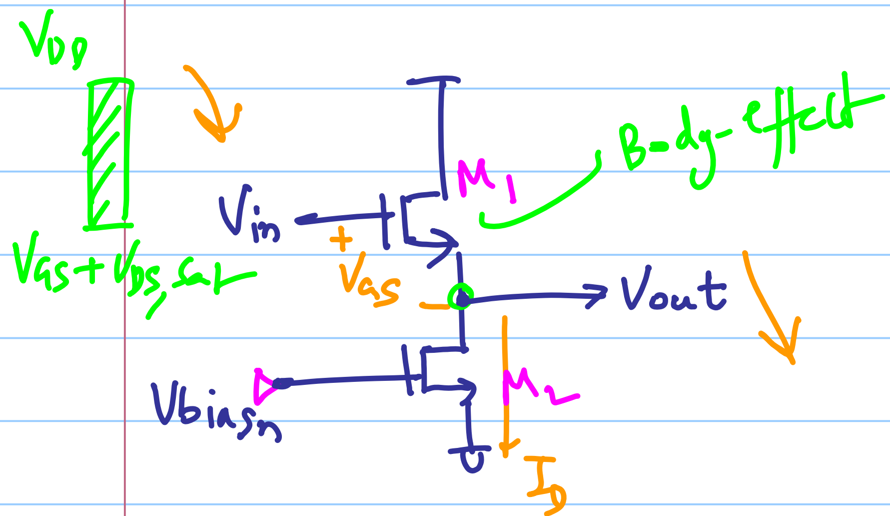
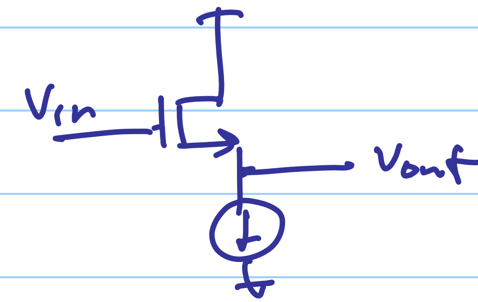
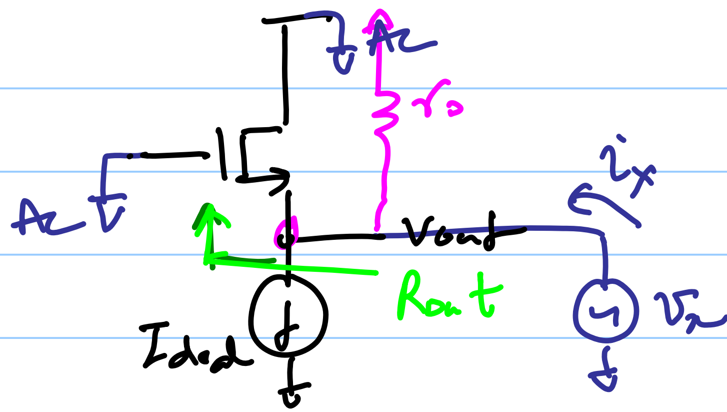
ECE 511 - Lecture 14

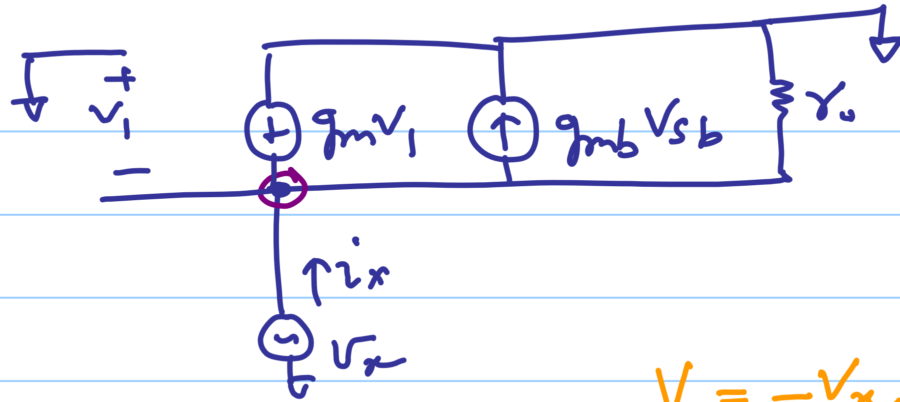
Note Title 3/5/2015





Voltage Buffer with DC level-shift





$V_1 = -V_x$

$V_{sb} = V_x$

$$i_x - g_m v_x - g_{mb} v_x - \frac{v_x}{r_o} = 0$$

$$R_{out} = \frac{v_x}{i_x} = \frac{1}{(g_m + g_{mb}) + \frac{1}{r_o}}$$

$$= \frac{1}{g_m} \,\|\, \frac{1}{g_{mb}} \,\|\, r_o \simeq \frac{1}{g_m} \text{ for } \gamma = 0$$

