7.37

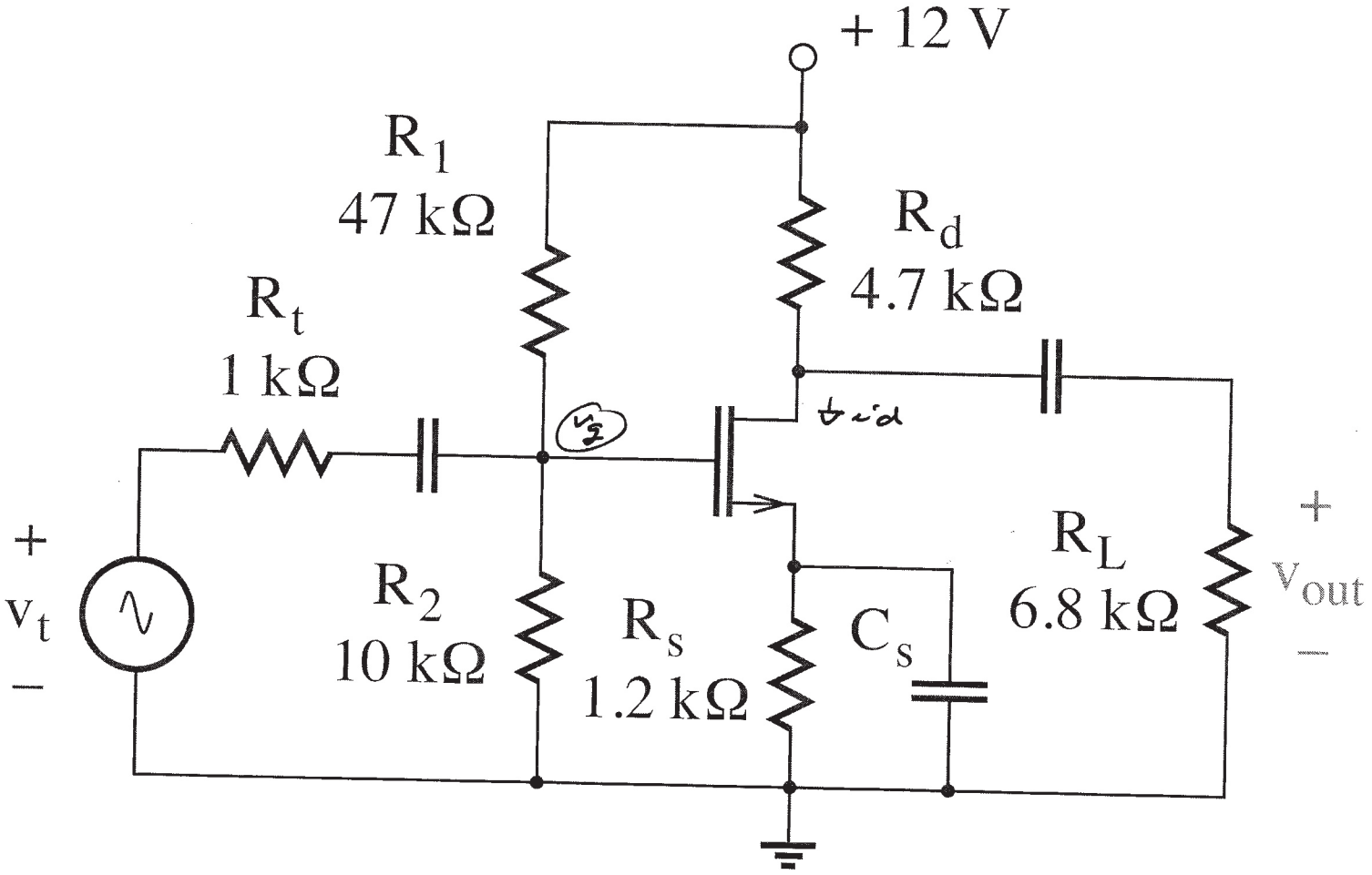
$K' \frac{W}{L} = 1.6\ mA/V^2$

$V_T = 0.6\ V$

$V_g = \frac{10}{10+47}(12) = 2.1\ V$

$V_s = 1.2\, i_d$

$\Big\} \quad V_{SG} = 2.1 - 1.2 i_d$



$V_{SG} = 2.1 - 1.2\left(\frac{1}{2}\right)(1.6)(V_{SG} - 0.6)^2$

$0.96\, V_{SG}^2 - 0.1 V_{SG} - 1.7 = 0$

$\longrightarrow \quad V_{SG} = 1.43, -\cancel{1.27}$

$i_d/2 = \frac{1}{2}(1.6)(1.43 - 0.6)^2 = 0.551\ mA$

7.37 (continued)

$$g_m = \sqrt{2 \times 1.6\ mA/V^2 \times 0.55\ mA} = 1.26 \times 10^{-3}\ \mho$$

common source amplifier: $A_{vm} = -g_m R_d'$

$$R_d' = 4.7k \,//\, 6.8k = 2.78k$$

$$A_{vm} = -1.26 \times 10^{-3}\ \mho \times 2.78 \times 10^{3}\ \Omega = -3.50$$

