Homework Solutions Electronics II [redacted]

6.34

From the circuit diagram

$I_{C1} = I_{C2} = I_{C3} = I_{C4} = I_{C5} = I_{C6} = I_{C7} = I_{C8}$

$I_{C8} = I_{C9} = I_{C10} = I_{C11} = I_R$

$I_R = \dfrac{V_{B1} - V_{B2}}{10k}$; $V_{B1} = 10 - 0.7 = 9.3\ V$

$V_{B2} = -10 + 0.7 = -9.3\ V$

$\therefore I_R = \dfrac{9.3 + 9.3}{10k} = 1.86\ mA$

$V_{B6} = V_{B5} = 0.7$

$V_{C5} = 0.7$

$V_{C6} = 5 - (1k)(1.86) = 3.14\ V$

$V_{C3} = (2k)(1.86) = 3.72\ V$

$I_{R4} = I_{C8} + I_{C7} = 3.72\ mA$

$V_{C7} = -(1k)(3.72) = -3.72\ V$

$V_{C11} = (1k)(1.86mA) = 1.86\ V$

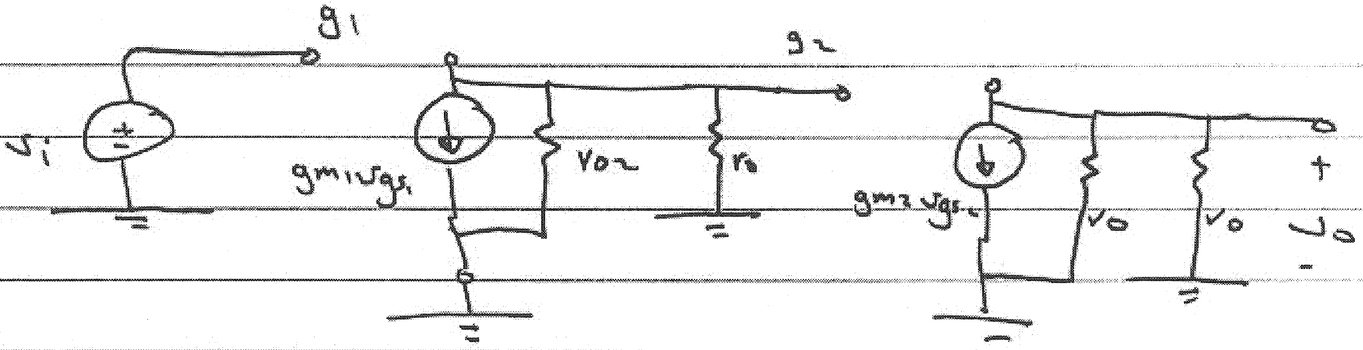
$V_{C10} = 5 - 0.7 = 4.3\ V$

6.61

since $I_{DS1} = I_{DS2}$, and $V_{AN} = |V_{AP}|$

$\therefore r_{o1} = r_{o2} = r_o$

ac small signal Equivalent ckr



$$v_o = -g_{m2}(r_o \| r_o) v_{gs2}$$

$$v_{gs2} = v_{g2} - v_{s2} = v_{g2}$$

$$v_{g2} = -(r_o \| r_o) g_{m1} v_{gs1}$$

$$v_{gs1} = v_{g1} = v_i$$

$$\therefore v_o = \left(\frac{1}{2}\right)\left(\frac{1}{2}\right)(r_o^2)\, g_{m1} g_{m2} \; v_i$$