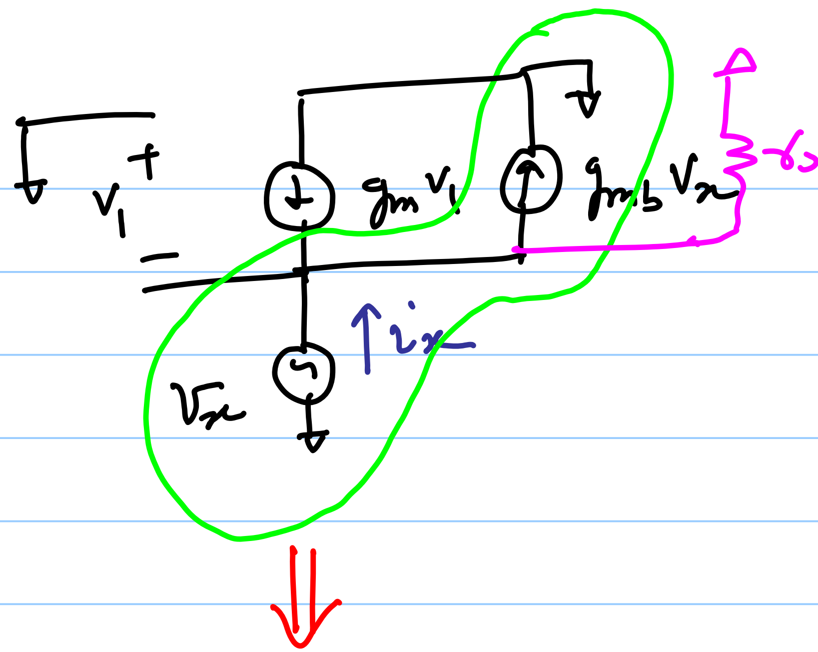
body-effect

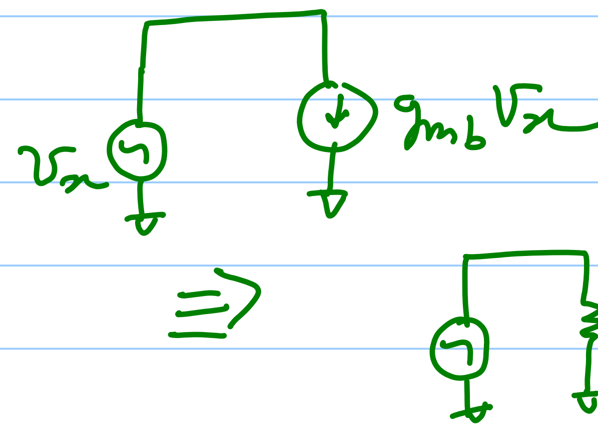
low-Z output

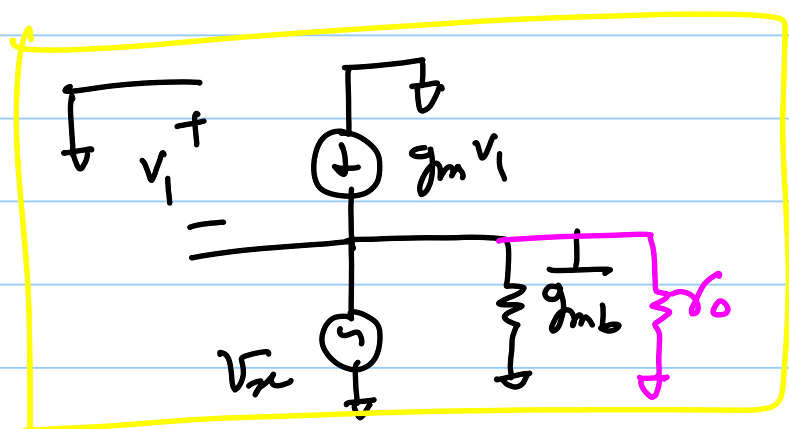
resistance looking into the source

↳ drain is at Ac ground

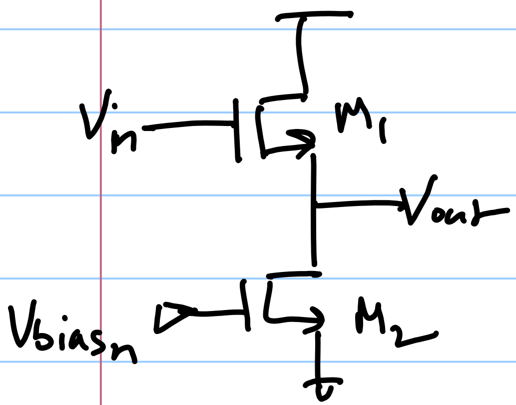
⇒

