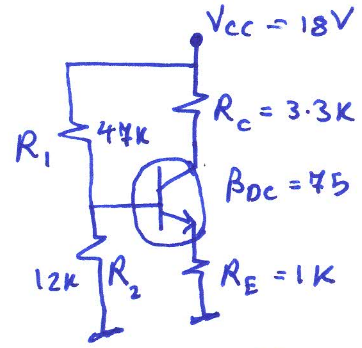
Ch. 6 HW Soln

13 DC-analysis:



DC-circuit "all C's are O.C."

a) $V_{TH} = \dfrac{R_2 V_{cc}}{R_1+R_2} \simeq 3.66$ ~~mA~~ V

$R_{TH} = R_1 // R_2 \simeq 9.56\ k\Omega$

$I_E = \dfrac{V_{TH} - V_{BE}}{R_E + R_{TH}/\beta_{DC}} = \dfrac{3.66 - 0.7}{1*10^3 + \dfrac{9.56*10^3}{75}}$

$\therefore\ \boxed{I_E \simeq 2.63\ mA}$

b) $V_E = I_E R_E$ $\quad\therefore\ \boxed{V_E = 2.63\ V}$

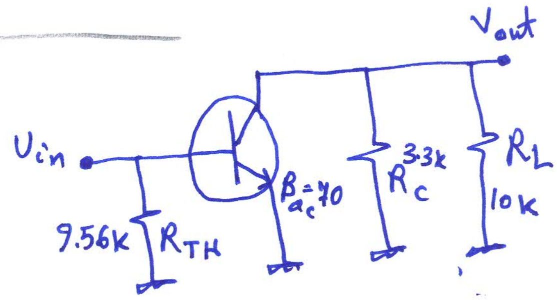
c) $V_B = V_{BE} + V_E = 0.7 + 2.63$ $\quad\therefore\ \boxed{V_B = 3.33\ V}$

d) $\boxed{I_C \simeq I_E = 2.63\ mA}$

e) $V_C = V_{cc} - I_C R_C$ $\quad\therefore\ \boxed{V_C = 9.32\ V}$

f) $V_{CE} = V_C - V_E$ $\quad\therefore\ \boxed{V_{CE} = 6.69\ V}$

14 AC-analysis:-



AC-circuit
" all c's & dc-supplies ar S.C. are AC-grounds"

a) $\because\ R_{in(base)} = \beta_{ac}\, r_e'$

as $r_e' = \dfrac{25\,mV}{I_E} = \dfrac{25*10^{-3}}{2.63*10^{-3}} \simeq 9.51\ \Omega$

$\therefore\ R_{in(base)} = 70 * 9.51 = \underline{665.7\ \Omega}$

b) $R_{in(tot)} = R_{TH} // R_{in(base)}$

$= \dfrac{9.56*10^3 * 665.7}{9.56*10^3 + 665.7}$ $\quad\therefore\ \boxed{R_{in(tot)} \simeq 622.4\ \Omega}$

c) $A_v = \dfrac{R_C // R_L}{r_e'} = \dfrac{3.3k // 10k}{9.51\ \Omega}$ $\quad\therefore\ \boxed{A_v = 260.9}$

d) $A_i = \beta_{ac} = \underline{70}$, e) $A_p = A_v A_i = 260.9 * 70$

$\therefore\ \boxed{A_p = 18263}$

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$R_s = 600\,\Omega$, $v_{in} = 12\,\mu V$ (rms)

$A_v' = ??$, V_{out} ??, θ??

$\because$ Attenuation $= \dfrac{v_{in}}{V_b} = \dfrac{R_s + R_{in(tot)}}{R_{in(tot)}} = \dfrac{600 + 622.4}{622.4} \simeq 1.964$

$\because A_v' = \dfrac{A_v}{\text{Attenuation}} = \dfrac{260.9}{1.964} = 132.8$

$\therefore \boxed{A_v' = 132.8}$

$\because v_{out}|_{ac} = A_v' \, v_{in}$

$\therefore \boxed{v_{out}|_{ac} = 1.594\ mV\ (rms)}$

$\boxed{V_{out}|_{dc} = V_C = 9.32V}$

$\boxed{\text{Phase shift, } \theta = 180^\circ}$

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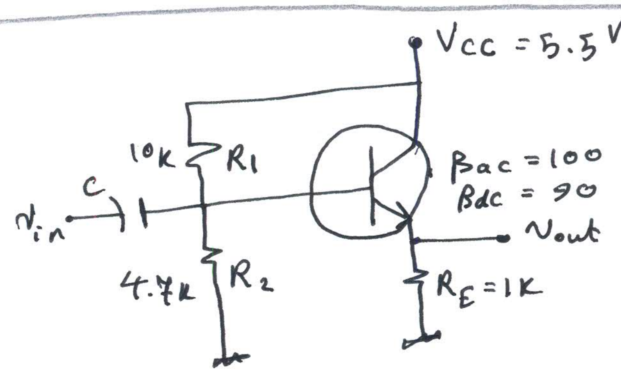
$\because A_v = \dfrac{R_E}{r_e' + R_E}$; $r_e' = \dfrac{25\,mV}{I_E}$



dc-analysis:

$R_{TH} = R_1 // R_2 \simeq 3.2\,K\Omega$

$V_{TH} = \dfrac{V_{CC} R_2}{R_1 + R_2} \simeq 1.76\ V$

as, $V_{TH} = \dfrac{I_E}{\beta_{DC}} R_{TH} + V_{BE} + I_E R_E$

$\therefore I_E = \dfrac{V_{TH} - V_{BE}}{R_E + R_{TH}/\beta_{DC}} = \dfrac{1.76 - 0.7}{1K + 3.2K/90} \simeq 1.024\ mA$

$\therefore A_v = \dfrac{1*10^3}{\dfrac{25*10^{-3}}{1.024*10^{-3}} + 1*10^3} \simeq 0.976$

$\therefore \boxed{A_v = 0.976}$

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$R_{in(tot)} = ?$, $V_{out}|_{dc} = ?$

$V_{out}|_{dc} = V_E = I_E R_E = 1.024\,mA * 1K$

$\therefore \boxed{V_{out}|_{dc} = 1.024\ V}$

$R_{in(tot)} = R_{TH} // R_{in(base)}$

$R_{in(base)} = \beta_{ac}(r_e' + R_E) = 100\left(\dfrac{25}{1.024} + 1*10^3\right) = 102.4\ K\Omega$

$\therefore \boxed{R_{in(tot)} \simeq 3.1\ K\Omega}$

$\boxed{22}$ if $R_L < \infty$, A_v increase or decreases ??

$$\because A_v = \frac{R_E // R_L}{R_E // R_L + r_e'} = \frac{\frac{R_E R_L}{R_E + R_L}}{\frac{R_E R_L}{R_E + R_L} + r_e'}$$

$$A_v = \frac{R_E R_L}{R_E R_L + R_E r_e' + R_L r_e'}$$

$$\therefore A_v = \frac{R_E}{R_E + r_e' + \frac{R_E r_e'}{R_L}}$$

$\therefore$ as $R_L \downarrow$, denominator$(A_v) \uparrow$, as a result $A_v \downarrow$

if R_L is "o.c" $\rightarrow$ $A_v = \frac{R_E}{R_E + r_e'}$

as $R_L < \infty$ $\rightarrow$ $A_v < \frac{R_E}{R_E + r_e'} = A_{v_1}$

$\boxed{23}$ $A_v = 0.9$, $R_L = ??$

$$\because A_v = \frac{R_E}{R_E + r_e' + \frac{R_E r_e'}{R_L}}$$

$$\therefore \frac{R_E r_e' A_v}{R_L} = R_E - A_v(R_E + r_e')$$

$$\therefore R_L = \frac{R_E r_e' A_v}{R_E - A_v(R_E + r_e')} \quad ; \quad r_e' = \frac{25mV}{1.024mA} = 24.4\,\Omega$$

$$= \frac{1K * 24.4\,\Omega * 0.9}{1K - 0.9(1K + 24.4)}$$

$$= \frac{21960\,\Omega^2}{78.04\,\Omega} \quad \therefore \boxed{R_L = 281.4\,\Omega}$$

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a) i) dc- analysis : " for both Q_1 & Q_2 ccts "

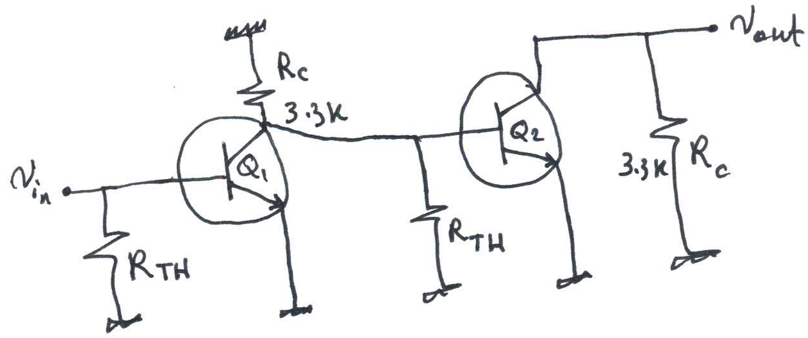
$$V_{TH} = \frac{R_2 V_{cc}}{R_1 + R_2} = \frac{8.2K * 15}{8.2K + 33K} \simeq 2.99\ V$$

