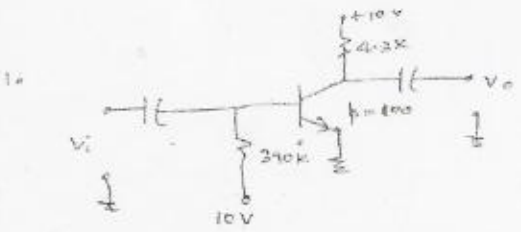
TW3

3.



I_B, I_c & r_e :

$$10 - 4.3K I_c - V_{CE} = 0$$

$$10 - 390K \times I_B - 0.7 = 0$$

$$9.3 = 390K \times I_B \qquad I_B = \frac{9.3}{390K}$$

$$I_B = 23.85\,\mu A$$

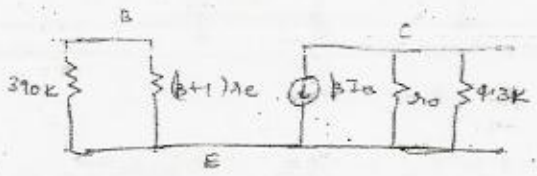
$$I_c = \beta I_B$$

$$= 2.38\,mA$$

$$I_E = (\beta+1) I_B = 2.41\,mA$$

$$r_e = \frac{V_T}{I_E} = \frac{26mV}{2.4mA} = 10.83\,\Omega$$

Eqt ckt



(i) $r_o = \infty$

$$Z_i = 390K \parallel (\beta+1) r_e \qquad Z_{out} = 4.3k$$

$$= 390K \parallel 101 \times 10.83\,\Omega$$

$$= 390K \parallel 1.094K = 1.091K \qquad A_{vc} = \frac{-4.3K}{10.83}$$

$$= -397.04$$

(ii) $r_o = 50K$

$Z_{in} = 1.091K$

$Z_{out} = 50K \parallel 4.3K$

$= 3.96K$

$A_V = -\frac{3.96K}{10.83} = -365.65$

(iii) $r_o = 20K$

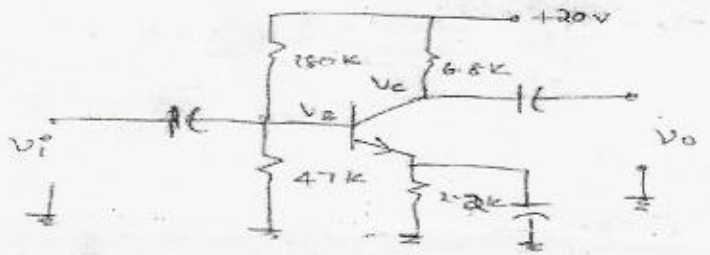
$Z_{in} = 1.091K$

$Z_{out} = 20K \parallel 4.3K$

$= 3.54K$

$A_V = -\frac{3.54K}{10.83} = -326.78$

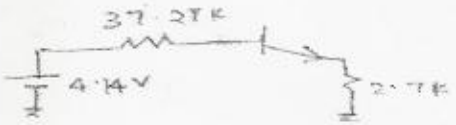
2. V_B, V_C r_e; Z_i, Z_o A_V $r_o = 50K$ $\beta = 120$



$20 - 6.8 \times I_C - V_{CE} - 2.2K \times I_E = 0$

$V_T = \frac{47 \times 20}{(150+47)} = 4.14V$

$R_T = 37.27K\Omega$



$4.14 - 37.27K \times I_B - 0.7 - 121 \times I_B \times 2.2K = 0$

$4.14 - 0.7 = (37.27K + 121 \times 2.2K) I_B$

$I_B = 14.33 \mu A$

$I_C = 1.36 mA$

$I_E = 1.37 mA$

$V_E = I_E R_C = 1.37 \times 2.2 = 3.014 V$

$V_B = 3.714 V$

$\frac{20 - V_C}{6.8K} = 1.36 mA \qquad V_C = 20 - 6.8 \times 1.36$

$= 10.752 V$

$Z_i = R_B \,||\, (\beta+1) r_e$

$= 37.27K \,||\, (121) \times r_e$

$= 37.27K \,||\, 2.3K$

$= 2.17K$

$r_e = \frac{26 mV}{1.37 mA}$

$= 18.97 \Omega$

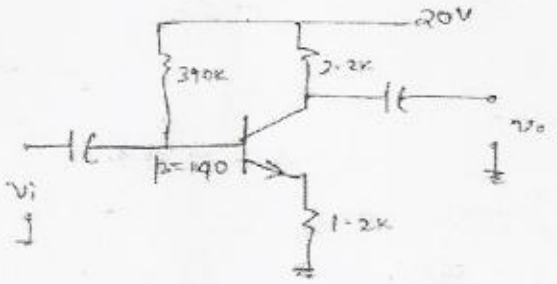
$(\beta+1) r_e = 2.3K$

$Z_{out} = R_C \,||\, r_o$

$= 6.8K \,||\, 50K = 5.986K$

$A_V = -\frac{R_C'}{r_e} = -\frac{5.986K}{18.97} = -315.55$

3.



