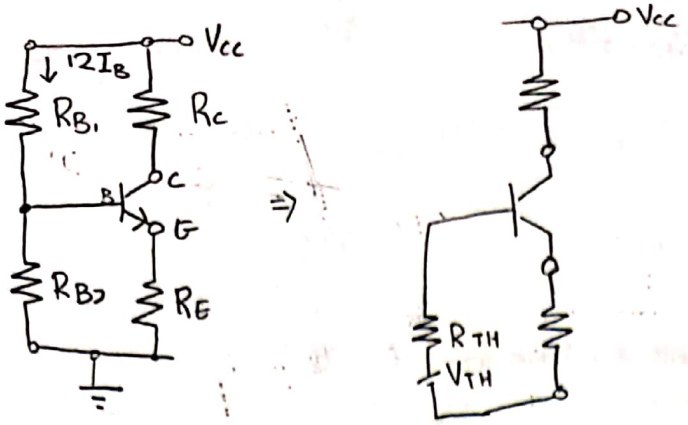
Servo Tutorial 3

$V_B = 1V$, $V_c = 6V$, $V_{cc} = 9V$

$\beta = 120$, $R_E = 1k\Omega$

$R_B = 12\, I_B$, $V_{BE} = 0.7V$

1)



$$I_E = \frac{V_E}{R_E}$$
$$= \frac{1}{1000}$$
$$= 1mA$$

$$I_E = (\beta + 1)\, I_B$$

$$I_B = \frac{I_E}{\beta + 1}$$
$$= \frac{1mA}{120 + 1}$$
$$= 8.26\,\mu A$$

$$I_c = \beta (I_B)$$
$$= 120\ (8.26\,\mu A)$$
$$= 0.991mA$$

$$R_C = \frac{V_{cc} - V_c}{I_c}$$
$$= \frac{9V - 6V}{0.991mA}$$
$$= 3027$$
$$\approx 3.03\,k\Omega //$$

$$V_{B2} = V_E + V_{BE}$$
$$= 1V + 0.7V$$
$$= 1.7V$$

$$I_{B1} = 12\, I_B$$
$$= 12(8.26\,\mu A)$$
$$= 99.1\,\mu A$$

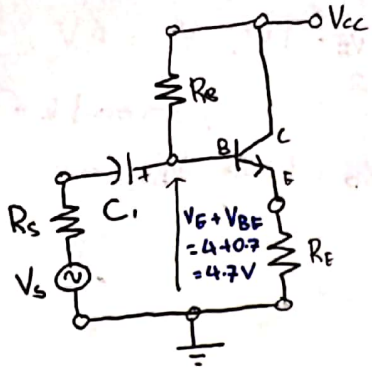
$$V_{B1} = V_{cc} - V_{B2}$$
$$= 9 - 1.7$$
$$= 7.3V$$

$$R_{B1} = \frac{7.3V}{99.1\,\mu A}$$
$$= 73662$$
$$\approx 73.7\,k\Omega //$$

$$I_{B2} = I_{B1} - I_B$$
$$= 99.1 - 8.26$$
$$= 90.84\,\mu A$$

$$R_{B2} = \frac{V_{B2}}{I_{B2}}$$
$$= \frac{1.7V}{90.84\,\mu A}$$
$$= 18714$$
$$\approx 18.7k\Omega //$$

2.



