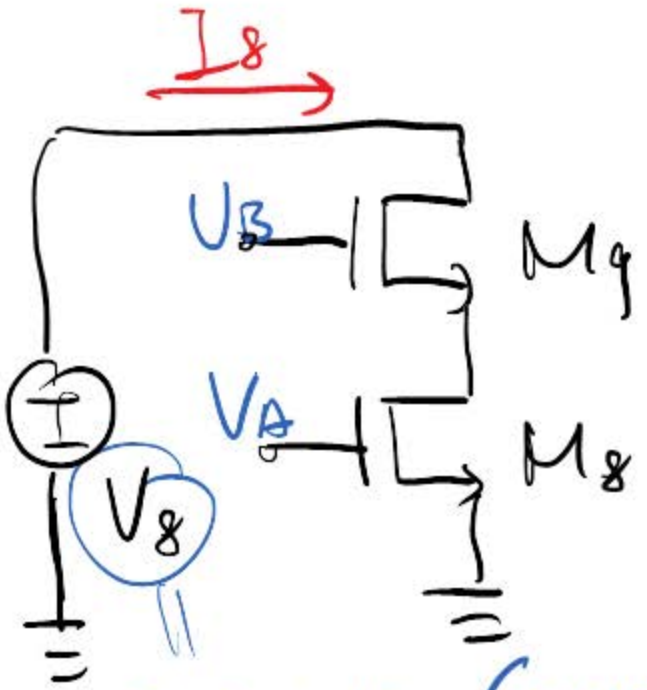
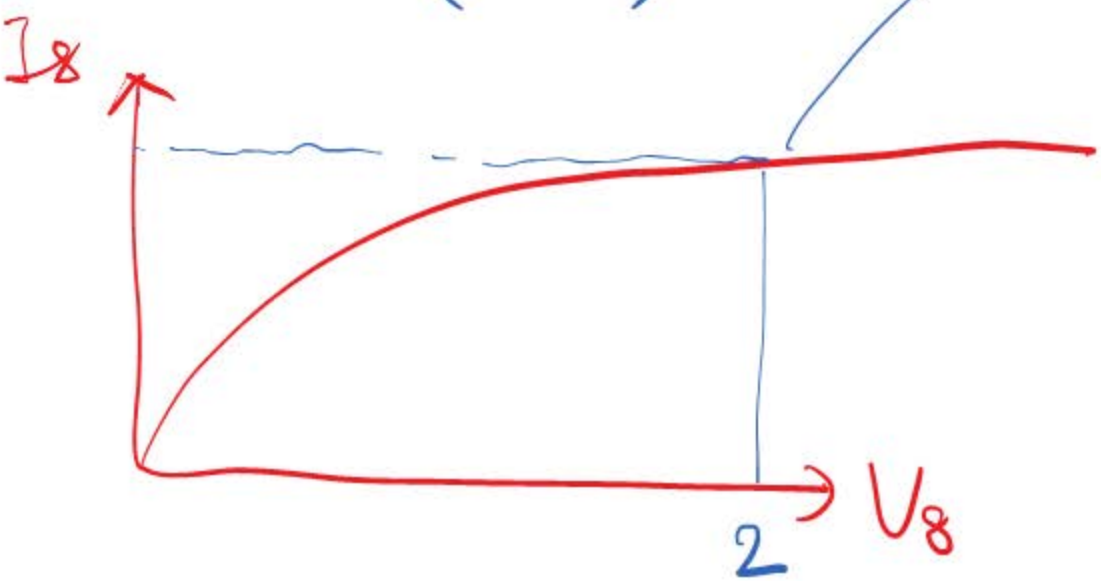


V_A and V_B are DC voltages properly chosen so that $M_{8,9}$ are in the sat.