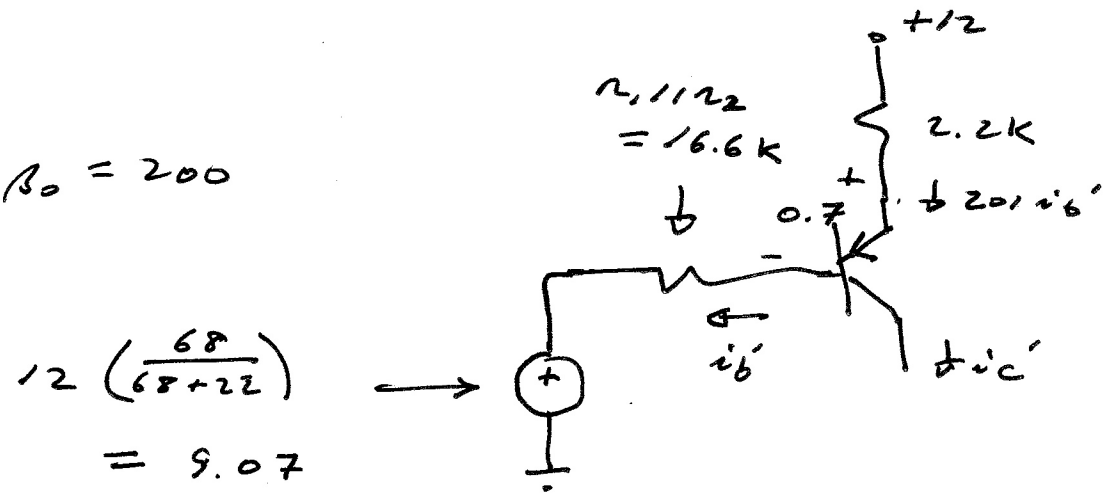
$$R_{in} = 47k \,//\, 10k = 8.25k$$

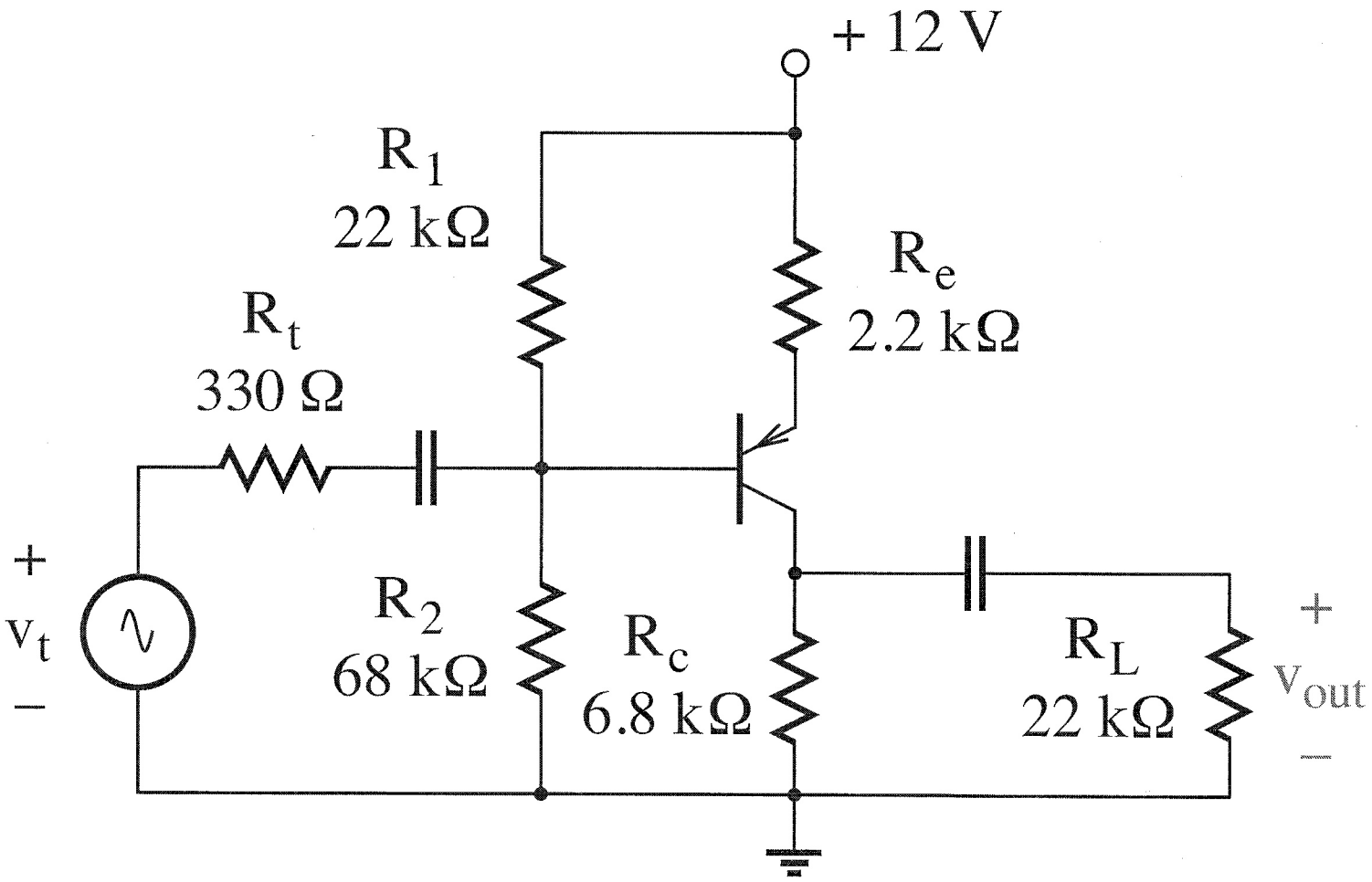
$$\text{Loading factor} = \frac{R_{in}}{R_{in} + R_t} = \frac{8.25k}{8.25k + 1k} = 0.892$$

$$A_{vm}^{TOTAL} = -3.50 \times 0.892 = \underline{-3.1}$$

7.41

$\beta_F = \beta_o = 200$





$12 = 9.07 + 16.6\, i_b' + 0.7 + 201\, i_b' (2_{e2})$

$\longrightarrow \quad i_b' = \frac{2.23}{4.9} \qquad i_c' = -i_c|_Q = \frac{2.23(200)}{4.9}$

$= 0.972\ mA$

$g_m = \frac{|i_c|_Q|}{kT/q} = \frac{0.972\ mA}{25.9\ mV} = 37.5 \times 10^{-3}\ \mho$

$r_\pi = \frac{A_o}{g_m} = 5.33\ K$

(7.41) common emitter amplifier (no bypass)

