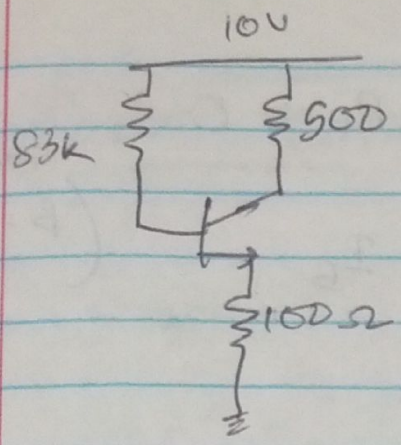
LH 15-2

(1)



$$10 - (83\times10^3)I_b - 0.7 - (100)I_E = 0$$

$$I_E = (100+1)I_B$$

$$\Rightarrow 9.3 = (83\times10^3)I_b + (100\times101)I_b$$

$$\Rightarrow I_b = \frac{9.3}{(83+10.1)}\times10^{-3}$$

$$= 0.099\,mA$$

$$\simeq 0.1\,mA$$

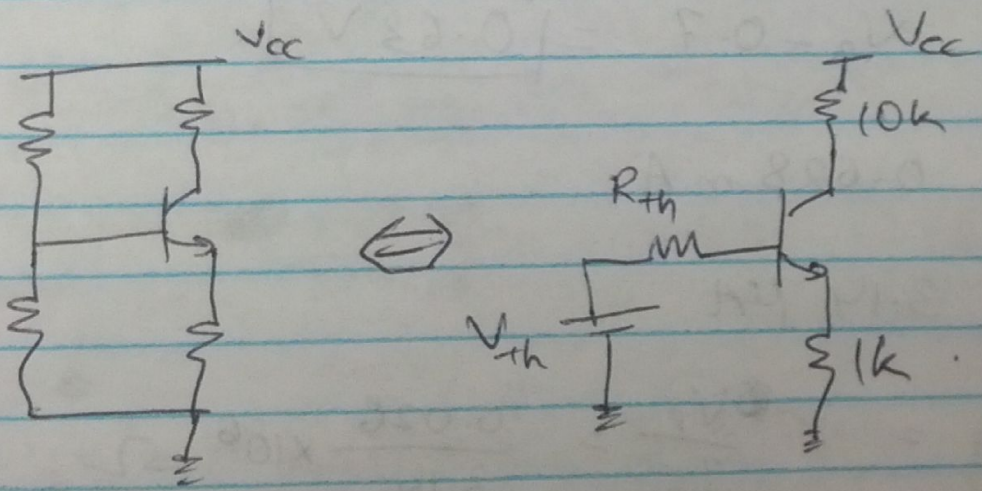
$$\therefore V_B = 10 - 83\times0.1 = \boxed{1.7V}$$

$$V_E = V_B - 0.7 = \boxed{1V}$$

$$I_C = \beta\cdot I_b = 100\times0.1\,mA = 10mA$$

$$\therefore V_C = 10 - 500\times10^{-2} = \boxed{5V}$$

(2)



$$V_{th} = \frac{15\cdot10}{110} = \frac{15}{11} = 1.36V$$

$$R_{th} = (10k \parallel 100k) = 9.09k\Omega$$

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$\therefore V_{th} - I_B R_{th} - 0.7 - I_E R_E = 0$

$\Rightarrow \frac{1.36 - 0.7}{(9.09 + 201 \times 1) \times 10^3} = I_B$ (Taking, $\beta = 200$)

$\Rightarrow I_B = \frac{0.66}{210.09}$ mA $\simeq 3.14\ \mu A$

$\therefore I_C = 200 \times 3.14 \times 10^{-3}$ mA

$= 0.628$ mA

$\therefore \boxed{V_C = 15 - (0.628 \times 10) = 8.72\ V}$

$V_B = V_{th} - I_B R_{th} =$

$= 1.36 - 3.14 \times 9.09 \times 10^{-3}$

$= \boxed{1.33\ V}$

$V_E = V_B - 0.7 = \boxed{0.63\ V}$

3. $I_C = 0.628$ mA

$I_B = 3.14\ \mu A$

$\Rightarrow r_\pi = \frac{V_T}{I_B} = \frac{0.026}{3.14} \times 10^6\ \Omega$

$= 8.28\ k\Omega$.