$2 + 0.001 \sin(2\pi 100 t)$

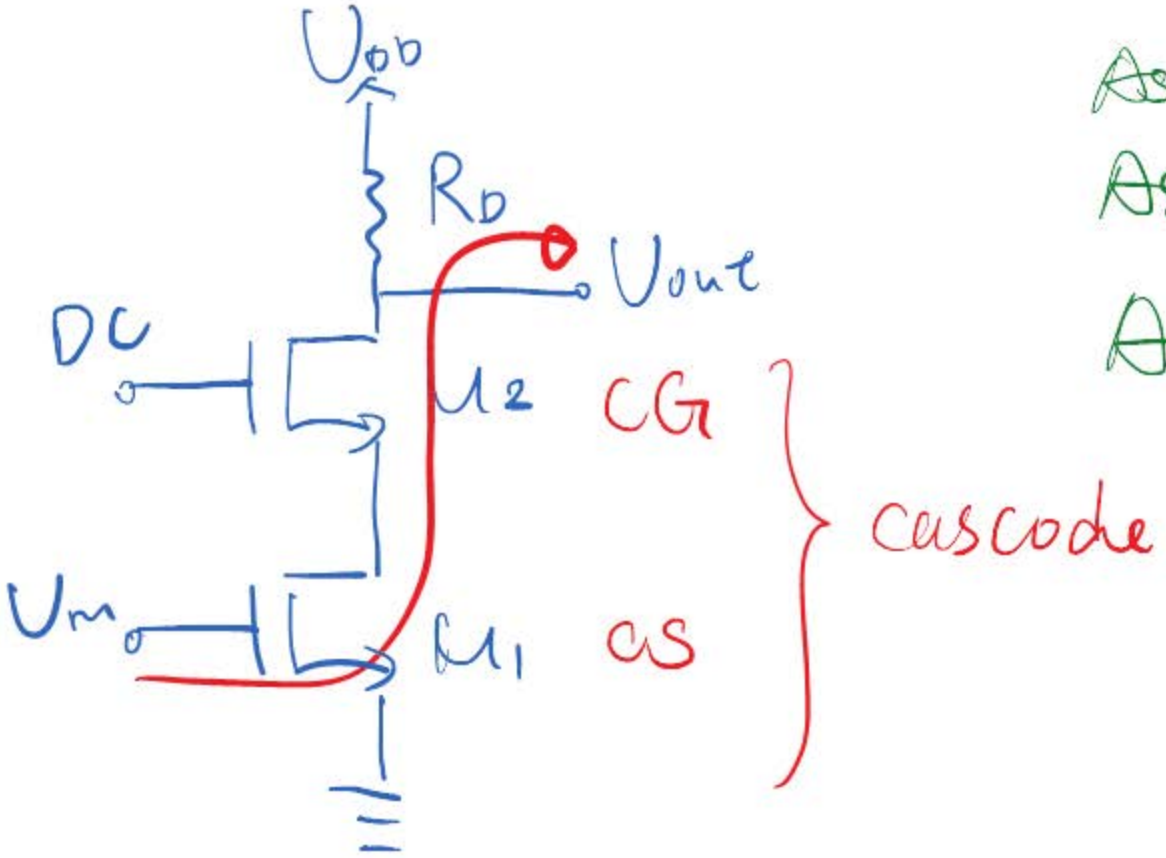


slope $= \dfrac{1}{\left[r_{o8} + r_{o9} + (g_{m9} + g_{mb9}) r_{o9} r_{o8} \right]}$

CS
SF
} both are voltage-in-voltage-out amplifiers.

Common-Gate (CG)

current-in-voltage-out

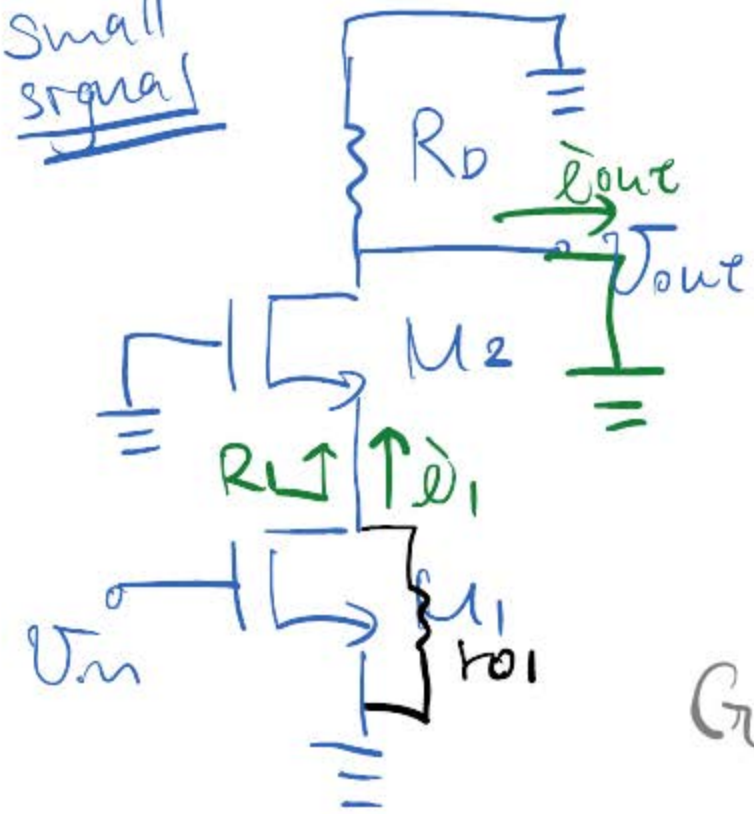


Assume M_1 and M_2 in Sat.

