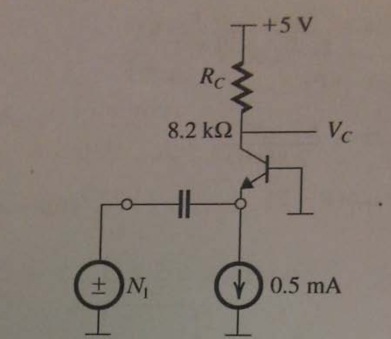
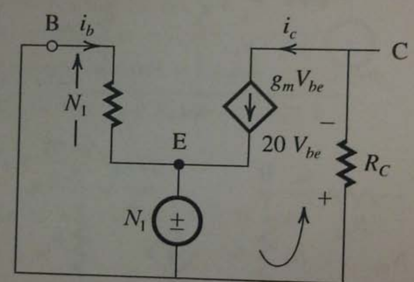
6.95





For β very high

$I_C \approx I_E = 0.5$ mA

$g_m = \frac{I_C}{V_T} = \frac{0.5}{0.025} = 20$ mA / V

$V_C = 5 - 8.2 \times 0.5 = 0.9$ V

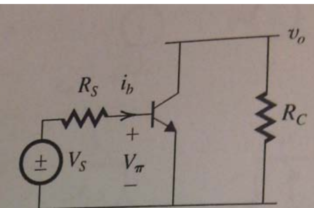
Note : $V_\pi = -V_1$

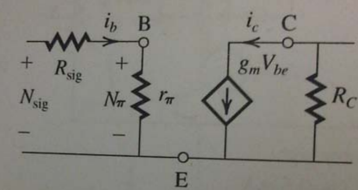
Then $V_C = -g_m R_C V_{be}$

$V_C = -20(-)V_1 \times 8.2$

$\therefore \frac{V_C}{V_1} = +164$ V / V

6.97



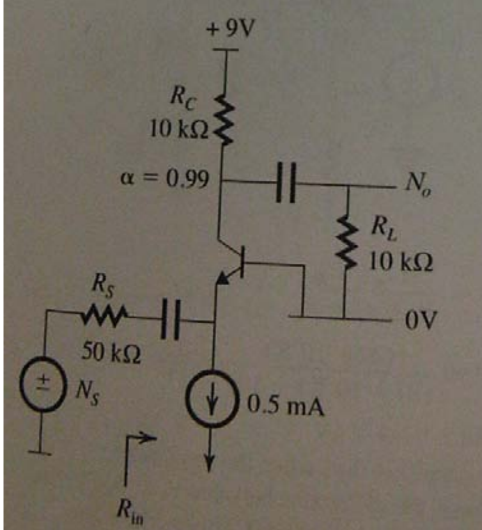


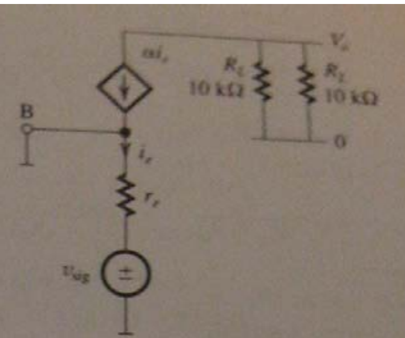
$\frac{v_O}{v_{sig}} = \frac{v_1}{v_1} = \frac{r_\pi}{r_\pi + R_{sig}}(-)g_m R_C$

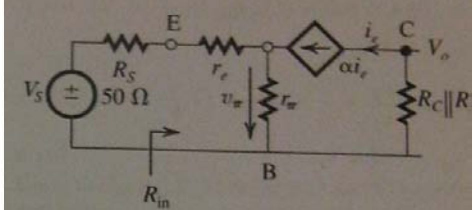
$= \frac{-r_\pi g_m}{r_\pi + R_{sig}} R_C$

