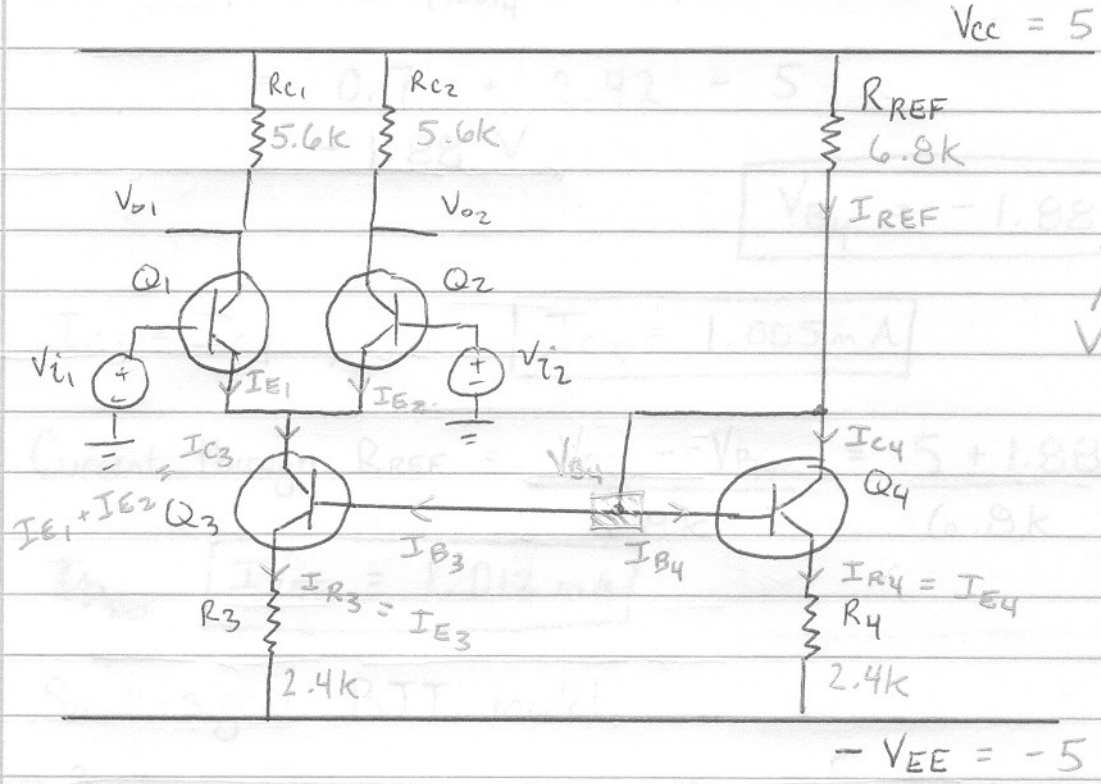
Q3 UE3003 SPR 2006

ALMOST EXAM WORTHY → NEED TO CHECK

10/8/06



(a)

$I_{REF} = I_{C4} + I_{B4} + I_{B3}$ but $I_{C4} = \beta_F I_{B4}$

$= (1+\beta_F) I_{B4} + I_{B3}$

$= (2+\beta_F) I_{B4}$

$$\boxed{I_{REF} = 252\, I_{B4}}$$

$10 - 0.7 = (2+\beta) I_{B4} R_{REF} + (1+\beta) I_{B4} R_4$

$9.3 = (252) I_{B4} (6.8k) + (251) I_{B4} (2.4k)$

$9.3 = (1713.6k) I_{B4} + (602.4k) I_{B4}$

$\frac{9.3}{2316\,k} = I_{B4}$,

$$\boxed{I_{B4} = 4.02\,\mu A}$$

$I_{C4} = \beta_F I_{B4} = (250)(4.02\mu)$

$= 1.005\,mA$

$$\boxed{I_{C4} = 1.005\,mA}$$

$I_{E4} = I_{B4} + I_{C4} = 1.00902\,mA$

$$\boxed{I_{E4} = 1\,mA}$$

$V_{R4} = I_{R4} \cdot R_4 = 2.42\,V$ dropped across R_4

So, $V_{B4} = V_{BE(sat)_4} + V_{R4} - V_{EE}$

$= 0.7 + 2.42 - 5$

$= -1.88\ V$

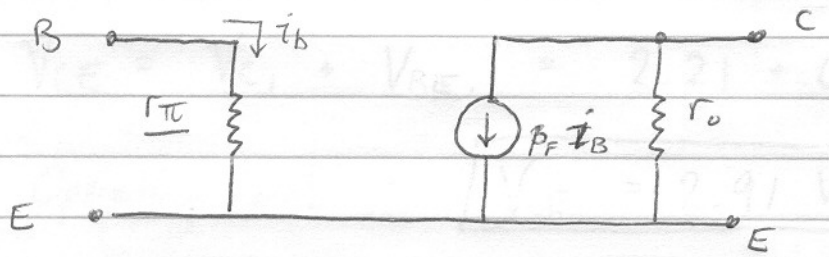
$\boxed{V_{B4} = -1.88\ V}$

$I_{C3} = I_{C4}$, so $\boxed{I_{C3} = 1.005\,mA}$

Current through $R_{REF} = \dfrac{V_{CC} - V_{B4}}{6.8k} = \dfrac{5 + 1.88}{6.8k} = 1.012\,mA$