Assume $\lambda \neq 0$, $\gamma \neq 0$

$A_V = ?$

Small signal



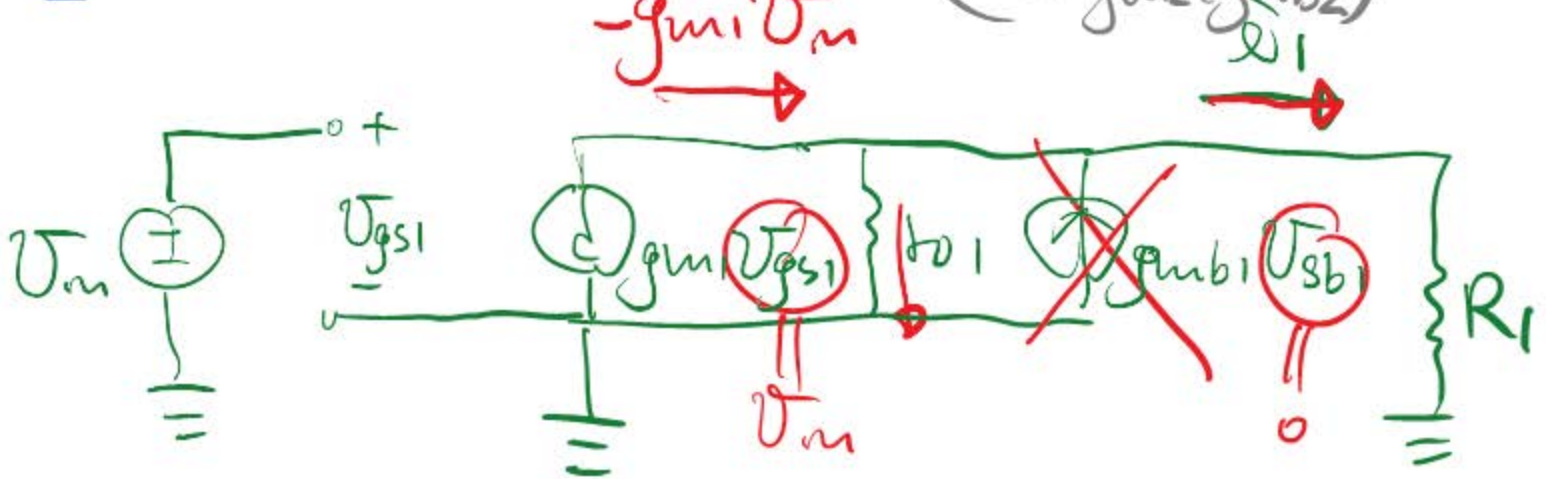
$$G_m = i_{out} / v_m$$

$$i_1 = i_{out}$$

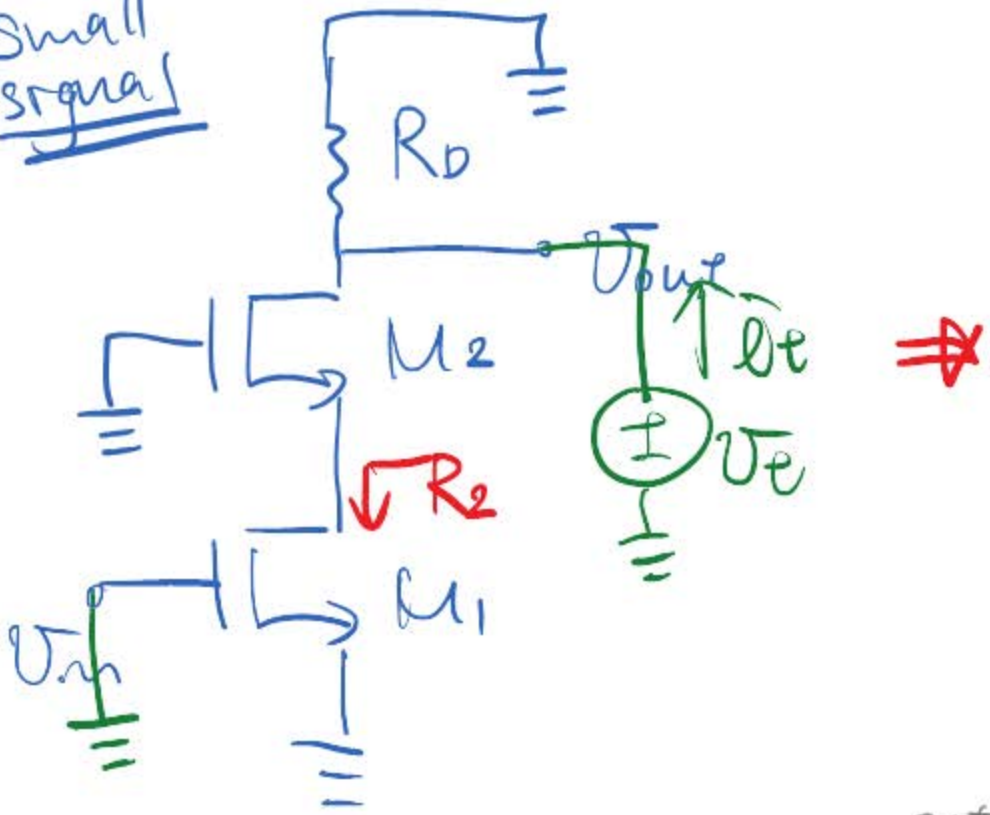
$$R_1 = r_{o2} \,//\, \frac{1}{g_{m2} + g_{mb2}}$$ small

$$i_1 = (-g_{m1} v_m) \frac{r_{o1}}{r_{o1} + R_1}$$

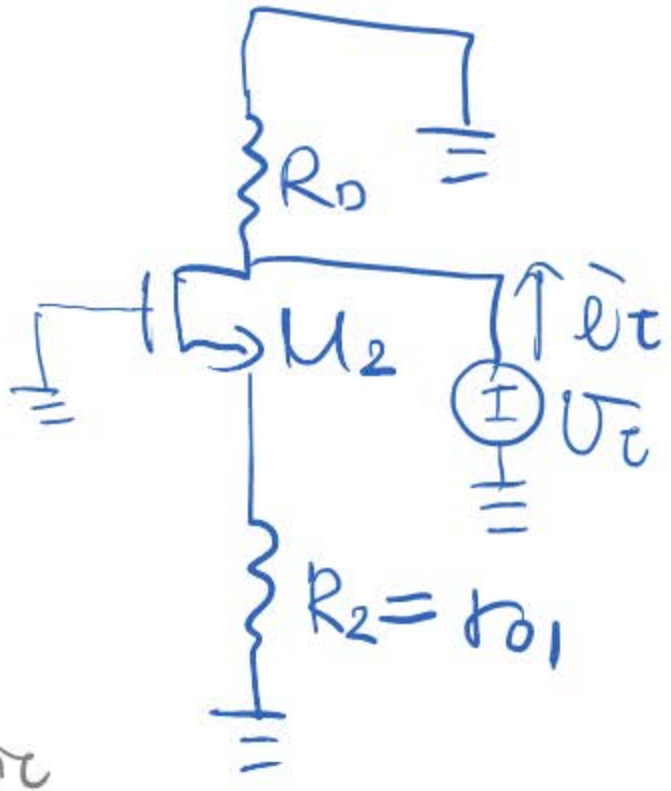
$$G_m = -g_{m1} \frac{r_{o1}}{r_{o1} + \left(r_{o2} \,//\, \frac{1}{g_{m2} + g_{mb2}}\right)}$$



