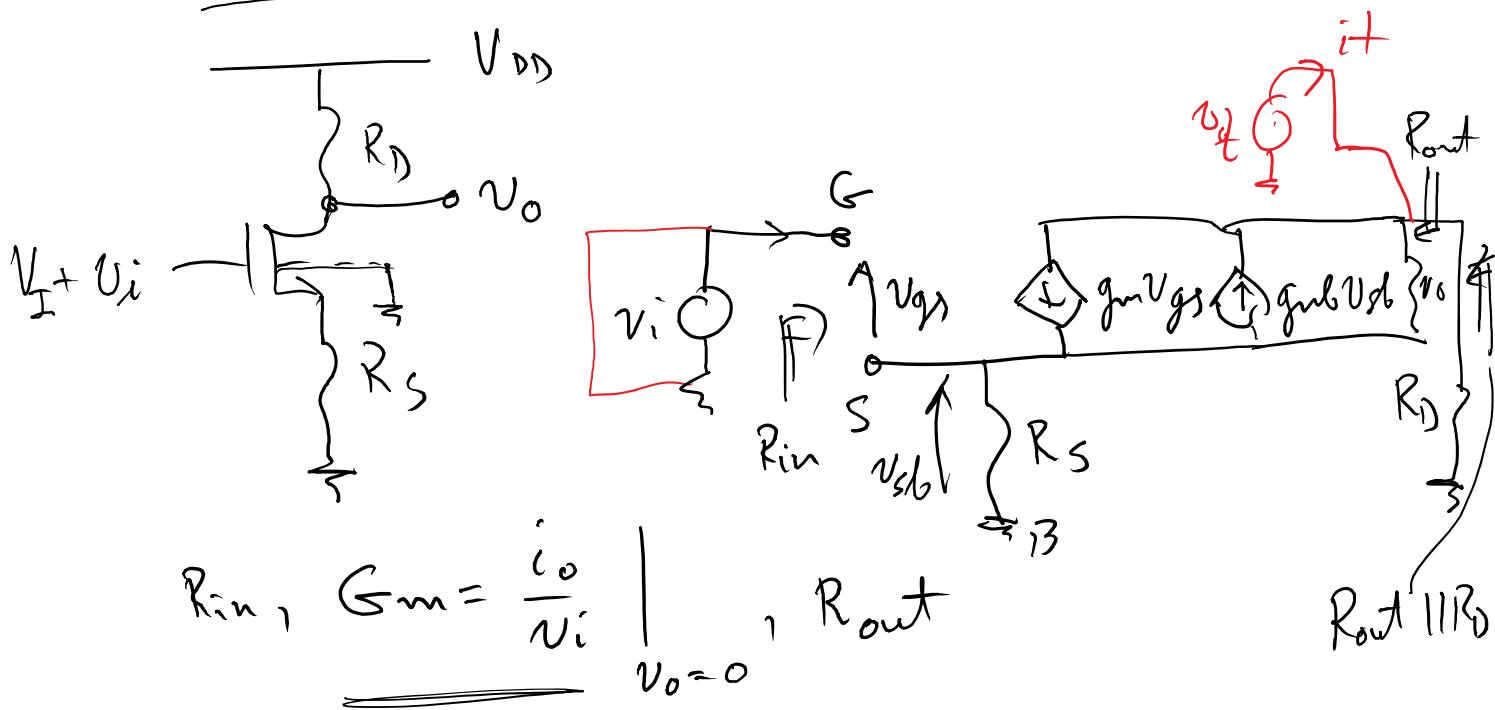


Common - Source + Source Degeneration

$$R_{in} = \infty$$

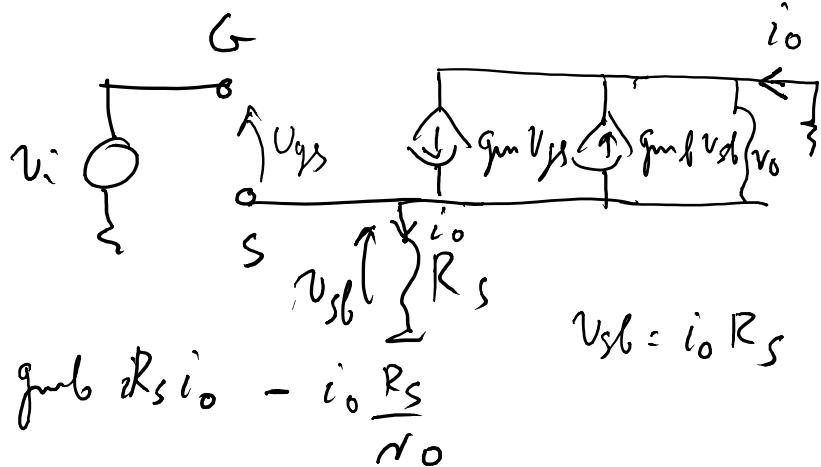
$$R_{out} : R_{out} = R_{out CG}$$

$$V_t = (v_o + R_s) i_t + (g_m + g_{mb}) v_o - \cancel{V_{db}} \rightarrow R_s \cdot i_t$$