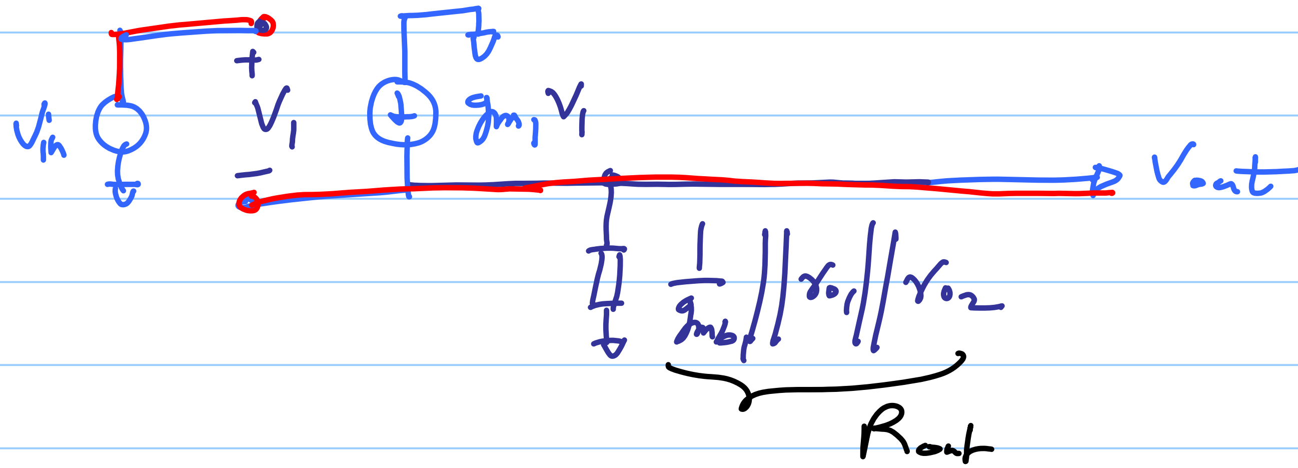






Model for SF device M_L.



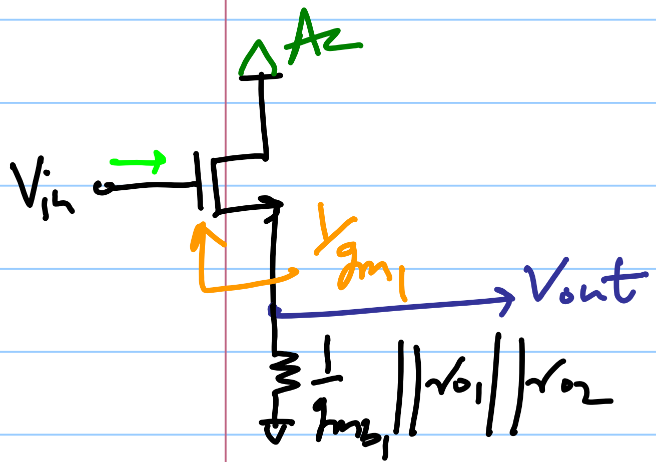


$$V_{out} = g_{m_1} V_1 \cdot R_{out}$$

$$\Rightarrow \quad V_{out} = g_{m_1} R_{out} \left(\underbrace{V_{in} - V_{out}}_{V_1} \right)$$