Small signal



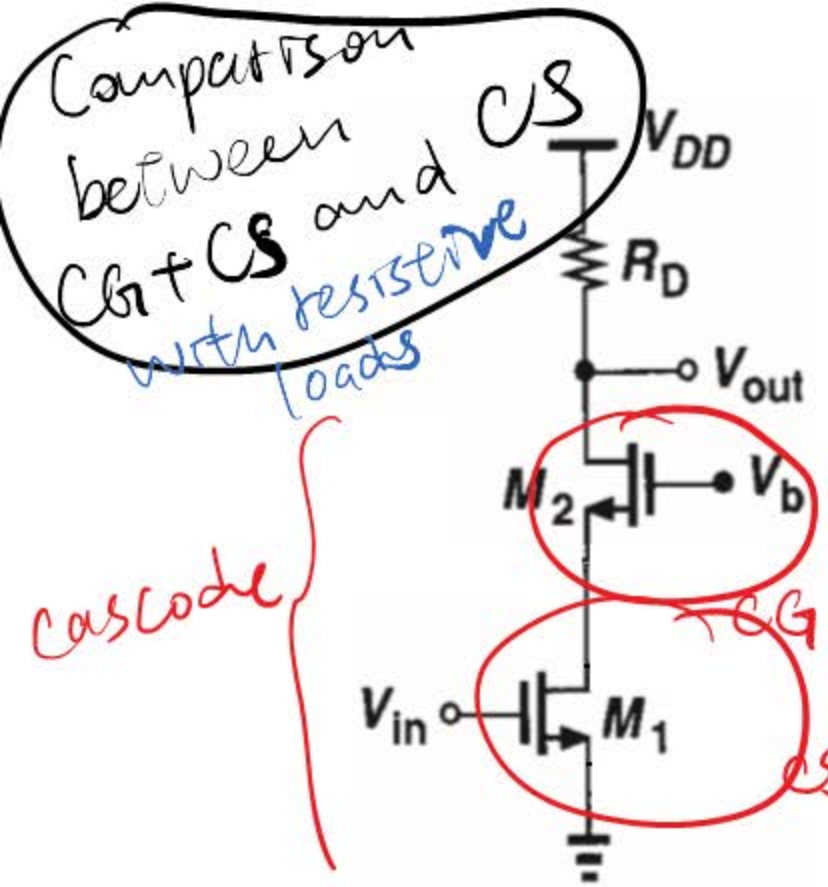
$\Rightarrow$



intrinsic gain of M_2

$$R_{out} = R_D // \left[r_{O2} + r_{O1} + (g_{m2} + g_{mb2}) r_{O2} r_{O1} \right]$$

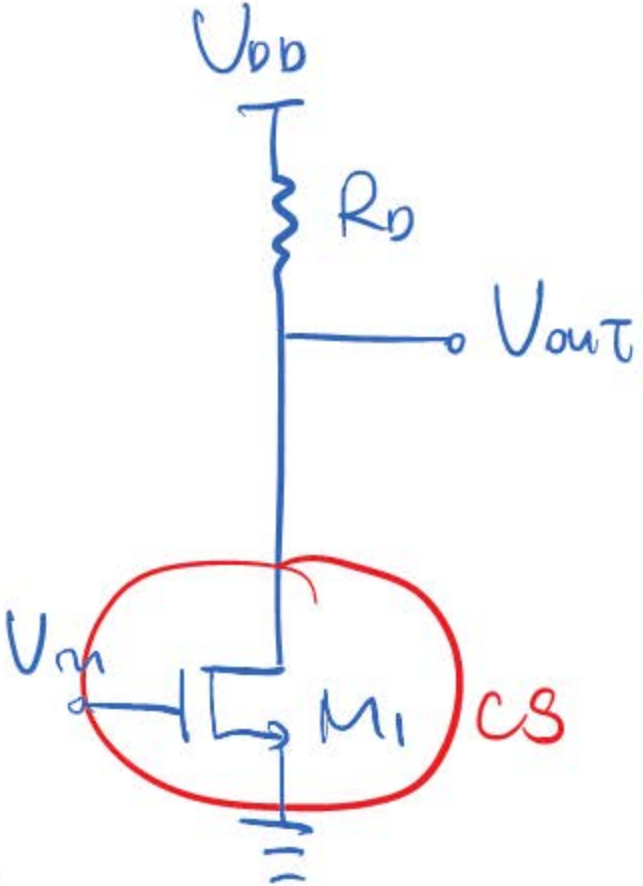
Comparison between CG+CS and CS with resistive loads



