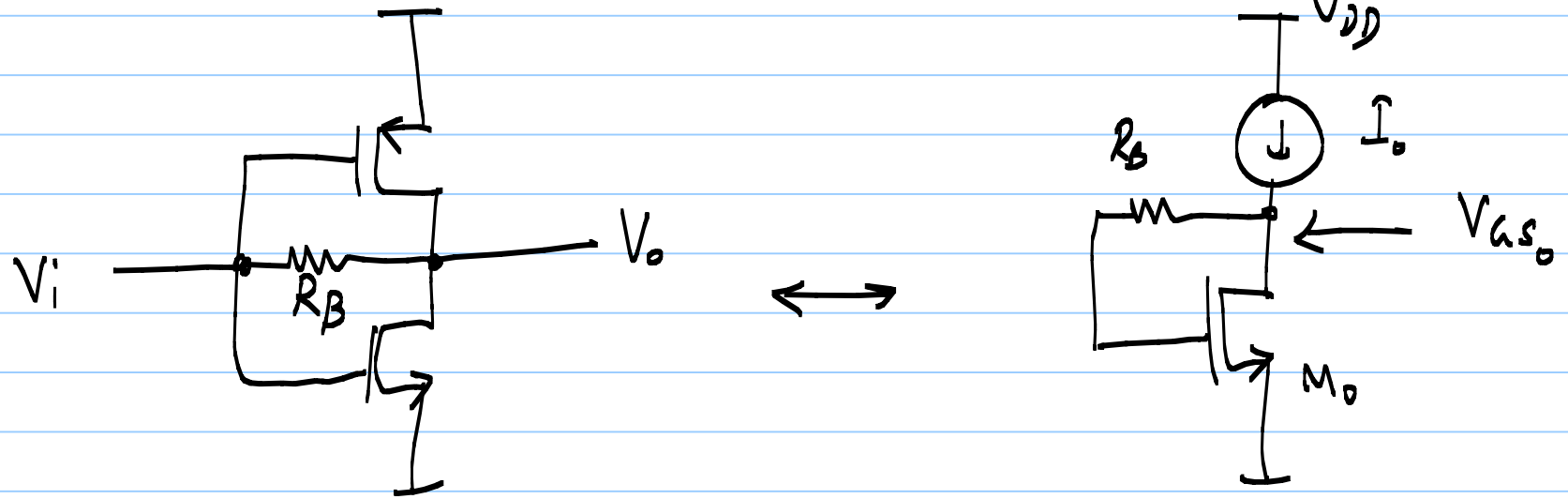
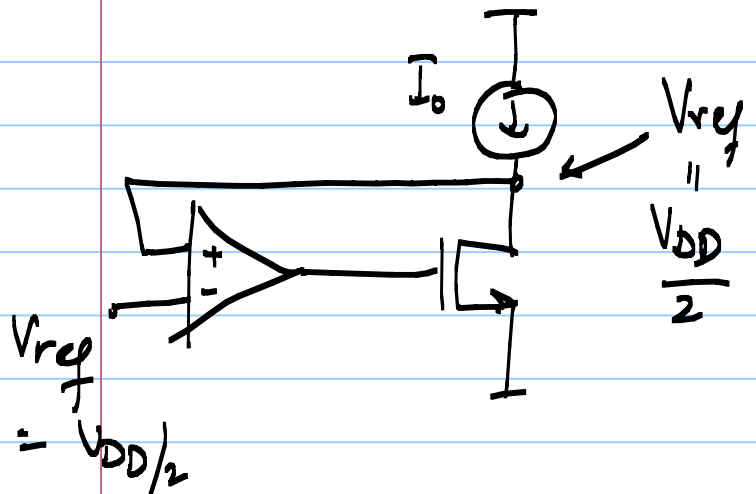
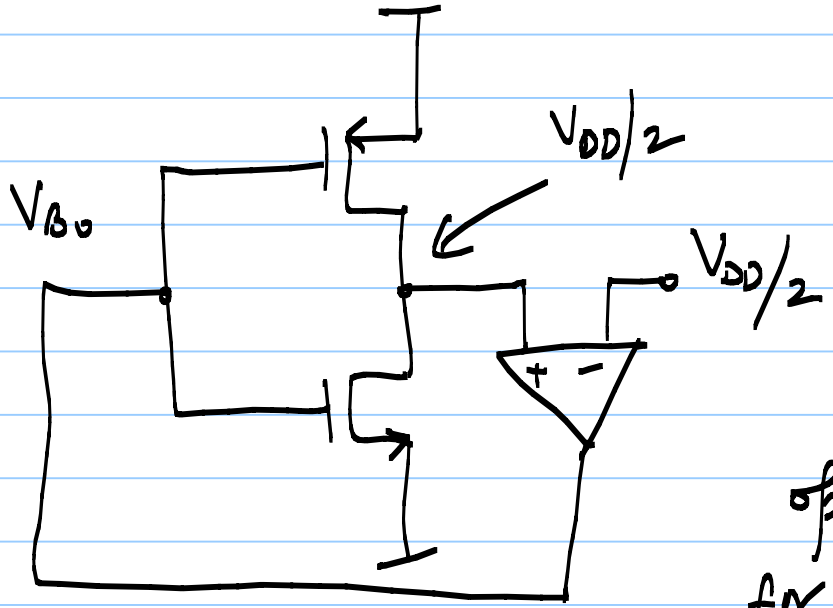
24|9|2020