$V_{cc} = 9V$, $V_{CE} = 5V$, $\beta = 100$, $R_E = 1.2k\Omega$

$V_{BE} = 0.7$

Fig 3.2 shows a capacitor amplifier with a voltage gain of ≈ 1

$$V_E = V_{cc} - V_{CE}$$
$$= 9 - 5$$
$$= 4V$$

$$I_E = \frac{V_E}{R_E}$$
$$= \frac{4\,V}{1.2k\Omega}$$
$$= 3.33mA$$

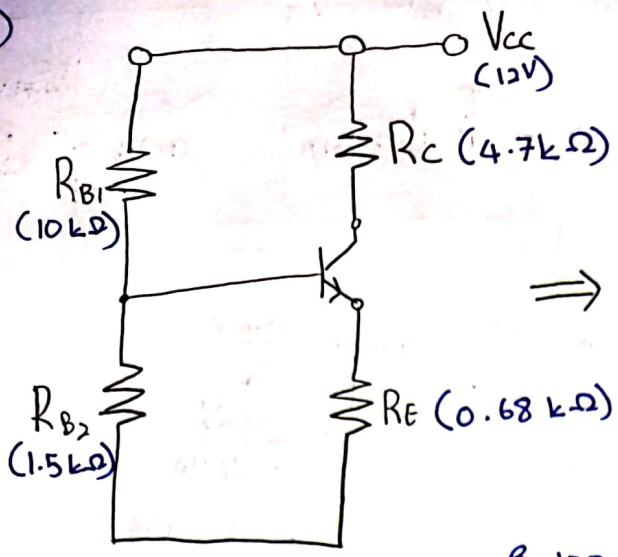
$$I_E = (\beta + 1)\, I_B$$

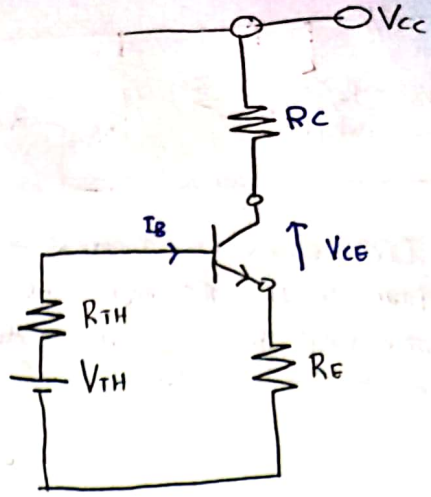
$$I_B = \frac{I_E}{(\beta+1)}$$
$$= \frac{3.33\,mA}{(101)}$$
$$= 33\,\mu A$$

$$V_B = 9V - 4.7V$$
$$= 4.3V$$

$$R_B = \frac{V_B}{I_B}$$
$$= \frac{4.3V}{33\,\mu A}$$
$$= 130303$$
$$\approx 130k\Omega //$$

3)





$R_L = 2.2k\Omega$, $\beta = 150$

$$R_{TH} = \left(\frac{1}{10} + \frac{1}{1.5}\right)^{-1}$$
$$= 1.3\,k\Omega$$

$$V_{TH} = \frac{R_{B2}}{R_{B1}+R_{B2}}$$
$$= \frac{1.5}{10+1.5}(12)$$
$$= 1.57V$$

$$I_B = \frac{V_{TH} - V_{BE}}{(R_{TH} + (\beta+1)R_E)}$$
$$= \frac{1.57 - 0.7}{1.3k\Omega + (150+1)(0.68k\Omega)}$$
$$= 8.37\,\mu A_{//}$$

$$I_C = I_B \cdot \beta$$
$$= 8.37\mu A \cdot 150$$
$$= 1.25\,mA_{//}$$

$$I_E = (\beta+1)I_B$$
$$= (151)(8.37\mu A)$$
$$= 1.26\,mA_{//}$$

$I_L = 0$ (C_o blocks DC)

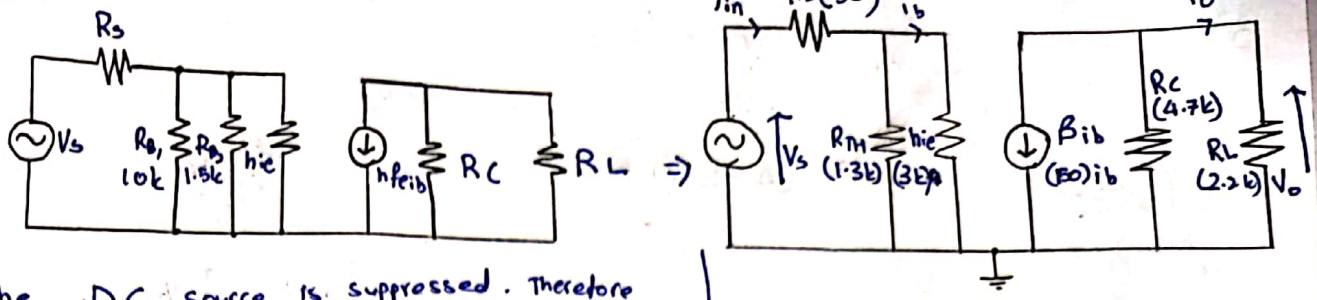
$$V_E = I_E \cdot R_E$$
$$= 1.26mA \cdot 0.68k\Omega$$
$$= 0.857V_{//}$$

$$V_C = V_{CC} - I_C R_C$$
$$= 12 - (1.25mA)(4.7k\Omega)$$
$$= 6.13V_{//}$$

$$V_{CE} = V_C - V_E$$
$$= 6.13 - 0.857$$
$$= 5.27V_{//}$$

$$V_B = V_E + V_{BE}$$
$$= 0.857 + 0.7$$
$$= 1.56V_{//}$$

4)



The DC source is suppressed. Therefore it does not appear in the AC equivalent circuit. The Capacitances have negligible reactance at mid frequency range and are treated as short circuit.

~~hie~~ $hie = \frac{25mV}{I_B}$

$= \frac{29mV}{8.37\mu A}$

$= ~~2648~~ \ 2986$

$\approx 3.00k\Omega$

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5) $A_V = ?$, $A_I = ?$, $R_{IN} = ?$, $R_O = ?$