$$v_o = \frac{1}{4} r_o^2 \, g_{m1} g_{m2} \, v_i$$

6.65

since $V_{BE_2} = V_{BE_3}$

and $I_{S_2} = 5 I_{S_3}$

$\therefore I_{C_2} = 5 I_{C_3}$

$$I_{C_3} = I_R = \frac{3-0.7}{23k} = 0.1\,mA$$

$I_{C_2} = 0.5\,mA$

since $I_{C_2} = 5 I_{C_3}$

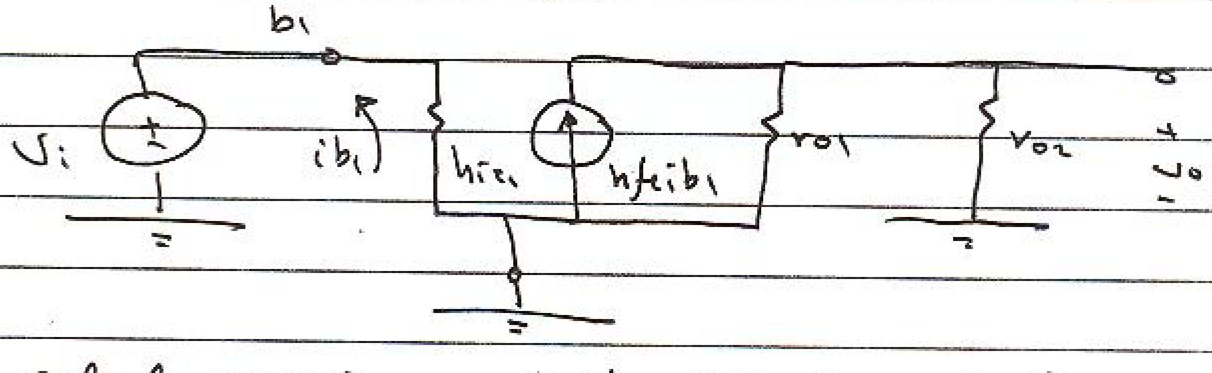
$$r_{o2} = \frac{V_A}{I_{C_2}} = \frac{50}{0.5} = 100k$$

$$r_{o3} = \frac{V_A}{I_{C_3}} = \frac{50}{0.1} = 500k$$

since $I_{C_1} = I_{C_2}$

$\therefore r_{o1} = r_{o2} = 100k$

ac small signal Equivalent circuit



Total resistance at the Collector of Q_1 is $r_{o2} \| r_{o1} = 50k$

$$h_{ie1} = \frac{\beta V_T}{I_{CQ1}} = \frac{(50)(25.69)}{0.5} = 2.569k$$

$$g_{m1} = \frac{h_{fe}}{h_{ie1}} = 19.46 \ m\mho$$

$$v_o = (r_{o1} \| r_{o2}) \, h_{fe} \, i_{b1}$$

$$i_{b1} = -\frac{v_i}{h_{ie1}}$$

$$\therefore \frac{v_o}{v_i} = -973$$

$$Z_o = r_{o1} \| r_{o2} = 50k$$

6.140

$V_T = 0.6\ V$

$K_n \frac{W}{L} = 2mA/V^2$

$V_A = 20$

$I_R = 100\mu A$

In this problem we must use the exact equation for I_{DS}.

$$I_{DS2} = \frac{1}{2} k_n' \frac{W}{L} (V_{GS2} - V_T)^2 \left(1 + \frac{V_{DS}}{V_A}\right)$$

$$V_{DS2} = V_{GS3} + V_{GS1} = 2V_{GS1} = 2V_{GS2}$$

$$I_{DS2} = I_R = 100\mu A$$

$$I_{DS2} = \left(\frac{1}{2}\right)(2\times10^{-3})(V_{GS2} - 0.6)^2\left(1 + \frac{2V_{GS2}}{20}\right) = 100\mu A$$

$$\therefore V_{GS2} = V_{GS1} \approx 0.9028\ V$$

$$I_{DS3} = I_{DS1} = \left(\frac{1}{2}\right)(2\times10^{-3})(V_{GS1} - 0.6)^2\left(1 + \frac{V_{GS1}}{V_A}\right)$$

$$\therefore I_{DS3} = I_{DS1} = 95.8266\ \mu A$$

$$\therefore I_o = 95.8266\ \mu A$$

But for the Circuit of fig 6.61 (c)

$$I_o = I_R = 100\mu A$$

since $V_{DS1} = V_{DS2}$

$V_{GS1} = V_{GS2}$