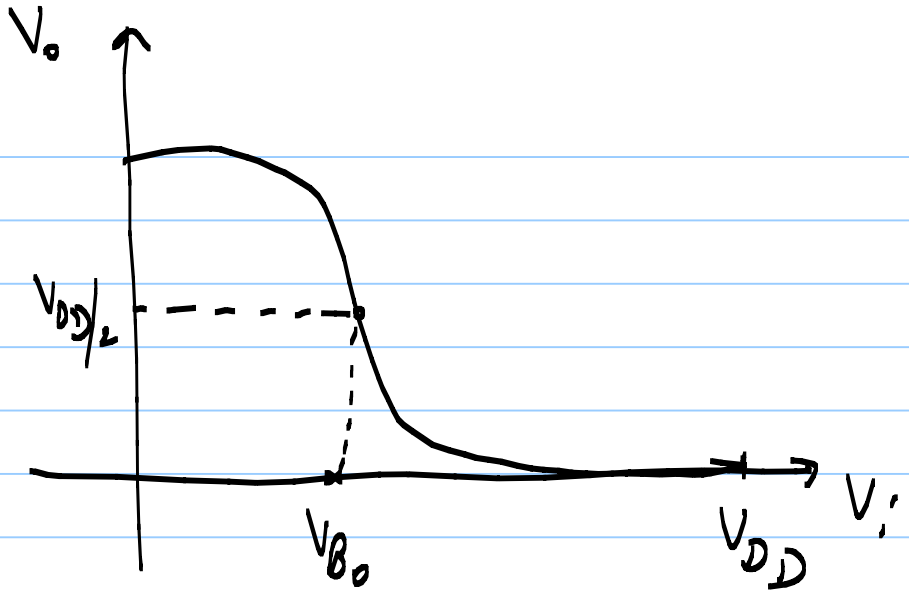
Lecture 30







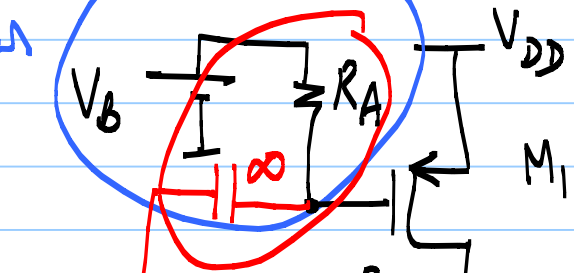
Modify the circuit to break opamp loop for AC.