$$R_{out} = \frac{V_t}{i_t} = v_o + R_s + \underbrace{(g_m + g_{mb}) v_o R_s}_{\approx (g_m + g_{mb}) v_o R_s}$$

Lecture 8 - 1Tx amps, freq analysis

$$G_m = \frac{i_o}{v_i} \mid v_o = 0$$

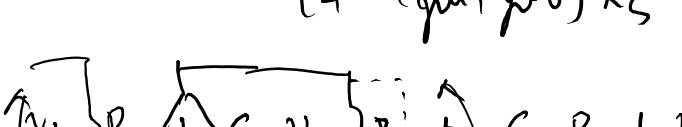


$$i_o = g_m \cdot (v_i - R_s i_o) - g_{mb} R_s i_o - i_o \frac{R_s}{r_o}$$

$v_{sb} = i_o R_s$

$$i_0 \left(1 + (g_m + g_b) R_S + \frac{R_S}{r_0} \right) = g_m v_i$$

$$G_m = \frac{i_o}{v_i} = \frac{g_m}{1 + (g_m + g_{lb})R_s + \frac{R_s}{R_o}} \approx \frac{g_m}{1 + (g_m + g_{lb})R_s}$$



$$G_m V_i - G_m R_{out} \cdot V_i \approx \frac{g_m}{(g_m + g_{lb}) \cdot R_s}$$

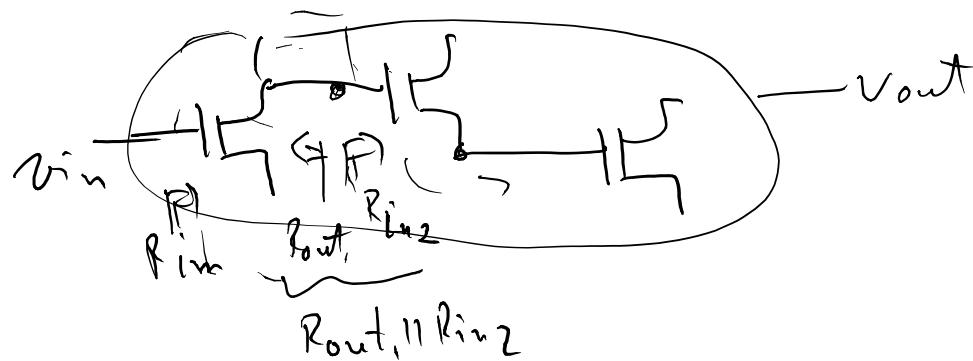
$$Av = -G_m \cdot R_{out} \| R_D =$$

$$= - \frac{g_{mu} R_o}{R_o + R_S + (g_{mu} + g_{ub}) V_0 R_S} \cdot R_{out} \| R_D$$

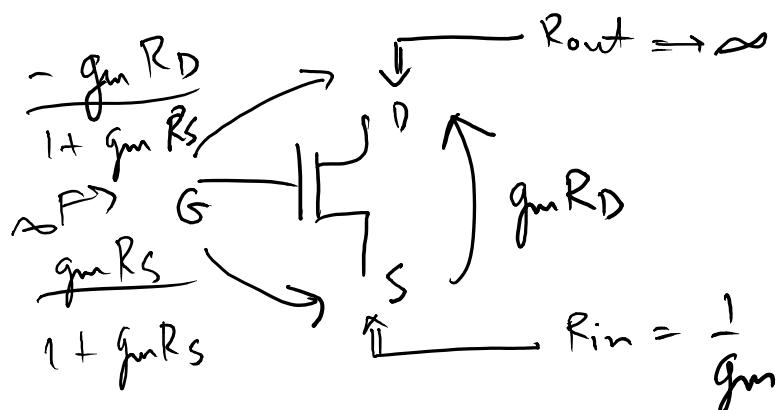
$$= - \frac{g_m v_o}{R_{out}} \cdot \frac{R_{out} \cdot R_D}{R_{out} + R_D} = - \frac{g_m v_o R_D}{v_o + R_S + (g_m + g_{ub}) r_o f_S + R_D}$$

$$= \frac{g_m R_D}{1 + \frac{R_S}{R_O} + (g_m + g_m b) R_S + \frac{R_D}{R_O}} = \frac{g_m R_D}{1 + (g_m + g_m b) R_S}$$

