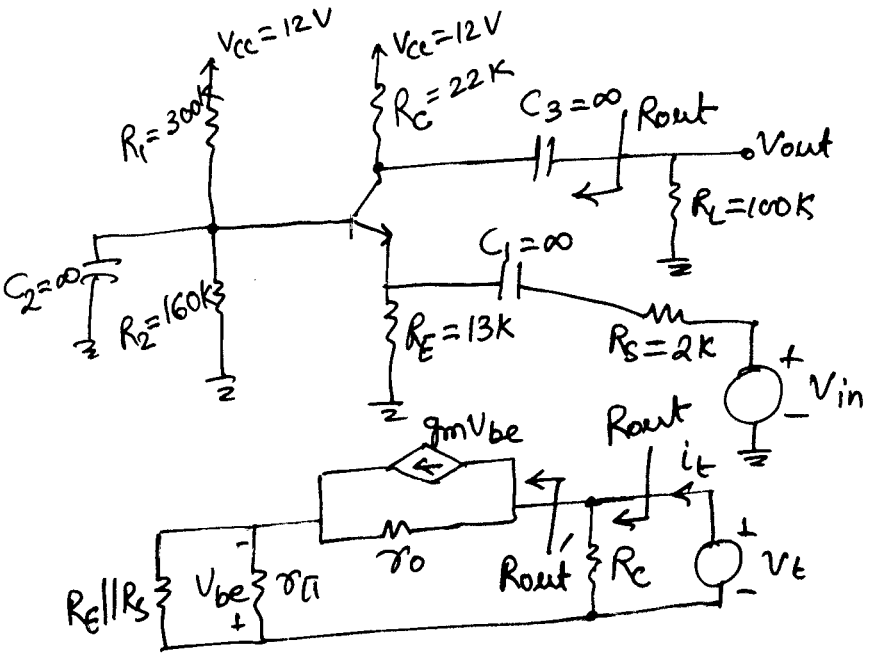
Common Base Amplifier (continued)

Output resistance



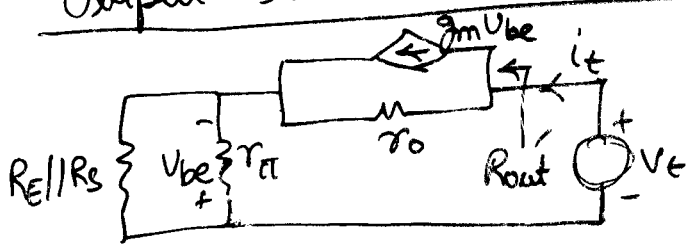
Case 1: When $r_o \to \infty$

$$R_{out} = R_c$$

Case 2: When r_o is not neglected

$$R_{out} = (R_c \,||\, R_{out}')$$

Output resistance at drain (R_{out}')



$$V_t = (i_t - g_m v_{be})\, r_o - v_{be} = r_o i_t - v_{be}(1 + g_m r_o)$$

$$-v_{be} = i_t\,(r_\pi \,||\, R_E \,||\, R_S)$$

$$V_t = r_o i_t + i_t\,(r_\pi \,||\, R_E \,||\, R_S)(1 + g_m r_o)$$

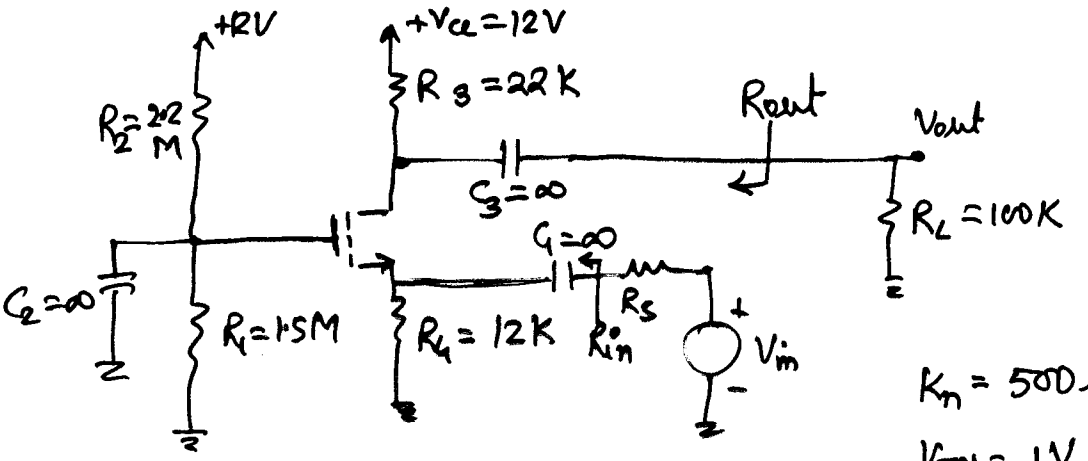
$$R_{out}' = \frac{V_t}{i_t} = \left[r_o + (r_\pi \,||\, R_E \,||\, R_S)(1 + g_m r_o) \right]$$