$R_e' = 6.8K // 22K = 5.19K$

$$A_{vm} = \frac{-g_m r_c'}{1 + g_m r_e' (1 + 1/\beta_o)}$$

$$= \frac{-37.5 \times 10^{-3} \times 5.19 \times 10^{3}}{1 + 37.5 \times 10^{-3} \times 2.2 \times 10^{3} \times 1.005}$$

$$= -2.32$$

$$r_{in} = \underbrace{r_1 // r_2}_{16.6K} // \underbrace{[r_\pi + (1+\beta_o) r_e']}_{447.5K}$$

$$= 16K$$

$$\text{Loading factor} = \frac{16K}{16K + 0.33K} = 0.980$$

$$A_{vm}^{TOTAL} = -2.32 \times 0.980 = -2.27$$

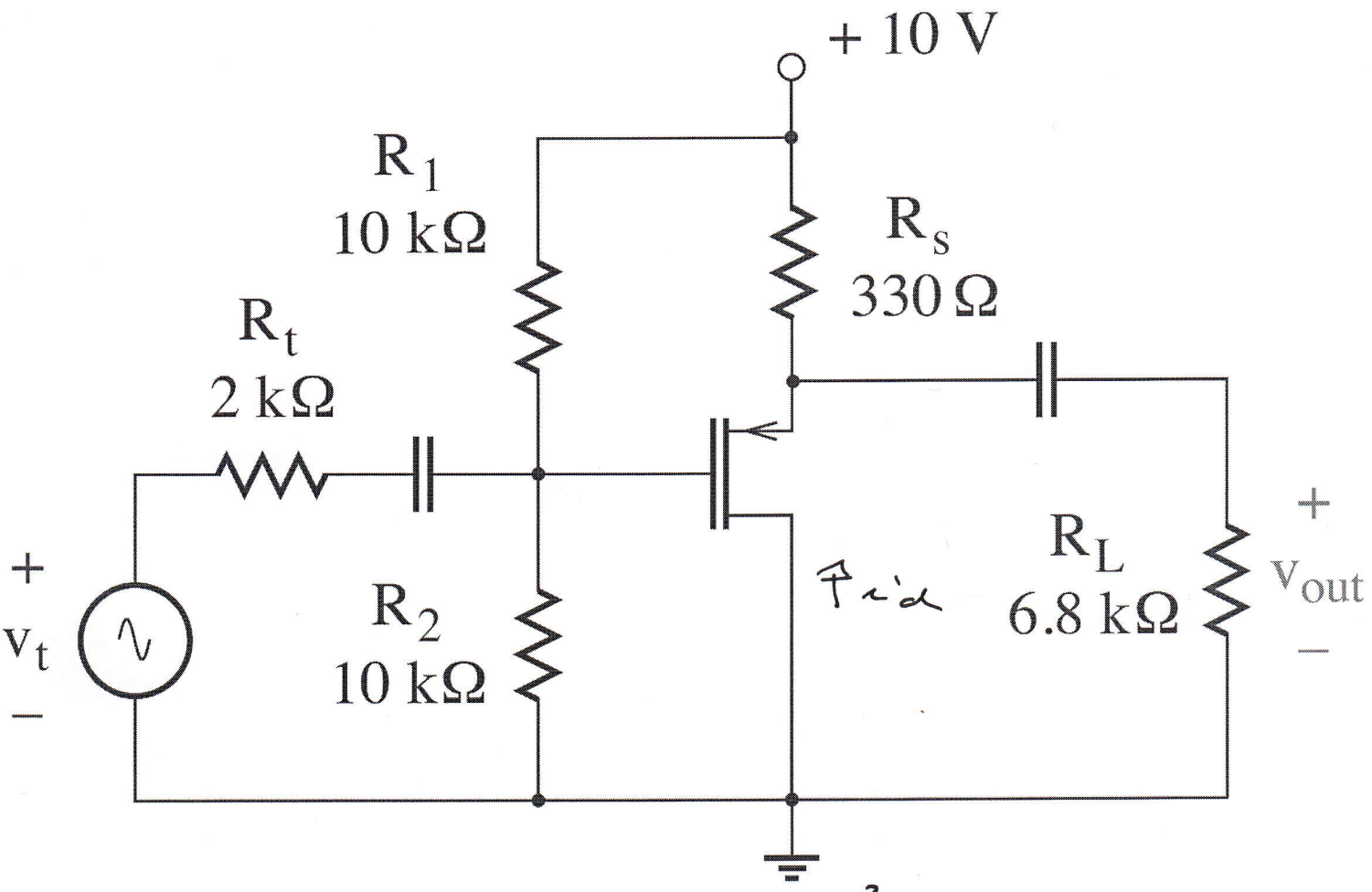
7.46 $K'\frac{W}{L} = 3.6\ mA/V^2$ $V_T = -0.5\ V$