$$\Rightarrow \quad V_{out} \left[1 + g_{m_1} R_{out} \right] = g_{m_1} R_{out} \cdot V_{in}$$

$$\Rightarrow \quad A_v = \frac{V_{out}}{V_{in}} = \frac{g_{m_1} R_{out}}{1 + g_{m_1} R_{out}}$$



$$= \frac{R_{out}}{\frac{1}{g_m} + R_{out}}$$

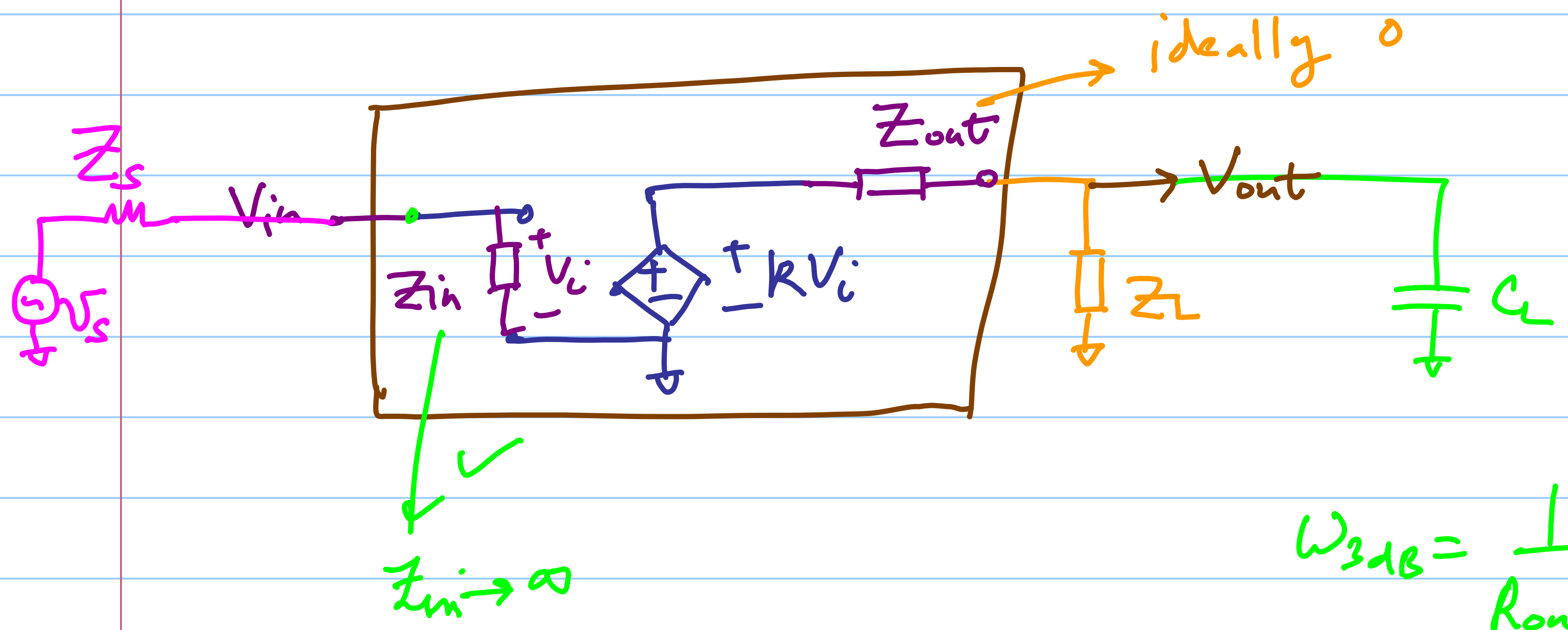
$$= \frac{\frac{1}{g_{mb_1}} \| r_{o_1} \| r_{o_2}}{\left(\frac{1}{g_{m_1}}\right) + \frac{1}{g_{mb_1}} \| r_{o_1} \| r_{o_2}}$$

Can visualize as a voltage divider between $\frac{1}{g_{m_1}}$ & $\frac{1}{g_{mb}} \| r_{o_1} \| r_{o_2}$