cascode

CG

CS

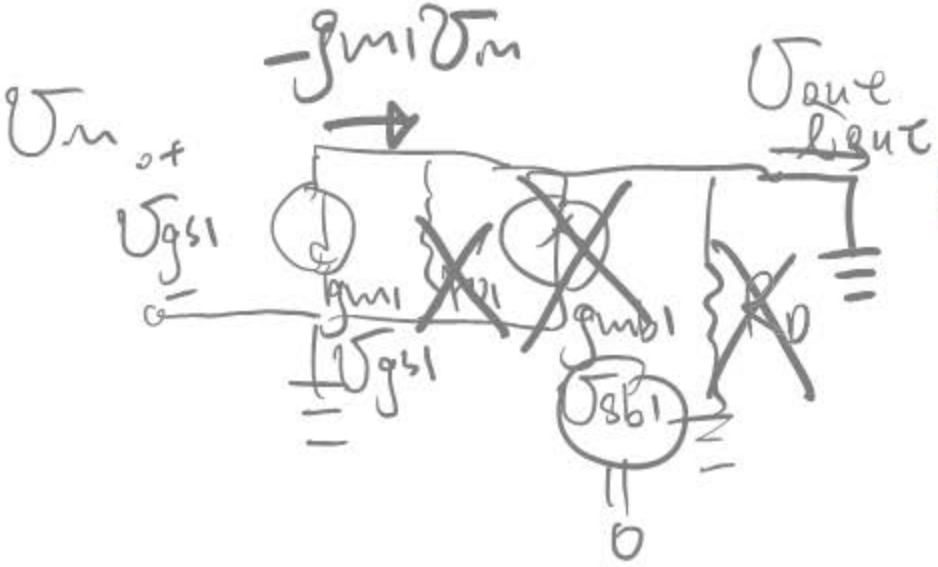


$$G_m = -g_{m1}\frac{r_{O1}}{r_{O1}+\left(r_{O2}\,\|\,\frac{1}{g_{m2}+g_{mb2}}\right)}$$

