Retake Exam Solution

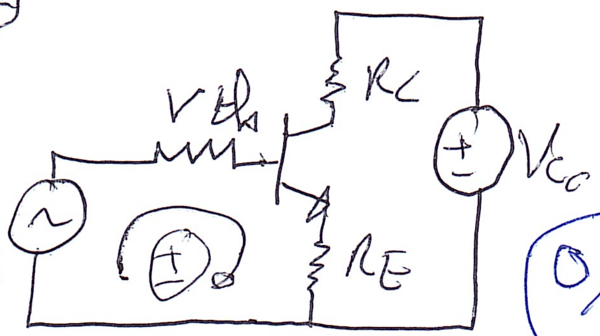
⊛ Problem:

0,5

1) The design C is different from A with only resistance $R_b = 964\Omega$ => it is clear that C is the approximation and (A, B) are the equivalent circuits. 0,5

<u>Justification</u>: apply Thevenin theo circuit B:

we obtain



0,5

with $\boxed{r_{th} = R_1 // R_2}$ ...(1)

and $\boxed{E_{th} = \frac{R_1}{R_1+R_2} V_{CC}}$ ...(2)

⊛ Validity of the approximation:

1) (I) => $E_{th} - r_{th} I_B - R_E I_E - V_{BE} = 0$

$$\Rightarrow -I_E\left(R_E + \frac{r_{th}}{\beta}\right) + (E_{th} - V_{BE}) = 0$$ 0,5

$$\boxed{I_E = \frac{E_{th} - V_{BE}}{R_E + \frac{r_{th}}{\beta}}} \quad ...(3)$$

from Desing A (3) => $\boxed{I_E = \frac{V_{BB} - V_{BE}}{R_E + \frac{R_1 // R_2}{\beta}}}$

USING Approximation we got

$$V_{BB} - R_E I'_E - V_{BE} = 0 \Rightarrow I'_E = \frac{V_{BB} - V_{BE}}{R_E}$$

$$I'_E \simeq I_E \text{ if } \frac{R_1 // R_2}{\beta} \ll R_E$$

$$\Rightarrow (R_1 // R_2) \ll \beta R_E \qquad ((R_1 // R_2) = R_b$$

2) Easiest circuit to me is A:

$$I_{E_0} = \frac{V_{BB} - V_{BE}}{R_E + \frac{R_1 // R_2}{\beta}} = \frac{3,22 - 0,7}{2,2 \cdot 10^3 + \frac{R_b}{213}} = \frac{2,52}{\dots} = \boxed{1,14\,mA}$$

AND $V_{CC} - V_{CE_0} - (R_C + R_E) I_E = 0$

$$\Rightarrow V_{CE_0} = V_{CC} - (R_C + R_E) I_E$$

$$V_{CE_0} = 4,59 \text{ volts}$$

0,5

$$\left\{ \begin{array}{l} R_1 // R_2 = R_b = 964\,\Omega \\ \dfrac{R_1 V_{CC}}{R_1 + R_2} = 3,22 \text{ volts} \end{array} \right\} \Rightarrow \frac{R_1 \cdot R_2}{R_1 + R_2} = R_b$$

0,5

$$\frac{R_1}{R_1 + R_2} V_{CC} = V_{BB}$$

$$R_2 = \frac{V_{CC}}{V_{BB}} \cdot R_b = \frac{9}{3,22} \cdot 964 = 2,7\,k\Omega$$

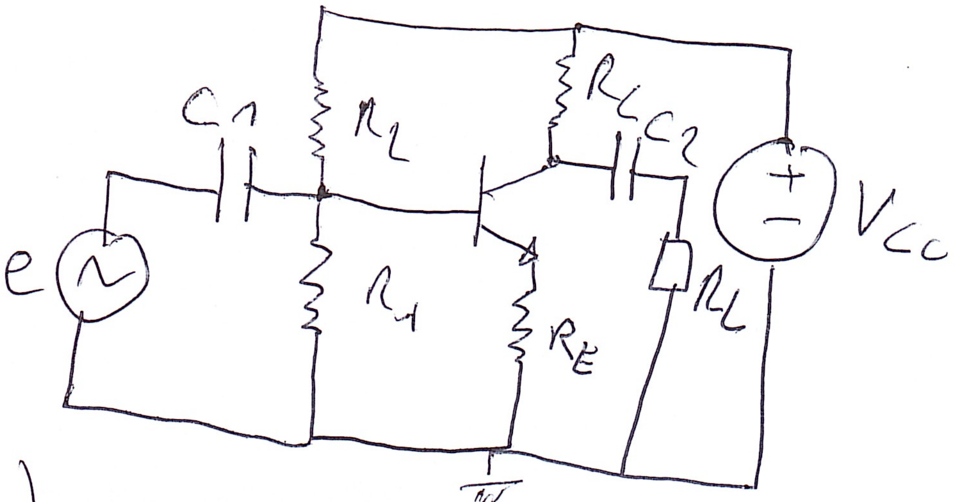
$$R_1 // R_2 = 2,7\,k\Omega \Rightarrow R_1 = 1,5\,k\Omega$$

3) $I'_E = \frac{V_{BB} - V_{BE}}{R_E} = 1,15\ mA$

$\varepsilon = \frac{|I_E - I'_E|}{I_E} = \frac{1,17 - 1,14}{1,14} \simeq 0,9\,\%$

0,5

4)