$g_m = \frac{I_C}{V_T} = \frac{0.628\ mA}{26\ mV} = 0.024\ A/V$.

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Note $g_m r_\pi = \beta$

$\therefore$ Gain $= -\dfrac{R_C}{\left(\frac{1}{g_m} + R_E\right)} = \dfrac{10k\Omega}{(41.66 + 1000)}$

$= -\dfrac{10}{1.041} = -9.6$ V/V $\quad \left(\approx -\dfrac{R_C}{R_E} = 10\right)$

Input resistance $= R_B \| (r_\pi + (\beta+1) R_E)$

$= (9.89) \| (8.28 + 201 \times 1)\, k\Omega$

$= 8.72\, k\Omega$ $\quad (\approx \beta R_E = 200k\Omega)$

Output resistance $= R_C =$ 10kΩ.

4 $A_v = \left(\dfrac{R_{in}}{R_{in} + R_s}\right) \cdot \dfrac{-R_C}{\left(\frac{1}{g_m} + R_E\right)} \cdot \left(\dfrac{R_L}{R_L + R_{out}}\right)$

$\therefore A_V = \left(\dfrac{8.72}{10 + 8.72}\right) \times (-9.6)$

$= \dfrac{8.72}{18.72} \times -(9.6) \approx -4.47$

5. $A_v = -\left(\dfrac{R_C}{\frac{1}{g_m} + R_E}\right)\left(\dfrac{R_L}{R_L + R_{out}}\right)$ (Assuming there is no R_s)

$= -9.6 \times \dfrac{2}{3} =$ −6.4 V/V.

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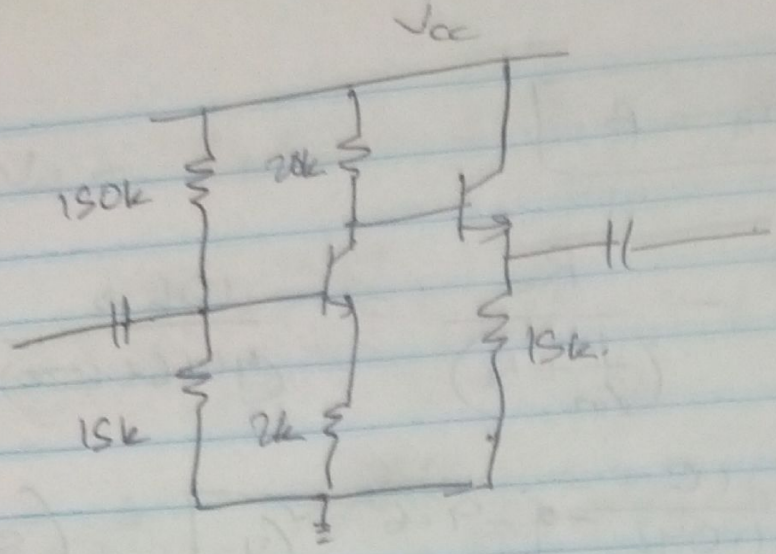

Assume $\beta = 200$

~~For first stage~~ :-

$$V_{th} = \frac{15 \times 15}{15+150} = 1.36\,V$$

$$R_{th} = (150 \,||\, 15)\,k\Omega = 13.64\,k\Omega$$

$$\therefore \frac{1.36 - 0.7}{(13.64 + 201 \times 2)} \times 10^{-3} = I_{B1}$$

$$\Rightarrow I_{B1} = \frac{0.66}{415.64} \times 10^{-3}\,A \approx 1.6\,\mu A$$

