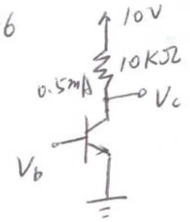
EE20242 HW7

6.86



$V_C = V_{CC} - I_C R_C = 10 - 0.5 \times 10 = 5V$

$\Delta V_{BE} = V_T \ln(I_{C2}/I_{C1})$

$(705mV - 700mV) = 25mV \ln(I_{C2}/0.5mA)$

$\Rightarrow I_{C2} = 0.61mA$

$V_{C2} = 10V - 0.61mA \times 10K\Omega = 3.98V$

$$A_V = -\frac{(0.61mA - 0.5mA) \times 10K\Omega}{705mV - 700mV} = -220\ V/V$$

$$A_V = -g_m R_C = -\frac{I_C R_C}{V_T} = \frac{-0.5mA \times 10K\Omega}{0.025V} = -200\ V/V$$

6.87

$g_m = \frac{I_C}{V_T} = \frac{0.6\ mA}{0.025V} = 24\ mA/V$;

$r_\pi = \frac{\beta}{g_m} = \frac{120}{24} = 5K\Omega$;

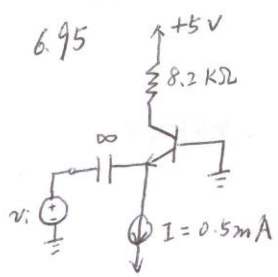
$r_e = \frac{r_\pi}{\beta+1} = \frac{5K\Omega}{121} = 41.3\Omega$;

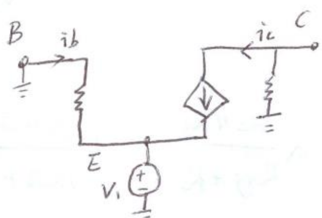
$g_m = \frac{60\ uA}{0.025V} = 2.4mA/V$,

$r_\pi = \frac{\beta}{g_m} = \frac{120}{2.4} = 50K\Omega$

$r_e = \frac{r_\pi}{\beta+1} = \frac{50K}{121} = 413\Omega$

6.95





for a very high β,

$I_C \approx I_E = 0.5mA$

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

$V_C = 5V - 8.2K\Omega \times 0.5mA = 0.9V$

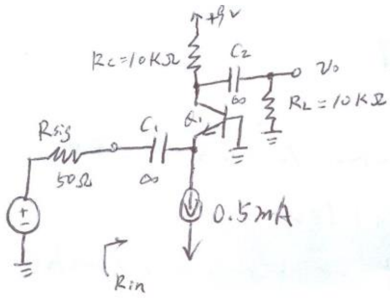
$V_\pi = -V_i$

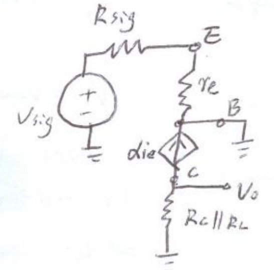
$V_C = -g_m R_C V_{be}$

$= -20 \times 8.2 \times (-V_i)$

$\frac{V_c}{V_i} = 20 \times 8.2 = 164\ V/V$

6.100





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

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

$$v_o = -0.99\, i_c\,(R_c \| R_L) = -0.99\, \frac{-v_{sig}}{R_{in}} (10K\Omega \| 10K\Omega)$$

$$\frac{v_o}{v_{sig}} = +\frac{0.99 \times 5k\Omega}{50K} = 99\ V/V$$

6.122 $v_{be}(t) = r_e i_e$, $v_o(t) = -\alpha i_e (R_c \| R_L)$

$$\Rightarrow v_{be}(t) = -r_e \frac{v_o(t)}{\alpha (R_c \| R_L)}$$

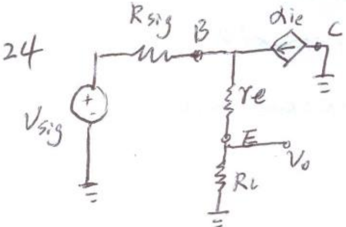
$$|v_o(t)| = \frac{\alpha (R_c \| R_L)}{r_e} |v_{be}(t)| = \frac{\alpha (R_c \| R_L) \cdot I_E}{V_T} |v_{be}(t)| = \frac{1 \times (10K\Omega \| 10K\Omega) \times 0.25m}{0.025} \times 10m$$

$$= 0.5V$$

$$G_v = \frac{v_o(t)}{v_{sig}(t)} = \alpha \frac{R_c \| R_L}{R_{sig} + r_e} = \frac{1 \times (10K\Omega \| 10K\Omega)}{1K\Omega + \frac{0.025V}{0.25mA}} = 4.55\ V/V$$

$$|v_{sig}(t)| = \frac{v_o(t)}{G_v} = 0.5V / 4.55 = 0.11V$$

6.124



(a).

