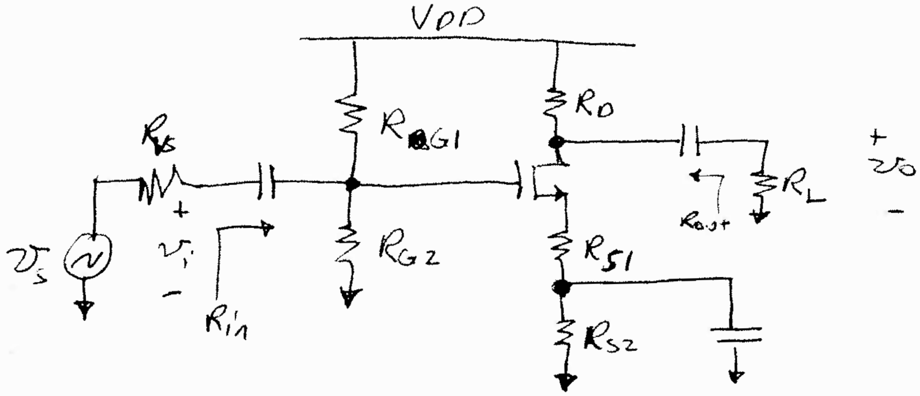
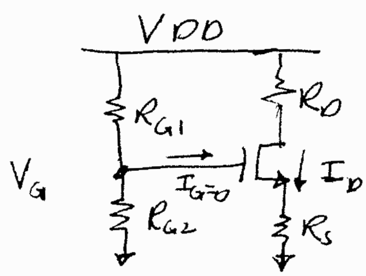
Common Source w/ Source Resistance



* Why $R_S = R_{S1} + R_{S2}$?

The source resistor provides a DC bias point more robust to variations (KP, V_T, temperature). This comes at the cost of reduced gain.

* DC Biasing



$$V_G = V_{DD}\left(\frac{R_{G2}}{R_{G1} + R_{G2}}\right)$$

$$I_D = \frac{1}{2} KP_N \frac{W}{L}\left[V_G - I_D R_S - V_{TN}\right]^2$$

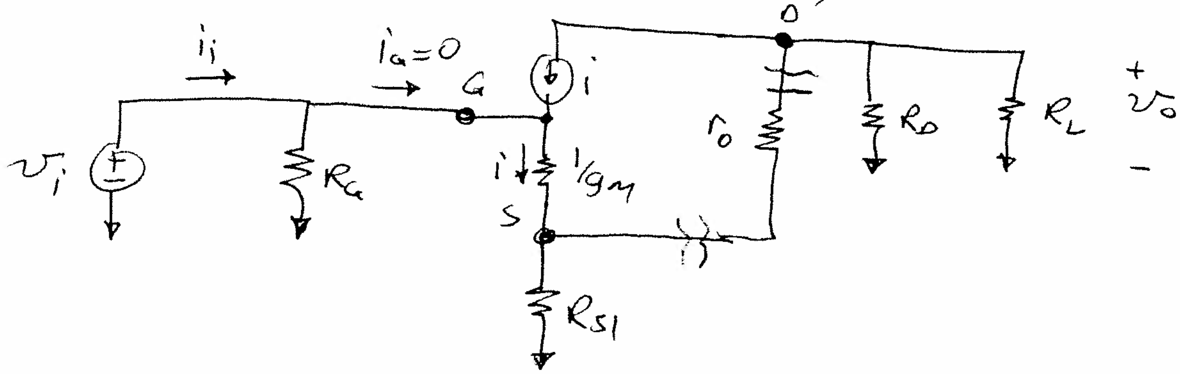
$\Rightarrow$ Must solve quadratic equation for I_D

After some algebra....

$$I_D^2 R_S^2 - I_D\left[2(V_G - V_{TN})R_S + \frac{2}{KP_N \frac{W}{L}}\right] + (V_G - V_{TN})^2 = 0$$