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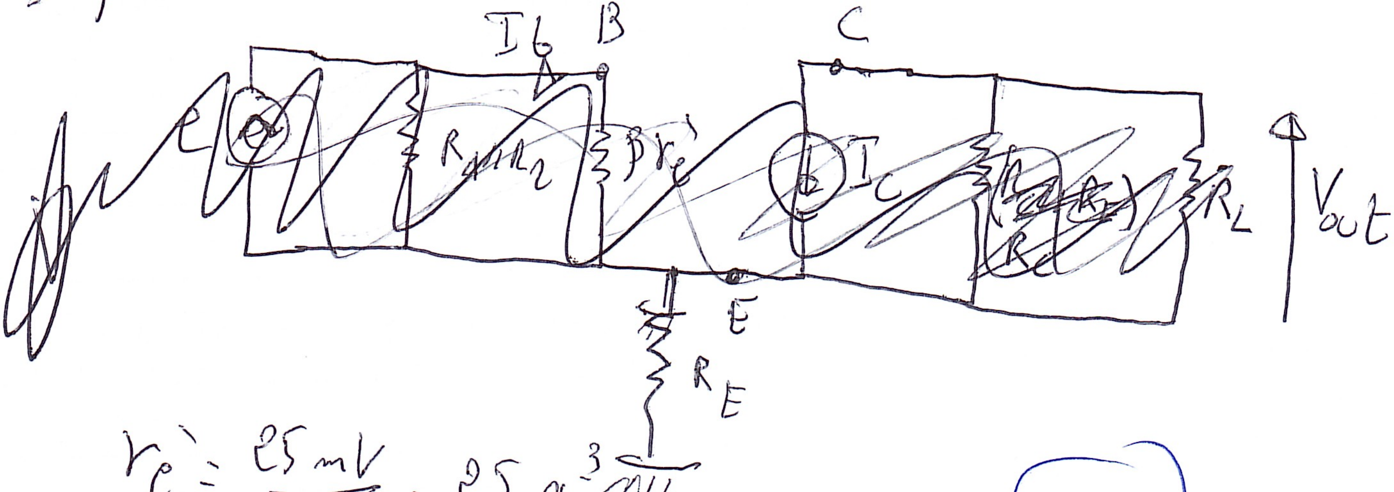
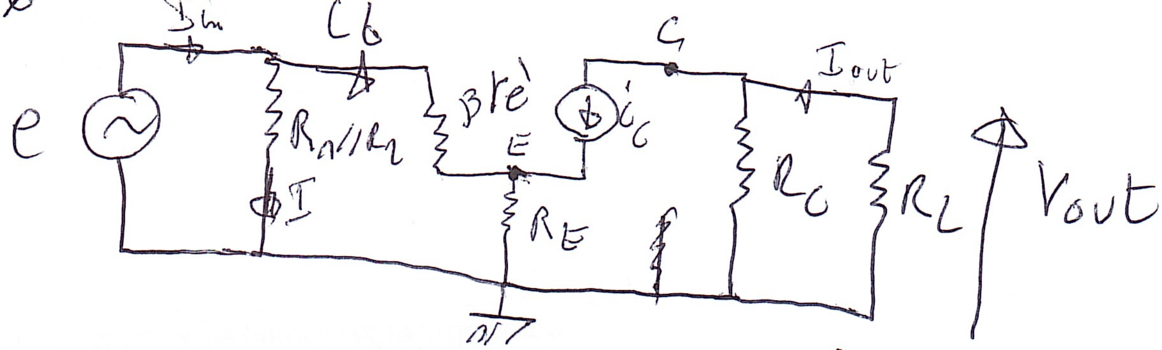
5)



$r'_e = \frac{25\ mV}{I_E} = \frac{25\cdot 10^{-3}}{1,14\cdot 10^{-3}} = 21,93\ \Omega$.

0,25

6)



0,75

6) $G_V = \dfrac{V_{out}}{e}$ $\left\{ \begin{array}{l} e = i_b(\beta r_e') + \beta R_E i_b \\ \quad = i_E(r_e' + R_E) \\ V_{out} = -(R_L // R_C) I_E \end{array} \right.$ 0,5

$$G_V = -\frac{(R_L // R_E)}{r_e' + R_E}$$

$$G_V = -0{,}73$$

7) $Z_{in} = \dfrac{e}{i_{in}}$ (we have $e = \beta i_b r_e' + i_e R_E$

$$e = i_e(r_e' + R_E)$$

$$I_{in} = I + I_b = \frac{e}{(R_1 // R_2)} + \frac{I_e}{\beta}$$

$$I_n = \frac{e}{(R_1 // R_2)} + \frac{e}{\beta(r_e' + R_E)}$$

$$I_n = e\left(\frac{1}{R_1 // R_2} + \frac{1}{\beta(r_e' + R_E)}\right) \Rightarrow Z_{in} = \frac{e}{I_n} = \frac{1}{\frac{1}{R_1 // R_2} + \frac{1}{\beta(r_e' + R_E)}}$$

$$Z_{in} = (R_1 // R_2) // (\beta(r_e' + R_E)) = 964 // 2200 \cdot 213$$

0,5 $Z_{in} \simeq 960\,\Omega \simeq (R_1 // R_2)$

$Z_{out} = R_L // R_C // R_E \simeq 933\,\Omega$ 0,5

(4 /5)

8) we have to add a capacitor in // to R_E (1)

$$G_V \to -\frac{R_L // R_C}{r_e'} = \frac{-1,62 \cdot 10^3}{21,93}$$ (0,5)

$G_V \simeq -73,9$

Zin stays the same (0,5)

$Zout = R_L // R_C \simeq 1,62 k\Omega$ (1)

(5/5)