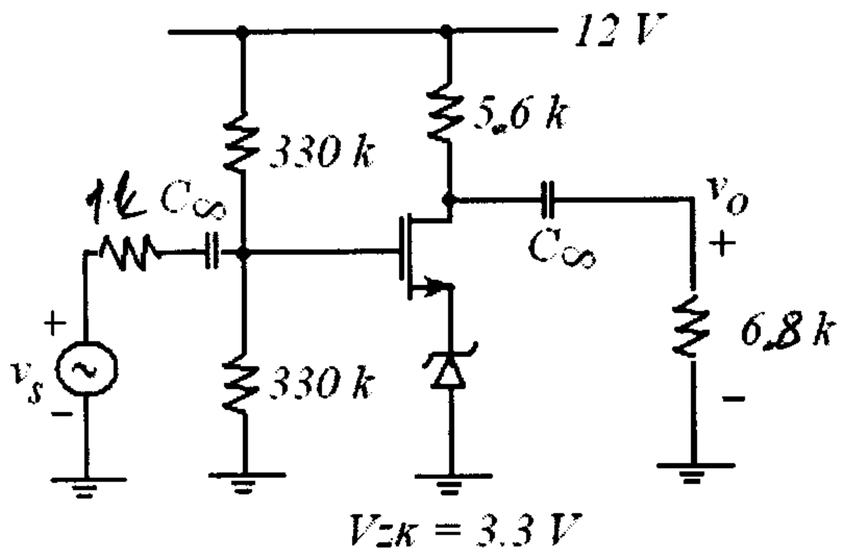
Obtain a small-signal equivalent circuit for the amplifier given below. Then find the input resistance, output resistance and voltage gain of the amplifier. *Threshold voltage* = 2.3 V, K=5mA/V^2, r_o=200 kΩ.