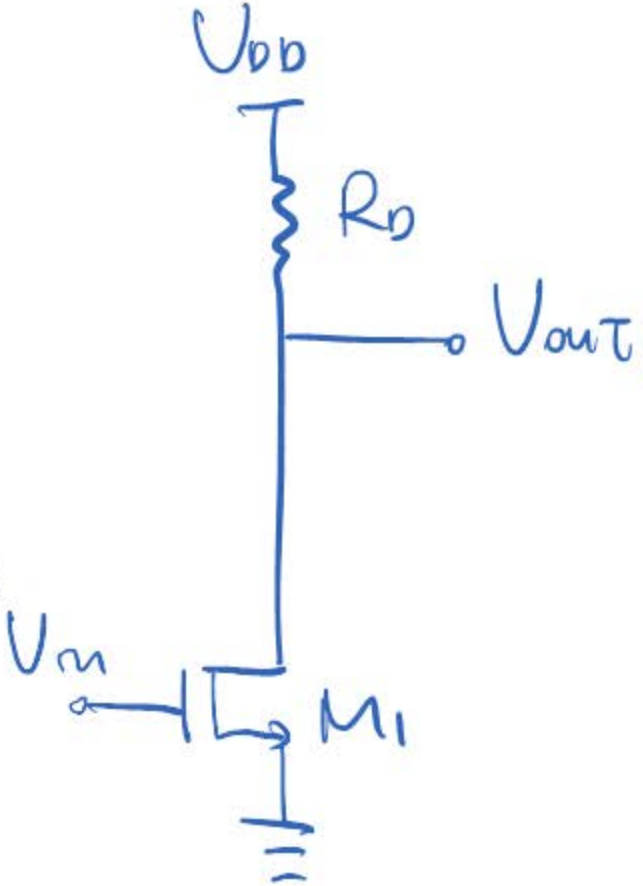
$$G_m = -g_{m1}$$

$$R_{out} = R_D \,\|\, \left[r_{O2}+r_{O1}+(g_{m2}+g_{mb2})r_{O2}r_{O1}\right]$$

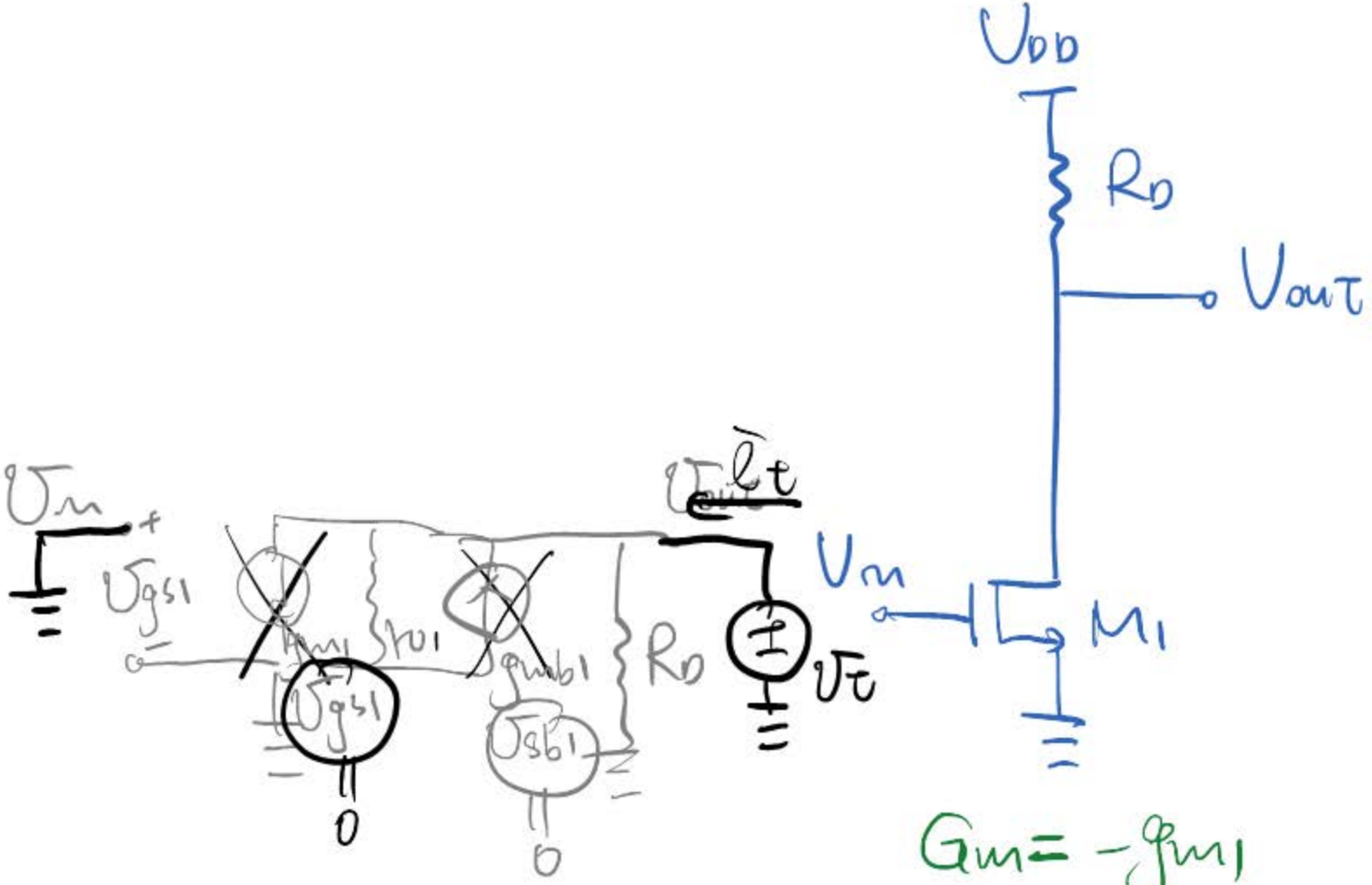
$$R_{out} = r_{O1} \,\|\, R_D$$



$$i_{out} = -g_{m1} v_{in}$$

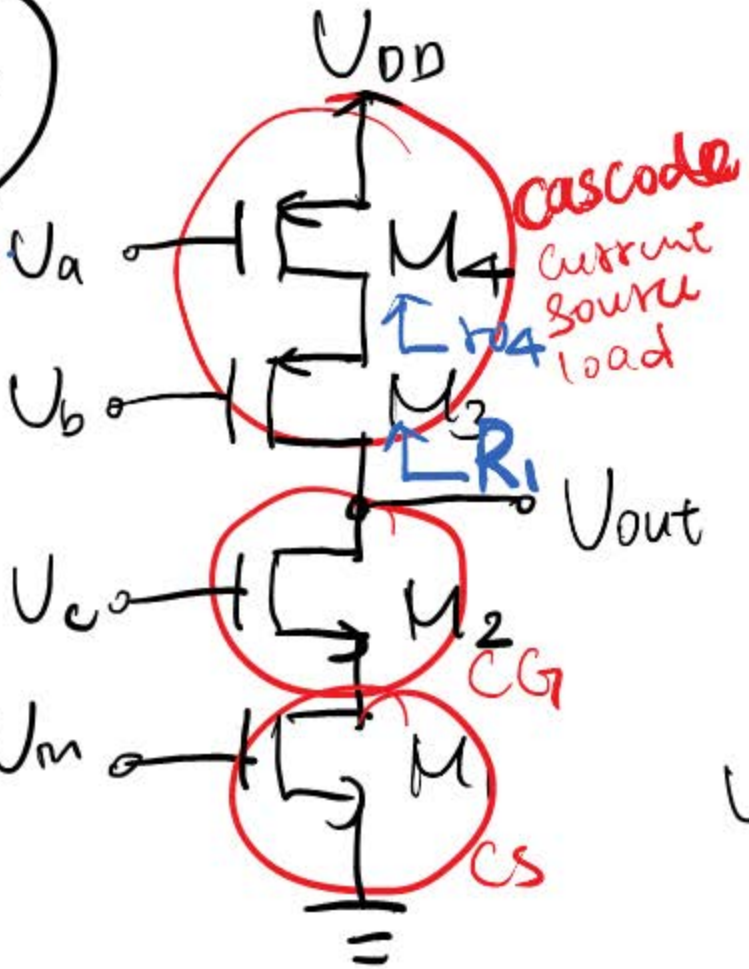


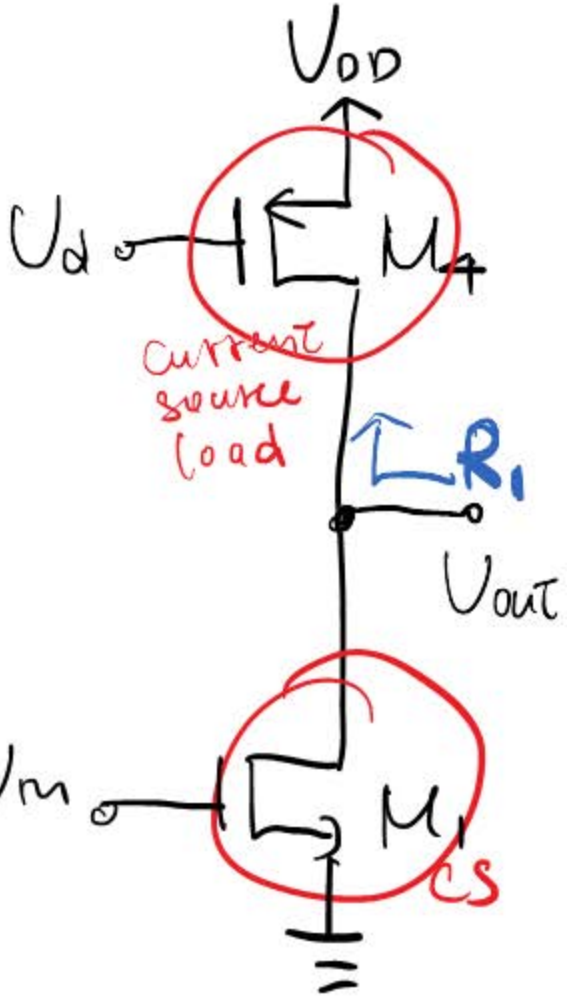
$$G_m = -g_{m1}$$