r_e, Z_i, Z_o, A_v

r_o (i) 100K

(ii) 20K

$$20 - 2.2K \times I_C - V_{CE} - 1.2K \times I_E = 0$$

$$20 - 390K \times I_B - 0.7 - 1.2K \times 141 \times I_B = 0$$

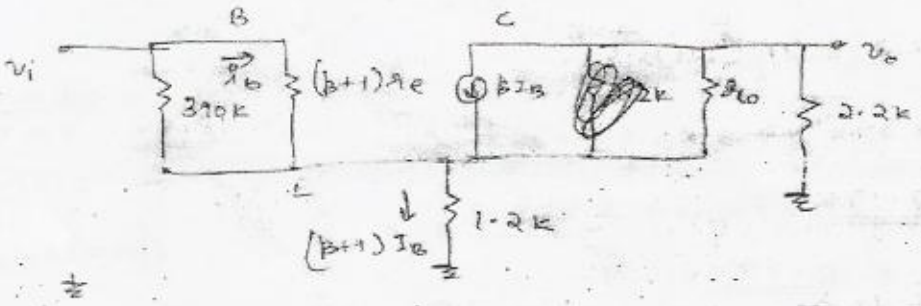
$$\therefore \quad 19.3 = I_B(390K + 1.2K \times 141)$$

$$I_B = \frac{19.3}{(390 + 1.2 \times 141)K}$$

$$= 34.5\,\mu A$$

$$I_E = 4.87\,mA$$

$$r_e = \frac{26mV}{4.87mA} = 5.34\Omega$$



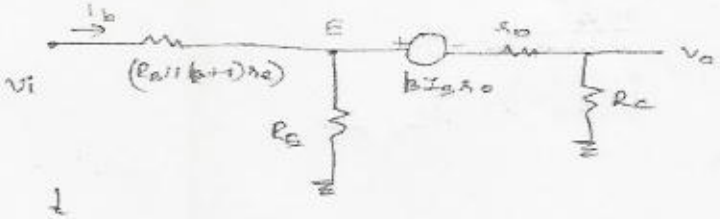
$$(\beta+1)r_e = 5.34 \times 141$$

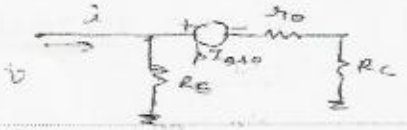
$$= 752.94\Omega \quad \| 390K \approx 752.94\Omega$$

~~$v_i = i_b [R_B \| (\beta+1) r_e] + (\beta+1) I_B R_E$~~

~~$v_o = \beta I_B R_C$~~

$Z_{in} = R_B \| (\_ Z_{in})$





~~$Z_{in} = (R_B \| (\beta+1) r_e)(\quad) + R_E \left(1 + \frac{\beta}{1 + \frac{R_E + R_C}{r_o}}\right)$~~

$\beta I_B r_o - i R_E - i R_C - i r_o = 0$

$\beta I_B r_o = i (R_E + R_C + r_o)$

$v = i R_E \quad i =$

$v = L \quad I_B = i \left(\frac{R_E + R_C}{\beta r_o} + \frac{1}{\beta} \right)$

$i = \frac{\beta I_B r_o}{R_E + R_C + r_o}$

$i = \frac{\beta I_B}{\left(\frac{R_E + R_C}{r_o}\right) + 1}$

$i = I_B \left[\frac{\beta}{\left(\frac{R_E + R_C}{r_o}\right) + 1} \right] \quad \beta = \beta'$

$v = (\beta+1) I_B \times R_E$

$R_E \left(1 + \frac{\beta}{1 + \frac{R_E + R_C}{r_o}}\right)$

$\frac{v_o}{v_{in}} = -\frac{R_C}{R_E} \left(\frac{1}{1 + \frac{R_E + R_C}{\beta r_o}} \right)$