$= \frac{-\beta R_C}{r_\pi + R_{sig}}$

6.100







$$r_e = \frac{V_T}{I_E} = \frac{25\text{ mV}}{0.5\text{ mA}} = 50\ \Omega$$

$$R_{IN} = r_e = 50\ \Omega$$

$$v_o = -0.99\, i_e(R_C \| R_L)$$

$$= -0.99\frac{(-v_s)}{R_{IN}}\, 5\text{ k}\Omega$$

$$\frac{v_o}{v_S} = +\frac{0.99 \times 5}{050} = +99\text{ V/V}$$

6.101

Refer to Fig P5.1166

$\beta = 200 \rightarrow \alpha = 0.995$

$I_C - \alpha I_E = 0.995 \times 10 \text{ mA} = 9.95 \text{ mA}$

$V_C = 9.95 \text{ mV} \times 100 = 0.995 \text{ V}$

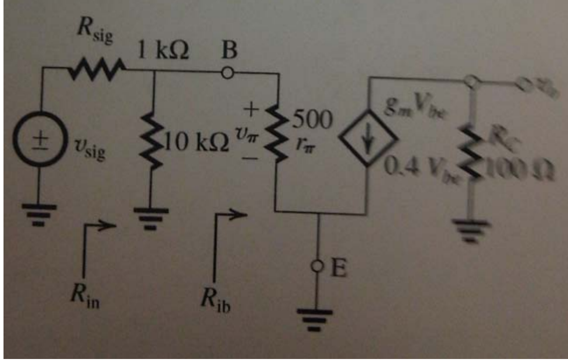
$I_B \cong \frac{10 \text{ m}}{200} = 0.05 \text{ mA}$

$V_B = 1.5 - 10 \text{ k}\Omega \times 0.05 \text{ mA}$

$= 1 \text{ V}$

$\Rightarrow V_{BC} = +0.005$

$\rightarrow$ Active region



$$g_m = \frac{I_C}{V_T} = \frac{9.95}{25 \text{ m}} = 0.4 \text{ A/V}$$

$$r_\pi = \frac{\beta}{g_m} = \frac{200}{0.4} = 500\ \Omega$$

$$R_{i6} = r_\pi = 500\ \Omega$$

$$R_{in} = 10 \text{ k}\Omega \parallel r_\pi = 476\ \Omega$$

$$v_{be} = v_{sig} \times \frac{R_{in}}{R_{sig} + R_{in}} = v_{sig} \times 0.32$$

also :

$$v_O = -g_m v_{be} \cdot R_C$$

$$= -g_m R_C \times 0.32\ v_{sig}$$

$$= -0.4 \times 100 \times 0.32\ v_{sig}$$

$$= -12.8\ v_{sig}$$

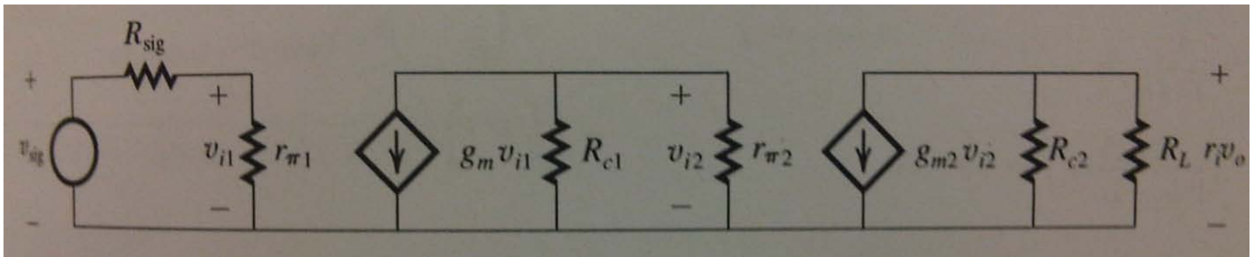
$$\Rightarrow \text{gain } \frac{v_O}{v_S} = -12.8 \simeq -13 \frac{v}{V}$$

If $v_O = \pm 0.4 \text{ V}$

$$\hat{v}_S = \frac{\hat{v}_O}{13} = 30 \text{ mV}$$

$$\hat{v}_{be} = 0.32 \times 30 \text{ m} = 9.8 \text{ mA}$$

6.16]



b) Voltage tranfer from sig to first stage input

$$v_{i1} / v_{sig} = \frac{r_{\pi 1}}{r_{\pi 1} + R_{sig}}$$

Given $I_c = 0.25$ mA; $\beta = 100$; $V_A \to \infty$;