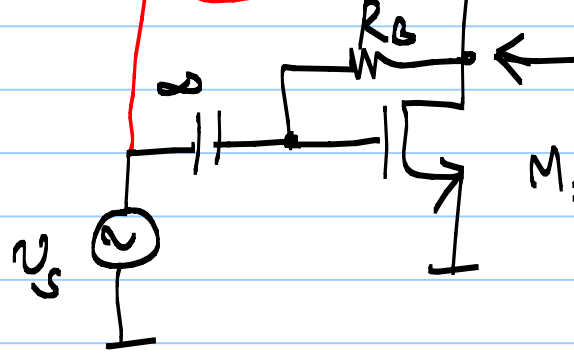


$< V_{DD}/2$

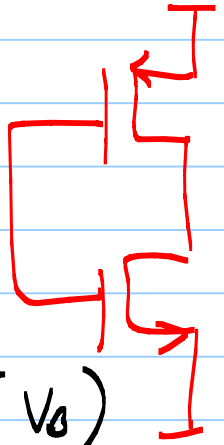
Thevenin equivalent

Z Bias



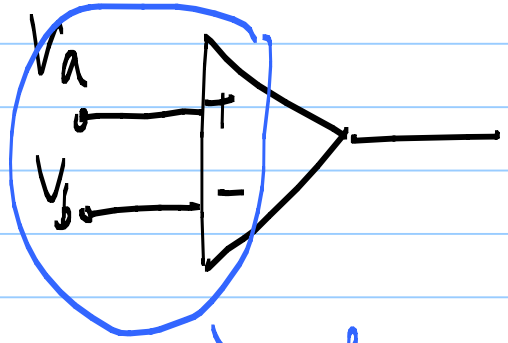


$\equiv$



for Ac

Differential Amplifiers

opamp: 

$A(V_a - V_b)$; $A \to \infty$

↖ first half of course

opamp responds only to $V_a - V_b$

$$V_a = \left(\frac{V_a + V_b}{2}\right) + \left(\frac{V_a - V_b}{2}\right)$$

$$V_b = \underbrace{\left(\frac{V_a + V_b}{2}\right)}_{\text{common-mode voltage } V_{CM}} - \underbrace{\left(\frac{V_a - V_b}{2}\right)}_{\text{differential mode voltage } V_{DM}}$$

e.g. 1) $V_a = 1\,V$, $V_b = 1.1\,V$

$V_{CM} = 1.05V$ $V_{DM} = -0.05V$

$V_a = V_{CM} + V_{DM}$

$V_b = V_{CM} - V_{DM}$

* opamp should amplify only V_{DM}

2) $V_a = 1.1V$, $V_b = 1V$

$V_{CM} = 1.05V$, $V_{DM} = 0.05V$

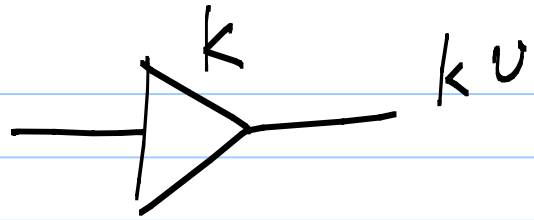
3) $V_a = 0.6V$, $V_b = 0.5V$

$V_{CM} = 0.55V$, $V_{DM} = 0.05V$

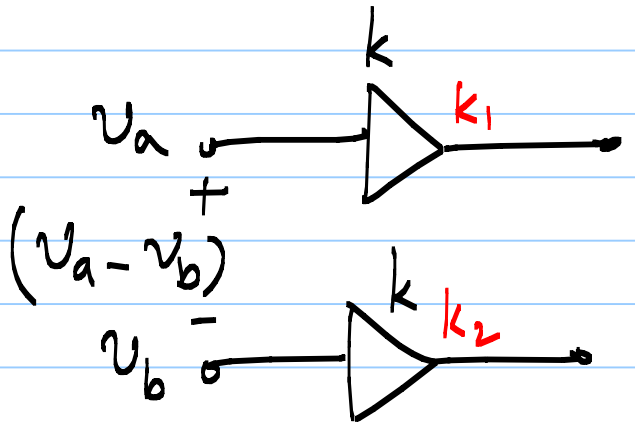
* Assume $V_a = v_a$ & $V_b = v_b$

$V_a = V_{CM} + \frac{\Delta V}{2}$ $V_b = V_{CM} - \frac{\Delta V}{2}$

We know:

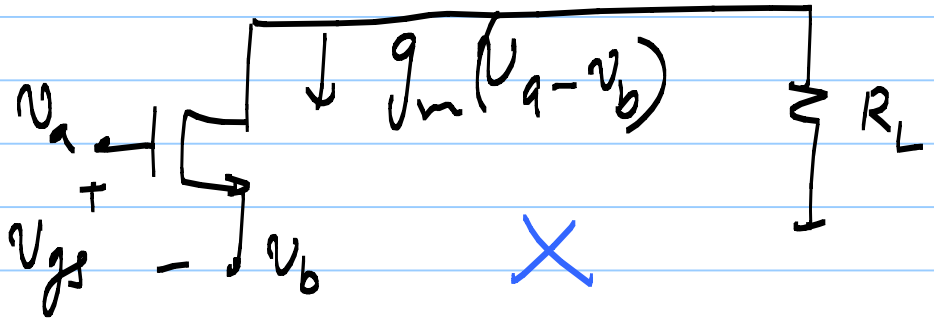


Circuit (I)



$V_o = k(v_a - v_b)$

* We wanted single-ended output (ignore this for now)



For circuit (I), what are $v_{i,cm}$, $v_{i,dm}$, $v_{o,cm}$, $v_{o,dm}$?

(I) has equal A_{CM} & A_{DM}

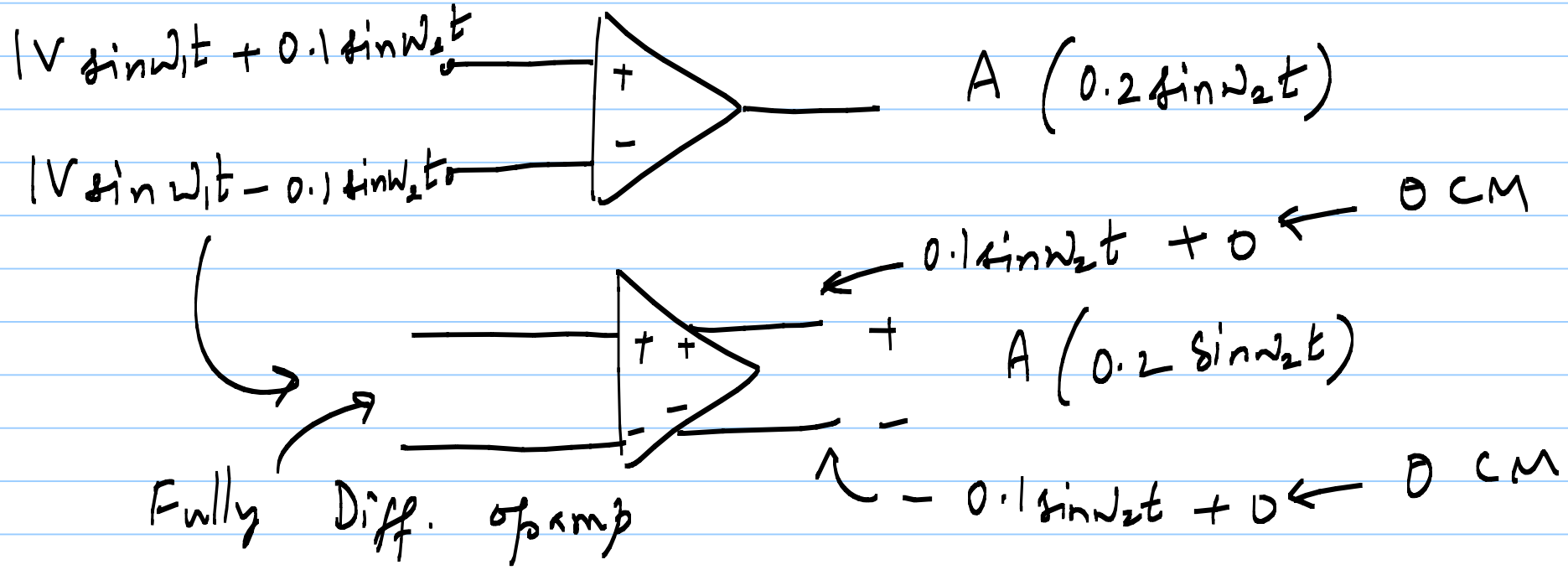
$$v_{i_{CM}} = \frac{v_a + v_b}{2} \quad ; \quad v_{i_{DM}} = \frac{v_a - v_b}{2}$$