$Z_{out} = R_E' + r_o (1 + g_m R_E')$

$R_E' = R_E \| (\beta+1) r_e \| R_B$

$R_E' = 1.2K \| 752.94\Omega$

$= 1.2K \| 0.753K\Omega$

$= 0.463K$

$r_o = 100K$

$Z_{in} = 752.94\Omega + 1.2K \left(1 + \frac{140}{1 + \frac{1.2 + 2.2}{100}}\right)$

$= 752.94\Omega + 1.2K \left(1 + \frac{140}{1.034}\right)$

$= 164.4K\Omega$

$= 20K$

$Z_{in} = 752.94\Omega + 1.2K \left(1 + \frac{140}{1 + \frac{1.2 + 2.2}{20}}\right)$

$= 145.54K\Omega$

$r_o = 100K$

$Z_{out} = R_E' + r_o \left(1 + \frac{R_E'}{\quad}\right)$

$R_0 = 20\,k$

$$= R_E' + R_0\left(1 + \frac{R_E'}{R_e}\right)$$

$$= 0.463 + 20\left(1 + \frac{0.463}{0.005}\right)$$

$$= 1.872\,M\Omega$$

Gain:

$R_0 = 100\,k$

$$A_V = \frac{-R_C}{R_E}\left(\frac{1}{1 + \frac{R_E + R_L}{\beta R_0}}\right)$$

$$= \frac{-2.2}{1.2}\left(\frac{1}{1 + \frac{1.2 + 2.2}{140 \times 100k}}\right)$$

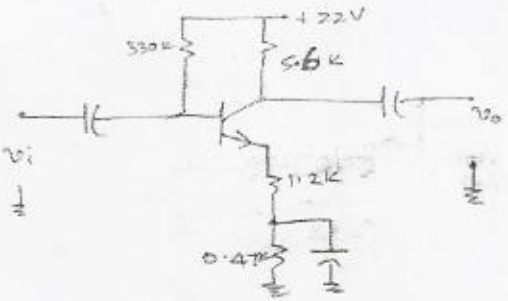
$$= -1.83$$

$R_0 = 20\,k$

$$= \frac{-2.2}{1.2}\left(\frac{1}{1 + \frac{1.2 + 2.2}{140 \times 20k}}\right)$$

$$= -1.83$$

4. r_e, Z_i, A_v $r_o = 40K\Omega$



$$22 - 5.6 \times I_c - V_{EB} - I_E \times 1.67 = 0$$

$$22 - I_B \times 330 - 0.7 - 81 \times I_B \times 1.67 = 0$$

$$21.3 = I_B(330 + 81 \times 1.67)K$$

$$I_B = 45.77\,\mu A$$

$$I_E = 8.7mA$$

$$r_e = \frac{V_T}{I_E} = \frac{26}{3.7} = 7.02\Omega$$

$$Z_i = R_B \,||\, \left((\beta+1) r_e + R_E \left(1 + \frac{\beta}{1 + \frac{R_E + R_C}{r_o}} \right) \right)$$

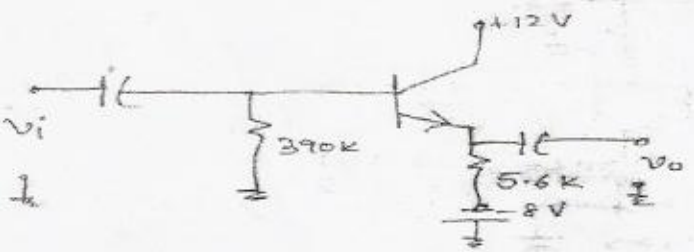
$$Z_i = 81 \times 7.02\Omega + 1.2K \left(1 + \frac{80}{1 + \frac{1.2 + 5.6}{40}} \right)$$

$$= 83.82K\Omega \,||\, 330K = 66.842K$$

$$A_v = -\frac{R_C}{R_E} \left(\frac{1}{1 + \frac{R_E + R_C}{\beta r_o}} \right) = -\frac{5.6}{1.2} \left(\frac{1}{1 + \frac{6.8}{80 \times 40}} \right)$$