$-i_d = \frac{1}{2}(3.6)(V_{SG} - V_T)^2$

$V_S = 10\left(\frac{10}{10+10}\right) = 5$

$V_S = 10 + 0.33\, i_d$

$\Big\}\ V_{SG} = -5 - 0.33\, i_d$



$V_{SG} = -5 + 0.6\,(V_{SG} + 0.5)^2$

$0.6\,V_{SG}^2 - 0.4\,V_{SG} - 4.85 = 0 \rightarrow V_{SG} = -2.53,\ \cancel{3.2}$

$i_{d|a} = -1.8\,(-2.53 + 0.5)^2 = -7.41\ mA$

$g_m = \sqrt{2K'\frac{W}{L}\,|i_{d|a}|} = 7.3 \times 10^{-3}\ \mho$

7.46 cont.

Common drain

$$A_{vm} = \frac{g_m r_o'}{1 + g_m r_o'}$$

$r_o' = 0.33\,k\Omega \,//\, 6.8\,k\Omega = 0.315\,k\Omega$

$g_m r_o' = 2.1$

$\longrightarrow A_{vm} = 0.677$

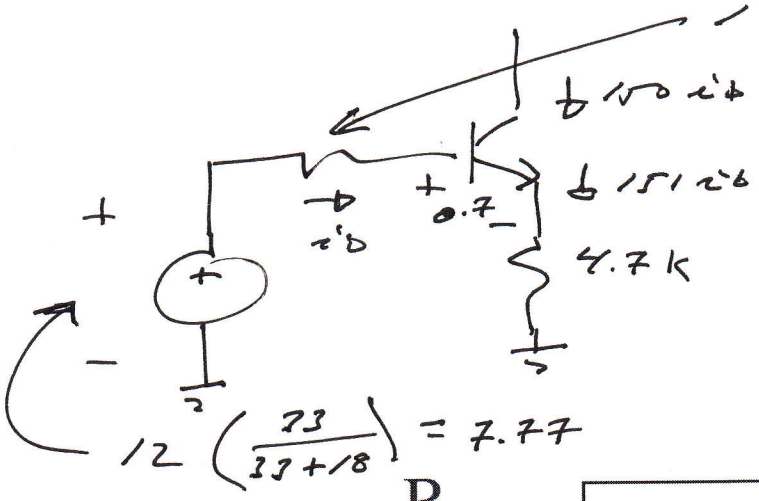
$CF = \frac{r_{in}}{r_{in} + 2k}$ $\qquad r_{in} = 10k\Omega \,//\, 10k\Omega = 5k\Omega$