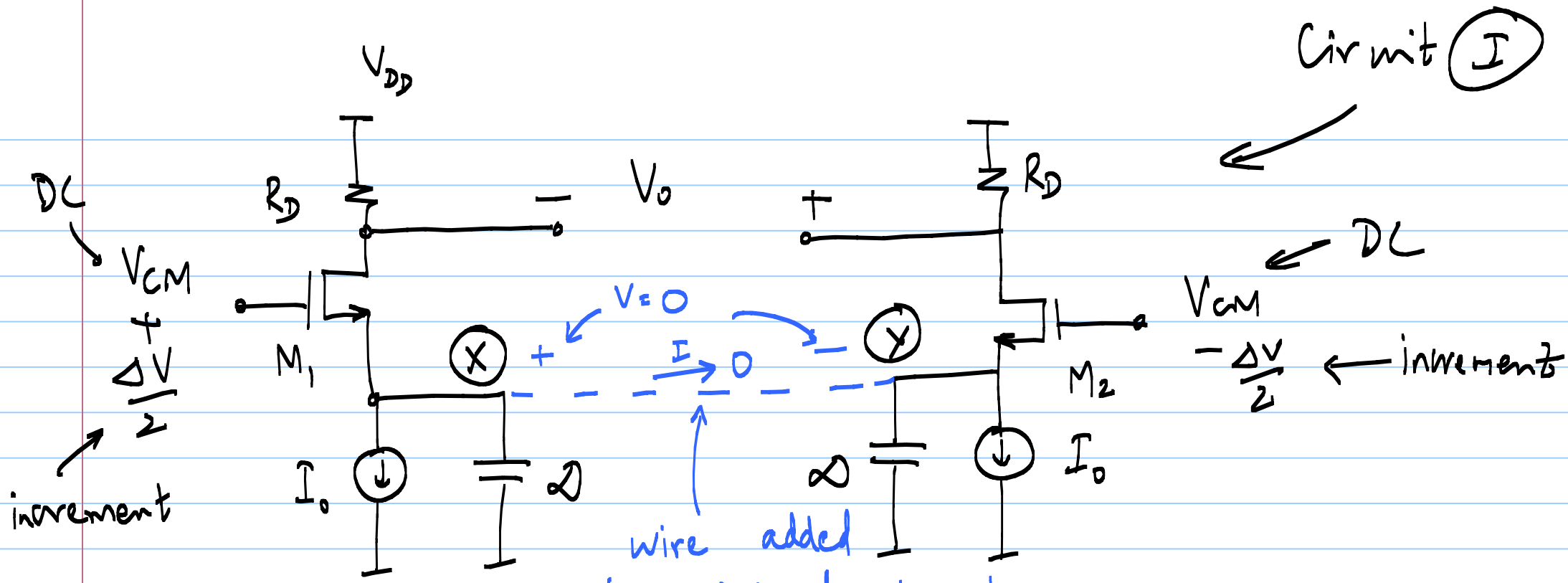
bad ↓ ↓ good

$$v_{o_{CM}} = k\left(\frac{v_a + v_b}{2}\right) \quad ; \quad v_{o_{DM}} = k\left(\frac{v_a - v_b}{2}\right)$$

We want large A_{DM} & 0 A_{CM}

e.g.





$$V_x = V_{CM} - V_{GS_1} \quad ; \quad V_y = V_{CM} - V_{GS_2}$$

$$V_{GS_1} = V_{GS_2} \Rightarrow V_x = V_y$$