$\boxed{I_{REF} = 1.012\,mA}$

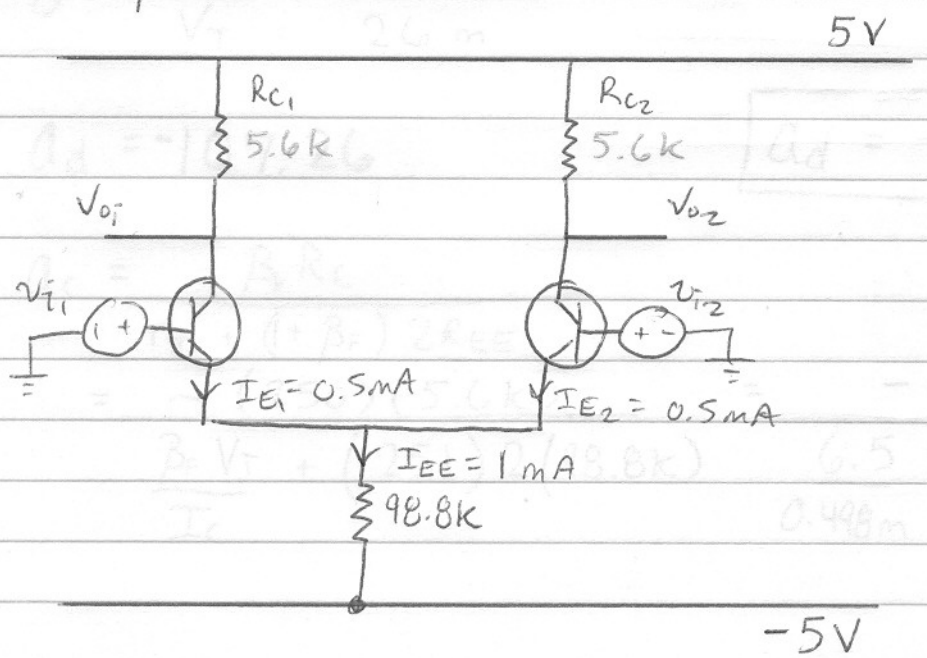
Small-signal BJT model



$r_o = \dfrac{V_A}{I_C} = \dfrac{100}{1.012m} = 98.8\,k\Omega$

$\boxed{r_o = 98.8\,k\Omega}$

The equivalent circuit is:



$I_{E_1} = I_{B_1} + I_{C_1}$ | $I_{C_1} = \beta_F I_{B_1}$

$I_{E_1} = I_{C_1}\left(1 + 1/\beta_F\right)$ | $\frac{I_{C_1}}{\beta_F} = I_{B_1}$

$(0.5m) = I_{C_1}\left(1 + 1/250\right)$

$I_{C_1} = \frac{0.5m}{1.004} = 4.98 \times 10^{-4} = 0.498\,mA$

$\boxed{I_{C_1} = 0.498\,mA}$

$V_{C_1} = V_{CC} - I_{C_1} R_{C_1} = 5 - (0.498m)(5.6k)$
$= 2.21\ V$

$\boxed{V_{C_1} = 2.21\ V}$

$V_{CE} = V_{C_1} + V_{BE_1} = 2.21 + 0.7 = 2.91\ V$

Operating Point = $\boxed{V_{CE_1} = 2.91\ V}$ *

(b) $a_d = \frac{-\beta_F R_C}{r_\pi} = -g_m R_C = -0.02\,R_C$
$= -0.02\,(5.6k)$
$= -107.26$

$g_m = \frac{I_C}{V_T} = \frac{0.498m}{26m} = 0.02$

$a_d = -107.26$ $\boxed{a_d = -107.26}$

(c) $a_c = \frac{-\beta_F R_C}{r_\pi + (1+\beta_F)\,2R_{EE}}$

$= \frac{-(250)(5.6k)}{\frac{\beta_F V_T}{I_C} + (251)\,2(98.8k)} = \frac{-1400k}{\frac{6.5}{0.498m} + (251)(197.6k)}$

$$= \frac{-1400\,k}{13052.2 + 49597.6\,k} = \frac{-1400\,k}{13.0522\,k + 49597.6\,k}$$

$$= \frac{-1400}{49610.65} = -0.0282$$

$$\boxed{a_c = -0.0282}$$

(d) $$CMRR = \frac{|a_d|}{|a_c|} = \frac{|-107.26|}{|-0.0282|} = 3803.55$$

$$CMRR\,(\text{in dB}) = 20 \log (3803.55)$$

$$= 71.6\ dB$$

$$\boxed{CMRR = 3803.6}$$

In dB = 71.6 dB

$$\boxed{CMRR\,(\text{in dB}) = 71.6\ dB}$$