$\Rightarrow$ Get 2 solutions, choose the one consistent w/ Saturation (Smaller value)

AC Equivalent Model (w/T model)



Neglecting r_o to simplify analysis

$$v_o = -i\,(R_D \| R_L)$$

$$i = \frac{v_i}{\frac{1}{g_m} + R_{S1}}$$

$$v_o = -\frac{v_i\,(R_D \| R_L)}{1/g_m + R_{S1}} = -\frac{g_m\,(R_D \| R_L)}{1 + g_m R_{S1}}\,v_i$$

$$\boxed{A_v = \frac{v_o}{v_i} = -\frac{g_m\,(R_D \| R_L)}{1 + g_m R_{S1}}}$$

A_v reduced by $\frac{1}{1 + g_m R_{S1}}$

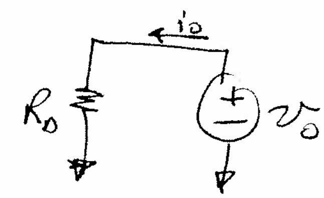
If $g_m R_{S1} \gg 1 \Rightarrow$ gain approaches $-\frac{R_D}{R_{S1}}$
(and R_L big)

Source Cap allows for both stable DC bias and high AC gain.

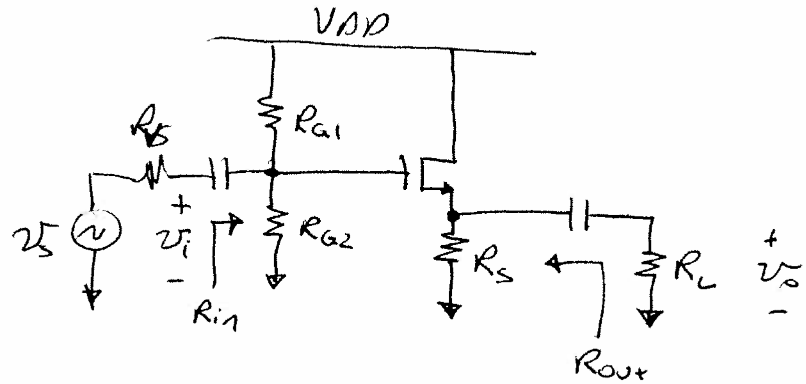
* For R_{in}, since $i_G = 0$ $\boxed{R_{in} = \frac{v_i}{i_i} = R_G}$ (unaffected by R_s)

* For R_{OUT}: w/ $v_i = 0$, $i = 0$

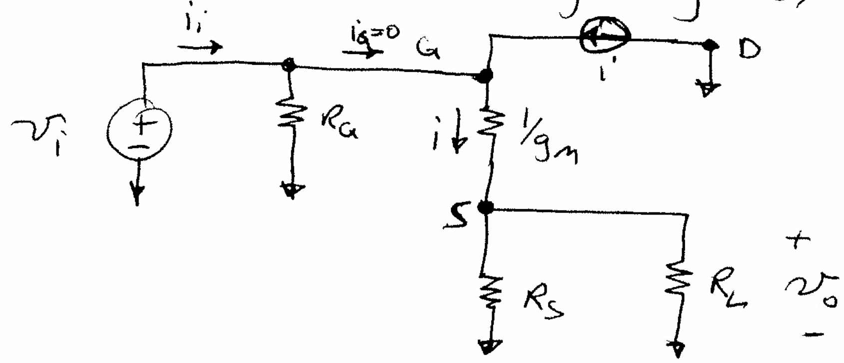
(unaffected by R_s) $\boxed{R_{OUT} = R_D}$



Common Drain



AC Equivalent Circuit (neglecting r_o)