$$R_{out} = \frac{v_t}{i_e} = R_D \parallel r_{o1}$$

Comparison between CG+CS and CS with current source loads





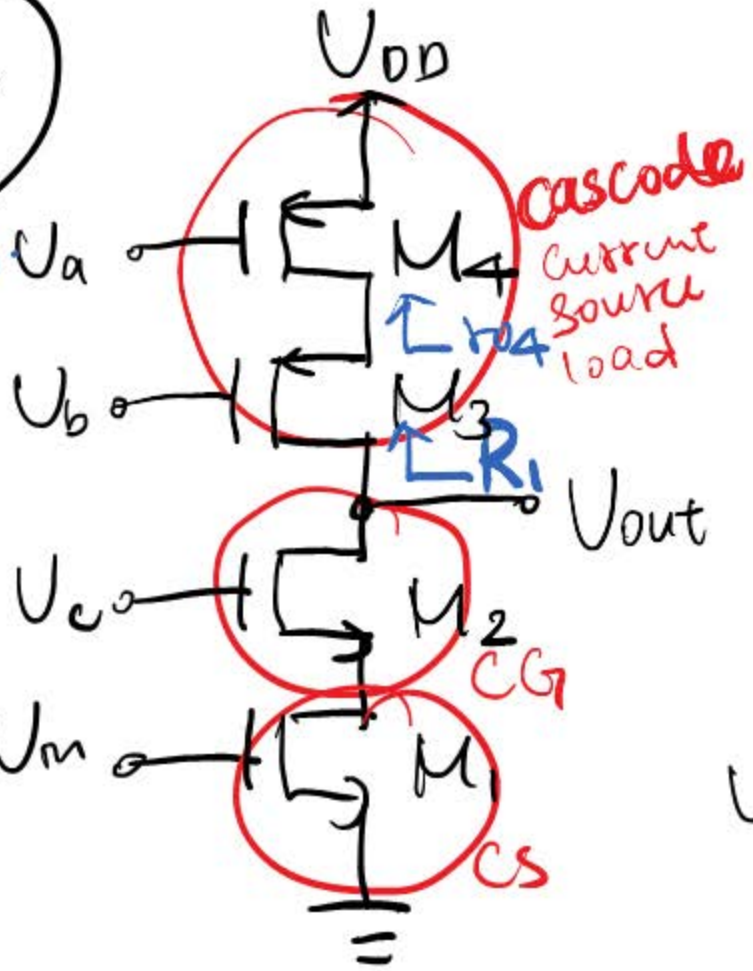
* Assume all nsat.
* Assume $\lambda \neq 0, \gamma \neq 0$
* $V_{a,b,c,d}$ are DC

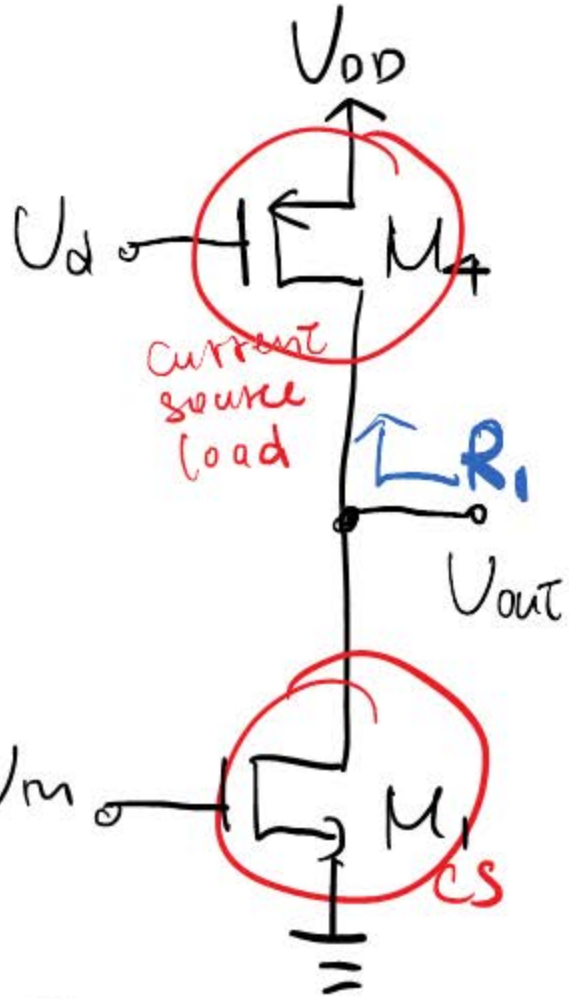
$$R_1 = r_{o3} + r_{o4} + (g_{m3} + g_{mb3}) r_{o3} r_{o4}$$