$$R_{TH} = \frac{R_1 R_2}{R_1 + R_2} = \frac{33K * 8.2K}{33K + 8.2K} \simeq 6.57\ K\Omega$$

$$I_E = \frac{V_{TH} - V_{BE}}{R_E + \frac{R_{TH}}{\beta_{DC}}} = \frac{2.99 - 0.7}{1K + \frac{6.57K}{175}} = 2.21\ mA$$

$$r'_e = \frac{25mV}{I_E} = \frac{25mV}{2.21mA} = 11.3\ \Omega$$

ii) ac- analysis :-



$$A_{v_1} = \frac{R_c // R_{TH} // R_{in(base)}|_{Q_2}}{r'_e}$$

$$R_{in(base)}|_{Q_2} = \beta_{ac} r'_e$$
$$= 175 * 11.3 = 1.98K\Omega$$

$$\therefore A_{v_1} = \frac{\dfrac{1}{\frac{1}{3.3K} + \frac{1}{6.57K} + \frac{1}{1.98K}}}{11.3}$$

$\cancel{\therefore A_{v_1} \simeq 92.16}$

$$\therefore \boxed{A_{v_1} \simeq 92.16}$$

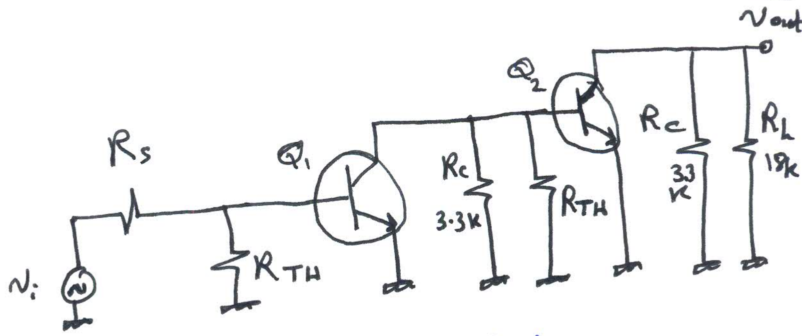
$$A_{v_2} = \frac{R_c}{r'_e} = \frac{3.3K}{11.3\Omega} \quad \therefore \boxed{A_{v_2} = 292.04}$$

b) $$A_{v(tot)} = A_{v_1} * A_{v_2} = \boxed{26914.41}$$

c) $$A_v|_{dB} = 20 \log_{10}(A_v)$$

$$\therefore A_{v_1}|_{dB} = \underline{39.3\ dB}$$
$$A_{v_2}|_{dB} = \underline{49.3\ dB}$$
$$A_{v(tot)}|_{dB} = 20 \log(A_{v(tot)}) = A_{v_1}|_{dB} + A_{v_2}|_{dB}$$
$$= \underline{88.6\ dB}$$

$\boxed{32}$ $R_S = 75\,\Omega$, $V_{in} = 50\,\mu V$, $R_L = 18\,k\Omega$



a) $$A_{V_1} = \frac{R_C \| R_{TH} \| R_{in(base)}|_{Q_2}}{r_e'}$$

$$= 92.16$$

$$A_{V_1}' = \frac{A_{V_1}}{\text{Attenuation}}, \quad \text{Attenuation} = \frac{R_S + (R_{TH} \| R_{in(base)}|_{Q_1})}{R_{TH} \| R_{in(base)}|_{Q_1}}$$

$$\therefore \text{Attenuation} = \frac{75\,\Omega + (6.57K \| 1.98K)}{(6.57K \| 1.98K)}$$

$$\cong \frac{75\,\Omega + 1.52K}{1.52K} = 1.049$$

$$\therefore A_{V_1}' = \frac{92.16}{1.049} = \underline{\underline{87.86}}$$

$$A_{V_2} = \frac{R_C \| R_L}{r_e'} = \frac{3.3k \| 18K}{11.3\,\Omega} = \underline{\underline{246.79}}$$

