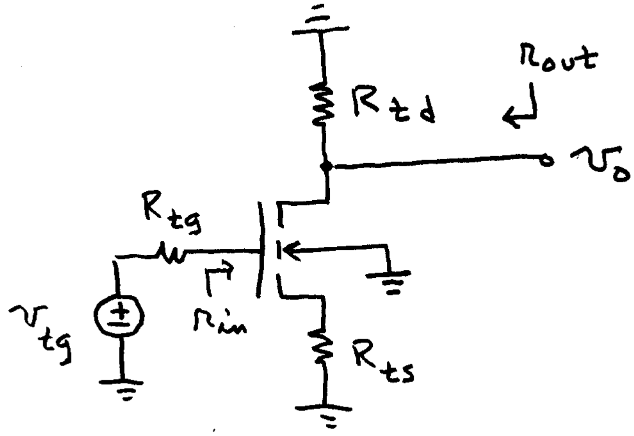
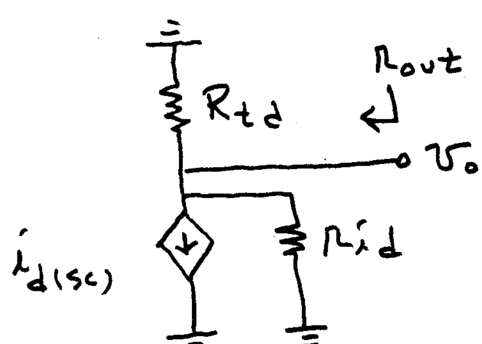
# The Common Source Amplifier with Body Effect

Assume a Thévenin equivalent is made of the signal source connected to the gate. The ac signal circuit is




Because no gate current flows, it follows that $r_{in} = \infty$.

To solve for $v_o$ and $r_{out}$, use the Norton drain circuit.



$$v_o = -i_{d(sc)}\, r_{id} \| R_{td}$$

$$= -G_{mg}\, v_{tg}\, r_{id} \| R_{td}$$

Thus the voltage gain is

$$\frac{v_o}{v_{tg}} = -G_{mg}\, r_{id} \| R_{td}$$

where $$G_{mg} = \frac{1}{1+\chi}\, \frac{1}{r_s' + R_{ts} \| r_0}\, \frac{r_0}{r_0 + R_{td}}$$

$$r_s' = \frac{r_s}{1+\chi} = \frac{1}{g_m(1+\chi)}$$

$$r_{id} = r_0\left(1 + \frac{R_{ts}}{r_s'}\right) + R_{ts}$$

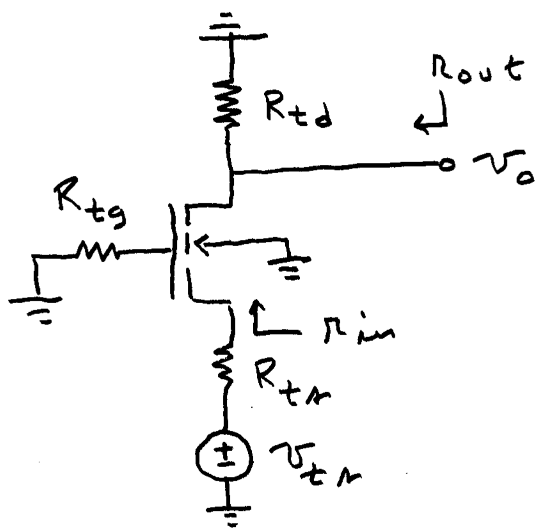
The output resistance is

$$r_{out} = r_{id} \| R_{td}$$

If the body connects to the source lead, not to ac ground, set $\chi = 0$ in the equations.

# The Common Gate Amplifier with Body Effect

Assume a Thévenin equivalent is made of the signal source connected to the source. The ac signal circuit is

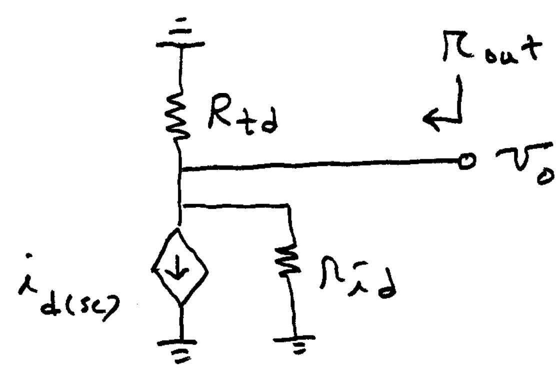



The input resistance is given by

$$r_{in} = r_{is} = r_s' \frac{r_o + R_{td}}{r_s' + R_{td}}$$

where $r_s' = \dfrac{r_s}{1+\chi} = \dfrac{1}{g_m(1+\chi)}$

To solve for $v_o$ and $r_{out}$, use the Norton drain circuit.