Intrinsic gain of M_3

$$R_1 = r_{o4}$$

Comparison between CG+CS and CS with current source loads



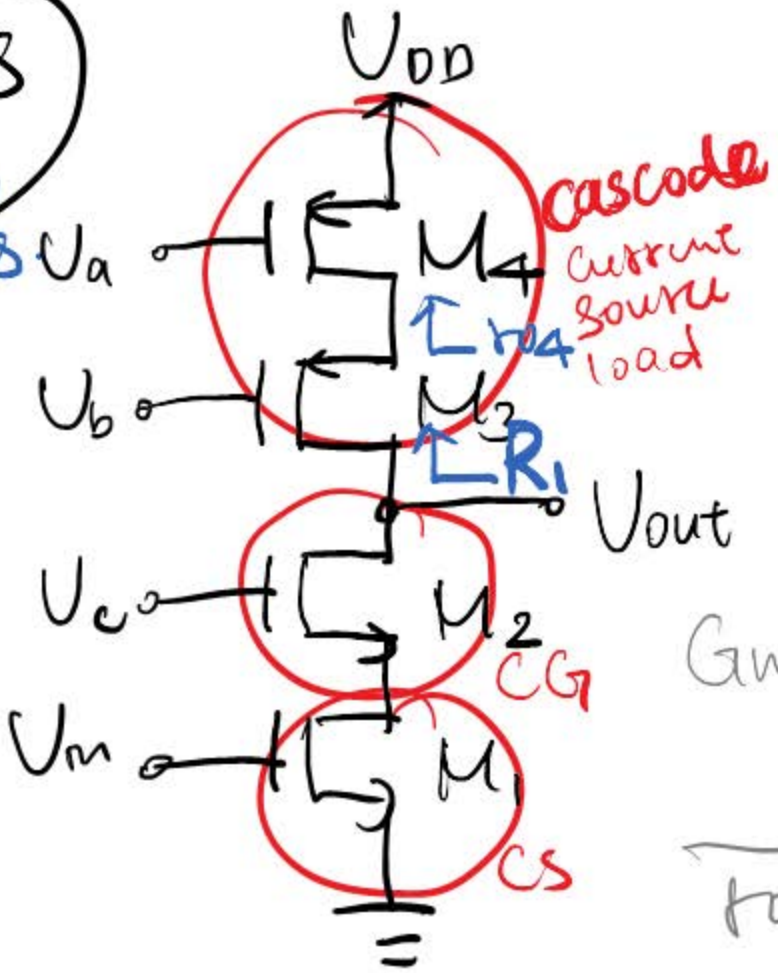


* Assume all nsat.
* Assume $\lambda \neq 0, \gamma \neq 0$
* $V_{a,b,c,d}$ are DC

$G_m = -g_{m1}$

$R_{out} = r_{o1} // r_{o4}$

Comparison between CG+CS and CS with current source loads

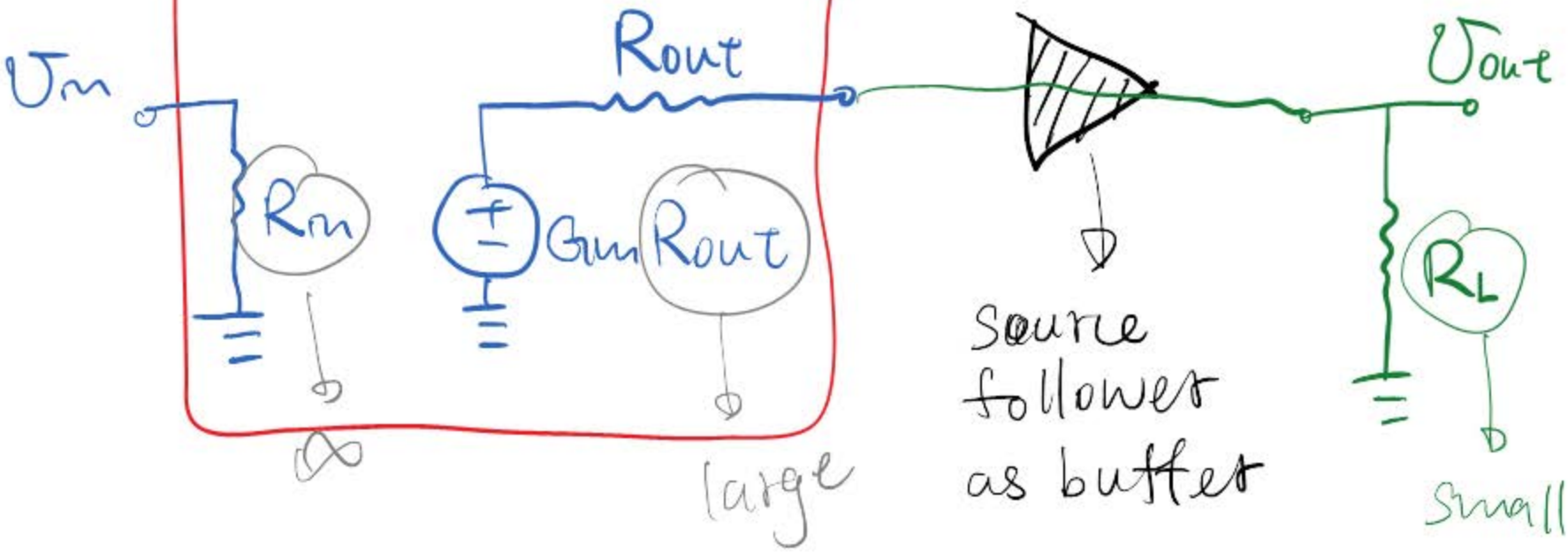


* Assume all nsat.
* Assume $\lambda \neq 0, \gamma \neq 0$
* $V_{a,b,c,d}$ are DC

$$G_m = -g_{m1} \cdot \frac{r_{o1}}{r_{o1} + \left(r_{o2} \,//\, \frac{1}{g_{m2}+g_{mb2}}\right)}$$

$$R_{out} = \left[r_{o3} + r_{o4} + (g_{m3}+g_{mb3}) r_{o3}\, r_{o4}\right] // \left[r_{o2} + r_{o1} + (g_{m2}+g_{mb2}) r_{o2}\, r_{o1}\right]$$

Equivalent small signal circuit for cascode with cascode current source.



$$A_v = \frac{v_{out}}{v_{in}} = G_m R_{out} \frac{R_L}{R_{out} + R_L} \text{ (without buffer)}$$