$V_G = 12\frac{330}{330+330} = 6\,V$

$V_{GS} = 6 - 3.3 = 2.7\,V$

$I_D = 5(2.7-2.3)^2 = 0.8\,mA$

$g_m = 2\sqrt{KI_D} = 2\sqrt{5\times 0.8} = 4\,mA/V$

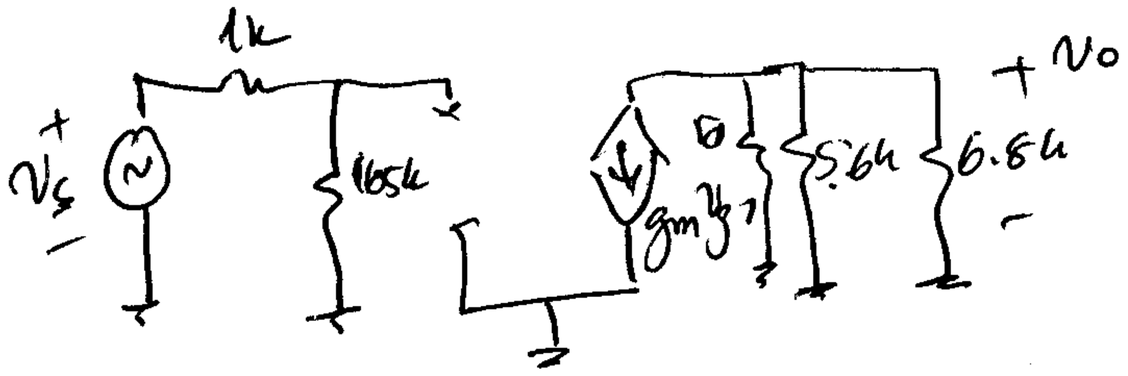
$r_{in} =$ 165k

$r_{out} =$ 5.6k

$v_o/v_s =$ −12.09

$\frac{v_o}{v_{gs}} = -g_m(r_o \| R_D \| R_L) = -4(200\|5.6\|6.8)$

$= -12.098$



$\frac{v_{gs}}{v_s} = \frac{165}{1+165} \simeq 1$

$\frac{v_o}{v_s} \simeq -12.09$

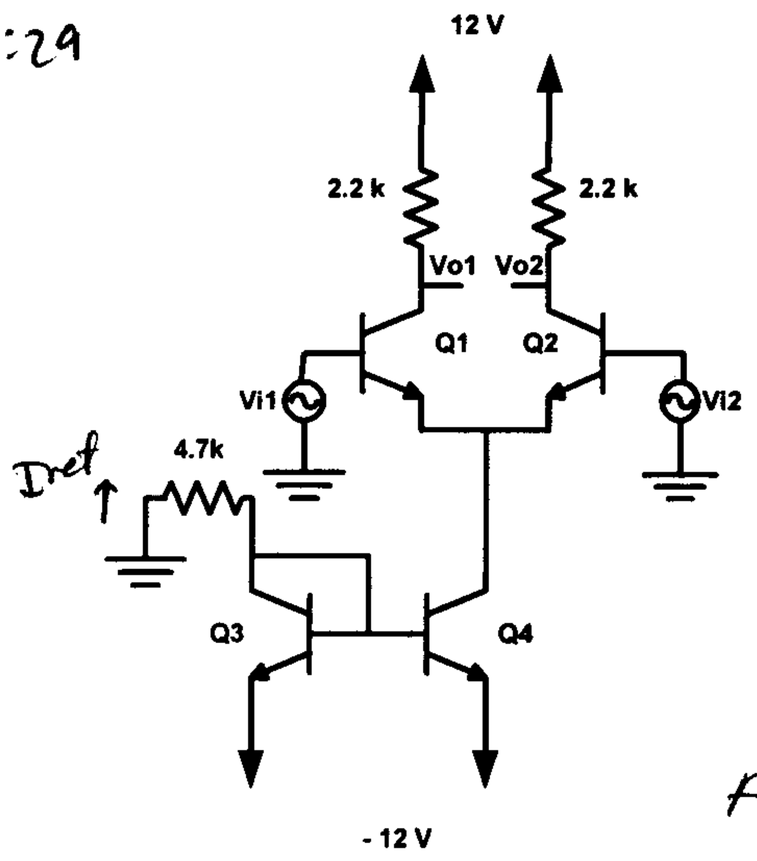
$r_{in} = 165k$

$r_{out} = 5.6k \| 200k \simeq 5.6k$

9:27

For the differential amplifier below, find the dc collector currents of Q1 and Q2, differential mode single ended voltage gain, input resistance, output resistance, and common mode single ended voltage gain and input resistance. Also calculate the amplitude of the maximum differential mode input voltage that results in no distortion at the output. (Silicon BJT with β= 300, V_A=250V)

9:29



I_{C1} = 1.2mA (2pts)

I_{C2} = 1.2mA (2 pts)

$A_{dm\text{-}se1}$ = -52.8 (3 pts)

$r_{in\text{-}dm}$ = 12.5k (3 pts)

$r_{out\text{-}se}$ = 2.2k (2 pts)

$r_{in\text{-}cm}$ = 62.6MΩ (3 pts)

$A_{cm\text{-}se1}$ = -0.0105 (5 pts)

$|v_{idm}|_{max}$ = 0.05 V (5 pts)

$$I_{ref} = \frac{12-0.7}{4.7} = 2.4\ mA$$

$$I_{c1} \cong I_{c2} = \frac{2.4\ mA}{2} = 1.2\ mA$$

$$g_m = \frac{1.2}{0.025} = 48\ mA/V$$

$$r_\pi = \frac{\beta}{g_m} = \frac{300}{48} = 6.25\ k\Omega$$

$$r_{o4} = \frac{250}{2.4} = 104\ k\Omega$$

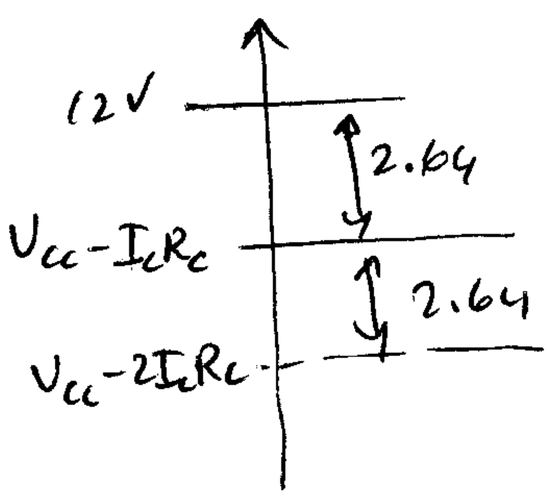
$$A_{dm\text{-}se} = -\frac{g_m R_c}{2} = -\frac{48 \times 2.2}{2} = -52.80$$

$$r_{in\text{-}dm} = 2r_\pi = 10\ k\Omega$$

$$r_{in\text{-}cm} = r_\pi + 2(\beta+1) r_{o4} = 5 + 602 \times 104^k = 62.6\ M\Omega$$

$$A_{cm\text{-}se1} = \frac{-\beta R_c}{r_\pi + 2(\beta+1) r_{o4}} = \frac{-300 \times 2.2}{62\,613} = -0.0105$$

Max signal amplitude in diff. mode: 2.64V



$$|V_{idm}|_{max} = \frac{2.64}{52.8} = 0.05V$$

9:38

9 + 5 + 12 = 26 min x 3 = 78 min