$$\therefore I_{C1} = 200 \times 1.6\,\mu A = 0.32\,mA$$

$$\therefore V_{C1} = 15 - 0.32 \times 20 = \boxed{8.6\,V}$$

$$V_{B1} = 1.36 - 1.6 \times 13.64 \times 10^{-3} = \boxed{1.33\,V}$$

$$\boxed{V_{E1} = 0.63\,V}$$

$$\boxed{V_{B2} = V_{C1} = 8.6\,V} \quad ; \quad \boxed{V_{C2} = 15\,V}$$

$$V_{E2} = V_{B2} - 0.7 = \boxed{7.9\,V}$$

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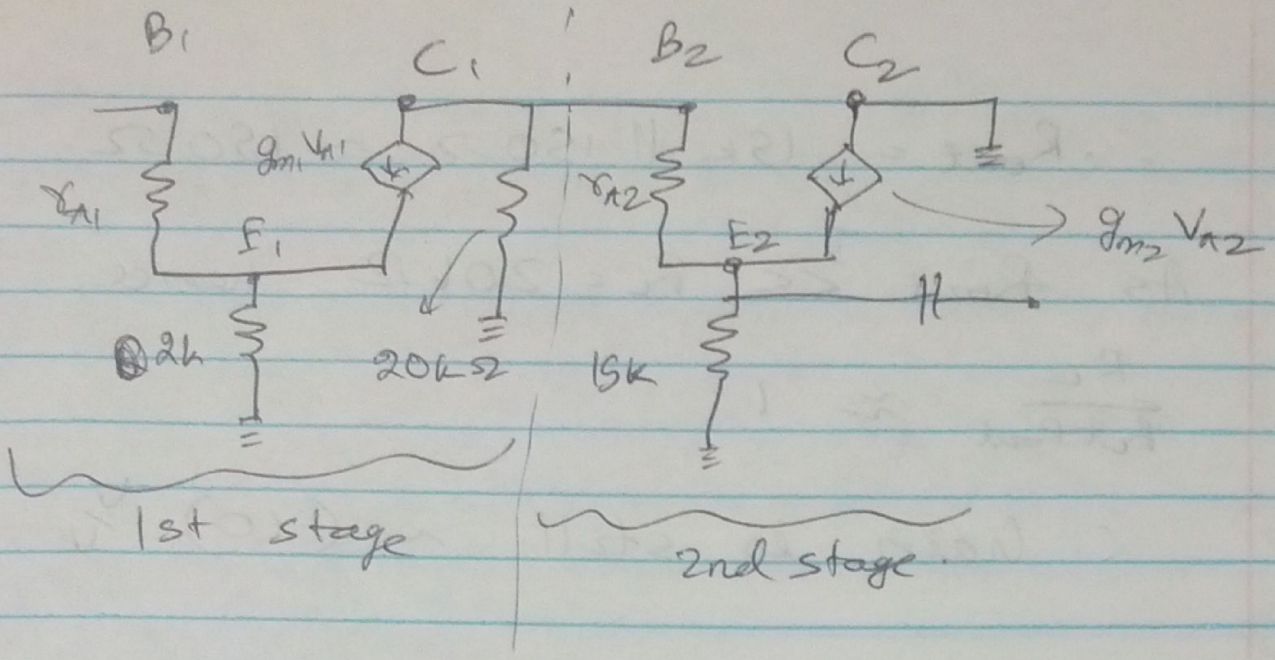

≡ As Rout of Stage-1 (= 20kΩ) ≪ Rin of Stage-2 (≈ βRE = 3000kΩ)

∴ there would be no loading effect and hence the gains can simply be multiplied.

$$\therefore A_V \approx -\left(\frac{R_{C1}}{R_{E1}}\right) \times 1 \approx \boxed{-10 \text{ V/V}}$$

Rout for the circuit = (15k) || R_{TE}

where, $R_{TE} = \frac{r_{\pi 2} + 20k}{200}$

Now, $r_{\pi 2} = \frac{V_T}{I_{B2}} = \frac{0.026}{\frac{I_{E2}}{\beta+1}} = \frac{0.026}{\left(\frac{V_{E2}}{R_{E2}}\right) \cdot \frac{1}{201}}$

$$= \frac{0.026\ V}{\frac{0.53}{201}\ mA} = \frac{26 \times 201}{0.53}\ \Omega = 9.86\ k\Omega$$

$$\therefore R_{TE} = \frac{29.86 \times 10^3}{200}\ \Omega \approx 150\ \Omega$$

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$\therefore R_{out} = 15k \parallel 150\Omega \approx 150\Omega$.

As $R_{out} << R_L = 20k\Omega$, hence,

$$\frac{R_L}{R_L + R_{out}} \approx 1$$

$\therefore$ Gain is still $\sim (-10)$ $\frac{V_o}{V_i}$.

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