$$v_o = -i_{d(sc)}\, r_{id} \| R_{td}$$

$$= -(-G_{ms} v_{ts})\, r_{id} \| R_{td}$$

Thus the voltage gain is given by

$$\frac{v_o}{v_{ts}} = +G_{ms}\, r_{id} \| R_{td}$$

where

$$G_{ms} = \frac{1}{R_{ts} + r_s' \| r_o}$$

$$r_{id} = r_o\left(1 + \frac{R_{ts}}{r_s'}\right) + R_{ts}$$

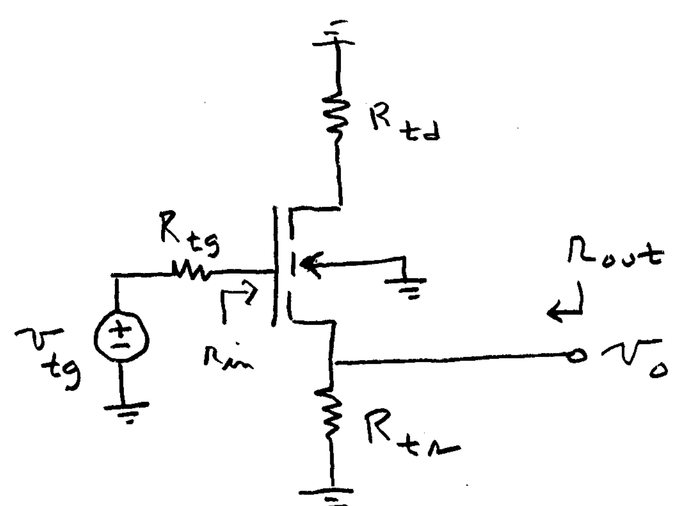
The output resistance is

$R_{out} = R_{id} \parallel R_{td}$

If the body lead connects to the source lead, not to ac ground, set $\chi = 0$ in the equations.

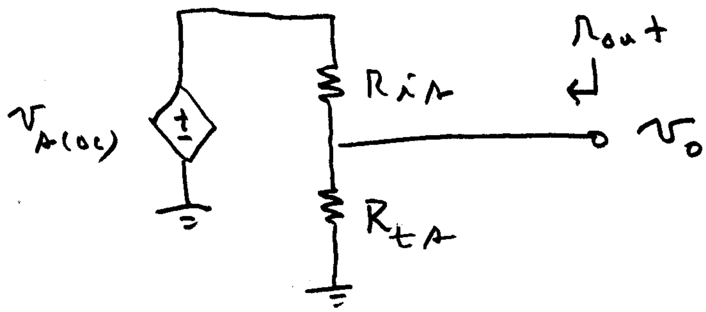
## The Common Drain Amplifier with Body Effect

Assume a Thévenin equivalent circuit is made of the signal source connected to the gate.




Because no gate current flows, it follows that $R_{in} = \infty$.

To solve for $v_o$ and $r_{out}$, we use the Thévenin source circuit.




where $v_{s(oc)}$ and $r_{is}$ are given by

$$v_{s(oc)} = \frac{v_{tg}}{1+\chi} \frac{r_o}{r_s' + r_o}$$

$$r_{is} = r_s' \frac{r_o + R_{td}}{r_s' + r_o}$$

$$r_s' = \frac{r_s}{1+\chi} = \frac{1}{g_m(1+\chi)}$$

The output voltage is given by

$$v_o = v_{s(oc)} \frac{R_{ts}}{r_{is} + R_{ts}}$$

$$= \frac{v_{tg}}{1+\chi} \frac{r_o}{r_s' + r_o} \frac{R_{ts}}{r_{is} + R_{ts}}$$

Thus the voltage gain is given by

$$A_v = \frac{v_o}{v_{tg}} = \frac{1}{1+\chi} \frac{r_o}{r_s' + r_o} \frac{R_{ts}}{r_{is} + R_{ts}}$$

The output resistance is given by

$$r_{out} = r_{is} \| R_{ts}$$