$R_c = 10$ kΩ; $R_{sig} = 10$ kΩ

$$g_m = \frac{I_C}{V_T}, \quad r_\pi = \frac{\beta}{g_m} = \frac{\beta}{I_C} V_T$$

$$r_\pi = \frac{100}{0.25 \times 10^{-3}}(0.015) = 10 \text{ k}\Omega$$

$$v_{i1} / v_{sig} = \frac{10 \text{ k}\Omega}{10 \text{ k}\Omega + 10 \text{ k}\Omega} = 1/2$$

c) $A_{V1} = v_{i2} / v_{i1} = -g_m(R_{c1} \| r_{\pi 2})$

Since $r_\pi = r_{\pi 1} = r_{\pi 2}$ & $R_C = R_{C1} = R_{C2} = 10$ kΩ

$$A_{V1} = -\frac{I_C}{V_T}(10 \text{ k}\Omega \| 10 \text{ k}\Omega)$$

$$= -\frac{0.25 \times 10^{-3}}{0.025}(5 \text{ k}\Omega) = -50$$

d) $A_{V2} = v_O / v_{i2} = -g_m \times (R_{c2} \| R_L)$

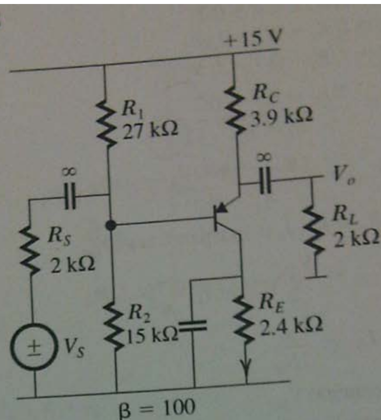
$$= -\frac{I_C}{V_T}(R_{c2} \| R_L) = \frac{0.25 \times 10^{-3}}{0.025}(5 \text{ k}\Omega)$$

$$= -50$$

e) $G_V = v_O / v_{sig} = \frac{v_{i1}}{v_{sig}} \times \frac{v_{i2}}{v_{i3}} \times \frac{v_O}{v_{i2}}$

$$= (0,5)(-50)(-50) = G_V = -1250$$

6.142



$$R_1 \| R_2 = 9.64 \text{ k}\Omega$$

$$V_{BB} = \frac{15 \times R_2}{R_1 + R_2} = 5.36 \text{ V}$$

$$I_E = \frac{V_{BB} - 0.7}{2.4 + \frac{9.64}{101}} = 1.87 \text{ mA}$$

$$g_m = \frac{I_C}{V_T} = \frac{0.99 I_E}{V_T} = 74 \text{ V/V}$$

$$r_O = \frac{V_A}{I_C} = 54 \text{ k}\Omega$$

$$r_\pi = \frac{\beta}{g_m} = \frac{100}{74} = 1.35 \text{ k}\Omega$$

$$R_C \| R_L = \frac{3.9 \times 2}{5.9} = 1.32 \text{ k}\Omega << r_o$$

Thus we can neglect r_o

$$I_c = 0.99 \times I = 1.68 \text{ mA}$$

$$R_{in} = (R_1 \| R_2) | r_\pi = 1.18 \text{ k}\Omega$$

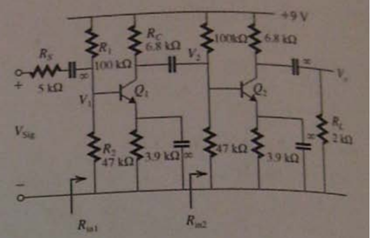
$$R_O = r_O \| R_C \approx 1.32 \text{ k}\Omega$$

$$\frac{v_O}{v_1} = -\frac{R_{IN}}{R_{IN} + R_s} \times g_m(r_O \| R_C \| R_L)$$

$$R_S = -\frac{1.18}{3.18} \times 74 \times 1.29$$

$$= -35.4 \text{ V/V}$$

6.147



$$I_E = \frac{V_{BB} - 0.7}{R_E + (R_1 \| R_2)/(\beta + 1)}$$

$$= \frac{2.88 - 0.7}{3.9 + 32/101} \approx 0.5 \text{ mA}$$

$$g_m = \frac{I_C}{V_T} = \frac{0.99 \times 0.5}{0.025} = 19.8 \text{ mA/V}$$

$$r_\pi = \frac{\beta}{g_m} = \frac{100}{19.8} \approx 5.05 \text{ k}\Omega$$

(c) $R_{IN} = [(R_1 \| R_2) \| r_\pi]$

$= 32 \| 5 = 4.3 \text{ k}\Omega$

Stage 2 is identical

(d) $\frac{v_e}{v_{sig}} = \frac{v_1}{v_{sig}} \cdot \frac{v_2}{v_1}$

$$= \frac{R_{IN}}{R_S + R_{IN}} \times [(-g_m(R_C \| R_{IN})]$$

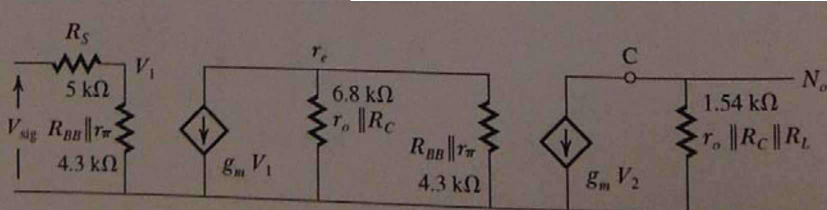
$$= \frac{4.3}{9.3} \times (-)\ 9.8 \times 2.6$$