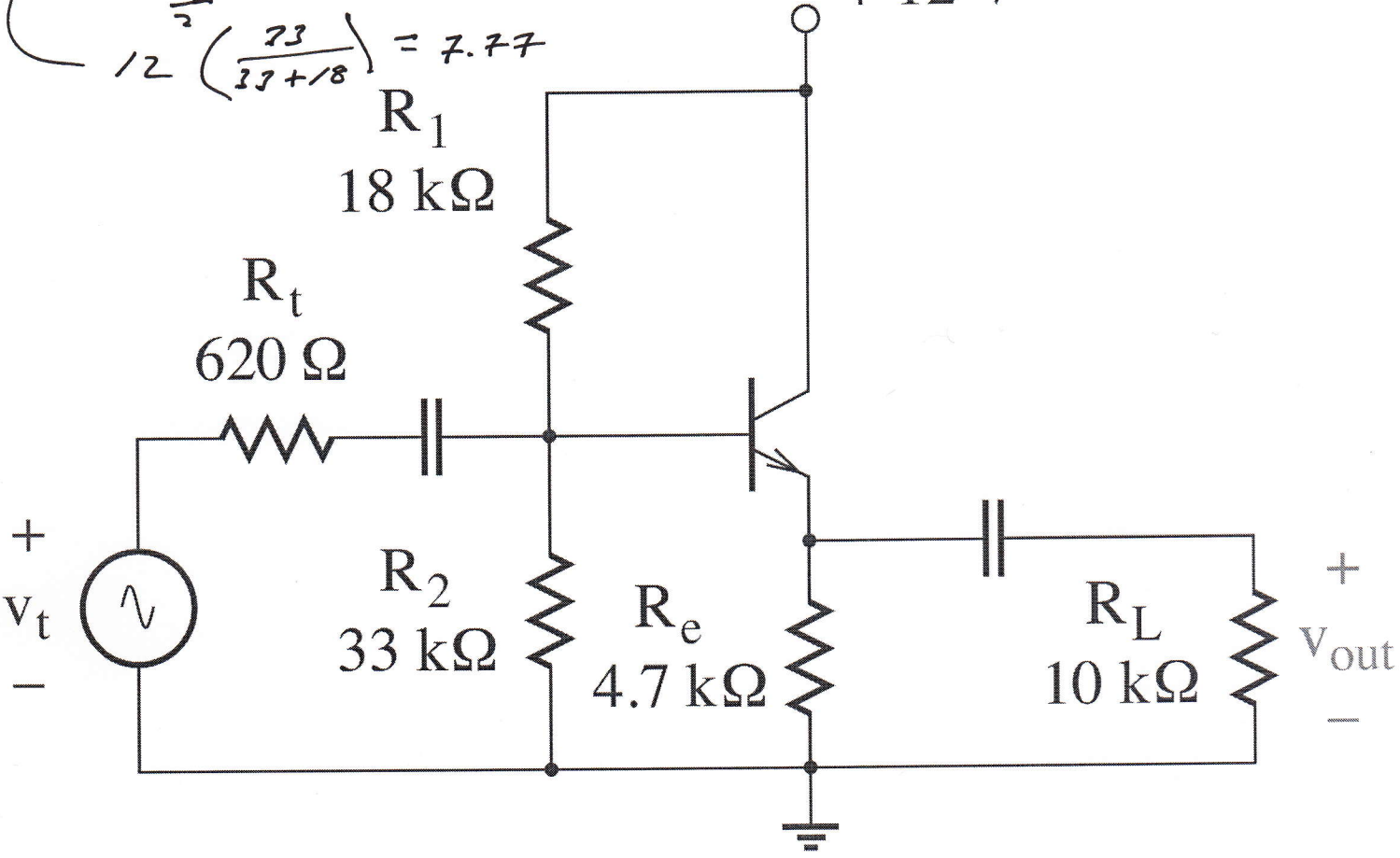
$\longrightarrow CF = 0.714$

$A_{vm}^{TOTAL} = A_{vm} \times CF = \underline{0.5}$

7.49 $\beta_F = \beta_0 = 150$

$18K \| 33K = 11.7K$





$7.77 = 11.7\, i_b + 0.7 + 151\, i_b (4.7)$

$i_b = \frac{7.07}{721} \qquad i_c \approx i_e = 150\left(\frac{7.07}{721}\right) = 1.47$ mA