↑ Resistance looking into the source

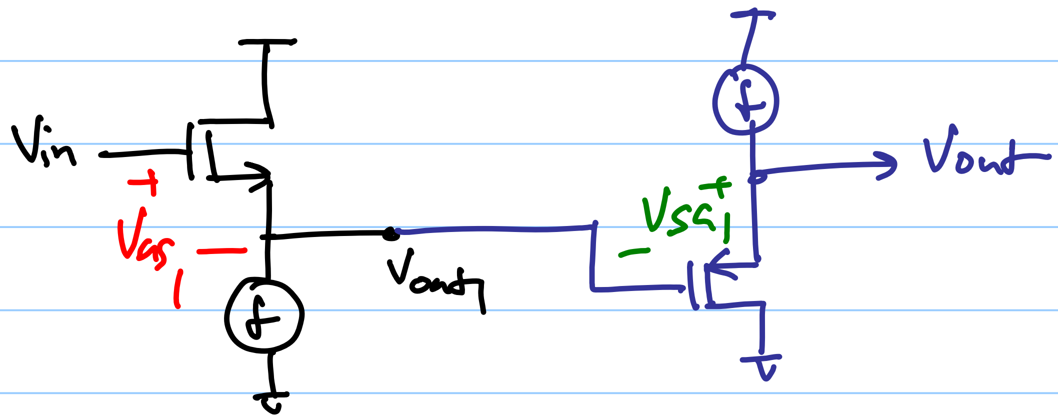
↑ Resistance connected to the source

Voltage Buffer (VCVS, gain = 1)



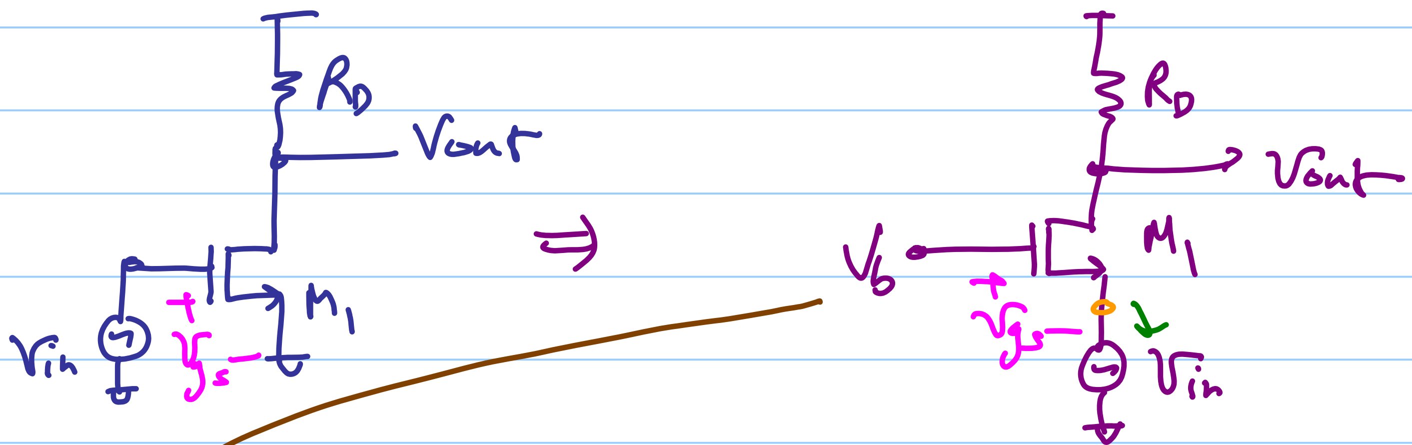
$$\omega_{3dB} = \frac{1}{R_{out} C_L}$$

