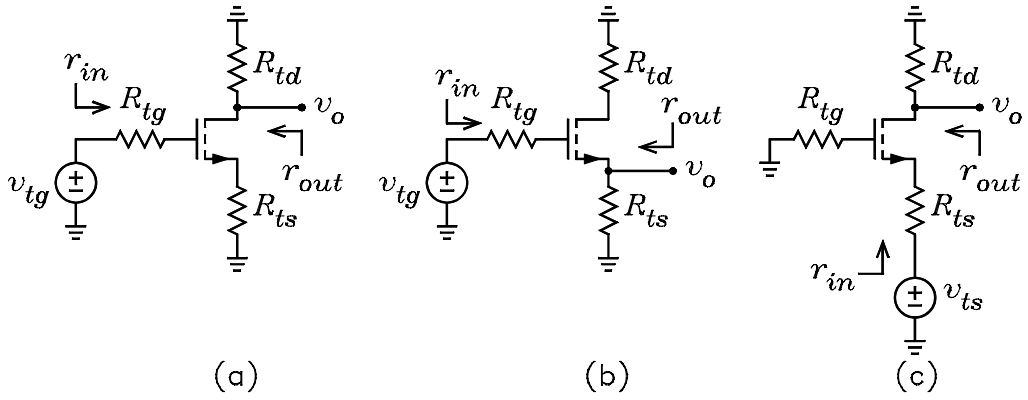
ECE3050 Homework Set 10

The figures show a common-source amplifier, a common-drain amplifier, and a common-gate amplifier. For each circuit, it is given that $R_{tg} = 1\,\text{k}\Omega$, $R_{ts} = 100\,\Omega$, and $R_{td} = 10\,\text{k}\Omega$. The transistors have the parameters $I_D = 1.5\,\text{mA}$, $V_{DS} = 10\,\text{V}$, $K = 0.005\,\text{A/V}^2$, and $\lambda = 0\,\text{V}^{-1}$.



1. For each transistor, show that $g_m = 1/182.6\,\text{S}$, $r_s = 182.6\,\Omega$, and $r_0 = \infty\,\text{k}\Omega$.

2. For the common-source amplifier of Figure (a):

   (a) Replace the MOSFET with the T model or simplified T model and show that

$$v_o = -i_d' R_{td} = -10^4 i_d'$$

$$i_d' = i_s' = \frac{v_{tg}}{r_s + R_{ts}} = \frac{v_{tg}}{282.6}$$

$$\frac{v_o}{v_{tg}} = \frac{-R_{td}}{r_s + R_{ts}} = -35.4$$

   (b) Replace the MOSFET with the π model and show that

$$v_o = -i_d' R_{td} = -10^4 i_d'$$

$$i_d' = \frac{v_{tg}}{\dfrac{1}{g_m} + R_{ts}} = \frac{v_{tg}}{282.6}$$

$$\frac{v_o}{v_{tg}} = \frac{-R_{td}}{\dfrac{1}{g_m} + R_{ts}} = -35.4$$

3. For the common-drain amplifier of Figure (b):

   (a) Use the T model or simplified T model to show that

$$\frac{v_o}{v_{tg}} = \frac{R_{ts}}{r_s + R_{ts}} = 0.354$$

$$r_{out} = R_{ts} \| r_s = 64.61\,\Omega$$

(b) Use the π model to show that

$$\frac{v_o}{v_{tg}} = \frac{R_{ts}}{\dfrac{1}{g_m} + R_{ts}} = 0.354$$

$$r_{out} = R_{ts} \| \frac{1}{g_m} = 64.61\,\Omega$$

4. For the common-gate amplifier of Figure (c)

(a) Use the T model or simplified T model to show that

$$\frac{v_o}{v_{ts}} = \frac{-1}{r_s + R_{ts}} \times (-R_{td}) = \frac{R_{td}}{r_s + R_{ts}} = 35.4$$

$$r_{out} = R_{td} = 10\,\text{k}\Omega$$

(b) Use the π model to show that

$$\frac{v_o}{v_{ts}} = \frac{-1}{\dfrac{1}{g_m} + R_{ts}} \times (-R_{td}) = \frac{R_{td}}{\dfrac{1}{g_m} + R_{ts}} = 35.4$$

$$r_{out} = R_{td} = 10\,\text{k}\Omega$$

5. What are the new answers to problems 4 through 6 if the body lead connects to ac ground and $\chi = 0.3$? Answers: For problem 2, $v_o/v_{tg} = -32.0$ and $r_{out} = 10\,\text{k}\Omega$. For problem 3, $v_o/v_{tg} = 0.32$ and $r_{out} = 58.4\,\Omega$. For problem 4, $v_o/v_{ts} = 32$ and $r_{out} = 10\,\text{k}\Omega$.