$g_m = \frac{1.47\ mA}{25.9\ mV} = 56.8 \times 10^{-3}\ \mho$

$r_\pi = \frac{\beta_0}{g_m} = 2.64K$

7.49 (cont.) Common collector

$$A_{vm} = \frac{g_{m} r_e' (1 + 1/\beta_0)}{1 + g_{m} r_e' (1 + 1/\beta_0)}$$

$r_e' = 4.7K \,//\, 10K = 3.2K$

$g_{m} r_e' (1 + 1/\beta_0) = 183$

$A_{vm} = 0.995$

$r_{in} = R_1 // R_2 // [r_\pi + \underbrace{(1+\beta_0) r_e'}_{487K}]$

$= 11.4K$

$CF = \frac{r_{in}}{r_{in} + 0.62K} = 0.948$

$A_{vm}^{TOTAL} = A_{vm} \times CF = \underline{0.94}$

→ current gain $A_{im} = A_{vm} \frac{r_{in}}{R_L}$

$A_{im} = 0.995 \frac{11.4K}{10K} = 1.13$

7.60 stage 2 $g_{m2} = \frac{1.2\text{ mA}}{25.9\text{ mV}} = 46.3 \times 10^{-3}\ \mathrm{V}$

$r_{\pi 2} = \frac{\beta_0}{g_{m2}} = 2.16\text{ k}$

$R_{c2}' = 10\text{k} \| 10\text{k} = 5\text{k}$

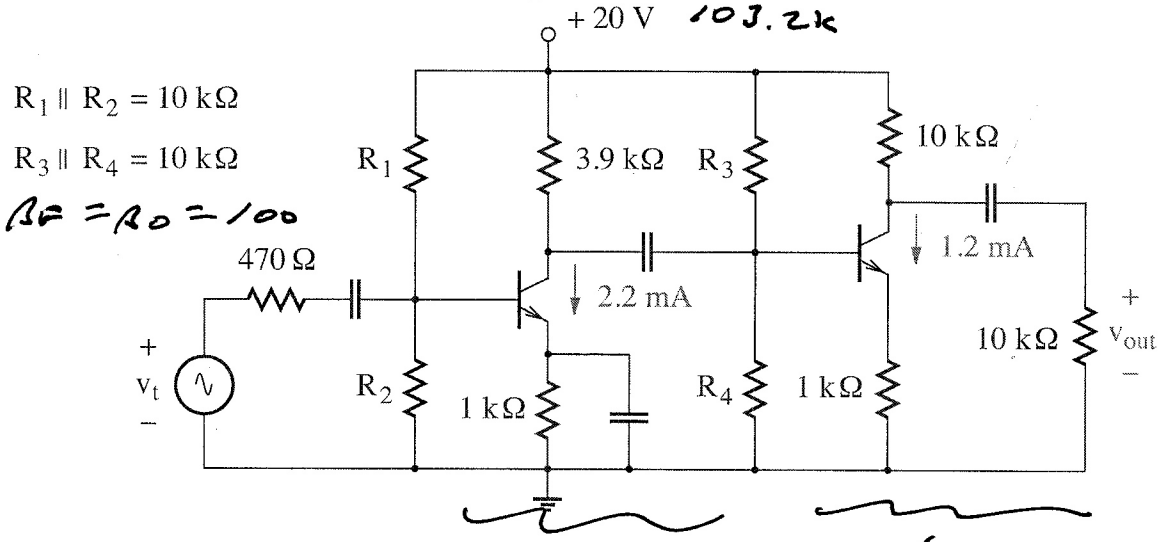
$$A_{vm}^{(2)} = \frac{-g_{m2} r_{c2}'}{1 + g_{m2} r_{e2}' (1 + 1/\beta_0)}$$

$$= \frac{-46.3 \times 10^{-3}\ \mathrm{V} \times 5 \times 10^{3}\ \Omega}{1 + 46.3 \times 10^{-3}\ \mathrm{V} \times 1 \times 10^{3}\ \Omega\ (1.01)}$$

$$= -4.85$$

$$r_{in}^{(2)} = [r_{\pi 2} + (1+\beta_0)1\text{k}] \| (R_3 \| R_4) = 5.12\text{ k}$$