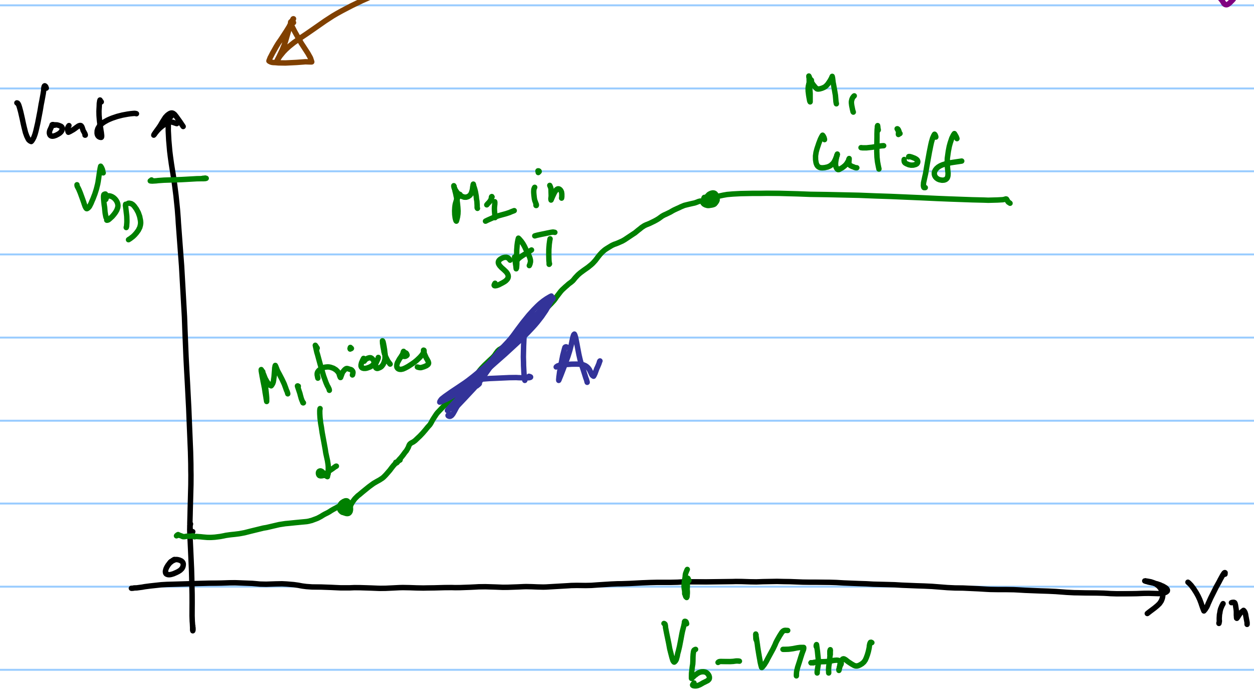
$$\simeq \frac{g_m}{C_L}$$



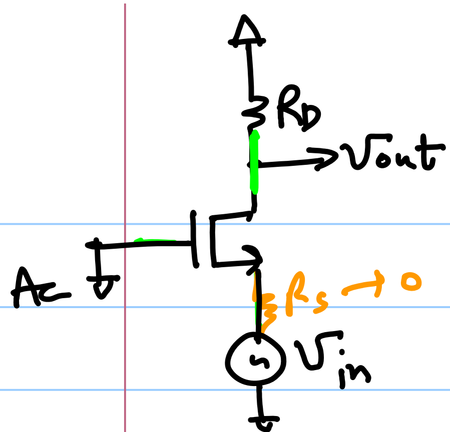
Vin
+
V_{GS_1}
−
V_{out_1}
V_{SG_1}
+
−
Vout

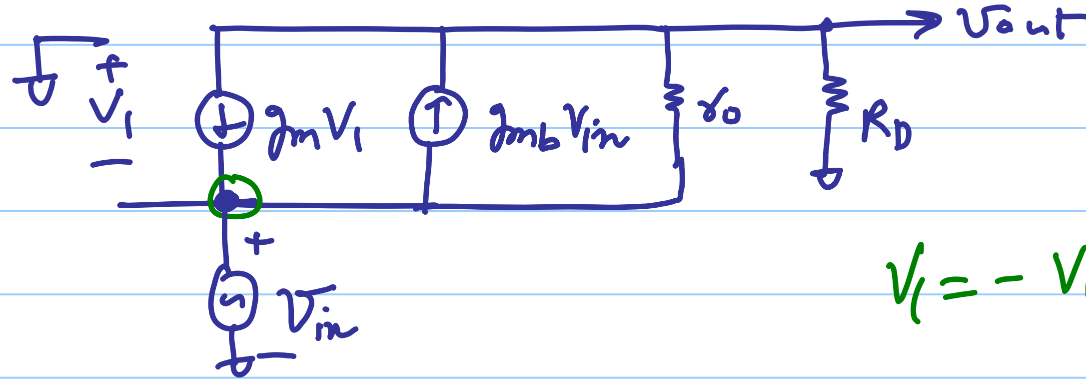
Common-Gate Stage





MMIC





$$V_1 = -V_{in}$$

KCL

$$-g_m V_1 + g_{mb} V_{in} - \frac{(V_{out} - V_{in})}{r_o} - \frac{V_{out}}{R_D} = 0$$