$$= 3.166\ M\Omega$$

$$R_{out} = (R_C \,||\, R_{out}')$$

$$= (22K \,||\, 3.166\ M\Omega) \cong 22K$$

Common gate amplifier



$K_n = 500\,\mu A/V^2$

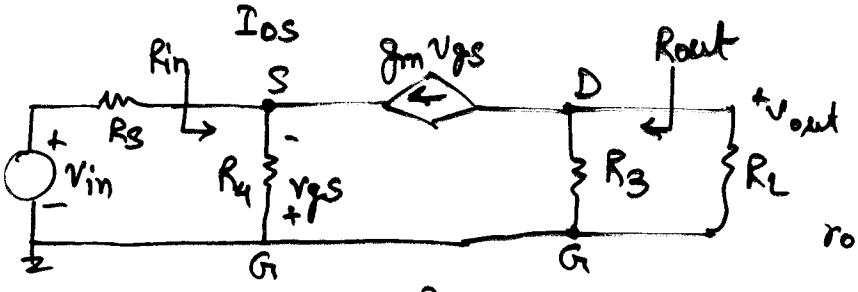
$V_{TN} = 1V$

$\lambda = 0.02\,V^{-1}$

Q point $\{ I_{DS} = 241\,\mu A,\ V_{DS} = 3.8V \}$

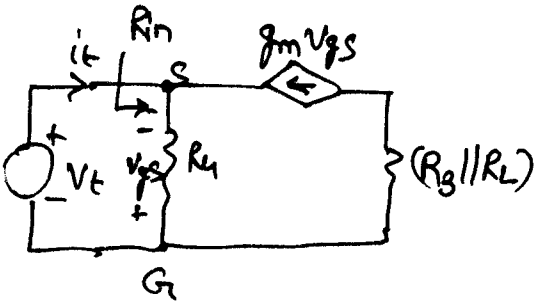
$$g_m = \sqrt{2K_n \cdot I_{DS}(1+\lambda V_{DS})} = 509\,\mu S$$

$$r_o = \frac{\frac{1}{\lambda} + V_{DS}}{I_{DS}} = 223\,k\Omega$$



$r_o \rightarrow$ neglected

$$R_{in} = \frac{V_t}{i_t}$$



$(V_{gs} = -V_t)$

$$i_t = \frac{V_t}{R_4} - g_m V_{gs} = \frac{V_t}{R_4} + g_m \cdot V_t$$

$$R_{in} = \frac{V_t}{i_t} = \frac{R_4}{(1+g_m R_4)} \cong \frac{1}{g_m} \cong 1.96\,k\Omega$$

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

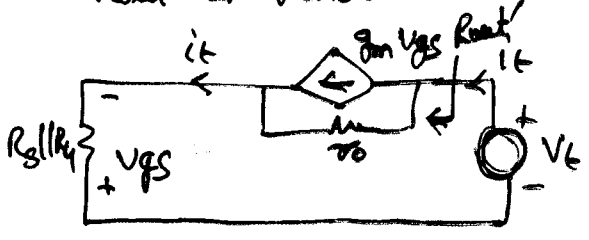
$$= \left[-g_m (R_3 \| R_4)\right]\left[\frac{-R_{in}}{R_{in}+R_s}\right] = 4.54 \text{ V/V}$$

Rout = ??

If $r_o \rightarrow$ neglected, $R_{out} = R_3 = 22K$

$R_{out} = (R_3 \| R_{out}')$

R_{out}' = resistance at the drain



$$R_{out}' = \frac{v_t}{i_t}$$

$$v_t = (i_t - g_m v_{gs}) r_o - v_{gs} = i_t r_o - v_{gs}(1 + g_m r_o)$$

$$v_{gs} = -i_t (R_3 \| R_4)$$

$$v_t = i_t r_o + i_t (1 + g_m r_o)(R_3 \| R_4)$$

$$= i_t \left\{ r_o + (1 + g_m r_o)(R_3 \| R_4) \right\}$$

$$R_{out}' = \frac{v_t}{i_t} = \left[r_o + (1 + g_m r_o)(R_3 \| R_4) \right] = 416 \text{ K}\Omega$$

$$R_{out} = (R_3 \| R_{out}') = (22K \| 416K\Omega)$$