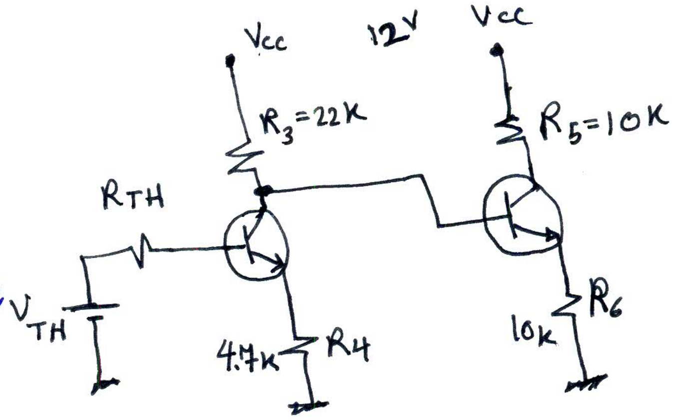
b) $$A_{V(tot)} = A_{V_1}' * A_{V_2} = 21682.97$$

c) $$A_{V_1}'|_{dB} = 20\log(87.86) = \underline{\underline{38.9\text{ dB}}}$$

$$A_{V_2}|_{dB} = 20\log(246.79) = \underline{\underline{47.8\text{ dB}}}$$

$$A_{V(tot)}|_{dB} = 38.9 + 47.8 = \underline{\underline{86.7\text{ dB}}}$$

33) i) dc - analysis :-



$\beta_{ac} = \beta_{DC} = 125$

$$V_{TH} = \frac{V_{cc} R_2}{R_1 + R_2} = \frac{12 * 22K}{100K + 22K} = 2.16^V$$

$$R_{TH} = \frac{R_1 R_2}{R_1 + R_2} = \frac{100K * 22K}{100K + 22K} \simeq 18.03\,K\Omega$$

$$I_{E_1} = \frac{V_{TH} - V_{BE}}{R_4 + \frac{R_{TH}}{\beta_{DC}}} = \frac{2.16 - 0.7}{4.7K + \frac{18.03K}{125}}$$

$\therefore I_{E_1} = 301.4\ \mu A$

$\therefore V_{E_1} = I_{E_1} R_4 = 301.4 * 10^{-6} * 4.7 * 10^{3}$ $\quad \therefore \underline{V_{E_1} = 1.42^V}$

$V_{B_1} = V_{BE} + V_{E_1} = 0.7 + 1.42$ $\quad \therefore \underline{V_{B_1} = 2.12^V}$

$V_{C_1} = V_{CC} - I_{C_1} R_3$

$\simeq V_{cc} - I_{E_1} R_3 = 12 - 301.4 * 10^{-6} * 22 * 10^{3}$ $\quad \therefore \underline{V_{C_1} = 5.37^V}$

$V_{B_2} = V_{C_1}$ $\quad \therefore \underline{V_{B_2} = 5.37^V}$

$V_{E_2} = V_{B2} - V_{BE} = 5.37 - 0.7$ $\quad \therefore \underline{V_{E_2} = 4.67^V}$

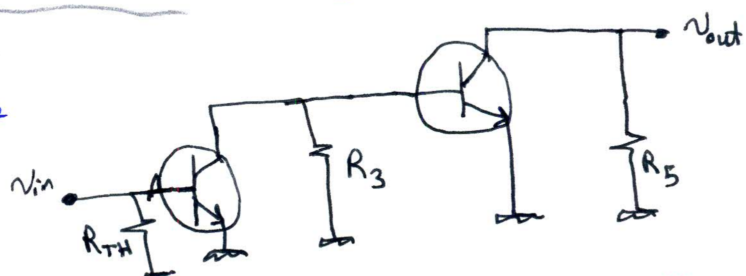
$$I_{E_2} = \frac{V_{E2}}{R_6} = \frac{4.67}{10K} = 467\ \mu A$$

$V_{C_2} = V_{cc} - I_{C_2} R_5 \simeq V_{cc} - I_{E_2} R_5 = 12 - 467 * 10^{-6} * 10 * 10^{3}$ $\quad \therefore \underline{V_{C_2} = 7.33^V}$

$$r'_{e_1} = \frac{25mV}{I_{E_1}} = 82.95\,\Omega \quad , \quad r'_{e_2} = \frac{25mV}{I_{E_2}} = 53.53\,\Omega$$

ii) ac - analysis :-

$A_{V(tot)} = A_{V_1} * A_{V_2}$



$$A_{V_1} = \frac{R_3 \,//\, R_{in(base)}|_{Q_2}}{r'_{e_1}} = \frac{R_3 \,//\, \beta_{ac} r'_{e_2}}{r'_{e_1}}$$

$$= \frac{22K \,//\, 125 * 53.53}{82.95} = 61.9$$

$$A_{V_2} = \frac{R_5}{r'_{e_2}} = \frac{10K}{53.53\,\Omega} = 186.8$$

$$\therefore \boxed{A_V|_{tot} = 11562.9 = 81.3\,dB}$$