$10\beta_0 = 2\text{k}$



stage 1 $g_{m1} = \frac{2.2\text{ mA}}{25.9\text{ mV}} = 84.9 \times 10^{-3}\ \mathrm{V}$

$r_{\pi 1} = \frac{\beta_0}{g_{m1}} = 1.18\text{ k}$

$R_{c1}' = r_{in}^{(2)} \| 3.9\text{k} = 2.73\text{ k}$

$A_{vm}^{(1)} = -g_{m1} R_{c1}' = -232$

$r_{in}^{(1)} = R_1 \| R_2 \| r_{\pi 1} = 1.05\text{ k}$

Coupling factor $= \frac{1.05}{1.05 + 0.47} = 0.691$

$A_{vm}^{TOTAL} = 0.691 \times (-232)(-4.85) = \underline{778}$

7.62

$K'\frac{W}{L} = 2.2\ mA/V^2$

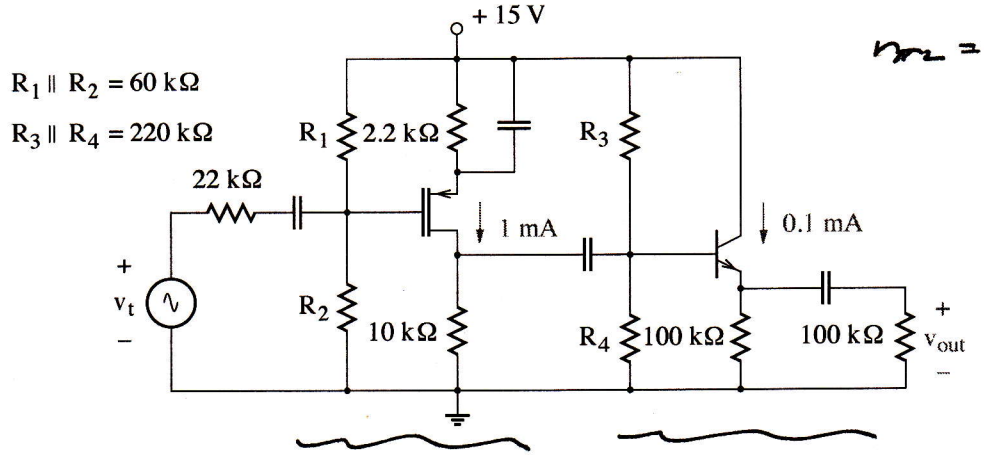
$g_{m1} = \sqrt{2 I_{DQ} K'\frac{W}{L}} = 2.10 \times 10^{-3}\ \mathrm{V}$

$r_{\pi 1} = \infty$

$\beta_0 = 120$

$g_{m2} = \frac{I_{CQ}}{kT/q} = \frac{0.1\ mA}{25.8\ mV} = 3.86 \times 10^{-3}\ \mathrm{V}$

$r_{\pi 2} = \frac{\beta_0}{g_m} = 31.1\ k$



CS 100K // 100K CC

$A_{vm}^{(2)} = \frac{g_{m2} r_{e2}' (1 + 1/\beta_0)}{g_{m2} r_{e2}' (1 + 1/\beta_0) + 1} = \frac{195}{195 + 1} = 0.995$

$r_{in}^{(2)} = r_3 \,//\, r_4 \,//\, [r_{\pi 2} + (\beta_0 + 1) r_{e2}'] = 212\ k$

6.08 MEG 50K

$A_{vm}^{(1)} = -g_{m1} r_{c1}' = -20.0$

$r_{c1}' = 10k \,//\, r_{in}^{(2)} = 9.57\ k$

$r_{in}^{(1)} = r_1 \,//\, r_2 = 60\ k$

$LF = \frac{r_{in}^{(1)}}{r_{in}^{(1)} + r_t} = \frac{60}{60 + 22} = 0.732$

$A_{vm}^{TOTAL} = LF \times A_{vm}^{(1)} \times A_{vm}^{(2)} = -15$