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Simple case: $g_{mb} = 0$, $r_o \rightarrow \infty$



More complex analysis: $r_o < \infty$, $g_{mb} \neq 0$

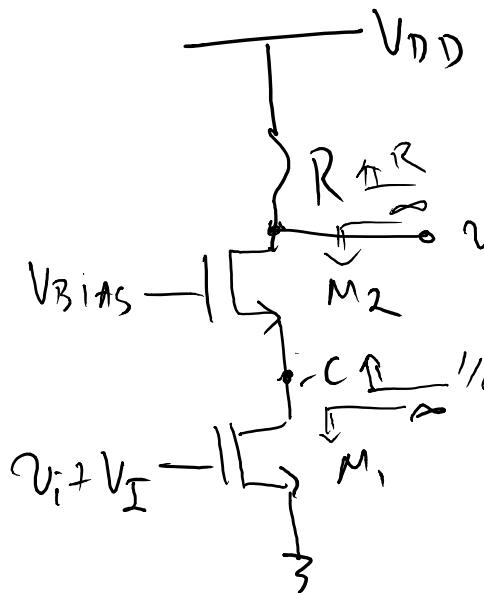
$$\frac{R_s + (1 + (g_m + g_{mb}) R_s) r_o}{1 + \frac{R_s}{r_o} + \frac{R_D}{r_o} + (g_m + g_{mb}) R_s}$$

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

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

$$\frac{g_m r_o || R_s}{1 + (g_m + g_{mb}) r_o || R_s}$$

$$R_s + (1 + (g_m + g_{mb}) R_s) r_o$$

Cascade Amplifier

$$A_v = \frac{V_o}{V_i} = \frac{V_o}{V_i} \cdot \frac{V_o}{V_o}$$

1st stage : CS

2nd stage : CG

Simple case: $g_{mb} = 0, r_o = \infty$

$$A_v = -g_{m1} \underbrace{\frac{1}{g_{m2}}}_{\text{CS}} \cdot g_{m2} R = -g_{m1} R$$

$$R_c = R_{out1} \parallel R_{in2}$$

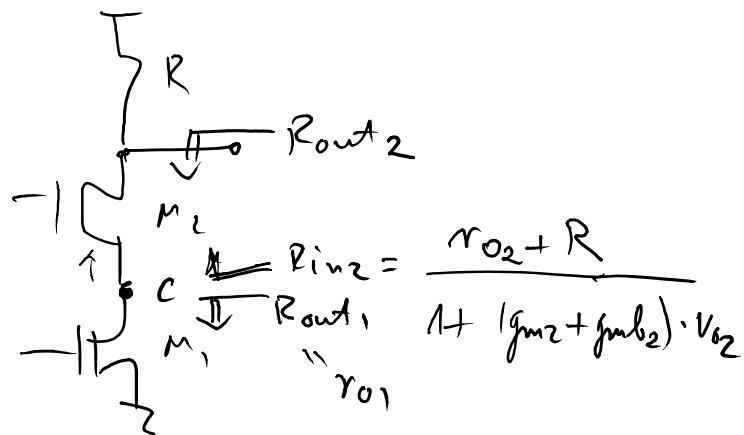
CS

More complex case:

$$g_{mb} \neq 0, V_o < \infty$$

$$R_{out1} \parallel R_{in2}$$

$$A_v = -g_{m1} \cdot R_c \underbrace{(-G_{m2})}_{CS} \cdot \underbrace{R_{out2} \parallel R}_{CG}$$



$$= -g_{m1} \left(r_{o1} \parallel \frac{r_{o2} + R}{1 + (g_{m2} + g_{mb2})r_{o2}} \right) \cdot \frac{(A + (g_{m2} + g_{mb2})r_{o2})R}{r_{o2} + R}$$

$$\approx -g_{m1} R$$

$$R_{out} = r_{o1} + (1 + (g_{m2} + g_{mb2})r_{o1})r_{o2}$$

$$\approx \underbrace{(g_{m2} + g_{mb2})r_{o2} \cdot r_{o1}}$$