$$I_E = \frac{\beta + 1}{\beta} I_C = \frac{101}{100} \times 10^{-3} A = 1.01mA$$

$$r_e = \frac{V_T}{I_E} = \frac{0.025V}{1.01mA} = 24.752\Omega$$

$$R_{in} = (\beta+1)(r_e + R_L) = 101 \times (24.752\Omega + 1k\Omega) = 103.5k\Omega$$

$$G_v = v_o/v_{sig} = \frac{(\beta+1)R_L}{(\beta+1)R_L + (\beta+1)r_e + R_{sig}} = \frac{101 \times 1k\Omega}{101\times 1k\Omega + 101\times 24.752 + 20k\Omega} = 0.8178$$

$$i_e(t) = v_o(t)/R_L = \frac{G_v \cdot v_{sig}}{R_L}$$

$$v_{be}(t) = r_e i_e(t) = (r_e/R_L)\,G_v\, v_{sig}(t) \Rightarrow \frac{v_{be}(t)}{v_{sig}(t)} = \frac{r_e G_v}{R_L} = \frac{24.752\times 0.8178}{1000} = 0.02024$$

$$v_b(t) = v_o(t) + v_{be}(t)$$

$$\frac{v_b(t)}{v_{sig}(t)} = \frac{v_o(t)}{v_{sig}(t)} + \frac{v_{be}(t)}{v_{sig}(t)} = G_v + \frac{r_e G_v}{R_L} = 0.8178 + 0.02024 = 0.838$$

(b) $v_{be}(t)/v_{sig}(t) = 0.02024$

$$\Rightarrow |v_{sig}(t)|_{max} = |v_{be}(t)|_{max}/0.02024 = 10\times10^{-3}/0.02024 = 0.494\ V_{old}$$

$$|v_o(t)|_{max} = G_v \cdot |v_{sig}(t)|_{max} = 0.494 \times 0.8178 = 0.404\ V$$

(c) If R_L is removed. $i_e = 0 \Rightarrow v_e = v_{sig} \Rightarrow G_{vo} = 1$

$$R_{out} = -\frac{v_x(t)}{i_e(t)} \qquad i_e(t) = \frac{v_b(t) - v_e(t)}{r_e} = \frac{v_b(t) - v_x(t)}{r_e}$$

$$v_b(t) = -i_e(t)\,(1-\alpha)R_{sig} \Rightarrow i_e(t) = \frac{-i_e(t)(1-\alpha)R_{sig} - v_x(t)}{r_e}$$

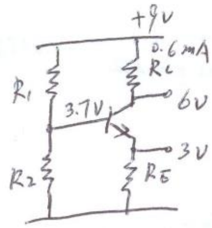
$$r_e i_e(t) = -i_e(1-\alpha)R_{sig} - v_x(t)$$

$$i_e(t) = \frac{-v_x}{r_e + (1-\alpha)R_{sig}}$$

$$\Rightarrow R_{out} = r_e + (1-\alpha)R_{sig} = r_e + \frac{1}{\beta+1}R_{sig} = 24.752 + \frac{20\times10^3}{101} = 222.772$$

$$\frac{v_o(t)}{v_{sig}(t)} = \frac{1000}{1000 + 222.772} = 0.8178$$ It agrees with G_v in (a).

6.130



For $\beta = \infty$, $I_B = 0$. $V_B = V_E + 0.7 = 3.7V$.

$I_E \approx I_C = 0.6mA$.

$I_{R1} = \frac{I_E}{10} = 0.06mA$, $R_1 = \frac{9-3.7}{0.06} = 88.3k\Omega$

$R_2 = \frac{3.7}{0.06} = 61.7k\Omega$

use $R_1 = 82k\Omega$, $R_2 = 68k\Omega$

Now $V_{BB} = \frac{9 \times 68}{82+68} = 4.08V$. $R_{BB} = \frac{68 \times 82}{150} = 37.2k\Omega$

$R_E = R_C = \frac{3V}{0.6mA} = 5k\Omega$ use $5.1k\Omega$

For $\beta = 90$, $I_E = \frac{V_{BB} - 0.7}{\frac{R_{BB}}{\beta+1} + R_E} = \frac{3.39}{0.41 + 5.1} = 0.615mA$

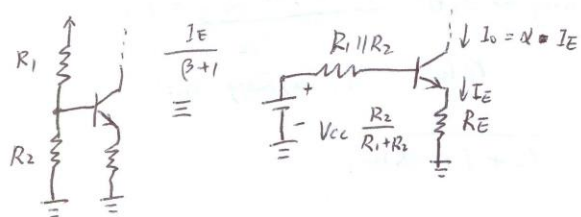
$V_E = 0.615mA \times 5.1 = 3.14V$

$V_B = V_E + 0.7 = 3.84V$

$V_C = 9 - 5.1 \times 0.65 \times 90/90 = 5.9V$

(check $V_B = V_{BB} - R_{BE} \times I_E / 91 = 3.83V$)

6.138



$$V_{CC} \cdot \frac{R_2}{R_1+R_2} = \frac{I_E}{\beta+1}(R_1 \| R_2) + V_{BE} + I_E R_E$$

$$\Rightarrow I_E = \frac{V_{CC}\frac{R_2}{R_1+R_2} - V_{BE}}{R_E + \frac{R_1 \| R_2}{\beta+1}}$$

$$\Rightarrow I_o = \alpha I_E = \frac{\alpha\left(\frac{V_{CC} R_2}{R_1+R_2} - V_{BE}\right)}{R_E + \frac{R_1 \| R_2}{\beta+1}}$$