$$V_{in}\left[\frac{1}{r_o} + g_m + g_{mb}\right] = \frac{V_{out}}{r_o} + \frac{V_{out}}{R_D} = V_{out}\left(\frac{1}{r_o \| R_D}\right)$$

$$A_v = \frac{V_{out}}{V_{in}} = \left[(g_m + g_{mb}) + \frac{1}{r_o}\right] \cdot (R_D \| r_o)$$

$$= \frac{(g_m + g_{mb}) r_o + 1}{r_o} \cdot \frac{R_D \cdot r_o}{R_D + r_o}$$

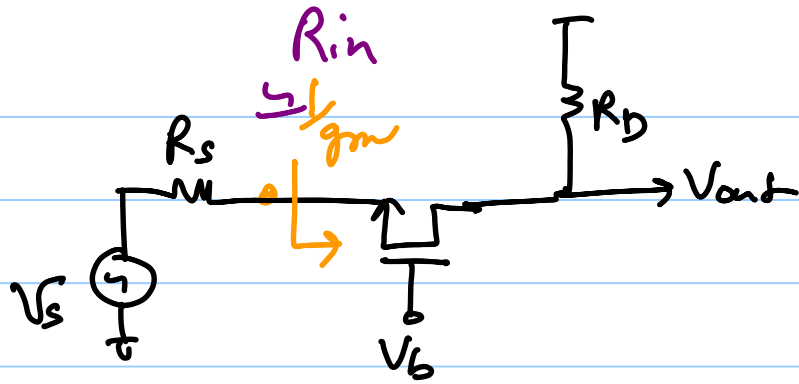
$$= \frac{((g_m + g_{mb}) r_o + 1) \cdot R_D}{R_D + r_o}$$

for $r_o >> R_D$ & $g_m r_o >> 1$

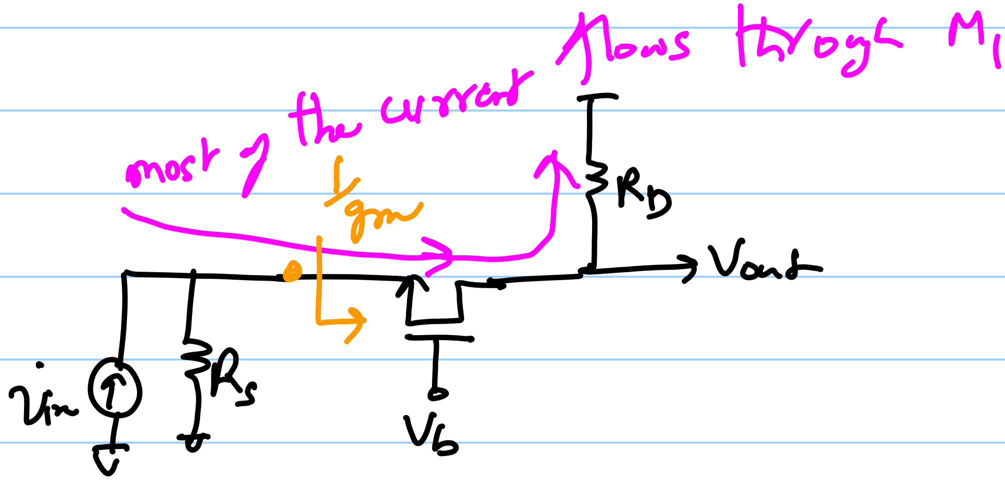
$$\rightarrow \frac{(g_m + g_{mb}) r_o \cdot R_D}{r_o}$$