$$\approx -4.656$$

5. Z_i, Z_o, A_V $\quad \beta = 120 \quad r_o = 40\,k$



$$-I_B \times 390K - 0.7 - 121 I_B \times 5.6 + 8 = 0$$

$$7.3 = I_B (121 \times 5.6 + 390)\,K$$

$$I_B = \frac{7.3}{(121 \times 5.6 + 390)K}$$

$$= 6.84\,\mu A$$

$$I_E = 0.83\,mA$$

$$r_e = \frac{26}{0.83} = 31.325\,\Omega$$

$$R_i = \left[R_B \,||\, (\beta+1) r_e\right] + R_E \left(1 + \frac{\beta}{1 + \frac{R_E}{r_o}}\right)$$

$$= 121 \times 31.325 + 5.6 \left(1 + \frac{120}{1 + \frac{5.6}{40}}\right)$$

$$= 5790.86\,K\Omega$$

$$Z_o = R_C' + r_o \left(1 + \frac{R_E'}{r_e}\right)$$

$$= 2.2K + 40 \left(1 + \frac{2.2K}{0.031\Omega}\right)$$

$R_C' = R_E'$

$= 5.6K$

$= 5.6K$

$=$

If Rs is there

$$r_e + \frac{(R_s \,||\, 390K)}{(\beta+1)}$$

$R_E' = R_E \,||\, r_o$

$= 5.6 \,||\, 40K$

$= 4.91K$

$r_e = 31.325\Omega$

$$A_V = \frac{4.91K}{0.031 + 4.91} = \frac{4.91}{4.91 + 0.031} = 0.994$$

$Z_{in} = [(\beta+1) r_e \,||\, R_B] + (\beta+1)(R_E')$

$= [121 \times 31.325 \,||\, 390K] + (121) \times 4.91K$

$= [3.79K \,||\, 390K] + 594.11K$

$= 597.86K$

$(\beta+1)(r_e + R_E') \,||\, R_B$

$= 121\,(31.325 + 4.91K) \,||\, 390K$

$= 597.89 \,||\, 390K$

$= 235.89K$

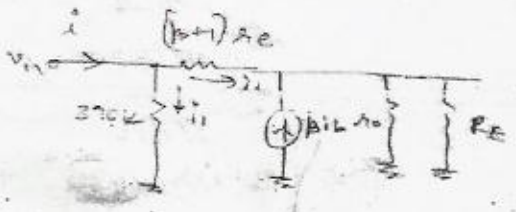
$Z_{out} = \frac{(R_B + r_s) \,||\, r_e}{(\beta+1)} \,||\, R_E'$

$= 31.325 \,||\, 4.91K$

$= 0.031K \,||\, 4.91K$

$= 0.0308K$

$= 30.8\Omega$

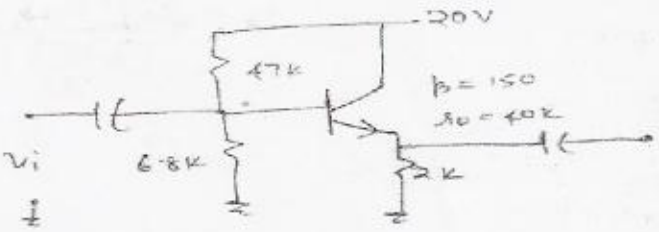


$i = i_1 + i_b$

$$\frac{v_{in}}{Z_{in}} = \frac{v_{in}}{R_B} + \frac{v_{in}}{(\beta+1)(r_e + R_E')}$$

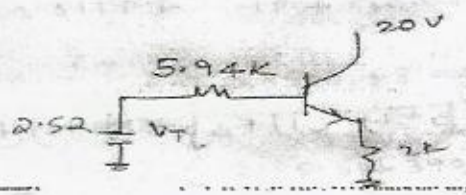
$Z_{in} = R_B \,||\, (\beta+1)(r_e + R_E')$

6. I_B, I_C, r_e, Z_i, Z_o, A_V



$$V_T = \frac{6.8 \times 20}{6.8 + 47}$$

$$= 2.52\ V$$



$$2.52 - I_B \times 5.94K - 0.7 - 151 I_B \times 2K = 0$$

$$1.82 = I_B (5.94K + 151 \times 2)$$

$$I_B = 5.91\ \mu A$$

$$I_C = 0.886\ mA$$

$$I_E = 0.892\ mA$$

$$r_e = \frac{V_T}{I_E} = \frac{26}{0.892} = 29.15\ \Omega$$

$$Z_i = \left[[(\beta+1) r_e \| R_E] + (\beta+1)[R_E \| r_o] \right] \| R_B$$

$R_E \| r_o = 2K \| 40K = 1.9K$ [illegible]