$A_V = -75$, $A_I = 30.8$, $R_{IN} = 907\Omega$

$V_s = 2mV$ 10kHz

$R_{in} = R_{TH} \,//\, hie$

$= \left(\frac{1}{1.3} + \frac{1}{3}\right)^{-1} k\Omega$

$= 907\Omega$ //

$i_{in} = \frac{V_s}{R_{in}}$

$= \frac{2mV}{907}$

$= 2.21\mu A$

$i_b = \frac{V_s}{hie}$

$= \frac{2mV}{3k\Omega}$

$= 0.667\mu A$

$i_o = (-\beta i_b)\left(\frac{R_C}{R_L + R_L}\right)$

$= (-(150)(0.667\mu A))\left(\frac{4.7k}{4.7 + 2.2k}\right)$

$= -68.1\mu A$

$A_I = \frac{i_o}{i_s}$

$= \frac{-68.1\mu A}{2.21\mu A}$

$= -30.8$ //

$A_V = \frac{i_o R_L}{V_s} = \frac{V_o}{V_s}$

$= \frac{(-68.1\mu A)(2.2k\Omega)}{2mV}$

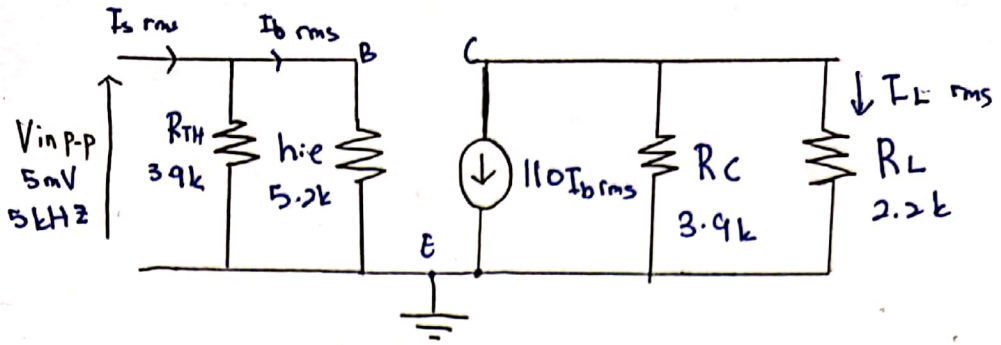
$= -74.91$

≈ -75 //

$R_O = R_C$

$= 4.7\Omega$ //

6)



a) $Z_{in} = R_{TH} \,//\, hie$

$= \left(\frac{1}{3.9k} + \frac{1}{5.2k}\right)^{-1}$

$= 2.23\,k\Omega_{//}$

$Z_{out} = R_C$

$= 3.9k\Omega_{//}$

b) $i_{s_{rms}} = \frac{V_s}{Z_{in}}$

$= \frac{((5 \div 2) \div \sqrt{2})\,mV_{rms}}{2.23k\Omega}$

$= 0.793\,\mu A_{//}$

$i_b = \left(\frac{R_{TH}}{R_{TH} + hie}\right) \cdot i_s$

$= \left(\frac{3.9k}{3.9k + 5.2k}\right) 0.793\,\mu A$

$= 0.3399\,\mu A$

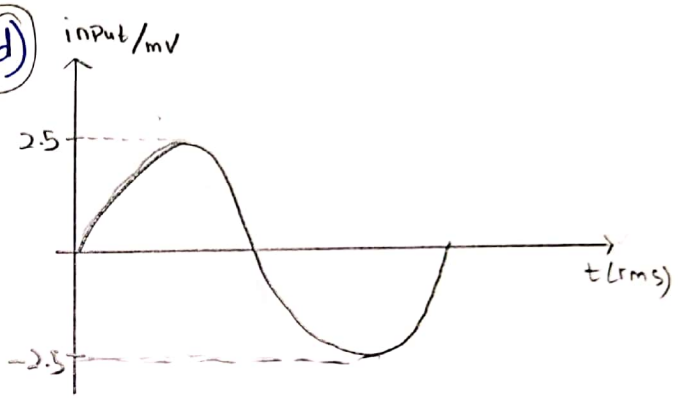
$i_{OL_{rms}} = -\beta\, i_b \times \frac{R_C}{R_C + R_L}$

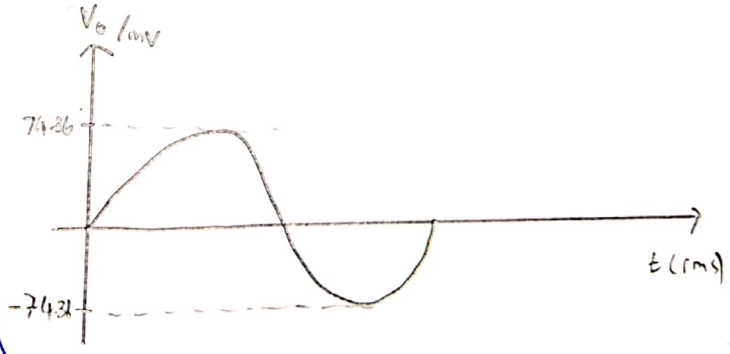
$= -(110)(0.3399\,\mu A) \times \left(\frac{3.9k}{3.9k + 2.2k}\right)$

$= -23.9\,\mu A_{//}$

c)

d)





$V_{o_{(P)}} = (i_o R_L) \times \sqrt{2}$

$= (23.9\,\mu A)(2.2k)(\sqrt{2})$

$= 74.36mV$