$$= -23.8$$

(e) $\frac{v_o}{v_2} = -g_m(R_C R_L) = -30.6 \text{ V/V}$

(f) $\frac{v_o}{v_{sig}} = -23.8(-30.6) = +728 \text{ V/V}$

(b) Equivalent circuit



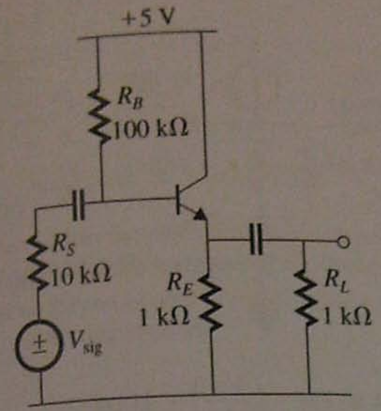
$$\left(r_o = \frac{100}{0.5} = 200 \text{ k}\Omega \text{ ignore}\right)$$

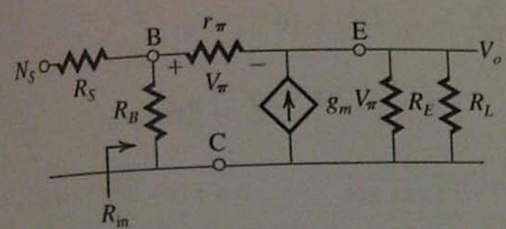
$g_m = 19.8 \text{ mA/V}$

(R_E's are assumed by-passed)

$$G_V = \frac{v_1}{v_{sig}} \cdot \frac{v_2}{v_1} \cdot \frac{v_o}{v_2}$$

6.152





$A_+ E.$

$$\frac{v_b - v_o}{r_\pi} + g_m r_\pi = \frac{V_O}{R}$$

where $v_\pi = v_b - v_o$

and $R = r_o \| R_E \| R_L$

$$\therefore \frac{v_o}{v_b} = \frac{1/r_\pi + g_m}{1/r_\pi + g_m + 1/R}$$

$$= \frac{R}{R + \dfrac{r_\pi}{1 + g_m r_\pi}}$$

$$= \frac{R}{R + r_e}$$

Now $R_{IN} = R_B \| \left(\frac{v_b}{i_b}\right)$

$$\therefore R_{IN} = R_B \| \left[v_b \times \frac{r_\pi}{v_b - v_O}\right]$$

$$= R_B \| \left[\frac{r_\pi}{1 - v_O / v_b}\right]$$

$$= R_B \| \left[\frac{r_\pi}{1 - A}\right]$$

$$I_E(\beta) = \frac{5 - 0.7}{R_B / (\beta + 1) + R_E}$$

$$I_E(50) = \frac{4.3}{100/51 + 1} = 1.45 \text{ mA}$$

$V_E(50) = 1.45$ V, $V_B(50) = 2.15$ V

$$I_E(200) = \frac{4.3}{100/201 + 1} = 2.87 \text{ mA}$$

$V_E(200) = 2.8$ mA, $V_B(200) = 3.57$ V

$$\frac{v_O}{v_S} = \frac{v_b}{v_S} \times \frac{v_O}{v_b} = \frac{R_{IN}}{R + R_{IN}} \times \frac{R}{R + r_e}$$

	$\beta = 50$	$\beta = 200$
I_E	1.45 mA	2.87 mA
V_E	1.45 V	2.87 V
V_B	2.15 V	3.57 V
g_m	$56.9 \frac{\text{mA}}{\text{V}}$	$114 \frac{\text{mA}}{\text{V}}$
r_e	17Ω	8.7Ω
R_{IN}	20.8 kΩ	49.3 kΩ
$Av = \frac{v_O}{v_b}$	0.967 V/V	0.982 V/V
$\frac{v_O}{v_{sig}}$	0.653 V/V	0.816 V/V