$(\beta+1) r_e = 151 \times 29.15 = 4.4K$

$[(\beta+1) r_e \| R_B] = 4.4 \| 5.9 = 2.52K$

$Z_{out} = \left[[(\beta+1) r_e \| R_B] \right] \| R_E'$

$= 2.52\text{K} \| 1.9\text{K}$ $\quad r_e \| R_E'$

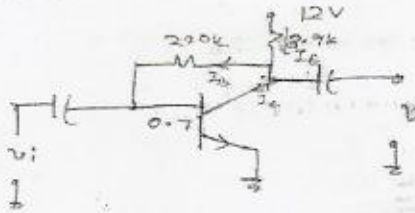
$= 1.08\text{K}$ $\quad 28.71\Omega$

$A_V = \frac{V_{out}}{V_{in}} = \frac{(\beta+1) i_b R_E'}{i_b [(\beta+1) r_e \| R_B] + (\beta+1) i_b R_E'}$

$= \frac{(\beta+1) R_E'}{[(\beta+1) r_e \| R_B] + (\beta+1) R_E'}$

$A_V = \frac{151 \times 1.9}{[2.52] + 151 \times 1.9} = 0.991$

7.



$r_o = 40\text{K}$

$\beta = 120$

$12 - I_E \times 3.9\text{K} - V_{CE} = 0$

$12 - 121 \times I_B \times 3.9 - 220 \times I_B - 0.7 = 0$

$11.3 = I_B (121 \times 2.9 + 220)\text{K}$

$I_B = 0.163\,\mu A$

$I_C = 1.96\,mA$

$I_E = 1.976\,mA$

$r_e = \frac{26}{1.976}$

$= 13.16\Omega$

$Z_{in} = \ldots A_V = -\frac{R_C'}{r_e} = -\frac{3.9 \| 40}{13.16} = \frac{-3.553\text{K}}{13.16}$

$$R_{Bin} = \frac{R_B}{1 - A_V} = \frac{220}{1 + 269.9} = 0.812\,K$$

$$R_{Bout} = \frac{R_B}{1 - 1/A_V} = \frac{220}{1 + 1/269.9} = 219.18\,K$$

$$Z_{in} = R_{Bin} \,||\, (\beta+1) r_e$$

$$= 0.812\,K \,||\, (180)\times 13.16\,\Omega$$

$$= 0.812\,K \,||\, 1.592$$

$$= 0.537\,K$$

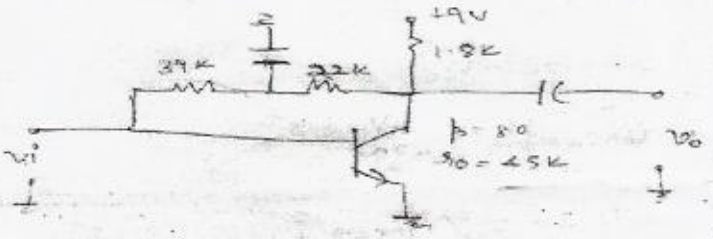
$$Z_{out} = R_C' \,||\, R_{Bout}$$

$$= 3.9K \,||\, 40K \,||\, 219.18\,K$$

$$= 3.55K \,||\, 219.18\,K$$

$$= 3.49K$$

8.