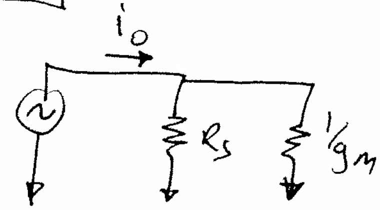


$$v_o = i(R_S \| R_L)$$

$$= \frac{v_i\,(R_S \| R_L)}{\frac{1}{g_m} + (R_S \| R_L)}$$

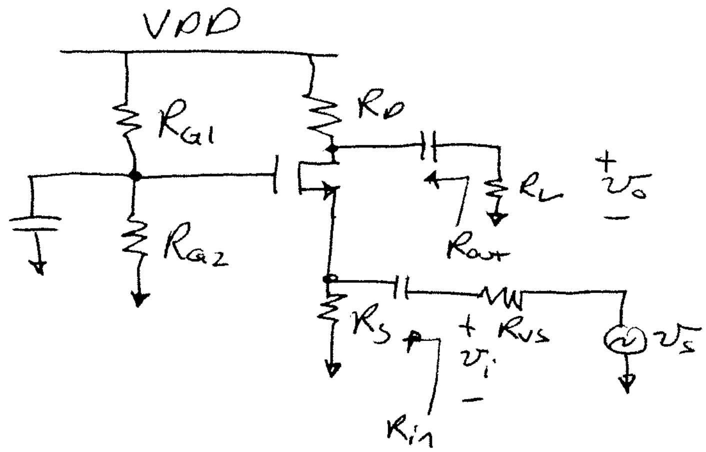
$$\boxed{A_v = \frac{v_o}{v_i} = \frac{g_m(R_S \| R_L)}{1 + g_m(R_S \| R_L)}} \quad (<1)$$

$$\boxed{R_{in} = \frac{v_i}{i_i} = R_G} \quad \text{(same as CS)}$$

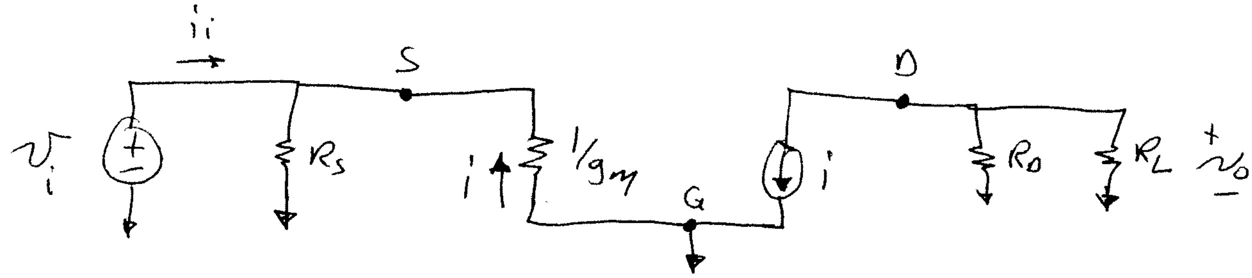
For R_{OUT}: v_o 

$$\boxed{R_{OUT} = R_S \,\|\, 1/g_m \simeq \frac{1}{g_m}} \quad \text{(low)}$$

Common Gate



AC Equivalent Circuit (Neglecting r_o)



$$v_o = -i(R_D \| R_L)$$

$$i = -\frac{v_i}{1/g_m}$$

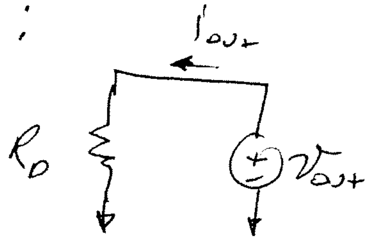
$$\boxed{A_V = \frac{v_o}{v_i} = g_m(R_D \| R_L)}$$

(Medium Gain)
(Non-Inv)

$$\boxed{R_{in} = R_S \| \frac{1}{g_m} \simeq \frac{1}{g_m}}$$

(low)

For R_{out}:



$$\boxed{R_{out} = R_D}$$

(High)