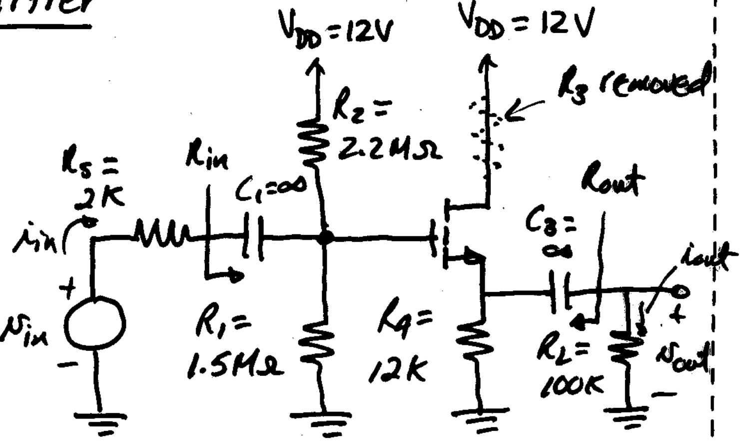
Jaeger: Overall voltage gain (v_{out}/v_{in}) vs. terminal voltage gain (v_{out}/v_b or v_{out}/v_g).

$$\frac{v_{out}}{v_{in}} = \left(\frac{v_{out}}{v_b}\right)\left(\frac{v_b}{v_{in}}\right) \text{ or } \left(\frac{v_{out}}{v_g}\right)\left(\frac{v_g}{v_{in}}\right)$$

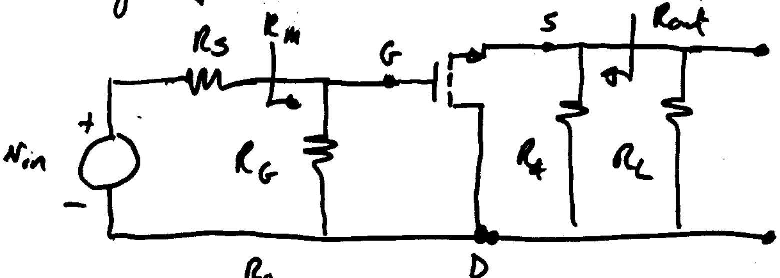
Common drain amplifier

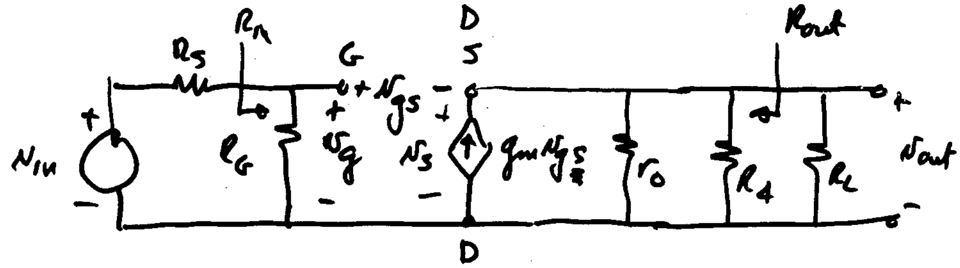
Find R_{in}, R_{out}, and v_{out}/v_{in} given $K_n = 0.5\,mA/V^2$, $V_{TN} = 1V$, $\lambda = 0.02\,V^{-1}$, $I_{DQ} = 241\,\mu A$ and $V_{DSQ} = 3.81V$



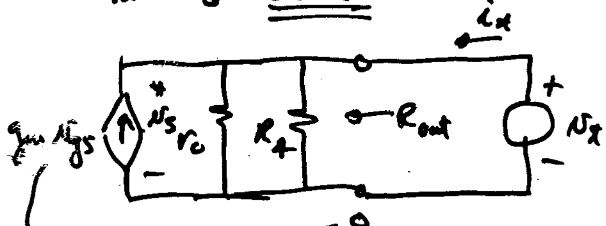
Small-signal model:

$$g_m = \sqrt{2K_n I_{DQ}(1+\lambda V_{DSQ})} = 509\,\mu S \quad \& \quad r_o = \frac{\frac{1}{\lambda} + V_{DSQ}}{I_{DQ}} = 223\,k\Omega$$





$R_{in} = R_G = \underline{\underline{892\,k\Omega}}$



$\Rightarrow R_{out} = \frac{v_x}{i_x}$

$$i_x = \frac{v_x}{R_4} + \frac{v_x}{r_o} + g_m v_x$$

$g_m v_{gs} = g_m \overset{0}{v_g} - g_m v_s$

$$R_{out} = r_o \| R_4 \| \frac{1}{g_m} = 223k \| 12k \| \frac{1K}{.509}$$

$= \cancel{1.96\,k\Omega}$ $= 1.675K$

$$\frac{v_{out}}{v_{in}} = \left(\frac{v_{out}}{v_{gs}}\right)\left(\frac{v_{gs}}{v_g}\right)\left(\frac{v_g}{v_{in}}\right)$$

$v_{gs} = v_g - v_s$

Ignoring r_o,

$$= \left[+g_m(\cancel{r_o}^{\infty}\|R_4\|R_L)\right]\left[\quad\right]\left[\quad\right]$$

$$\left[\quad\right] = \frac{1}{1+g_m(R_4\|R_L)} \qquad \left[\quad\right] = \frac{R_G}{R_S+R_G}$$

$v_s = g_m(\cancel{r_o}^{\infty}\|R_4\|R_L)v_{gs}$

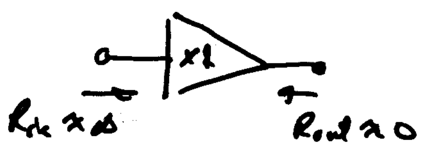
$v_{gs} = v_g - g_m(\cancel{r_o}^{\infty}\|R_4\|R_L)v_{gs}$

$v_{gs}\left[1+g_m(R_4\|R_L)\right] = v_g$

i.e. $$\frac{v_{out}}{v_{in}} = \left(\frac{R_G}{R_S+R_G}\right)\left[\frac{g_m(R_4\|R_L)}{1+g_m(R_4\|R_L)}\right] = \left(\frac{892}{894}\right)\left[\frac{\cancel{30.5}\ 5.45}{1+\cancel{30.5}\ 5.45}\right]$$

$$= \underline{\underline{\cancel{0.966}\ 0.843}}\ \text{V/V}$$

The common drain is called source follower or a buffer.



Check out the current gain of this circuit $\left(\frac{i_{out}}{i_{in}}\right)$

It should be ~~very~~ larger than 1

$$\frac{i_{out}}{i_{in}} = \frac{v_{out}/R_L}{v_{in}/R_{in}} = \left(\frac{v_{out}}{v_{in}}\right)\frac{R_{in}}{R_L} \approx 1 \times \frac{894}{100} = 8.94\ \text{A/A}$$