$$9 - 81 \times I_B \times 1.8 - I_B \times 61K - 0.7 = 0$$

$$8.3 = I_B [81 \times 1.8 + 61]$$

$$I_B = \frac{8.3}{[81 \times 18 + 61]} = 0.4\,\mu A$$

$I_E = 3.25\,mA$

$r_e = \frac{V_T}{I_E} = \underline{8\,\Omega}$

$A_V = \frac{-R_C'}{r_e}$ $\qquad R_C' = 1.8K \,||\, 45K$

$= 1.73K$

$= -\frac{1.73K}{8}$

$= -216.25K$

$R_{Bin} = \frac{22}{1 + \frac{1}{216.25}} = 0.1K$

$R_{Bout} = \frac{22}{1 + \frac{1}{21K25}} = 21.89K$

$A_V = \frac{-1.6}{8}$

$= \underline{-200}$

$Z_{in} = R_{Bin} \,||\, (\beta+1) r_e$

$= 0.1K \,||\, 81 \times 8$

$= 0.1K \,||\, 0.648\,K$

$= 0.0866\,K = \underline{86.6\,\Omega}$

$39K \,||\, 0.648\,K$

$= 0.637K$

$Z_{out} = R_C' \,||\, R_{Bout}$

$= 1.73K \,||\, 21.89K$

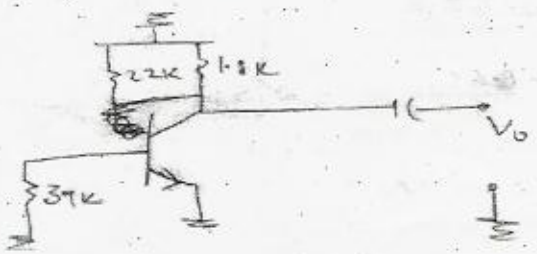
$= \underline{1.603K\,\Omega}$

$R_C = 2.2K \,||\, 1.8K$

$= \underline{1.66K}$

$Z_{out} = 1.66K \,||\, 45K$

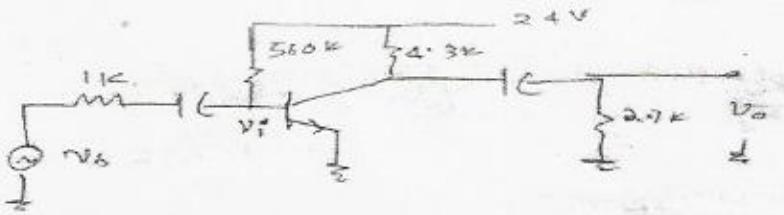
$= \underline{1.6K}$



9. V_o/V_i , V_o/V_s , Z_i & Z_o

$r_o = \infty$

$\beta = 80$



$$24 - 560 \times I_B - 0.7 = 0$$

$$23.3 = 560\,K\, I_B$$

$$I_B = 0.416\ \mu A$$

$$I_E = 3.37\ mA$$

$$r_e = \frac{V_T}{I_E} = 7.715\ \Omega$$

$$Z_{in} = \left[R_B \,||\, (\beta+1) r_e\right]$$

$$= \left[560K \,||\, 81 \times 7.715\Omega\right]$$

$$= \left[560K \,||\, 0.625K\right]$$

$$= 0.624\ K\Omega$$

$0.624K\Omega \,||\, 1K$

$0.384K$

$$Z_o = R_c' = 4.3K \,||\, 2.7K$$

$$= 1.66\ K$$

$$\frac{V_o}{V_i} = -\frac{1.66K}{7.715} = -215.16$$

$$v_i = v_s \times \frac{0.624K}{0.624 + 1K}$$

$$\frac{v_i}{v_s} = 0.384$$

$$\frac{v_o}{v_s} = \frac{v_o}{v_i} \times \frac{v_i}{v_s} = -82.62$$

When e_s & R_L changed

$$Z_{in} = 0.624\ K\Omega$$

$$Z_{out} = 4.3K \parallel 5.6K$$

$$= 2.43K$$

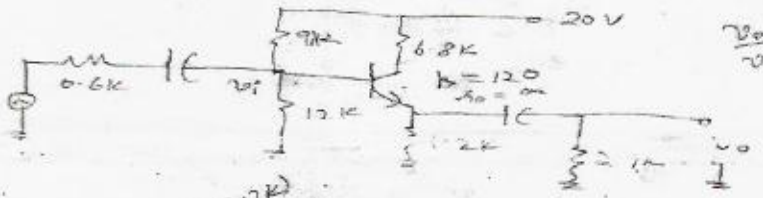
$$Av = \frac{v_o}{v_i} = \frac{-2.43K}{7.715} = -314.9$$

$$\frac{v_i'}{v_s} = \frac{0.624K}{0.5 + 0.624}$$

$$= 0.555$$

$$\boxed{\frac{v_o}{v_s} = -174.87}$$

10.



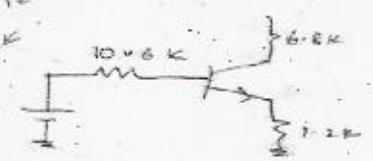
$$\frac{v_o}{v_i} = \frac{(1.2K \parallel 2.7K)}{20.537 + (1.2K \parallel 120K)}$$

$$= 0.975$$

$$121\,(20.54 + 1.2K \parallel 2.7K)$$

$$= 103K \parallel (91K \parallel 12K)$$

$$= 9.61K$$



$$Z_{out} = \left(R_e + \frac{0.6K \parallel 91K \parallel 12K}{\beta + 1}\right)$$

$1.2K \parallel 2.7K$

29.5Ω

$$2.33 - 10.6 \times I_B - 0.7 - 121 \times I_B \times 1.2K = 0$$