$$A_v = (\eta + 1) g_m R_D$$

+ve gain



issues as a voltage amplifier due to low Rin

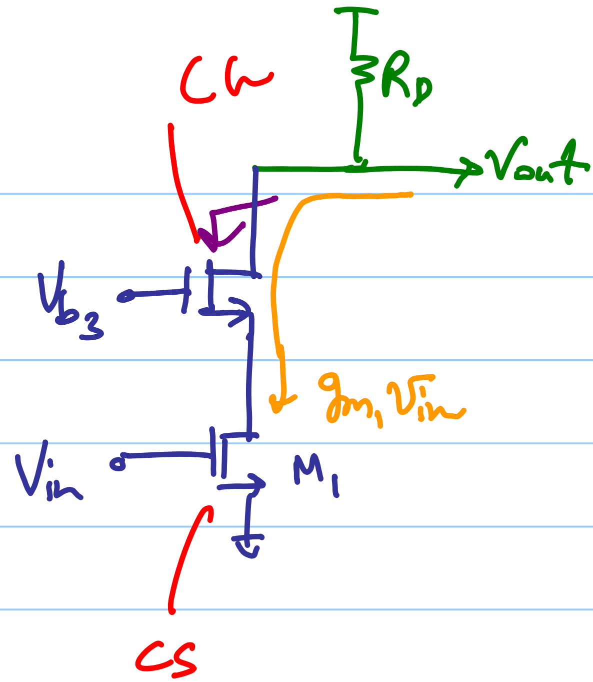


CG

Acts as a good current buffer

↳ preferred as an amplifier if the input is small signal current.

Ex.

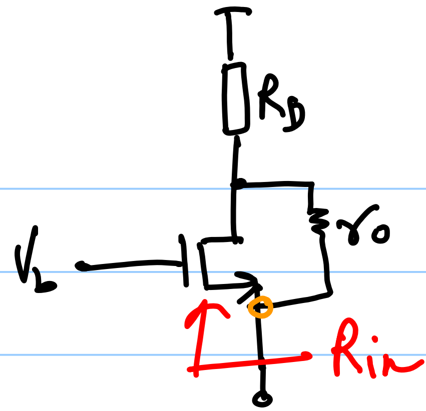


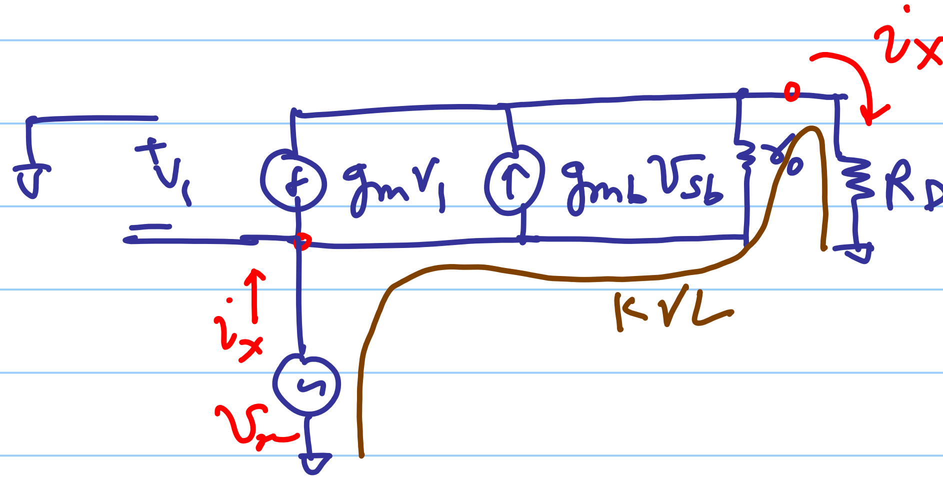
$$V_{out} = -g_m V_{in} \left(R_D \,||\, g_m r_o^2 \right)$$

$g_m r_o^2$

$\gamma \neq 0$

$V_1 = -V_x$





current thru r_o:

$$i_x + g_m V_1 + g_{mb} V_1 = i_x - (g_m + g_{mb}) v_x$$

adding up the voltages across r_o & R_D

$$v_x = R_D i_x + r_o \left[i_x - (g_m + g_{mb}) v_x \right]$$

$$R_{in} = \frac{v_x}{i_x} = \boxed{\frac{R_D + r_o}{1 + (g_m + g_{mb})r_o}}$$

Case (A)

$R_D = 0, \quad g_m r_o >> 1$

$$R_{in} \simeq \frac{1}{g_m + g_{mb}}$$